STUDY OF ENVIRONMENTAL IMPACTS
OF SELECTED DISPOSABLE VERSUS REUSABLE PRODUCTS
WITH HEALTH CONSIDERATIONS

This report (SW-152c) describes work performed for the Federal solid waste program under contract no. 4010-D and is reproduced as received in draft form from the contractor along with comments received from the reviewers

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U.S. Department of Commerce
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U.S. ENVIRONMENTAL PROTECTION AGENCY

1978

An environmental protection publication (SW-152c) in the solid waste management series.

Foreword

Section 205(2) of the Resource Recovery Act of 1970 charged the U.S. Environmental Protection Agency with the responsibility to study "changes in current product characteristics and production ... which would reduce the amount of solid waste." This Act was amended by the Resource Conservation and Recovery Act of 1976, which continues the Agency's responsiblity in the area of resource conservation.

This study on disposable versus reusable products is one of a series of studies that were undertaken as a result of the directive given the Environmental Protection Agency by the Resource Recovery Act. The other studies in the series examined beverage containers and milk containers. This study was an attempt to compare the resource and environmental impacts of reusable products with their disposable counterparts.

The resource and environmental impacts analyzed in this study are: raw material use, energy use, water use, industrial solid waste, post-consumer solid waste, air pollution emissions, and water effluents. These impacts are assessed at each step in the life cycle of a product. The cycle begins with raw materials extraction and continues through disposal.

A draft of the report was carefully reviewed by industrial and technical experts. These experts provided divergent views as to the accuracy of the report. In an attempt to provide as complete and descriptive a study as possible, the comments of these experts have been footnoted in the appropriate places in the study.

The study is being printed as received from the contractor, rather than attempt to rewrite the entire study. Therefore, you should refer to the footnotes when reading this study.

The primary cause of the divergent opinions of the experts lies in the assumptions upon which the resource and environmental impact data is developed. For example, a question was raised concerning the average number of pounds of laundry in a washing machine. This is a significant factor for the cloth products. It is in the cleaning step that the largest percentage of impacts occur. Therefore, a higher or lower average wash load will have a definite affect on how the cloth products compare vis-a-vis the disposable products.

In conclusion, those reading this study should pay particular attention to the comments made by the experts. Furthermore, the data presented in the study should be examined in light of conflicting evidence and viewpoints. Therefore, it would be inappropriate for an organization to develop a policy position on this subject based on this study.

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PREFACE

The objective of this research study is to describe the resource and environmental, health, and economic aspects for selected disposable and reusable products in the following product categories: (1) Towels; (2) Napkins; (3) Diapers; (4) Bedding; (5) Containers (cups and tumblers); and (6) Plates. Volume I contains the resource and environmental impact report, while Volume II describes selected health and economic considerations.

The research effort was conducted for the United States Environmental Protection Agency (Resource Recovery Division - Office of Solid Waste Management). The study was conducted under the general direction of Mr. Robert Levesque, Manager of Technoeconomics Programs at Midwest Research Institute. The project leader for the study and a principal investigator for the resource and environmental aspects was Mr. Richard O. Welch, Senior Industrial Research Analyst. The principal researcher for the health aspects was Mr. Ron Fellman, aided by Ms. Mary Simister. Mr. Chuck Romine was the principal investigator for the economic analysis. Mr. Dan Keyes assisted in the preparation of the resource and environmental report.

The co-principal investigator responsible for the paper products considered in the study was Mr. Robert G. Hunt, Franklin Associates, Ltd., a subcontractor to MRI. Mr. William E. Franklin provided managerial review functions for the subcontractor.

The research team is greatly indebted to many companies and organizations for the active support they provided for the study. Contributors to the study are identified in the Bibliography section.

This document is a draft report being circulated for comment on technical accuracy and policy implications. The findings and conclusions are tentative and subject to change in the final report.

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INTRODUCTION

This research study concerning six disposable and reusable product categories is divided into three phases: Resource and Environmental Profile Analysis, Health Aspects, and Economic Aspects (which was not completed due to lack of data).

1. Resource and Environmental Profile Analysis:[1,2,3] The purpose of this phase is to provide a comparison of the resource inputs (raw materials, energy, and water) and environmental outputs (air emission, waterborne wastes, process solid wastes, and postconsumer solid wastes) associated with the products within each product category. The analysis includes the impacts from raw material extraction through product disposal, including the steps of materials processing, product manufacture and use.

2. Health Aspects:[3,4,5,6] This phase reports on the health concerns which have been identified concerning the use and disposal of the disposable and reusable products. The research involved literature searches and documentation of public health and sanitation laws, ordinances, etc; interviews with companies, organizations, public officials, and knowledgable professionals; and site visits to laundries, hospitals, etc. The comments presented by the Single Service Institute, February 1975, and the Tissue Division of the American Paper Institute, March 1975, to the U.S. Environmental Protection Agency were reviewed during this task.

Summary - Public Health and Sanitation Concerns: The products included in this study--towels, napkins, sheets, diapers and foodservice ware--are vital components in the American way of life. The average individual uses or comes into contact with the majority of these types of products during the course of each day. Accordingly, the relative sanitation of the disposable and reusable variants within each product type is a significant concern of all involved in delivering these items to the consumer.

The "Public Health and Sanitation" component of this comprehensive study of selected disposable versus reusable products examines concerns that have been raised regarding the public health and sanitation aspects of these products. In accordance with the scope of work for this investigation, MRI conducted a literature review of relevant sanitation studies, as well as of the U.S. Food and Drug Administration Sanitation Code and selected state and local sanitation ordinances. A total of 85 references were reviewed for this task. Additionally, MRI contacted 32 public health associations and industrial associations, 40 product manufacturers, national and regional FDA officials, and 5 state health agencies. The research effort resulted in the following general conclusions:

1/ See comment No. 1 Appendix B, page 3.
2/ See comment Appendix E, pages 1-2.
3/ See comments Appendix J.
4/ See comments Appendix B, pages 11-16.
5/ See comments Appendix C, pages 1-2.
6/ See comments Appendix D.

Sanitation concerns related to the cloth products studied involve a wide range of variables, and no definitive conclusions can be reached regarding absolute degrees of contamination or sanitation of a given product. However, the following points are overwhelmingly supported by the literature:

1. Cloth products are potential disseminators of microorganisms;

2. Laundering at 160° for 25 minutes can reasonably ensure destruction of pathogenic bacteria (lesser time and temperature being effective for some bacteria);

3. Commercial laundering methods are generally superior to home laundering methods in sanitizing cloth products; and

4. The impacts of inadequate sanitation on the public health cannot be definitively determined, since variables such as degree of contamination and susceptibility of the exposed populace significantly affect the relationship between contaminated fabrics and the development of disease.

Additionally, no definitive conclusions could be drawn relative to the comparable disposable products studied (paper towels and napkins, disposable diapers and sheets); however, issues such as the effect of landfill disposal of contaminated diapers are addressed in the body of the report.

Regarding the use of foodservice ware in commercial and institutional settings, it is extremely difficult to make direct comparisons between reusables and disposables. The impact of human variables, from day to day, from restaurant to restaurant or institution to institution, negates virtually every attempt to quantify differences in the sanitary status of disposables versus reusables. As correctly stated by the Single Service Institute, "the only precise way to assess the health values of disposables versus reusables would be to survey the bacteriological quality of one versus the other by testing the utensils in food-serving establishments just prior to their use." And even then, the scope of the investigation would have to be massive in order to be equitable. Additionally, bacteriological standards alone do not measure the capacity of foodservice ware (or any other product) to transmit disease; the most such standards can do is to indicate potential for disease transmission.

The problem in assessing sanitation standards on foodservice ware is summarized quite effectively by Bailus Walker, the author of several studies in this field: "Questions involving the health effects of environmental bioloads are particularly prone to uncertainty and the health impact of various environmental levels of microorganisms on food or beverage contact surfaces are often unknown, and not infrequently unknowable."

3. Economic Aspects:[1,2,3,4] The objective of the economic analysis was to describe markets served, annual quantities shipped, fixed capital assets, annual capital investment rates; and employment rates for the industries which manufacture the disposable and reusable products included in the study. This was to be used to permit assessment of the impacts which would occur in the national economy should any of the products be replaced or deleted from the market place.

However, the research team was unable to complete the objectives of the economics analysis due to lack of detailed information available from the industries representing the products. Several organizations did submit summary data for the study, but the overall response was not adequate to permit a fair comparison of the economic parameters. Therefore, an economic analysis will not be a part of this report.

Should policymakers want to pass legislation which could result in deletions and additions of products in the market place, a research study which is sufficiently funded to evaluate the affects on the following should be considered: employment, raw materials availability and demand shifts, new capital investments required, cost to redirect existing capital equipment, labor productivity, the gross national product, regional economic and social effects, cost to the consumer, losses and gains in federal revenue, etc.

4. General Comments:[3,5] The six products studied along with a brief description of their physical characteristics are presented in Table 1. One or two disposable and reusable products were selected for each category, making a total of 23 products researched. The towel category includes cloth and paper towels and also sponges. Sponges were included in the towel category due to similarity in use basis.

The descriptions and weights of the products were chosen to represent the most prevalent sizes in the market place. The disposable paper and plastic products were recommended by the American Paper Institute and the Single Service Institute. The china products were selected by the American Restaurant China Council. The remaining products were selected by MRI, with assistance from EPA.

The results of the study are presented in three separate volumes. Volume I-A contains the results of the REPA study. Volume I-B contains the appendix material for the information presented in Volume I-A. Volume II is concerned with selected health considerations.

Most of the detail data leading to the information presented in Volume I-A is contained in Volume I-B. Also many scenarios of use factors (times used before discarding) are presented through Volume I-A. The scenarios are used so that information will be available for a range of use factors, since the factors can change from year to year.[6]

1/ See comments Appendix B, pages 18-19.
2/ See comments Appendix C, page 5.
3/ See comments Appendix H.
4/ See comments Appendix J, cover letter.
5/ See comments Appendix J, pages 2 and 12-13.
6/ See comments Appendix E, pages 2-3.

TABLE 1

DESCRIPTION OF PRODUCTS

Category	Classification	Product	Product Description	Product Weight Grams	Product Weight Pounds	Comparison Basis
1. Towels	R	Cloth	16 x 27 inches, 100% cotton	60.0	0.132	1,000 Spills
	D	Paper	11 x 11 inches, two-ply	3.4	0.0075	
	R	Sponge	6-3/16 x 3-11/16 x 1-1/8 inches, cellulose	26.8	0.059	
2. Napkins	R	Cloth-Home	17 x 17 inches, 50% rayon, 50% polyester	44.2	0.097	1,000 Meals
	D	Paper-Home	12-1/2 x 13 inches, one-ply	2.4	0.0053	
	R	Cloth-Commercial	18 x 18 inches, 100% cotton	45.4	0.100	
	D	Paper-Commercial	16 x 16 inches, two-ply	9.5	0.021	
3. Diapers	R	Cloth	21 x 40 inches, 100% cotton	62.0	0.137	100 Changes
	D	Disposable	Industry composite paper/plastic	47.6	0.105	
4. Bedding	R	Cloth	66 x 108 inches, 50% cotton, 50% polyester	510.0	1.124	1,000 Changes
	D	Disposable	60 x 96 paper/plastic	108.0	0.238	
5. Containers (cups and tumblers) (cold drink, 9 fl oz)	D	Paper Cup	Wax coated	6.62	0.01460	1 Million Servings
	D	Plastic Cup	Thermoformed polystyrene	6.33	0.01396	
	R	Glass Tumbler	Glass	132.0	0.291	
	R	Plastic Tumbler	Polypropylene	40.0	0.088	
(hot drink,[1] 7 fl oz)	D	Paper Cup	Low density polystyrene lined	6.64	0.01465	
	D	Plastic Cup	Foam polystyrene	2.00	0.00440	
	R	China	China	290.3	0.64	
	R	Melamine Cup	Melamine plastic	120.5	0.266	
6. Plates (9 inch)	D	Paper	White, uncoated, pressed	10.60	0.02336	1 Million Servings
	D	Plastic	Foam polystyrene	11.84	0.02610	
	R	China	China	684.9	1.51	
	R	Melamine	Melamine plastic	205.5	0.453	

R = Reusable, D = Disposable.

1/ See comments Appendix J, pages 3, 19 and 21.

CHAPTER 2

SUMMARY OF STUDY RESULTS - RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS (REPA)

This chapter contains a summary of comparative REPA analyses for the disposable and reusable products within the six product categories identified and described in Chapter 1. The summary data for each product represents the resource inputs and environmental outputs for the entire system profile. Each system profile is composed of all the processes involved from raw materials extraction to disposal of the final product. The summary data for the profile consists of impacts for the seven resource and environmental impact categories (raw materials, energy, water, process solid wastes, atmospheric emissions, waterborne wastes, and postconsumer solid wastes).

A. Resource and Environmental Data Summaries[1,2,3]

This section will present the summary tables which compare the values of the seven impact categories for each disposable and reusable product comparison. The values will be discussed to assist the reader in achieving an understanding of the analysis technique. The summary will begin with the towel category and proceed through the other five product categories. The summary tables should be used with Tables 39 through 62 when studying the impact data.

1. Towels[4,5,6]: The comparison of the resource and environmental summaries for products in the towel category is presented in Table 2. The data represent the impacts associated with using each product to clean up 1,000 spills in the home kitchen area.

Table 2 contains data for eight product scenarios; five for the cloth towel, two for the sponge and one for the paper towel. In the scenarios, the cloth towel data are presented for a useful life (number of uses before discarding the product to the postconsumer solid waste stream) of 32 (U32) and 100 (U100) uses. These use values are MRI estimates based on industry averages for commercial kitchen towels. The information is also divided into data for one laundering after each use (L1) and one laundering after the towel has been used to clean up five spills (L5). Therefore, the column identified by cloth towel, U32, L1 refers to a towel used 32 times before discarding and the towel is laundered after each spill cleanup. Data for the cellulose sponge are presented in the same manner. With respect to paper towels, each towel is used one time and discarded. Data submitted by the American Paper Institute state that on the average, 1.83 paper towels are used for cleaning up one spill.

1/ See comment No. 1 Appendix B, page 3.
2/ See comments Appendix J, pages 1-2 and 11-12.
3/ See comments Appendix B, pages 20-21.
4/ See comment No. 2 Appendix B, page 3.
5/ See comments Appendix B, page 17.
6/ See comments Appendix B, page 21.

TABLE 2

SUMMARY IMPACT DATA FOR 1,000 USES OF EACH TOWEL CATEGORY PRODUCT[1,2,3]

Impact Category	Units	Cloth Towel U32 L1	Cloth Towel U32 L5	Cloth Towel U100 L1	Cloth Towel U100 L5	Cloth Towel Cold Wash U100 L1	Cellulose Sponge U100 L1	Cellulose Sponge U100 L1	Paper Towel Two-Ply 1,830 Towels
		Towel Category Systems							
Raw Materials	lb	10.31	7.69	5.53	2.91	5.53	2.48	1.31	14.22
Energy	10^6 Btu	1.19	0.44	1.02	0.27	0.54	0.48	0.14	0.50[a/]
Water	10^3 Gal.	0.64	0.20	0.58	0.14	0.57	0.33	0.13	0.28
Industrial Solid Waste	cu ft	0.21	0.10	0.16	0.05	0.13	0.07	0.02	0.05
Atmospheric Emissions	lb	4.89	2.00	4.03	1.13	2.47	1.96	0.66	1.79
Waterborne Waste	lb	1.30	0.62	1.00	0.31	0.89	0.48	0.17	0.48
Postconsumer Solid Waste	cu ft	0.08	0.08	0.03	0.03	0.03	0.01	0.01	0.27

Source: Midwest Research Institute.

Note: Refer to Volume IB, pages E-16 and E-17, for summary impacts based on 8 and 12 pound home laundry loads.

a/ Includes energy derived from wood wastes. Total without including wood wastes energy is 0.37 million Btu.

1/ See comments No. 3-5 Appendix B, pages 5-6.
2/ See comments No. 8-14 Appendix B, pages 7-9.
3/ See comment No. 1 Appendix B, pages 9-10.

The impact data in Table 2 show, with the exception of raw materials and postconsumer solid waste, that the reusable cloth towel product has higher impacts than the disposable paper towel unless the cloth towel is used four to five times before laundering. The laundry impacts (included in the cloth towel profile) are representative of home laundries and assume 12 pounds of laundry per load. The use of a cold water wash in the U100, L1 towel scenario reduces the energy value from 1.02 to 0.54 million Btu (47 percent), which compares closely with the energy for the paper towel.

The data for the cellulose sponge product shows that the U100, L1 scenario has impacts very similar in magnitude to the paper towel, with the exception of the raw material and PCSW values. The U100 L1 sponge has smaller impact values than shown by the U100 L1 cloth towel. The U100 L5 sponge scenario shows the most favorable REPA profile of the products described in Table 2.

The information in Table 2 shows that the resource and environmental impacts for the reusable products are heavily dependent upon the number of times a product is used before it is laundered. The research team was unable to locate open literature information identifying typical use and laundering practices for cloth towels and sponge products used in the home. Information from the Linen Supply Association of America shows that in 1972, the typical kitchen towel in commercial use is used 16.3 times before replacement is necessary. This value includes towels lost from their intended service due to robbery and change in service application. The expected life of a kitchen towel used in the home is assumed to be greater than 32. MRI assumption of home use factor based on commercial use of 16.3. After approximately 100 uses, the reduction in profile impact values becomes very small. Again, the most important criteria affecting the REPA data is the number of towel uses before laundering. With a life of 32 uses before discard, the cloth towel energy category becomes equal to the energy for the disposable paper towel when the cloth towel is used three to four times before washing. At a useful life of 100, the cloth towel and paper energy values become equal when the towel is used two to three times before laundering (Figure 3, page 41)[1]. The extremely light reusable towels would approach the energy level of the paper with one to two uses before laundering. In some households, the reusable kitchen towel is used several times per day for 2 or 3 days before laundering. At 15 uses before laundering the energy value would approach 0.06 million Btu per spill cleanup, compared with 0.5 million Btu for the paper towel at 1.86 towels per spill, or 0.27 million Btu at one towel used per spill.

2. Napkins[2,3,4]

a. Home Use (50 percent rayon, 50 percent polyester): The impact data for the napkin product category (Table 3) are based on the product profiles associated with 1,000 uses (or use at 1,000 meals). The reusable napkins are assumed to be used for one meal and then laundered. It was assumed that one paper napkin (one ply) is used for each meal.

1/ Page 41 should be page 42.
2/ See comment No. 2 Appendix B, page 3.
3/ See comments Appendix B, page 17.
4/ See comments Appendix B, page 22.

TABLE 3

SUMMARY IMPACT DATA FOR 1,000 USES OF EACH HOME NAPKING PRODUCT [1,2,3]

Impact Category	Units	Home Napkin Systems						
		Cloth Napkin U1	Cloth Napkin U27	Cloth Napkin U54	Cloth Napkin U100	Cloth Napkin Cold Wash U54	Cloth Napkin Cold Wash U100	Paper Napkins One-Ply 1,000 Napkins
Raw Materials	lb	164.32	8.36	5.39	4.04	5.39	4.04	4.66
Energy	10^6 Btu	12.48	1.13	0.91	0.81	0.56	0.46	0.17 a/
Water	10^3 Gal.	4.32	0.55	0.48	0.45	0.47	0.44	0.10
Industrial Solid Waste	cu ft	2.21	0.18	0.14	0.12	0.12	0.10	0.02
Atmospheric Emissions	lb	57.00	4.67	3.67	3.22	2.52	2.06	0.65
Waterborne Waste	lb	15.86	1.20	0.92	0.79	0.83	0.70	0.18
Postconsumer Solid Waste	cu ft	1.91	0.07	0.04	0.02	0.04	0.02	0.09

Source: Midwest Research Institute.

Note: Refer to Volume II, pages E-16 and E-17, for summary impacts based on 8 and 12 pound home laundry loads.

a/ Includes energy derived from wood wastes. Total without including wood wastes energy is 0.12 million Btu.

1/ See comments No. 3-7 Appendix B, pages 5-6.
2/ See comments No. 8-13 Appendix B, pages 7-9.
3/ See comment No. 1 Appendix B, pages 9-10.

Scenarios for the cloth napkin show the impacts for 1, 27, 54, and 100 uses before discarding. Profile impacts using a cold wash are presented for the 54 and 100 use napkin. The expected life of the home napkin is estimated to be greater than 54 uses before discarding. For the one use napkin the energy used in laundering represents 5.6 percent of the total system energy. With a life of 100 uses, the energy for laundering represent 93 percent of the total profile energy. Therefore only small impact reductions are realized after 100 uses. For the hot wash system, the cloth napkin system value would approach 0.7 million Btu as the minimum energy, regardless of the expected life of the napkin. The cold wash system would approach a limiting value of 0.35 million Btu.

The one-ply paper napkin system shows lower impact values in five of the seven impact categories when compared with the most favorable cloth system. The reusable systems have lower impacts only in the postconsumer solid waste category. The energy requirements of the paper system are only 21 percent of the 100 use, hot wash napkin, and 37 percent of the 100 use cold wash napkin system. The water volume, industrial solid waste, atmospheric emission and waterborne waste values for the paper system are significantly lower than the reusable napkin systems.

b. Commercial Use (100 percent cotton): In commercial use, the cloth napkin is expected to achieve 27.1 uses (1972 average from Linen Supply Association of America). The impact data in Table 4 show the profile values for an expected life of 1, 27, and 54 uses. The cloth napkins are assumed to be used for one meal and then laundered. One two-ply paper napkin is assumed to be used per meal.

The data in Table 4 shows the disposable paper napkin to have lower values in five of the seven impact categories when compared with the 27 use cloth napkin (the industry use figure has varied from 40 to 27 from 1968 to 1972). The paper napkin has higher values in raw materials and postconsumer solid waste. During meals where two paper napkins are used, the impacts for the disposable and reusable products would be very similar except for raw materials and postconsumer solid wastes. A commercial cold wash system would be very competitive with the disposable product. However, commercial laundries using cold water washes were not encountered during the research work, and the data for cold wash is thus presented as a hypothetical situation only.

3. Diapers[1,2,3]: The comparisons for the diaper products are based on the impacts associated with 100 changes. One diapering change requires 1.47 cloth diapers and 1.03 disposable on the average. The cloth values are based on 37 percent double and 5 percent three or more diapers per change, while 3 percent of the disposable diaper changes use two diapers.

The summary impact data in Table 5 show scenarios for the cloth system, home laundry, with a useful life of 25, 50, and 100 uses before discarding. Cloth diapers are reported to last for over 100 uses with home

1/ See comment No. 2 Appendix B, page 3.
2/ See comments Appendix B, pages 18-19.
3/ See comments Appendix B, pages 22-23.

TABLE 4

SUMMARY IMPACT DATA FOR 1,000 USES OF EACH COMMERCIAL NAPKIN PRODUCT[1,2,3,4]

Impact Category	Units	Commercial Napkin Systems: Cloth Napkin U1	Cloth Napkin U27	Cloth Napkin U54	Cloth Napkin Cold Wash U27	Paper Napkin Two-Ply 1,000 Napkins
Raw Materials	lb	172.28	8.27	5.12	8.27	11.07
Energy	10^6 Btu	6.65	0.75	0.64	0.42	0.37[a]
Water	10^3 gal.	2.58	0.46	0.42	0.46	0.25
Industrial Solid Waste	cu ft	1.80	0.14	0.11	0.14	0.04
Atmospheric Emissions	lb	33.20	2.21	1.61	1.66	1.27
Waterborne Waste	lb	11.24	0.83	0.63	0.77	0.40
Postconsumer Solid Waste	cu ft	1.96	0.07	0.04	0.07	0.22

Source: Midwest Research Institute.

a/ Includes energy derived from wood wastes. Total without including wood wastes energy is 0.27 million Btu.

1/ See comments No. 3-5 Appendix B, pages 5-6.
2/ See comments No. 10-13 Appendix B, pages 8-9.
3/ See comment No. 15 Appendix B, page 9.
4/ See comments No. 1-2 Appendix B, page 9-10.

TABLE 5

SUMMARY IMPACT DATA FOR 100 CHANGES EACH DIAPER PRODUCT [1,2,3,4]

Impact Category	Units	Diaper Systems: Cloth Diaper Home Laundered U25	Cloth Diaper Home Laundered U50	Cloth Diaper Home Laundered U100	Cloth Diaper Commercial Laundered U1	Cloth Diaper Commercial Laundered U50	Cloth Diaper Commercial Laundered U100	Disposable Diaper 103 Diapers
Raw Materials	lb	2.483	1.792	1.445	35.932	1.124	0.773	12.889
Energy	10^6 Btu	0.450	0.426	0.413	1.350	0.164	0.152	0.371
Water	10^3 gal.	0.523	0.514	0.510	0.562	0.129	0.125	0.166
Industrial Solid Waste	cu ft	0.074	0.067	0.064	0.371	0.031	0.027	1.196
Atmospheric Emissions	lb	1.789	1.664	1.602	6.543	0.388	0.326	0.356
Waterborne Wastes	lb	0.666	0.623	0.601	2.331	0.177	0.155	0.190
Postconsumer Solid Waste	cu ft	0.016	0.008	0.004	0.338	0.008	0.004	

Source: Midwest Research Institute.

a/ Includes energy derived from wood wastes. Total without including wood wastes energy is 0.271 million Btu.

1/ See comments No. 3-5 Appendix B, pages 5-6.
2/ See comments No. 8-13 Appendix B, pages 7-9.
3/ See comment No. 15 Appendix B, page 9.
4/ See comments No. 1-2 Appendix B, page 9-10.

laundry. The other use systems are presented to show the effect of change in useful life. The expected life of a diaper in the commerical wash systems is reported to be around 75 uses. Some commercial laundries reported that on occation the expected life of the diaper is below five uses, due to theft and change in service application.

The comparisons of the most typical situation would include the 100-use home laundered diaper, the 50-use commercial laundered diaper and the disposable diaper system. The commercial laundry diaper system shows the lowest impacts in each of the seven impact categories. With the exception of raw materials and postconsumer solid waste, the disposable diaper shows impact levels lower than the home diaper system. However, all of the disposable diaper system impacts are higher than the 50-use commercial diaper system.

As the number of uses before discard increases, the impacts for the cloth systems approach the impacts represented by the laundering processes of each cloth system. The home laundry diaper system will approach 0.4 million Btu as its minimum energy value. After 25 uses the decrease in system energy becomes minimal. Therefore, when using a hot water wash, the home diaper system energy requirements will only approach the disposable system energy requirements. The commercial cloth system will approach a minimum energy value of 0.14 million Btu. The energy requirements of the commercial and disposable systems are about the same for four to five uses before discard for the cloth diaper. Energy savings in the commercial system become minimal after 15 to 20 uses.

4. Bedding: The sheet systems were compared on the basis of 1,000 changes, one sheet per change. Normal life for the cloth sheet (50 percent polyester and 50 percent cotton) is 300 uses before discard. The cloth sheets were assumed to be laundered after each use. Impacts for the disposable sheet are based on a nonwoven paper fiber sheet backed by a polyethylene film. The product manufacturing process impacts of the disposable system profile are assumed to be similar to the disposable diaper converting impacts. For this study, only commercial laundering for the cloth sheet is considered.

Table 6 contains the resource and environmental profile summaries. In the raw materials and energy categories, the cloth sheet shows the smallest impacts. The disposable sheet system has the lowest wastewater volume and the least amount of waterborne wastes and industrial solid wastes. Atmospheric emissions and postconsumer solid waste values favor the cloth system.

The energy requirements for the reusable and disposable system become equal at around 20 uses of the cloth sheet. Energy savings become minimal after 100 uses.

TABLE 6

SUMMARY IMPACT DATA FOR 1,000 CHANGES EACH SHEET PRODUCT

		Sheet Systems				
Impact Category	Units	Cotton Sheets U1 L1	Cotton Sheets U50 L1	Cotton Sheets U100 L1	Cotton Sheets U300 L1	Disposable Sheets 1,000 Sheets
Raw Materials	lb	1,166.48	36.91	25.39	17.71	106.68
Energy	10^6 Btu	98.03	7.10	6.17	5.56	10.06[a/]
Water	10^3 gal.	29.33	4.19	3.93	3.76	2.32
Industrial Solid Waste	cu ft	18.34	1.18	1.00	0.88	0.61
Atmospheric Emissions	lb	455.61	18.99	14.53	11.56	28.64
Waterborne Wastes	lb	114.21	6.45	5.35	4.61	4.35
Postconsumer Solid Waste	cu ft	21.99	0.44	0.22	0.07	3.74

Source: Midwest Research Institute.

a/ Includes energy derived from wood wastes. Total without including wood wastes energy is 9.27 million Btu.

5. Containers (cups and tumblers): The container product category is divided into cold drink and hot drink containers.

a. Cold Drink Containers (9 fluid ounce): The container systems were compared on the basis of 1 million servings in a commercial establishment. The reusable containers are assumed to be washed after each use by a commercial dishwashing machine. The useful life of the reusable containers is expected to be around 1,000 uses based on information submitted by the American Restaurant China Council.[1] The data in Table 7 show impacts for 100 and 1,000 uses to show the relation of useful life to impact summaries.[2]

The reusable containers show lower impact values for the raw materials, energy, industrial solid waste, atmospheric emission and postconsumer solid waste categories, when compared to the paper and plastic disposable products. The disposable plastic cup has the smallest quantity of wastewater volume. Both of the disposable products show less waterborne wastes than the reusable products. After 100 uses, more than 97 percent of the waterborne wastes from the reusable containers is due to the dishwashing process. After 1,000 uses, more than 90 percent of the total impacts are due to the washing process. The energy requirement for both reusable container profiles become less than the energy for the disposable systems between 10 and 20 uses before discard.[3]

b. Hot Drink Containers (7 fluid ounce):[1,4] Table 8 presents the impact summaries for the hot drink cups. Data submitted by the American Restaurant China Council show the expected life for the china cup to be 1,360 uses before loss or discard. The scenarios presented for the reusable cups include a use life of 100 and 1,000, for commercial use.[2]

The comparison of the reusable systems (1,000 uses) with the paper cup system, shows that the reusables have less impacts in the raw materials, energy, industrial solid waste, atmospheric emissions, and postconsumer solid waste categories. The paper system shows less wastewater volume and waterborne wastes.

The comparison of the reusable systems (1,000 uses) with the plastic foam cup reveals the disposable product to have less raw materials, wastewater volume, and waterborne waste, and less industrial solid waste.

The resource and environmental benefits from reusing the china and melamine products level out after 300 uses so that only minimal advantages are gained with additional uses. At 100 uses the washing impacts represent approximately 50 percent of the total, while at 1,000 uses most of the impact categories show that greater than 90 percent of the impacts are due to washing the cups.

1/ See comment No. 1 Appendix C, page 1.
2/ See comments Appendix J, pages 32 and 34.
3/ See comments No. 3 Appendix J, page 39.
4/ See comments Appendix J, pages 3, 19 and 21.

TABLE 7

SUMMARY IMPACT DATA FOR 1 MILLION SERVINGS--EACH 9 FLUID OUNCE COLD DRINK PRODUCT[1,2,3]

Impact Category	Units	Cold Drink Systems: Glass Tumbler U100	Glass Tumbler U1,000	Polypropylene Tumbler U100	Polypropylene Tumbler U1,000	Paper Cup Wax Coat (Million)	Thermoformed Polystyrene Cup (Million)
Raw Materials	lb	2,949.3	1,673.2	1,636.6	1,541.9	13,229.9	1,484.2
Energy	10^6 Btu	223.9	184.2	270.7	188.9	563.9[a]	696.8
Water	10^3 gal.	90.4	86.5	93.9	86.9	145.5	50.9
Industrial Solid Waste	cu ft	23.8	13.7	14.1	12.8	55.2	30.5
Atmospheric Emissions	lb	779.4	564.4	1,159.5	602.4	1,614.4	1,963.4
Waterborne Wastes	lb	439.0	394.0	427.7	392.8	266.7	266.0
Postconsumer Solid Waste	cu ft	18.3	1.8	14.1	1.4	241.4	186.8

Source: Midwest Research Institute.

Note: Refer to page 16 of this Volume, and page E-2 of Volume IB, for a discussion on energy reduction possible with chemical sanitization during dishwashing.

a/ Includes energy derived from wood wastes. Total without including wood wastes energy is 444 million Btu.

1/ See comments Appendix J, pages 3 and 17-18.
2/ See comments Appendix J, pages 3 and 18-20.
3/ See comments Appendix J, pages 4, 22-31 and 33-34.

TABLE 8

SUMMARY IMPACT DATA FOR 1 MILLION SERVINGS--EACH 7 FLUID OUNCE HOT DRINK PRODUCT[1,2,3,4]

		Hot Drink Systems					
Impact Category	Units	China Cup U100	China Cup U1,000	Melamine Cup U100	Melamine Cup U1,000	Paper Cup LDPE Lined (Million)	Foam Cup Polystyrene (Million)
Raw Materials	lb	15,233.8	4,777.7	4,632.6	3,717.5	19,057.1	1,655.0
Energy	10^6 Btu	680.5	434.1	550.8	421.1	568.5[a/]	571.0
Water	10^3 gal.	249.3	200.0	256.1	200.6	191.7	29.6
Industrial Solid Waste	cu ft	160.4	41.8	34.6	29.3	75.0	16.2
Atmospheric Emissions	lb	3,080.4	1,408.0	1,719.4	1,272.0	1,619.1	1,853.7
Waterborne Waste	lb	1,567.0	1,142.0	1,147.0	1,100.0	301.1	253.1
Postconsumer Solid Waste	cu ft	32.6	3.3	35.2	3.5	236.9	761.2

a/ Includes energy derived from wood wastes. Total without including wood wastes energy is 395 million Btu.

1/ See comments Appendix J, pages 3 and 17-18.
2/ See comments Appendix J, pages 3 and 18-20.
3/ See comments Appendix J, pages 3, 19 and 21.
4/ See comments Appendix J, pages 4, 22-31 and 33-34.

6. Plates: The impact summaries for the plate category represent the values for 1 million uses (meals) for each plate. The expected life of the china plate is 6,900 uses based on commercial replacement data. Scenarios are shown for 100, 1,000, and 6,900 uses for the china plate and 100 and 1,000 uses for the melamine plate.[1] Industry data were not submitted regarding the useful life of the melamine product; however, the plate is probably capable of withstanding well over 1,000 uses. The impact values become fairly constant at the 1,000 use level, therefore a higher use rate would have little effect on the comparisons.

With reference to Table 9, the disposable paper plate compares quite favorably with the china plate at the 100 use level, except for one impact category--postconsumer solid waste. However, with the 1,000 and 6,900 use china plate, the paper system has smaller impacts only in the waterborne waste category. In comparison with the paper plate, both melamine systems (100 and 1,000 use) show lower impacts in all categories except waterborne wastes.

The disposable polystyrene foam plate requires higher energy levels than the other plate systems. Also the atmospheric emissions for the foam plate are relatively high due to the loss of hydrocarbon blowing agent. The waterborne waste category shows less impacts for the foam plate than for the reusable systems.

The energy requirements for the reusable product systems (Table 9) are based on an electrically heated hot water approach to sanitizing dishes. An alternate method for sanitizing dishes would be to use a chemical sanitizing agent with 140°F water for the rinse water, rather than to heat the rinse water from 140°F to 180°F with electric booster heaters. For 1 hour of dishwasher operation, this would reduce the natural gas requirement by 66.3 cubic feet and the electrical requirement by 27.1 kilowatt-hours, for a total savings of around 362,500 Btu per hour, or 134 million Btu per million plates. This would reduce the total dishwashing energy by 42 percent. Refer to Volume I-B, pages E-2, E-3, and E-4 for a more complete discussion of the energy requirements of commercial dishwashing.

1/ See comments Appendix J, page 32 and 34.

TABLE 9

SUMMARY IMPACT DATA FOR 1 MILLION SERVINGS--EACH 9-INCH PLATE PRODUCT[1,2,3]

Impact Category	Units	Plate Systems						
		China Plates U100	China Plates U1,000	China Plates U6,900	Melamine Plates U100	Melamine Plates U1,000	Paper Plate White Press (Million)	Foam Plate Polystyrene (Million)
Raw Materials	lb	29,295	5,820	3,590	4,805	3,371	27,346	4,087
Energy	10^6 Btu	968	422	370	599	385	748 a/	1,479
Water	10^3 gal.	300	185	174	277	183	289	102
Industrial Solid Waste	cu ft	329	56	29	36	26	98	70
Atmospheric Emissions	lb	5,226	1,500	1,146	1,876	1,165	2,031	4,924
Waterborne Wastes	lb	1,839	915	827	891	820	364	609
Postconsumer Solid Waste	cu ft	77	8	1	60	6	368	4,582

Source: Midwest Research Institute.

a/ Includes energy derived from wood wastes. Total without including wood wastes energy is 497 million Btu.

1/ See comments Appendix J, page 3 and 17-18.
2/ See comments Appendix J, pages 5 and 18-20.
3/ See comments Appendix J, pages 4, 22-31 and 33-34.

CHAPTER 3

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

A. Description of REPA Technique[1,2]

In the past, most environmental analyses have focused on a single pollution category such as the air pollution caused by industry A or the water pollution and solid wastes associated with industry B. The pollution reported for these industries usually refers to one manufacturing step, at a single geographical location. This type of approach will generally account for less than 25 percent of the total impacts associated with a product. Accounting for a product's total environmental impact requires a systems approach, beginning at the point of raw material extraction and ending with the final disposal of the product. The systems approach includes the use of natural resources and the environmental pollution resulting from disposal.

The purpose of a total resource and environmental profile analysis (REPA) is to measure the resource and environmental impacts at each stage of a product's life, and then condense the data into several basic impact categories which can be used to determine a product's overall impact relative to other products. The REPA (along with other analysis tools) can be used to encourage the use of consumer products which cause minimum resource and environmental impacts. The results of a REPA analysis must be used with the understanding that the product may have much smaller impacts than its competitor, and still be a resource or environmental villain. To ascertain a product's absolute impact status would require a rigorous treatment of impact data, environmental desires or regulation, and the social values affected. However, after the impact data have been condensed into the seven impact categories, each category can be examined to see if abnormally high values exist. Comparisons of total impact values from similar products, or substitute products made from other materials, should establish a reasonable level of confidence for estimating the relative desirability of a product from a resource and environmental impact viewpoint.

Two broad classes of environmental impacts can be discerned: (1) quantifiable impacts; and (2) those of a more subjective, qualitative nature.[3] The former category includes impacts which can be measured, such as kilowatt-hours of energy and pounds of air pollutants, for various manufacturing processes. The latter category includes impacts for which hard data do not exist. For example, it is impossible to assign precise numerical measures of aesthetic blight caused by mining activities. Another impact of the latter type is that for which some data exist,

1/ See comments Appendix E, page 1-2.
2/ See comments Appendix J, pages 8-9.
3/ See comments Appendix E, page 3.

but which are of very poor quality. Examples of this are relative environmental damage resulting from solid waste disposal of various products, or the relative environmental damage caused by various air or water pollutants. This study is confined to the determination of the quantitative impacts only. Qualitative aspects, although referred to from time to time in this study, are not part of this analysis.

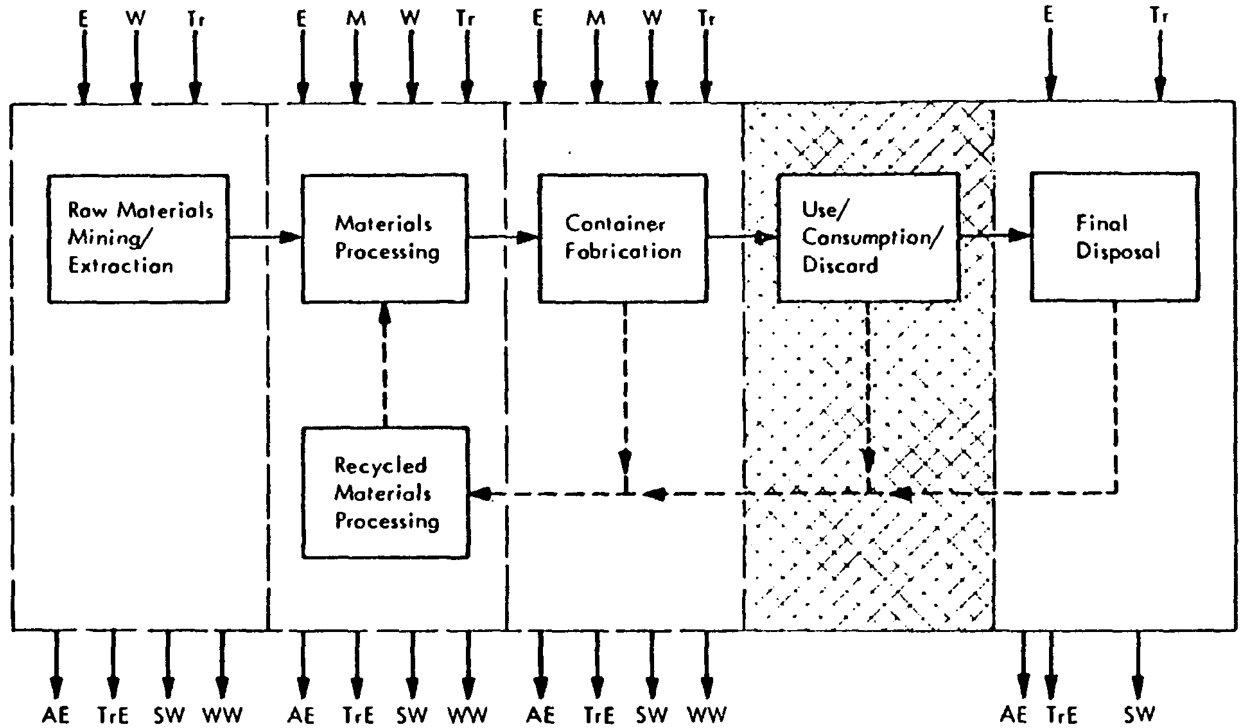
1. Basic approach: Much of the effort expended in this study went into determining the quantifiable impacts of manufacture. The term "manufacture" is used throughout this report in a general sense--it includes those activities associated with materials from the time they are extracted from the earth as raw materials to the point where they are returned to the earth as wastes, including all transportation links in the processing sequence. A summary of the impacts documented is shown in Figure 1a.

For each process and subprocess, a set of seven basic impact categories was established. These are described below:

Raw materials: The quantity and type of virgin raw materials input to each operation were calculated in terms of a given product output. Materials not intended to become part of the finished product, such as cooling water and fuels, were excluded from raw materials. Other raw materials, such as additives, which aggregate to less than 5 percent of the total weight of the finished container were included in this category by reporting their finished product weight. Each raw material was counted only one time--when it became a part of the product or entered the process as a solvent, catalyst, etc.

No attempt was made to define a relative weighting of the various virgin materials based on availability or scarcity. The possibility exists for developing such a scheme based on the projected reserves or scarcity of recoverable raw materials still in the earth. However, examination of the many raw materials consumed by these product systems shows that none of these materials are in short supply. The materials included are: limestone, salt, sand, soda ash, feldspar, and wood fiber. Crude oil and natural gas are in relatively short supply, but they have been classified as energy resources, not as material resources. Wood fiber is consumed, but timber growth exceeds the timber cut annually at present in this country. Thus it is not a "short" material.

Energy: The energy used by each operation, including transportation, for a given product output was reported. Process energy used by the actual manufacturing operations was employed. That used for space heating of buildings and other miscellaneous categories was excluded wherever possible. Energy content of organic raw materials was also included in energy summations. The second-order energy necessary to extract,



SUMMARY OF INPUT/OUTPUT CATEGORIES

INPUT

E = Energy (in all forms)

M = Virgin Materials (consumed and unconsumed)

W = Water

Tr = Transportation to Next Operation (including all modes, all fuels in each mode)

OUTPUT

AE = Atmospheric Emissions

TrE = Transportation Effluents (for each fuel type)

SW = Solid Wastes

WW = Waterborne Wastes

Figure 1a - Summary of environmental impacts are shown for container manufacture.

process and transport fuels was included, as well as the heating value of the specific fuels used in a system. In this report, the Btu equivalents used for a unit of the following types of energy are; kilowatt-hour - 10,720 Btu, standard cubic foot natural gas - 1,030 Btu, 1 pound of steam - 1,400 Btu, coal - 13,300 Btu per pound.

Water volume: The volume of wastewater per unit of product output from each operation was reported.

Industrial solid wastes: The volume of solid waste per unit of product output which must be landfilled or disposed of in some other way was determined. Three categories were measured: process losses, fuel combustion residues (ashes) and mining wastes. The first category--process discards--includes solids resulting from air pollution control and waste materials from manufacturing operations. Fuel combustion residues are ash generated by coal combustion. Mining wastes are primarily materials discarded due to raw ore processing and do not include overburden.

Atmospheric emissions: This category includes only those emissions generally considered to be pollutants, expressed in pounds per unit of product output. Thirteen identifiable pollutants were considered for each operation--particulates, nitrogen oxides, hydrocarbons, sulfur oxides, carbon monoxide, aldehydes, other organics, chlorine, odorous sulfur compounds, ammonia, hydrogen fluoride, lead and mercury. The amounts reported represent actual discharges into the atmosphere after existing emission controls have been applied. All such atmospheric emissions were treated as being of equal weight, and no attempt was made to determine the relative environmental damage caused by each of these pollutants. However, we do recognize that there are differences in the relative harm caused by air pollutants.

Waterborne wastes: This category includes the water pollutants from each operation expressed in pounds per unit product output. These are effluents after wastewater treatment has been applied and represent discharges into receiving waters. Twenty-three specific pollutants are included--BOD, COD, suspended solids, dissolved solids (oil field brine), oil, fluorides, phenol, sulfides, acid, alkalinity, metal ions, ammonia, cyanide, and others. Some factors such as turbidity and heat were not included because there was no acceptable way to quantify their impacts.

Postconsumer solid wastes: The volume of solid wastes generated by disposing of the product was determined. This is the solid waste which most likely would be discarded into municipal solid waste streams. It was assumed that 9 percent would be incinerated and 91 percent would be landfilled.

The first step in the REPA analysis is to determine the raw values for each of the above seven categories attributed to the production of some unit quantity of a product. The data in these categories are used to determine a product's resource and environmental impact relative to another product.

2. Organic raw materials--unique considerations: A unique situation exists for products utilizing organic raw materials such as wood, crude oil and natural gas. These materials have alternative uses as feedstocks for material goods such as paper or plastic products, or as fuels for energy. In assessing resource depletion, then, use of organic materials can be considered as depleting either material resources or energy resources.

In the first option, the organic materials intended to become part of a finished product are simply measured in pounds and treated as any mineral resource. In the second option, the energy equivalent of the pounds of organics used is added to the energy required to process the materials. The pounds of organics used is not added to the raw materials category.

Another consideration regarding the fuel value of synthetic materials is that finished plastic and paper containers are a potential fuel even after they have been used and discarded. Thus, if the solid waste stream is incinerated and energy recovered, part of the original fuel value of the natural gas and wood fiber is reclaimed.

Because of the importance of energy considerations, a strong case can be made for the second option, which counts organic materials as an energy resource rather than as a material resource. This treatment reflects more accurately the primary environmental concern of the plastics industry, which is the consumption of energy reserves in the form of natural gas and petroleum. These fuels at present, and in the near future, are in short supply to a greater extent than any other major natural resource. As mentioned earlier, the material resources considered in this study such as limestone and sand are much more abundant than natural gas and petroleum. Counting petroleum and natural gas use as equivalent on a pound-for-pound basis with limestone would not give as true an environmental picture as counting the energy value of these materials. Because essentially no recovery of the intrinsic fuel value of finished plastic products is practiced at present, the impact on the nation's energy reserves due to plastics manufacture is the sum of the process energy required for plastics manufacture, and the inherent fuel value of the organic materials consumed. Thus, treating an organic material as an energy input, rather than as a physical quantity of material, places the comparison of competitive product systems on a more logical basis.*

3. Methodology: The general approach used to carry out the calculations for the quantitative comparison follows a system approach. All processes and subprocesses were first considered to be separate and independent. For each process, a standard unit such as 1,000 pounds of output was used as a basis for calculations. A complete materials balance was first determined. If marketable coproducts or by-products were produced, the material inputs were adjusted to reflect only the input attributable to the output product of interest.

To illustrate this point, consider a hypothetical manufacturing process that produces 1,000 pounds of product A in which we are interested. At the same time, it produces 500 pounds of coproduct B and 100 pounds of waste in the form of air emissions, water pollution, and solid waste. The total input of raw materials is 1,600 pounds as shown in Figure 1b. An energy input of 3×10^9 Btu is assumed for this example. The output is 1,000 pounds of product A and 500 pounds of product B.

A 500-pound credit has been applied to the input materials because we are not interested in product B. This reduces the input from 1,600 pounds to 1,100 pounds. In addition, because product B is one-third of the product output of the process by weight, one-third of the wastes, or 33 pounds, is attributed to product B; a new waste figure of 67 pounds (100 pounds - 33 pounds = 67 pounds) results. Thus, the raw material input value for product A is 1,067 pounds (1,100 pounds - 33 pounds = 1,067 pounds).

Once the raw impacts for the production of 1,000 pounds of each process have been determined, a master flow chart can be established. This chart will show the pounds of each process necessary to produce 1,000 pounds of the container systems being studied. At this point, the raw data for a product system can be processed by the computer and combined with transportation, postconsumer solid waste, and secondary impacts to provide calculations showing the resource environmental profile for the system. The calculated impact data can be used alone to demonstrate the quantities of each impact category. Summary tables showing the total impacts for the processes and systems are provided and appear in the Appendix.

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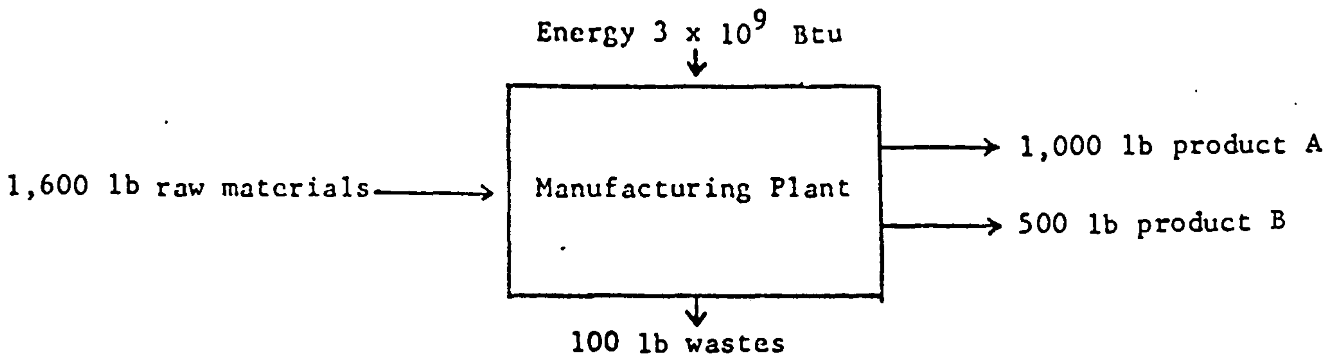
* The same logic applies to wood fiber, even though cellulosic materials are not now a viable (fuel) energy source in the same way that plastics feedstocks are. Thus, wood fiber was counted as a raw material rather than its energy equivalent when it becomes part of the product. Wood materials or wastes burned were counted as their energy equivalent.



For analysis purposes, a new flow diagram would be established as shown below.

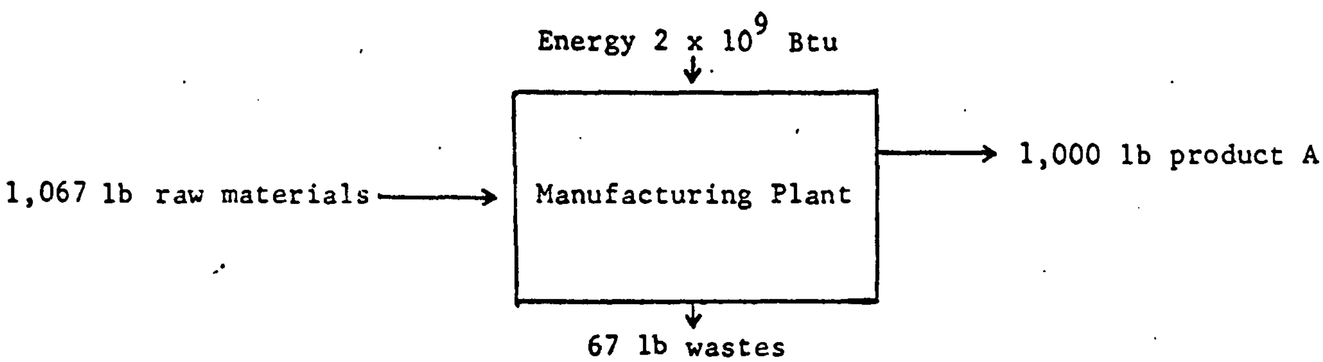


Figure 1b - Diagram illustrates coproduct credits.

4. Assumptions and limitations: Some assumptions are always necessary to limit a study to a reasonable scope. It is important for the reader to be aware of these limitations in order for him to understand fully the scope and applicability of the study.

In the course of this research, the following assumptions were made:

Data sources: An attempt was made in every case to obtain data which were "typical" and which could be verified in the open literature. Extensive use was made of government agencies and publications, technical associations and open literature sources. National average data were used where possible. Certain sets of data involved proprietary processes so that information was submitted to us on a confidential basis. However, data in the public domain were used whenever possible.

Geographic scope: The "environment" was defined as the environment of the world. However, impacts occurring outside this country are not well documented, so U.S. data were used to estimate foreign impacts.

Secondary impacts: Impacts resulting from extraction, processing and transporting fuels are secondary impacts and were considered as well as the primary impacts of the fuel combustion. However, secondary impacts resulting from such processes as manufacturing the capital are ment used in container manufacture are small per unit output and can be excluded without significant error.

Small quantities of materials: The impacts associated with materials which aggregate to less than 5 percent by weight of the container were not included. The materials are simply counted as pounds of raw materials. However, the list of materials which comprise the "less than 5 percent" category was examined to insure that no known "high environmental impact" materials were excluded from the analysis.

Electricity: Electrical energy is considered from the point of view of its impact on the total energy resources of the nation. A national average energy expenditure of 10,720 Btu is required for each kilowatt-hour of electricity made available to the public. Hence, this conversion factor is used rather than the direct use conversion factor of 3,413 Btu per kilowatt-hour. The impacts from mining or extraction of these fuels were included in the analysis.

Usage of scrap materials: Environmental impacts of scrap are considered to be only those impacts incurred after the scrap is discarded from the manufacturing site. Usually this includes only transportation and scrap processing steps. The environmental impact of manufacture of the material which subsequently becomes scrap is allocated to the prime product.

Point sources of pollution: The burden on specific ecosystems was not considered, i.e., at specific point sources or geographic locations. It was assumed the operations impacted the total environment everywhere, not just where specific manufacturing operations are presently located.

Availability of data: Some industrial plants do not keep records in sufficient detail to determine the data in the desired form for a REPA study. For instance, if pollutant emission data are needed for a specific subprocess in a plant, that information may not be available. The plant may have data only for several combined processes or the entire plant. In this event, allocation must be used for data on the particular processes of interest. As the concept of resource and environmental profile studies gains acceptance, it is likely that more industries will make an effort to collect these types of data from their own operations and on a unit process basis. Engineering calculations of materials balances for subprocesses were used in some instances where actual operating data were not available.

Effluent data: EPA 1977 guidelines were used where possible for air, water and solid waste discharges to the environment. If actual discharges are less than the guidelines, then the smaller values are used. For example some of the processes in the paperboard profile show impacts smaller than the 1977 guidelines. The application of future standards has the effect of shifting effluents from one category into others. It does not usually add or subtract from total amounts of effluents. For example, air pollution control usually removes air pollutants from air which are then discharged to water bodies or the solid waste stream. Thus, reducing air pollution from a plant will usually increase the water pollutant and/or solid waste discharge.

Consumer impacts: Impacts related to consumer activities such as transporting the milk home from the retail store were not included. We have assumed that trips to retail stores are necessary for other reasons and should not be attributed only to the product systems. [1]

1/ See comments No. 4 Appendix J, page 39.

CHAPTER 4

ANALYSIS OF THE RESOURCE AND ENVIRONMENTAL SUMMARY DATA

A. Analysis of Resource Inputs

1. Raw Materials[1,2,3,4]: The quantity of raw materials required for each product is presented in the summary tables. Petroleum and natural gas inputs which become part of the products are counted as their energy equivalents rather than as pounds of raw materials. The raw materials which are present in the plastic systems represent process additives and packaging contributions. Wood fiber which becomes part of a product is counted as pounds of raw material. As are cotton fiber and inorganic raw materials. The quantities of raw materials for the reusable products are generally less than the comparable disposable product due to their multiuse factor.

Figure 1c demonstrates the raw material requirements for selected reusable product systems as a function of the number of expected uses the products will experience before discard. The raw materials for the cloth towel system decrease sharply until the 10 use point. Thereafter, the decrease is minimal with increase in expected life. The use points for the other products where the decrease in raw materials becomes minimal are: home napkins, 5 to 10 uses; cloth diapers, 5 to 10 uses; cloth sheets, 25 uses; china cups, 200 to 400 uses; and china plates, 500 to 1,000 uses.

Table 10 compares the expected life of the products represented in Figure 1c with the use factor at the breaking point of raw material decrease vs. useful life.

TABLE 10

EXPECTED LIFE VS. USE FACTOR AT RAW MATERIAL BREAK POINT

Product	Expected Life (Uses)	Raw Material Breaking Point (Uses)
Cloth Towel	Greater Than 32	10
Home Napkin	Greater Than 54	10
Cloth Diaper, Home	50-100	10
Cloth Sheet	100-300	25
China Cup	1,360	100-200
China Plate	6,900	500-1,000

Source: MRI.

1/ See comment No. 5 Appendix B, page 6.
2/ See comments No. 8-9 Appendix B, pages 7-8.
3/ See comment No. 2 Appendix B, page 23.
4/ See comments Appendix J, pages 2 and 11-12.

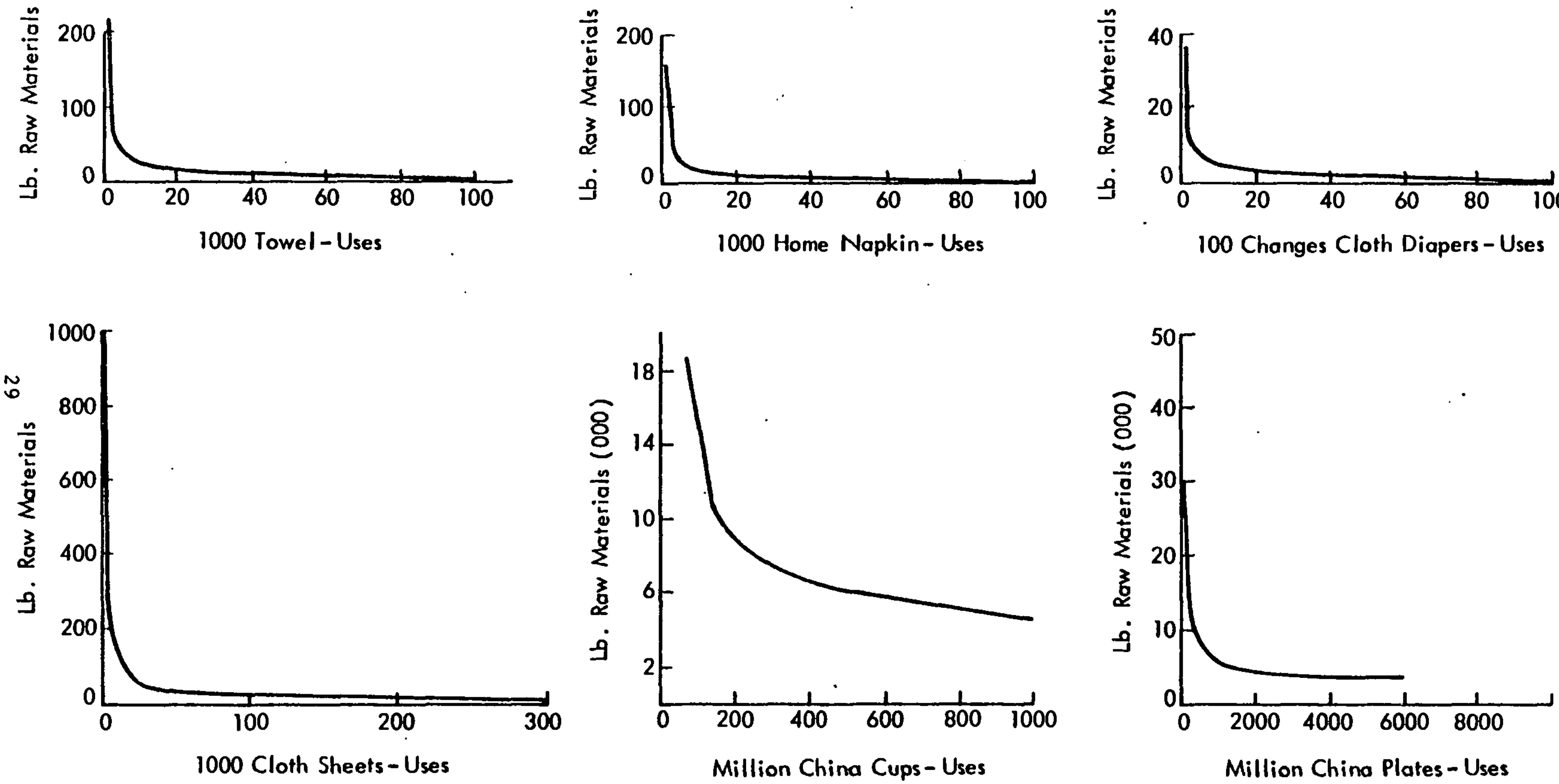


Figure 1c - Raw Material Requirements as a Function of Expected Uses

Based on the relationships of useful life and raw materials needed, the resource and environmental impact comparisons can be made without knowing the exact outer limit of the use factors since the break point of material increases occurs for below the expected life.

2. Wastewater volume:[1,2] The water volume reported in this study represents water discharged from the various processes as wastewater Figure 2 shows the comparison of water use for reusable and disposable products in each product category. In the towel category, the disposable paper product shows less wastewater than the cloth towel except when the towel is used five times before laundering. For the commercial napkin category, the disposable paper napkin has the least water volume. In the diaper comparisons, the disposable diaper shows less water use than the home laundry system but slightly more than the commercial laundry system. The disposable sheet system has lower wastewater volume than the reusable cloth sheet. In the cold drink container comparison, the paper cup uses more water and the plastic cup less water than the reusable systems. The plate comparisons also show wastewater volume for the paper system higher than the reusables and water volume for the plastic system lower than the reusables.

3. Energy Breakdown Analysis:[1,2,3,4,5,6,7,8] This section will describe the energy requirements of the product systems from the viewpoints of energy type (process, transportation, material resource), energy source (petroleum, natural gas, coal, wood fiber, etc.), and product usage patterns. Usage patterns refer to the times a product is used before discarded, coupled with the number of times used before washing.

a. Energy Type and Source: Tables 11 through 18 present the energy breakdown information for the six product categories, using the same scenarios presented in the summary impact tables (Tables 2 through 9). The individual energy values may not add exactly to the "total" values due to computer rounding. Each table contains a percentage breakdown for fossil fuel (petroleum, natural gas, and coal), and wood fiber (energy derived from burning wood residues).

(1) Table 11 - Towel Products: Process energy accounts for over 90 percent of the total energy for each product. The material resource energy is low since none of the products are manufactured from hydrocarbon raw materials. The energy source information shows that fossil fuel accounts for more than 90 percent of the energy for the reusable systems. The paper towel system derives 24.6 percent of its energy from burning wood residues.

(2) Tables 12 and 13 - Napkin Products: For both disposable and reusable systems, process energy represents over 90 percent of the total with transportation accounting for around 2 percent and material

1/ See comments No. 8-9 Appendix B, pages 7-8.
2/ See comments Appendix J, pages 4 and 22-31.
3/ See comments Appendix B, page 9.
4/ See comments No. 1-2 Appendix B, pages 9-10.
5/ See comments Appendix C, pages 4-5.
6/ See comments Appendix J, pages 2 and 11-12.
7/ See comments Appendix J, pages 2 and 14.
8/ See comments Appendix J, pages 3 and 17-18.

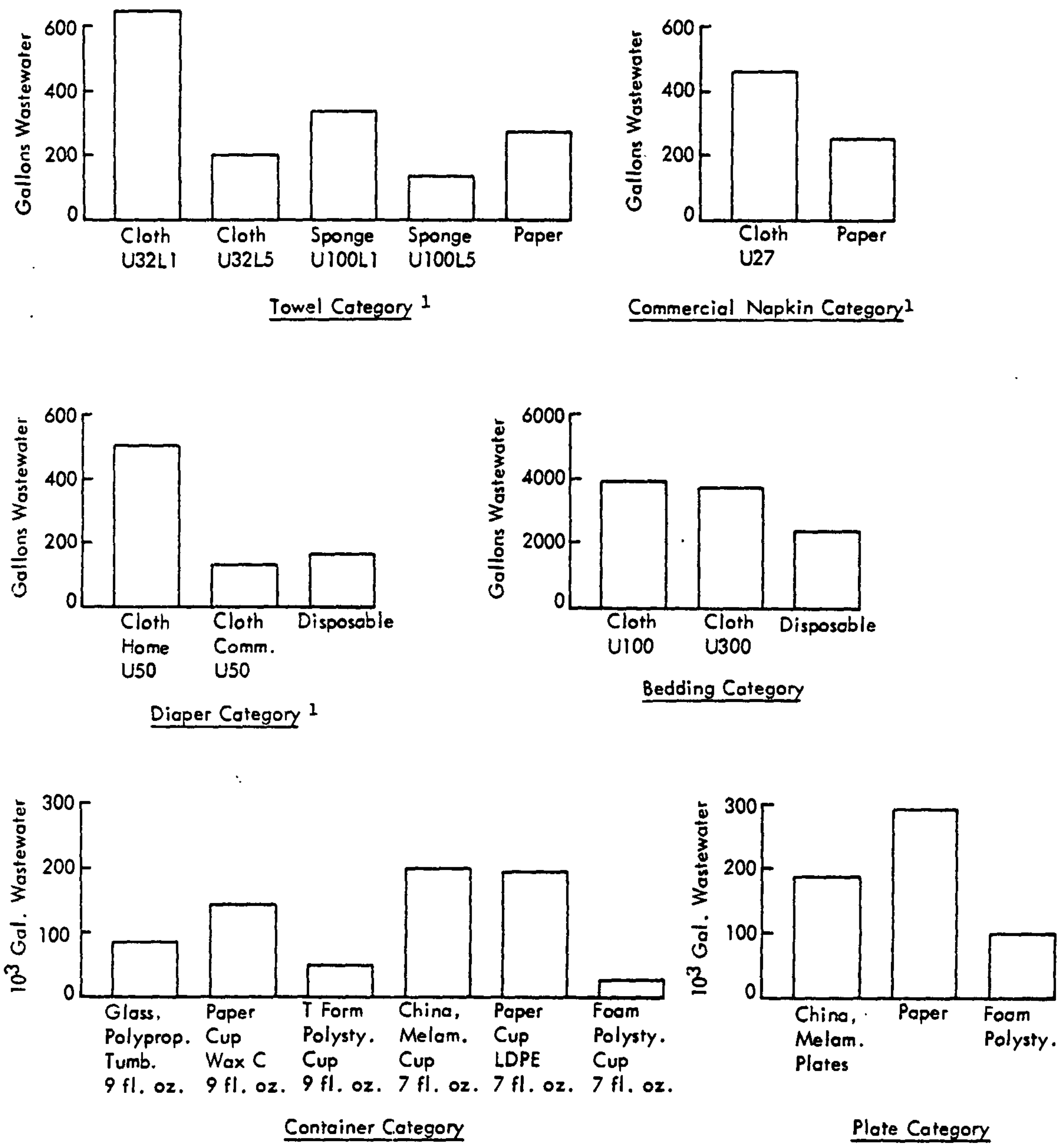


Figure 2 - Wastewater Volume for Representative Products in Each Category

1/ See comment No. 4 Appendix B, pages 5-6.

TABLE 11

ENERGY ANALYSIS - TOWEL CATEGORY PRODUCTS - 1,000 USES

	Cloth Towel U32 L1	Cloth Towel U32 L5	Cloth Towel U100 L1	Cloth Towel U100 L5	Cloth Towel Cold Wash U100 L1	Cellulose Sponge U100 L1	Cellulose Sponge U100 L5	Paper Towel Two-Ply 1,330 Towels
Energy Type 10^6 Btu								
Process	1.169	0.421	1.010	0.262	0.527	0.477	0.142	0.450
Transportation	0.007	0.007	0.003	0.002	0.003	0.001	0.001	0.032
Material Resource	0.011	0.006	0.008	0.003	0.008	0.004	0.002	0.014
Total	1.188	0.435	1.020	0.267	0.538	0.482	0.144	0.496
Energy Source 10^6 Btu								
Petroleum	0.258	0.107	0.211	0.060	0.110	0.095	0.027	0.157
Natural Gas	0.457	0.147	0.410	0.100	0.157	0.204	0.065	0.137
Coal	0.389	0.151	0.327	0.089	0.272	0.146	0.039	0.067
Nuclypwr	0.083	0.029	0.072	0.018	0.048	0.033	0.009	0.014
Wood Fiber	0.001	0.001	0.000	0.000	0.000	0.005	0.005	0.122
Fossil Fuel (%)	92.9	93.1	92.9	93.2	90.9	92.3	91.0	72.8
Wood Fiber (%)	0.1	0.2	0.0	0.0	0.0	1.0	3.5	24.6

Source: MRI.

TABLE 12

ENERGY ANALYSIS - HOME NAPKIN PRODUCTS - 1,000 USES

Energy Type 10^6 Btu	Cloth Napkin U1	Cloth Napkin U27	Cloth Napkin U54	Cloth Napkin U100	Cloth Napkin Cold Wash U54	Cloth Napkin Cold Wash U100	Paper Napkin One-Ply 1,000
Process	11.366	1.082	0.886	0.797	0.530	0.439	0.149
Transportation	0.299	0.011	0.006	0.003	0.006	0.003	0.013
Material Resource	0.816	0.034	0.019	0.013	0.019	0.013	0.007
Total	12.480	1.128	0.911	0.812	0.555	0.455	0.168
Energy Source 10^6 Btu							
Petroleum	3.568	0.265	0.202	0.173	0.128	0.098	0.055
Natural Gas	3.383	0.400	0.343	0.317	0.156	0.130	0.045
Coal	4.503	0.377	0.298	0.262	0.221	0.185	0.022
Nuclhypwr	0.521	0.067	0.058	0.054	0.041	0.037	0.004
Wood Fiber	0.505	0.019	0.009	0.005	0.009	0.005	0.042
Fossil Fuel (%)	91.8	92.4	92.5	92.6	91.0	90.8	72.6
Wood Fiber (%)	4.0	1.7	1.0	0.6	1.6	1.0	25.0

Source: MRI.

TABLE 13

ENERGY ANALYSIS - COMMERCIAL NAPKINS - 1,000 USES

	Cloth Napkin U1	Cloth Napkin N27	Cloth Napkin U54	Cloth Napkin U27	Paper Napkin Two-Ply 1,000 Napkins
Energy Type 10^6 Btu					
Process	6.219	0.732	0.627	0.398	0.359
Transportation	0.288	0.013	0.007	0.013	0.013
Material Resource	0.144	0.007	0.005	0.007	0.002
Total	6.652	0.752	0.638	0.417	0.374
Energy Source 10^6 Btu					
Petroleum	1.821	0.080	0.047	0.080	0.114
Natural Gas	2.194	0.553	0.521	0.218	0.098
Coal	2.241	0.100	0.059	0.100	0.051
Nuclhypwr	0.384	0.018	0.011	0.018	0.010
Wood Fiber	0.012	0.000	0.000	0.000	0.101
Fossil Fuel (%)	94.0	7.5	98.3	95.4	70.5
Wood Fiber (%)	0.2	0.0	0.0	0.0	27.0

Source: MRI.

TABLE 14

ENERGY ANALYSIS - DIAPER PRODUCTS - 100 CHANGES

	Cloth Home Laundered U25	Cloth Home Laundered U50	Cloth Home Laundered U100	Cloth Commercial Laundered U1	Cloth Commercial Laundered U50	Cloth Commercial Laundered U100	Disposable 1 Diaper 103 Diapers
Energy Type 10^6 Btu							
Process	0.445	0.422	0.410	1.291	0.162	0.150	0.332
Transportation	0.002	0.001	0.001	0.034	0.001	0.001	0.013
Material Resource	0.004	0.003	0.003	0.024	0.001	0.001	0.036
Total	0.450	0.426	0.413	1.350	0.164	0.152	0.382
Energy Source 10^6 Btu							
Petroleum	0.095	0.088	0.084	0.347	0.010	0.007	0.095
Natural Gas	0.179	0.172	0.169	0.471	0.139	0.136	0.112
Coal	0.144	0.135	0.131	0.450	0.013	0.008	0.063
Nuclhypwr	0.032	0.030	0.029	0.077	0.002	0.001	0.008
Wood Fiber	0.000	0.000	0.000	0.005	0.000	0.000	0.103
Fossil Fuel (%)	92.9	92.7	93.0	93.9	98.8	99.3	70.7
Wood Fiber (%)	0.0	0.0	0.0	0.0	0.0	0.4	27.0

Source: MRI.

TABLE 15

ENERGY ANALYSIS - SHEET PRODUCTS - 1,000 USES

	Sheet Systems				
	Cloth Sheet U1	Cloth Sheet U50	Cloth Sheet U100	Cloth Sheet U300	Disposable Sheet 1,000 Sheets
Energy Type 10^6 Btu					
Process	80.638	6.714	5.960	5.457	5.907
Transportation	3.575	0.091	0.055	0.032	0.492
Material Resource	13.822	0.297	0.059	0.067	3.659
Total	98.034	7.102	6.174	5.555	10.059
Energy Source 10^6 Btu					
Petroleum	34.634	0.820	0.475	0.245	2.025
Natural Gas	32.343	5.451	5.177	4.994	5.768
Coal	26.338	0.699	0.438	0.263	1.207
Nuclhypwr	4.582	0.128	0.083	0.052	0.267
Wood Fiber	0.138	0.003	0.002	0.001	0.793
Fossil Fuel (%)	95.2	98.1	98.6	99.0	89.5
Wood Fiber (%)	0.1	0.0	0.0	0.0	7.9

Source: MRI.

TABLE 16

ENERGY ANALYSIS - NINE FLUID OUNCE COLD DRINK PRODUCTS - MILLION SERVINGS

	Cold Drink Systems					
	Glass Tumbler U100	Glass Tumbler U1,000	Polypropylene Tumbler U100	Polypropylene Tumbler U1,000	Paper Cup Wax Coat (million)	Thermoformed Polystyrene Cup (million)
Energy Type 10^6 Btu						
Process	217.8	179.4	193.0	177.0	420.3	309.5
Transportation	1.8	0.5	50.8	5.4	31.3	43.4
Material Resource	4.3	4.3	26.9	6.5	112.3	343.9
Total	223.9	184.2	270.7	189.0	563.9	696.8
Energy Source 10^6 Btu						
Petroleum	29.7	21.0	70.6	25.2	218.1	375.8
Natural Gas	138.1	118.6	153.1	120.1	118.5	243.1
Coal	40.8	35.8	38.0	35.5	97.6	59.2
Nuclhypwr	8.3	7.9	8.4	7.9	9.8	12.7
Wood Fiber	7.0	0.8	0.6	0.2	119.8	6.0
Fossil Fuel (%)	93.1	95.2	96.7	95.7	77.0	97.3
Wood Fiber (%)	4.0	0.6	0.3	0.1	21.2	0.9

Source: MRI.

TABLE 17

ENERGY ANALYSIS - SEVEN FLUID OUNCE HOT DRINK PRODUCTS - MILLION SERVINGS

	Hot Drink Systems					
	China Cup U100	China Cup U1,000	Melamine Cup U100	Melamine Cup U1,000	Paper Cup LDPE Lined (million)	Foam Cup Polystyrene (million)
Energy Type 10^6 Btu						
Process	554.7	411.7	475.8	403.8	526.1	405.4
Transportation	115.7	12.3	10.4	1.8	18.8	42.3
Material Resource	10.1	10.1	64.5	15.6	23.6	123.3
Total	680.5	434.1	550.8	421.2	568.5	571.0
Energy Source 10^6 Btu						
Petroleum	180.7	59.4	71.8	48.5	94.0	297.7
Natural Gas	372.5	274.3	356.9	272.7	172.4	225.7
Coal	99.6	81.4	93.4	80.8	119.3	30.9
Nuclhypwr	21.1	18.1	20.7	18.0	9.1	5.8
Wood Fiber	6.6	0.9	7.9	1.0	173.7	10.8
Fossil Fuel (%)	95.9	95.6	94.8	95.4	67.8	97.1
Wood Fiber (%)	1.2	0.3	1.8	0.3	30.6	1.9

Source: MRI.

TABLE 18

ENERGY ANALYSIS - 9 INCH PLATE PRODUCTS - MILLION SERVINGS

	Plate System						
	China Plates U100	China Plates U1,000	China Plates U6,900	Melamine Plates U100	Melamine Plates U1,000	Paper Plate White Press (million)	Foam Plate Polystyrene (million)
Energy Type 10^6 Btu							
Process	688.1	385.4	356.7	488.3	365.4	706.7	660.4
Transportation	271.5	27.8	4.6	9.5	1.6	38.3	412.9
Material Resource	9.0	9.0	9.0	101.8	18.3	3.1	675.9
Total	968.6	422.2	370.3	599.6	385.3	748.1	1,479.2
Energy Source 10^6 Btu							
Petroleum	349.7	71.7	45.3	77.4	44.5	131.0	785.8
Natural Gas	478.6	258.6	237.6	393.4	250.0	193.6	502.9
Coal	112.1	74.7	71.2	95.4	73.1	161.4	140.1
Nuclhypwr	23.6	16.5	15.9	21.2	16.3	10.6	29.4
Wood Fiber	4.6	0.7	0.3	12.2	1.4	251.5	21.1
Fossil Fuel (%)	97.1	95.9	95.6	94.4	95.4	65.0	96.6
Wood Fiber (%)	0.5	0.2	0.1	2.4	0.5	33.6	1.4

Source: MRI.

resource energy from 3 to 7 percent. The material resource energy is associated with the polyester component of the cloth napkin and with any plastic packaging. The reusable systems rely on fossil fuels for over 90 percent of their system energy, while the paper napkin requires 72.6 percent fossil fuel and 25 percent wood-derived energy.

(3) Table 14 - Diapers: Again, process energy is the dominant type for the Diaper category. Transportation energy varies from 2 to 4 percent; for the reusable products, the variation is directly related to the product use factor. The cloth systems dependance on fossil fuel is greater than 90 percent. Commercial laundry systems use a higher percentage of fossil fuels for water heating than the home systems, which will use more electricity and thereby a higher percentage of nuclear and hydropower. The disposable diaper system derives 27 percent of its energy from wood residues.

(4) Table 15 - Sheets: The cloth sheet systems show substantial amounts of materials resource energy (1 to 41 percent depending on use factor) due to the polyester fiber comprising 50 percent of the sheet. The disposable sheet has around 35 percent material resource energy contributed by the polyethylene backing for the nonwoven fiber. For the cloth sheets the natural gas energy percentage varies from 33 percent for a low use factor to around 90 percent for the 300-use sheets. Again, the natural gas used to treat the wash water increases relative to electrical power demand, as the use factor increases. The disposable sheet system derives 7.9 percent of its energy requirements from wood residues while the reusable sheets depend almost entirely on fossil fuels.

(5) Tables 16 and 17 - Containers: The reusable products are heavily dependent upon fossil fuels as their primary energy source. The paper containers derive 20 to 30 percent of their energy requirements from wood residues. The higher transportation energy for the china cup systems is primarily due to the energy used in transporting the postconsumer waste to a landfill. The transportation energy varies from 20 percent of the total at 100 uses of the china cup to 3 percent for 1,000 use of the cup. Therefore, transportation of raw materials and postconsumer solid waste become important considerations in the china systems. Both the glass and china manufacturing steps use primarily natural gas as their energy source thereby increasing the percentage of fossil fuels required for the system. The thermoformed plastic cup system shows 49 percent and the foam cup 21 percent material resource energy.

(6) Table 18 - Plates: High transportation energy for the china products is again due to the energy required to dispose of the postconsumer solid waste, and to transport raw materials. This energy decreases to less than 2 percent for the expected life scenario of 6,900 uses for the china plate.

The material resource energy for the plastic foam plate represents 46 percent of the total system energy, while the paper system shows only 0.4 percent of the total. The melamine plate system varies from 5 to 17 percent for material resource energy depending on the use factor.

The reusable systems depend on fossil fuels for over 95 percent of their energy, while the paper plate system derives 33.6 percent of its energy from wood wastes.

b. <u>Energy as a Function of Use Factors and Usage Patterns</u>: In this report, the use factor refers to the number of times the product is used before discarding as solid waste. The usage pattern identifies the number of times the product is used before it is washed. Only the towel category has usage patterns greater than one throughout the report.

Figure 3 presents the relationship of cloth towel usage patterns and total system energy. The energy values are plotted for 1, 2, 3, 4 and 5 uses before laundering for cloth towels having use factors of 32 and 100. The figure shows the two-ply paper towel system to have a constant total energy of 0.496 million Btu. Both the 32 and 100 use cloth towel systems have larger total energy values at the usage pattern of one use before laundering. The 32 use cloth towel energy value becomes equal to the paper towel energy value at around 3.5 uses before laundering. The 100 use cloth towel energy reduces to the energy of the paper system at around 2.3 uses before laundering. If only one paper towel is used per spill, the paper system energy becomes 0.271 million Btu per 1,000 spills.

With a usage pattern of one, the paper towel has the most favorable position with respect to energy use. As the usage pattern and/or use factor for the cloth towel increases, the cloth towel energy position becomes very competitive with the paper system. Taking into account the varying use habits of households, there does not appear to be a disconcernible difference in energy requirements between the reusable and disposable towel products.

Figure 4 compares the energy of the cellulose sponge, at various usage patterns, with the paper towel system. With multiple uses before laundering, the sponge displays a favorable position with respect to total energy use.

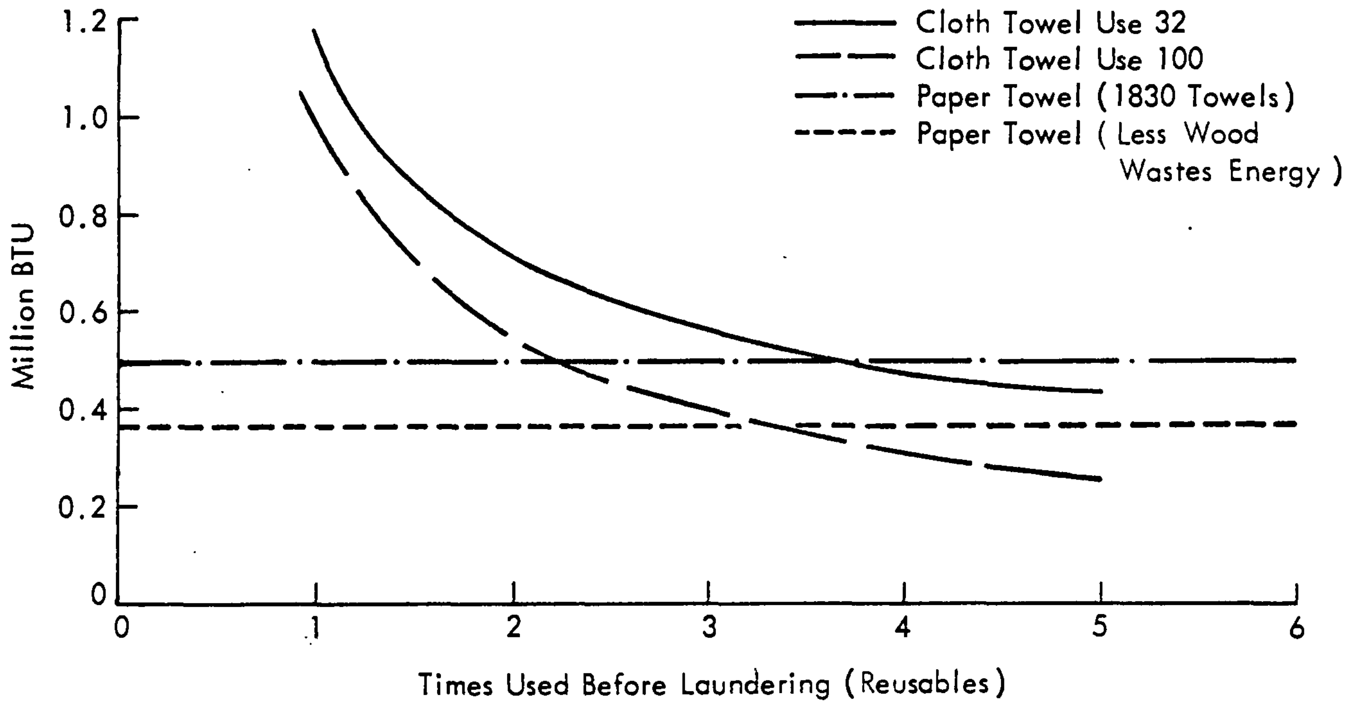


Figure 3 - Energy - Cloth Towel Usage Patterns Versus Paper Towel
(1,000 Spills)

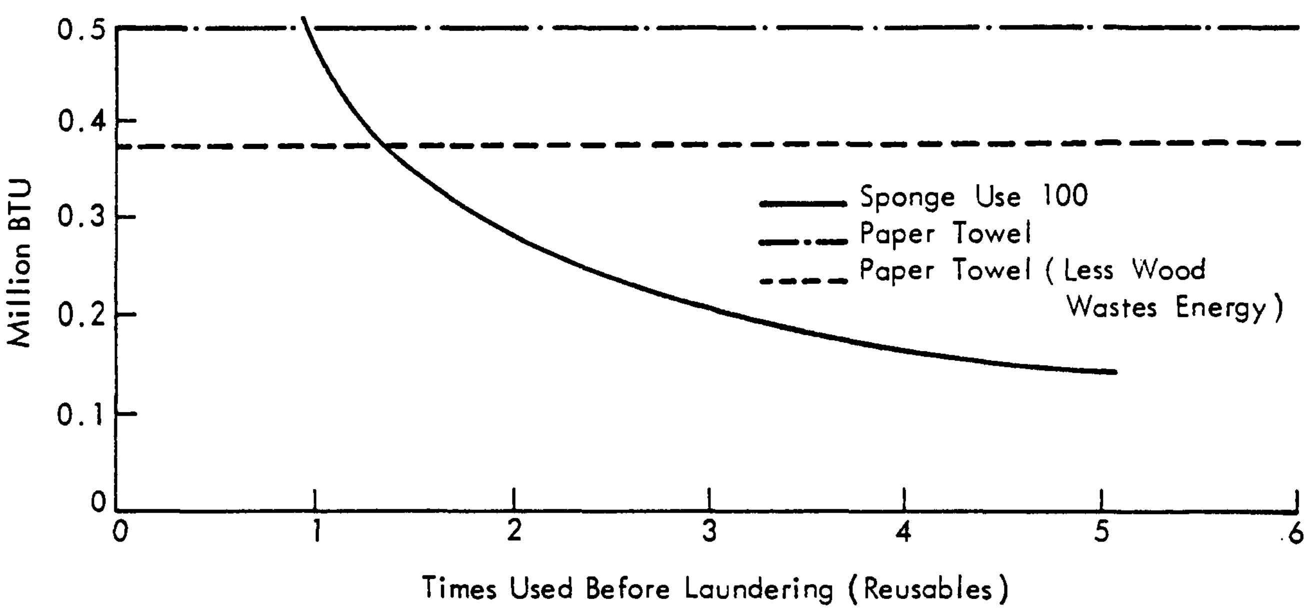


Figure 4 - Energy - Sponge Usage Patterns Versus Paper Towel

The comparative energy analysis for the home and commercial napkin systems is presented in Figure 5. The home napkin approaches a minimum energy value of 0.695 million Btu. The 0.695 million Btu represents the energy required to launder 1,000 napkins. As the use factor for the napkin increases, the impacts for process other than laundering become very small. The commercial cloth napkin system energy approaches 0.525 million Btu as its minimum value. Therefore, both the one-ply and two-ply paper napkins require the smaller amount of energy for 1,000 uses.

Figure 6 contains the energy analysis for the diaper systems. The cloth system using home laundry approaches the energy of the disposable diaper system. However, the cloth system using the commercial laundry requires less energy than the disposable system after a use factor of around five. The commercial system approaches a minimum energy of around 0.14 million Btu per 100 changes.

Figure 7 shows the energy comparison of the cloth sheet and nonwoven disposable sheet. Since energy estimates were made in the manufacturing step of the disposable sheet, the values in Figure 7 represent our best estimate of the actual energy value. According to the data, the reusable sheet requires less energy after around 20 uses. The estimate used for the disposable sheet manufacturing step (0.157 million Btu per 1,000 sheets) represents 1.6 percent of the total disposable system. The estimate used for the nonwoven fiber manufacture was 2.9 million Btu per 1,000 sheets or 29 percent of the system total.

The energy comparisons of the cold and hot drink container systems are presented in Figure 8. The reusable systems show less energy than the disposable systems after a use factor of around 20, considering commercial dishwashing only.

The energy analysis of the plate systems (Figure 9) shows that reusable systems use less energy after around 200 uses for the china plate, and 50 uses for the melamine plate. The energy values represent reusable systems with commercial dishwashers.

B. Analysis of Environmental Outputs

1. Atmospheric Emissions[1,2]: Tables 19 through 24 contain tabulated data for atmospheric emission summaries. The values have been grouped in six categories: particles, nitrogen oxides, hydrocarbons, sulfur oxides, carbon monoxide, and others. The first five pollutants generally account for more than 95 percent of the total emissions. The "other" category includes all other pollutants.

1/ See comments No. 8-9 Appendix B, pages 7-8.
2/ See comments No. 12-13 Appendix B, page 8.

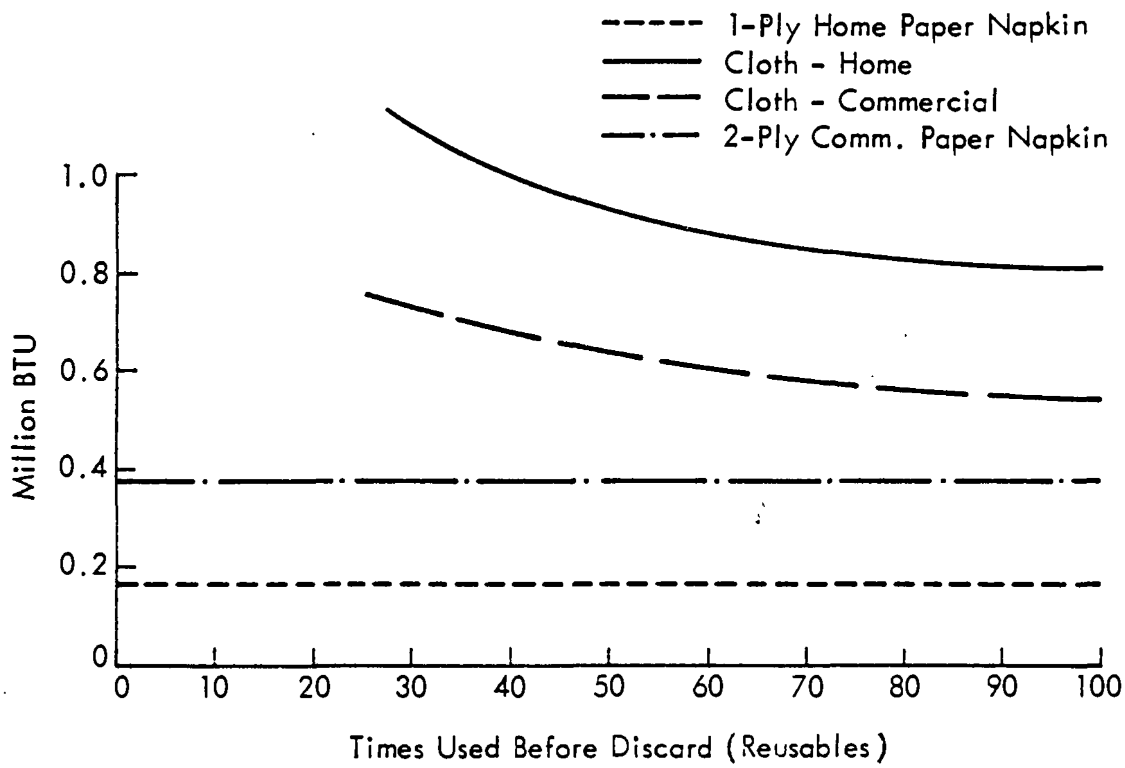


Figure 5 - Energy - Cloth Napkins Versus Paper Napkins

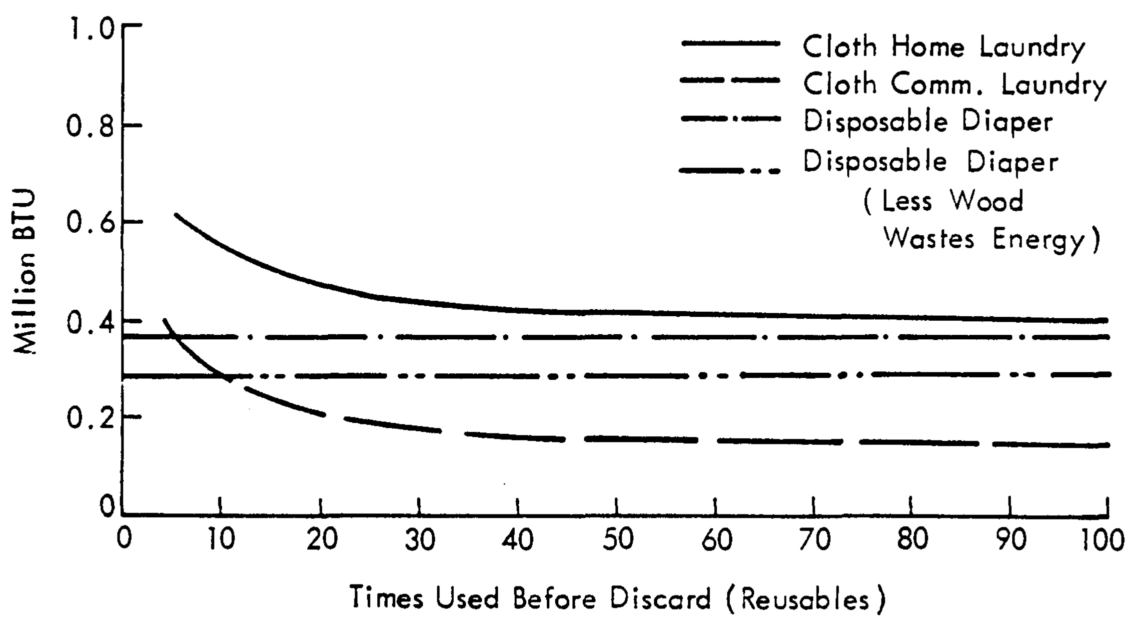


Figure 6 - Energy - Cloth Diapers Versus Disposable Diapers

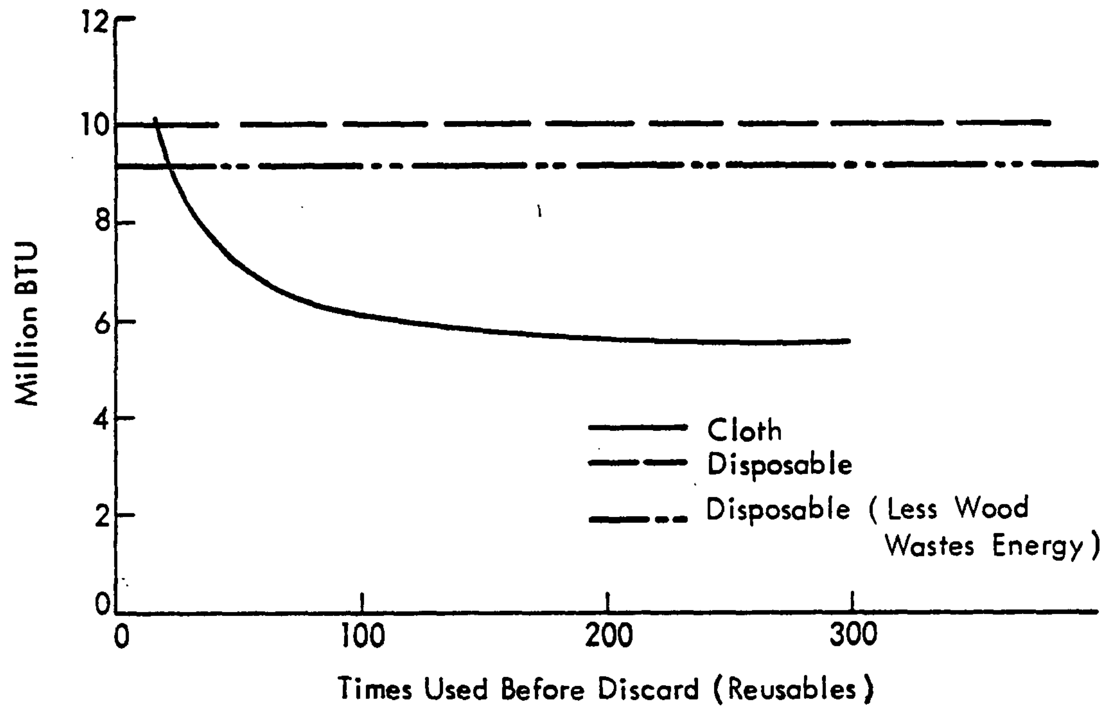


Figure 7 - Energy - Cloth Sheet Versus Disposable Sheet

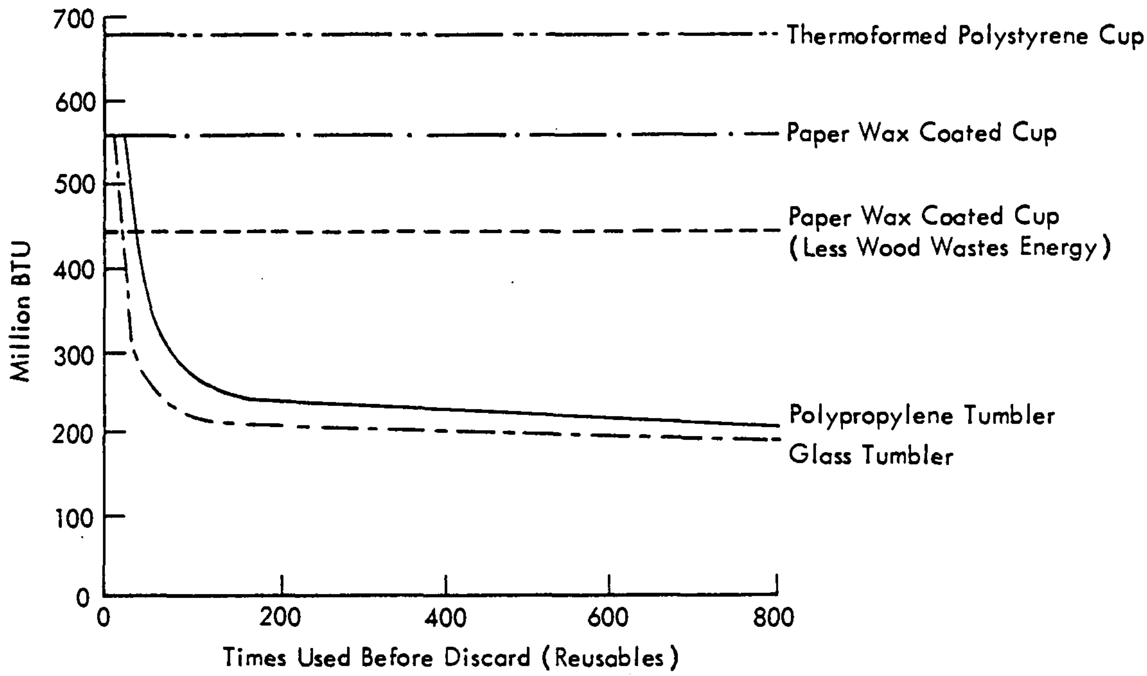


Figure 8 - Energy - Resuable Versus Disposable Containers (9 fl oz)

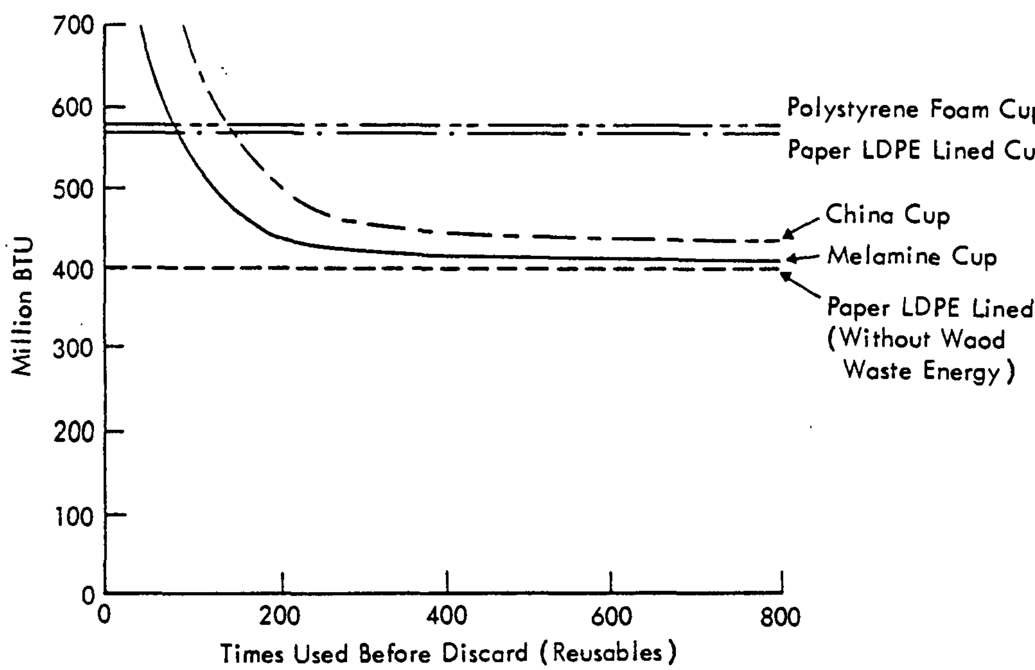


Figure 8a - Energy - Reusable Versus Disposable Containers (7 fl oz)

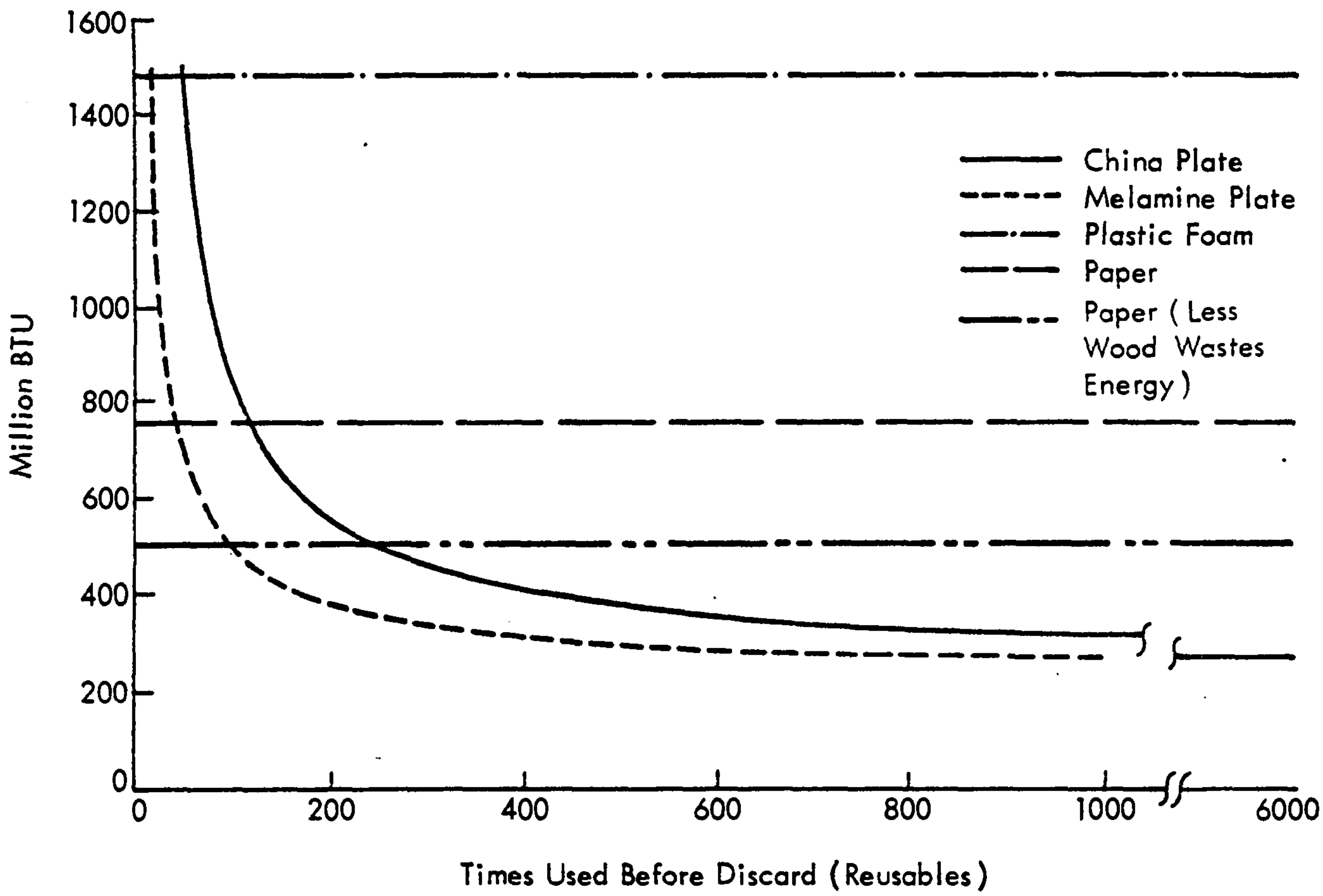


Figure 9 - Energy - Reusable Versus Disposable Plates

TABLE 19

ATMOSPHERIC EMISSIONS - TOWEL CATEGORY - 1,000 SPILLS

Pollutant	Cloth Towel U100 L1	Cloth Towel U100 L5	Sponge U100 L1	Sponge U100 L5	Paper Towel
Particles	0.47	0.16	0.20	0.06	0.22
Nitrogen Oxides	0.90	0.25	0.41	0.12	0.40
Hydrocarbons	0.57	0.15	0.27	0.08	0.24
Sulfur Oxides	1.90	0.50	0.86	0.24	0.66
Carbon Monoxide	0.16	0.06	0.07	0.02	0.23
Other	0.03	0.01	0.15	0.14	0.04
Total	4.03	1.13	1.96	0.66	1.79

Source: MRI.

TABLE 20

ATMOSPHERIC EMISSIONS - NAPKIN CATEGORY - 1,000 MEALS

Pollutant	Cloth U54 Home	Cloth U100 Home	Paper One-Ply Home	Cloth U27 Commercial	Paper Two-Ply Commercial
Particles	0.46	0.38	0.09	0.25	0.17
Nitrogen Oxides	0.77	0.70	0.14	0.53	0.30
Hydrocarbons	0.52	0.46	0.09	0.61	0.16
Sulfur Oxides	1.71	1.52	0.27	0.55	0.49
Carbon Monoxide	0.07	0.13	0.10	0.21	0.12
Other	0.04	0.01	0.01	0.06	0.03
Total	3.67	3.22	0.65	2.21	1.27

Source: MRI.

TABLE 21

ATMOSPHERIC EMISSIONS
DIAPER CATEGORY - 100 CHANGES

Pollutant	Cloth U100 Home	Cloth U50 Commercial	Disposable
Particles	0.18	0.03	0.19
Nitrogen Oxides	0.36	0.10	0.26
Hydrocarbons	0.23	0.14	0.18
Sulfur Oxides	0.77	0.07	0.44
Carbon Monoxide	0.06	0.03	0.09
Other	0.00	0.02	0.04
Total	1.60	0.39	1.20

Source: MRI.

TABLE 22

ATMOSPHERIC EMISSIONS
BEDDING CATEGORY - 1,000 CHANGES

Pollutant	Cloth Sheet U100	Cloth Sheet U300	Disposable Sheet
Particles	1.00	0.56	2.38
Nitrogen Oxides	3.71	3.20	6.32
Hydrocarbons	5.65	5.05	9.41
Sulfur Oxides	2.61	1.57	8.07
Carbon Monoxide	1.29	0.93	2.17
Other	0.27	0.25	0.29
Total	14.53	11.56	28.64

Source: MRI.

TABLE 23

ATMOSPHERIC EMISSIONS - CONTAINER CATEGORY (MILLION SERVINGS)

Pollutant	Glass Tumbler U1,000 9 Fl Oz	Polypropylene Tumbler U1,000 9 Fl Oz	Paper Wax Cup 9 Fl Oz	Thermoformed Polystyrene Cup 9 Fl Oz	China Cup U1,000 7 Fl Oz	Melamine Cup U1,000 7 Fl Oz	Paper LDPE Cup 7 Fl Oz	Foam Polystyrene Cup 7 Fl Oz
Particles	56	51	191	129	145	115	244	133
Nitrogen Oxides	134	138	293	365	320	304	305	366
Hydrocarbons	133	142	260	573	318	310	247	571
Sulfur Oxides	208	203	568	480	471	464	632	446
Carbon Monoxide	28	62	262	395	140	67	142	307
Other			40	21			49	31
Total	564	602	1,614	1,963	1,407	1,272	1,619	1,854

Source: MRI.

TABLE 24

ATMOSPHERIC EMISSIONS - PLATE CATEGORY (MILLION SERVINGS)

Pollutant	China U1,000	China U6,900	Melamine U100	Melamine U1,000	Paper	Foam Polystyrene
Particles	172	110	152	105	272	345
Nitrogen Oxides	317	270	405	277	391	893
Hydrocarbons	316	269	533	288	274	1,480
Sulfur Oxides	436	407	599	422	782	1,152
Carbon Monoxide	239	81	149	64	253	988
Other	20	9	38	9	59	66
Total	1,500	1,146	1,876	1,165	2,031	4,924

Source: MRI.

Figures 10 through 15 present the atmospheric emissions data graphically, for selected products in each product category. Figure 10 shows the primary pollutant for the towel category to be sulfur oxides. For the cloth and sponge products, the sulfur oxides result from the burning of coal used to generate the electricity required in the manufacturing steps. In the paper profile the sulfur oxides result from both power generation and papermaking process losses.

In Figure 11 the sulfur oxides emissions associated with the commercial napkin are less than the home napkin due to the more common use of natural gas rather than electricity to heat the laundry water.

Figures 12 and 13 show that the pollutant profiles for the cloth products are similar, in relative proportions, to the cloth towels and napkins. The disposable diaper profile is similar in makeup to the other paper products. The disposable sheet shows higher hydrocarbon emissions than a typical paper product, due to the emissions from the plastic film system.

Figures 14 and 15 show that the atmospheric emissions are fairly evenly distributed between the five primary pollutants.

2. Waterborne Waste:[1,2,3] The analyses of the waterborne waste impact categories are presented in graphic form in Figures 16 through 21, and numerically in Tables 25 through 30.

For all of the products, the primary impacts are dissolved solids, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), suspended solids, and dissolved solids. The pollutants reported in minor quantities are listed in the "other" category.

The waterborne waste impacts are broken down in Figures 16 through 19 according to the primary impacts. The waterborne waste for the container and plate category are divided into dissolved solids and other, since the dissolved solids is so predominant in the dishwashing process.

3. Industrial Solid Waste:[1,4,5] The industrial solid waste category is divided into three sections: those impacts resulting from process, fuel combustion, and mining/extraction operations. The results are presented graphically in Figures 22 through 27, and numerically in Tables 31 through 36.

From Figure 22, the towel category products industrial solid waste breakdown shows that process and mining wastes account for the largest poundage. The same is true for Figure 23, except the process solid wastes are more predominant for the commercial cotton napkin and paper napkin. The cotton napkin has more process wastes than the cotton-rayon[6] home napkin due to the solids resulting from the cotton ginning process.

1/ See comments No. 8-9 Appendix B, pages 7-8.
2/ See comment No. 10 Appendix B, page 8.
3/ See comments Appendix J, pages 4, 22-31, and 33-34.
4/ See comment No. 11 Appendix B, page 8.
5/ See comments Appendix J, page 3 and 18-s0.
6/ Should be polyester-rayon.

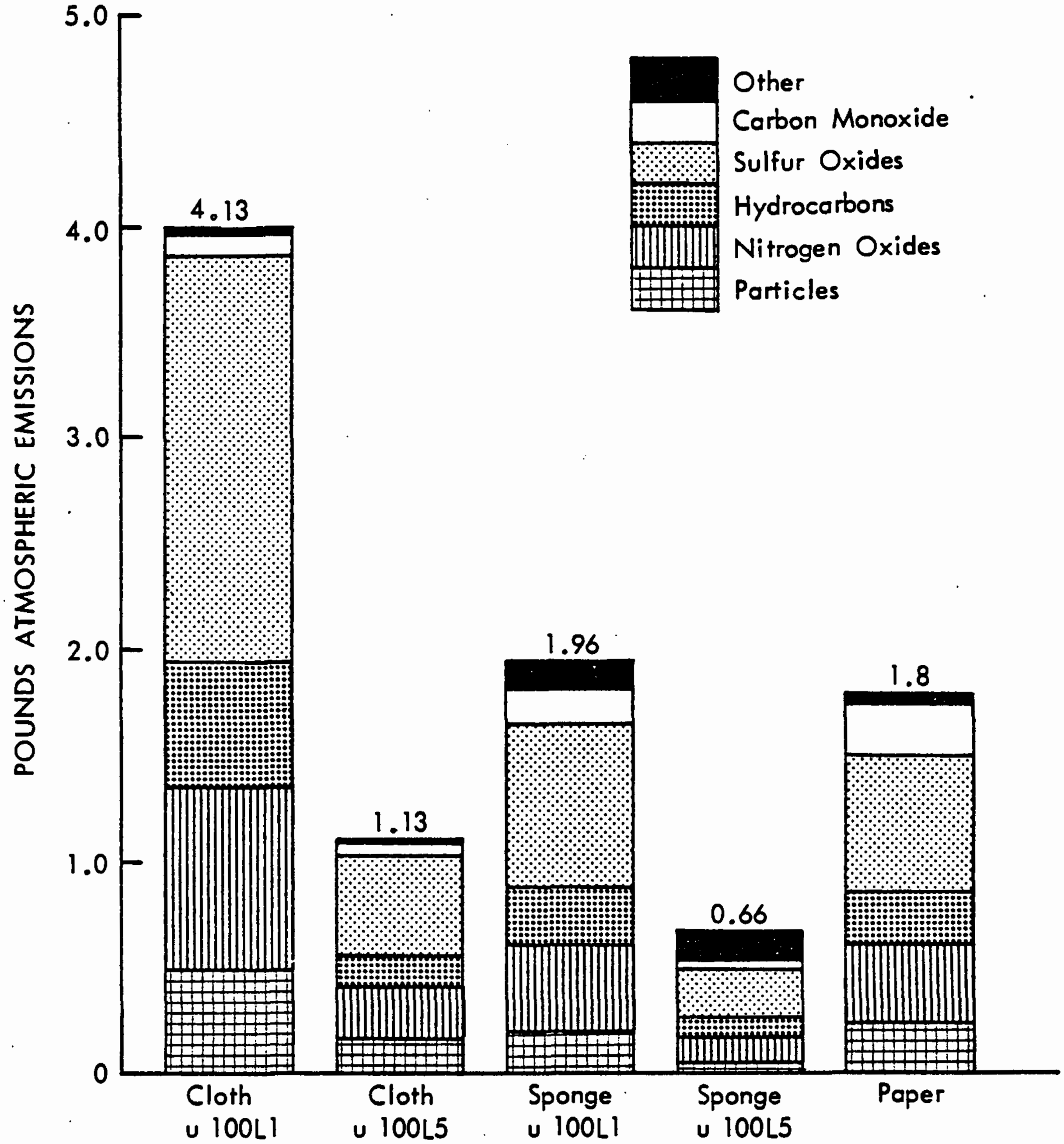


Figure 10 - Atmospheric Emissions Towel Category - 1,000 Uses

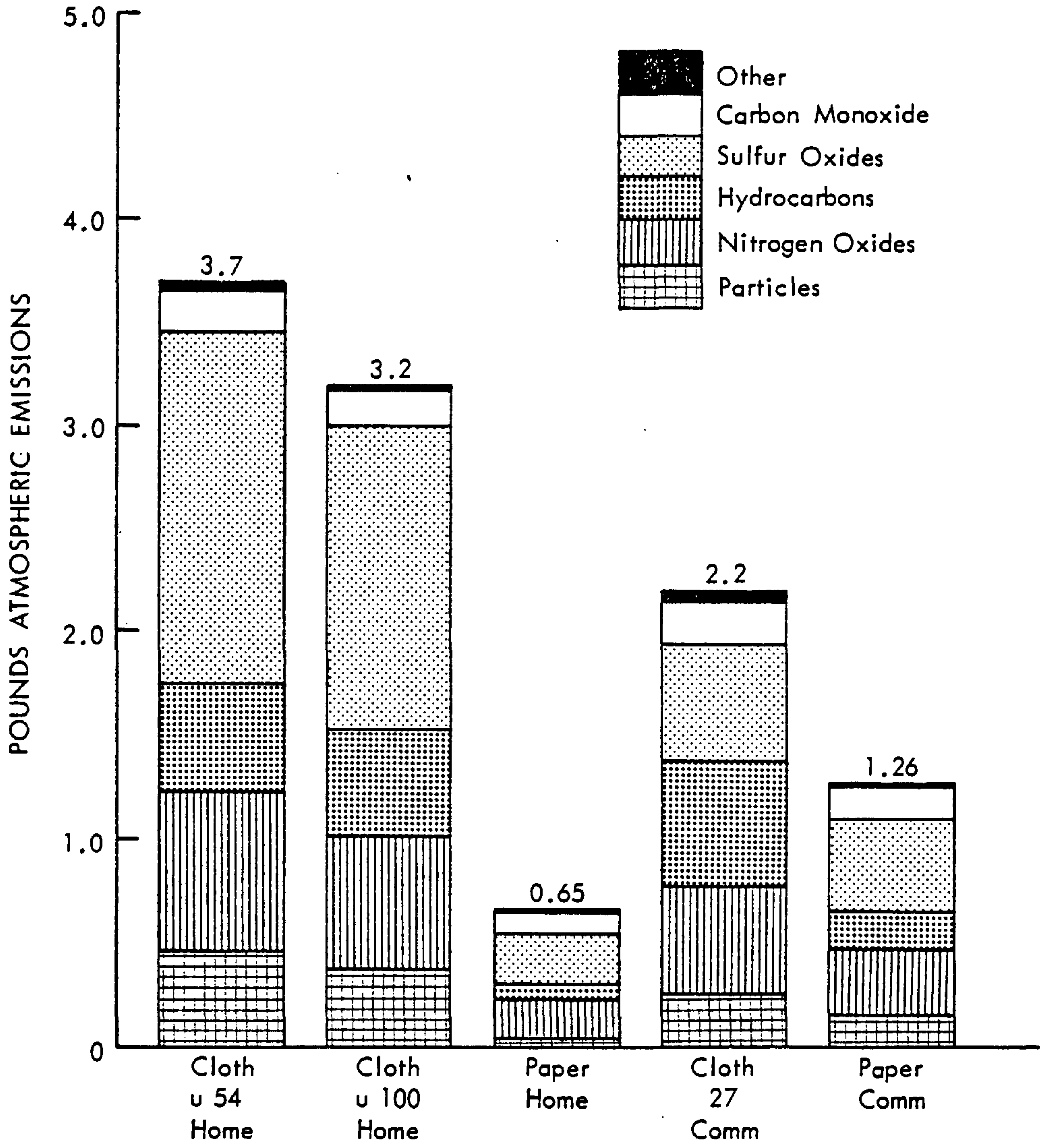


Figure 11 - Atmospheric Emissions Napkin Category

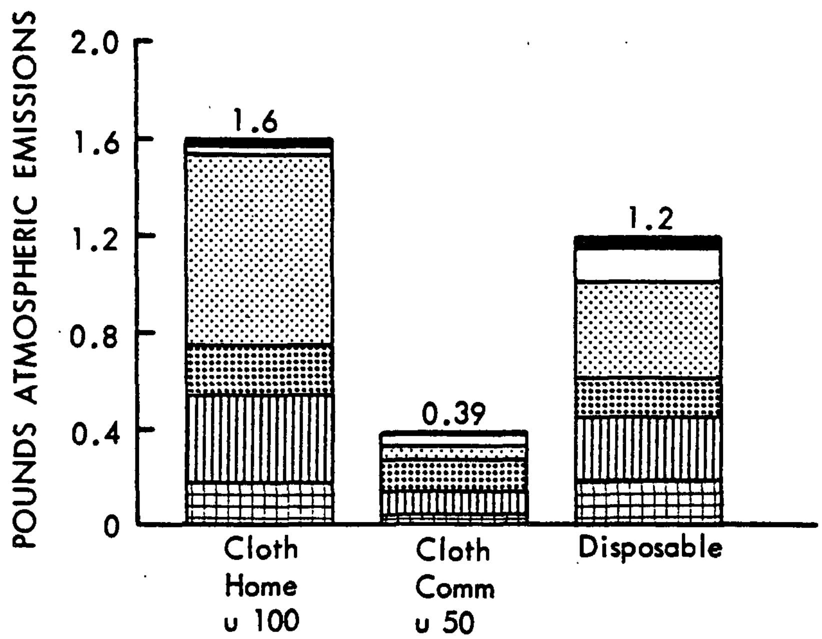


Figure 12 - Atmospheric Emissions Diaper Category

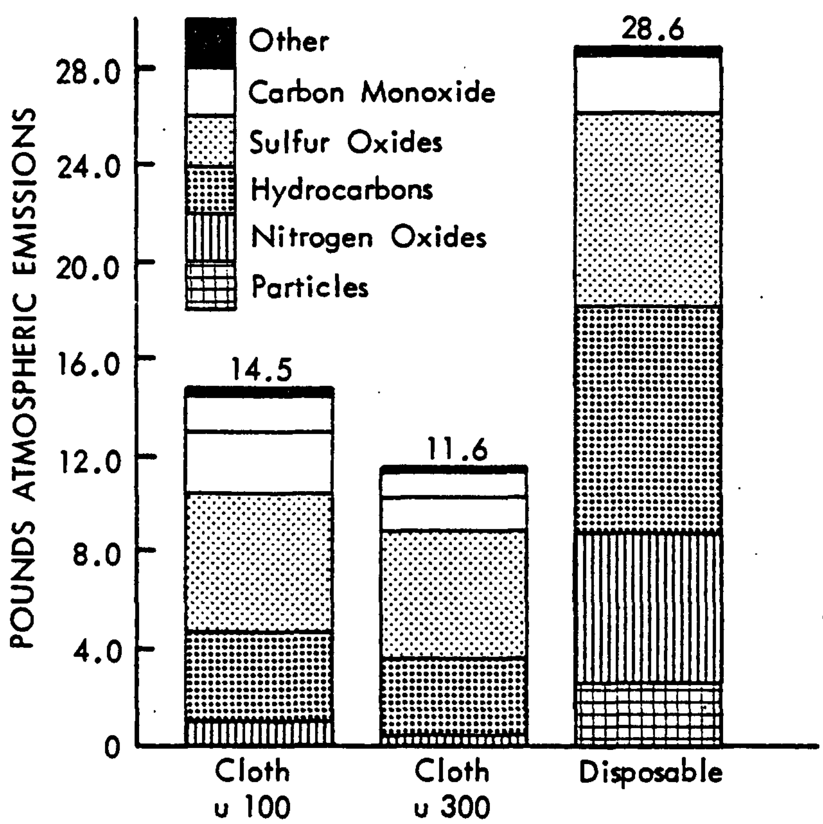


Figure 13 - Atmospheric Emissions Bedding Category

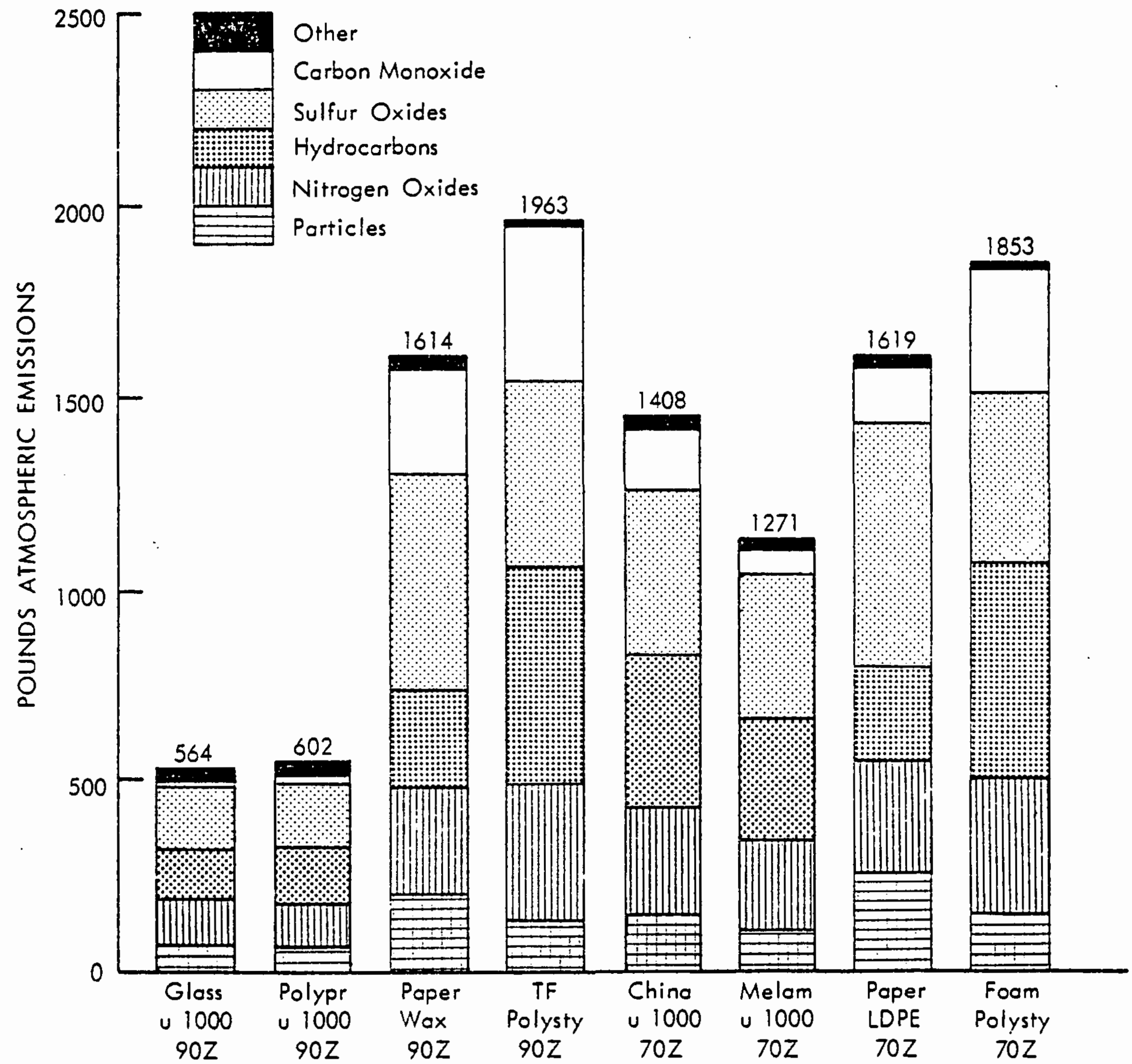


Figure 14 - Atmospheric Emissions Container Category

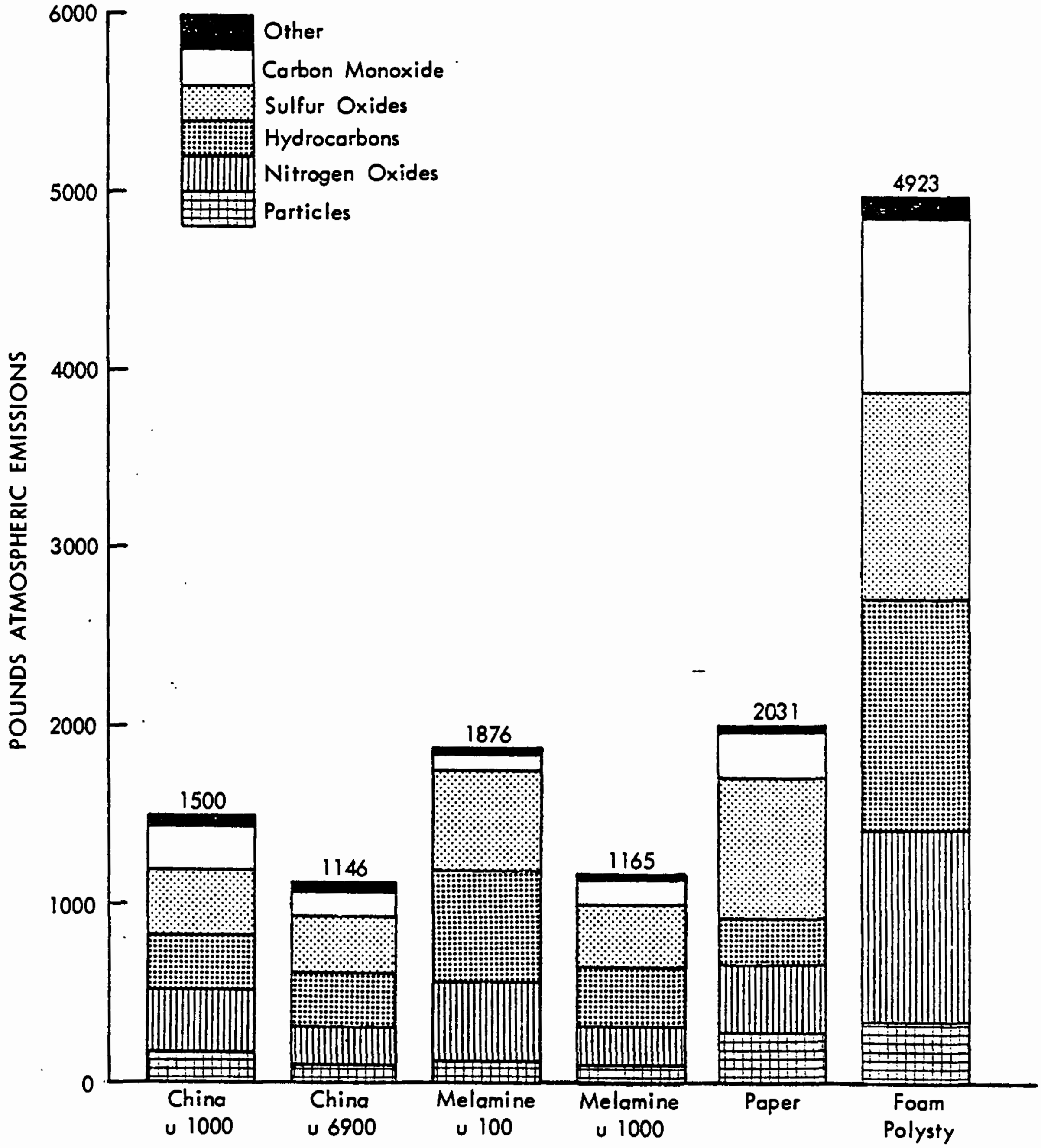


Figure 15 - Atmospheric Emissions Plate Category

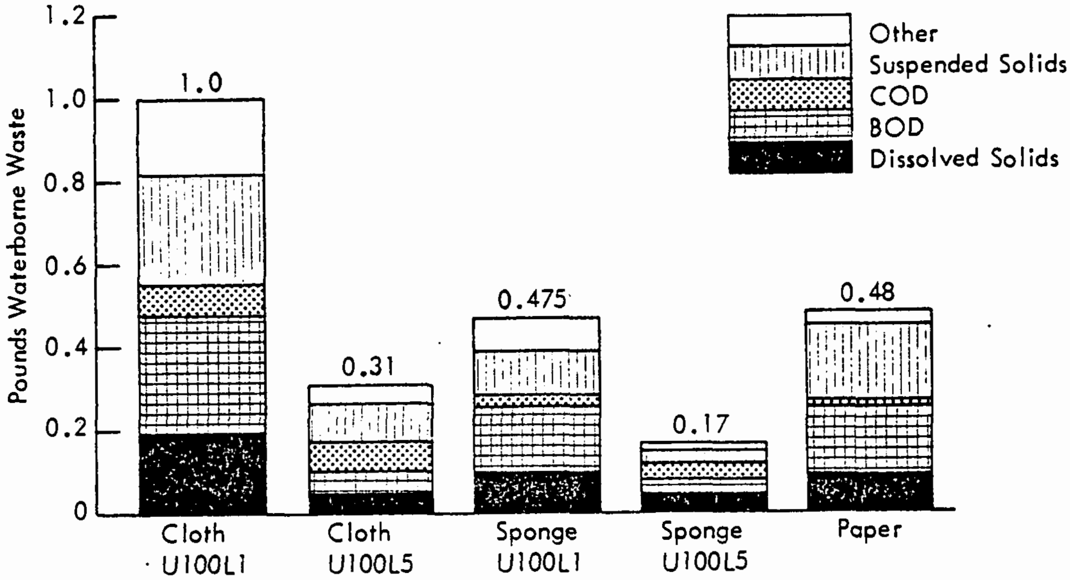


Figure 16 - Waterborne Wastes Towel Category (1,000 Spills)

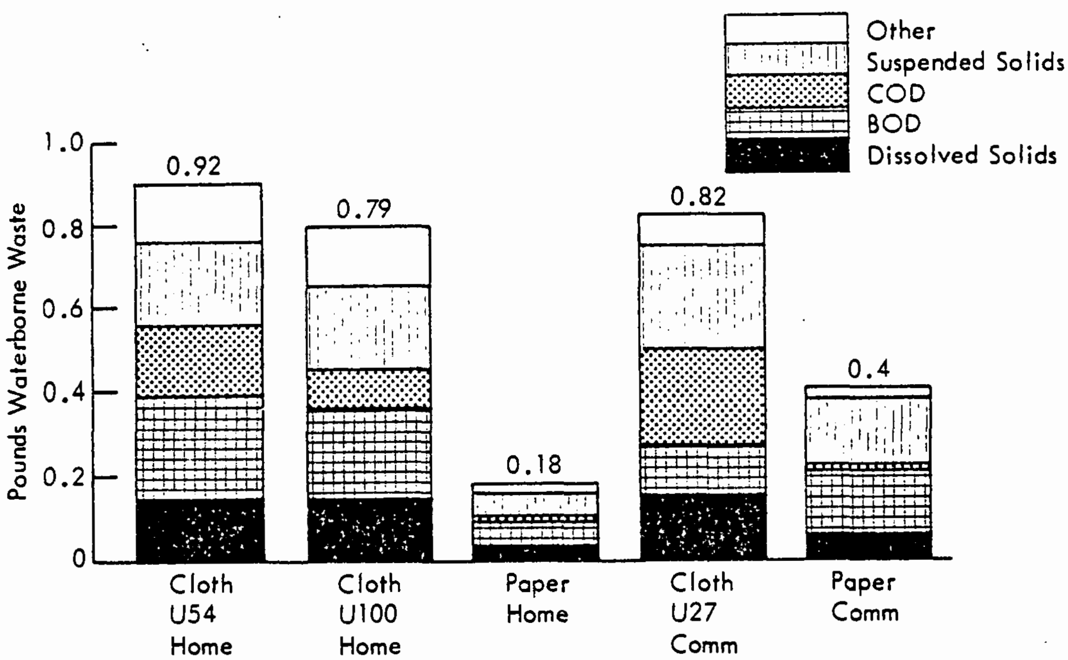


Figure 17 - Waterborne Wastes Home and Commercial Napkin Category
(1,000 Meals)

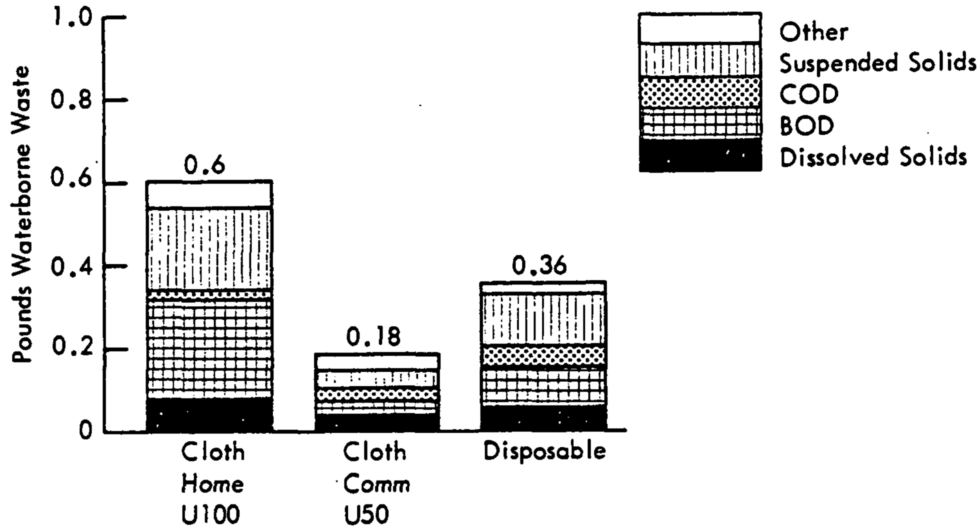


Figure 18 - Waterborne Wastes Diaper Category (100 Changes)

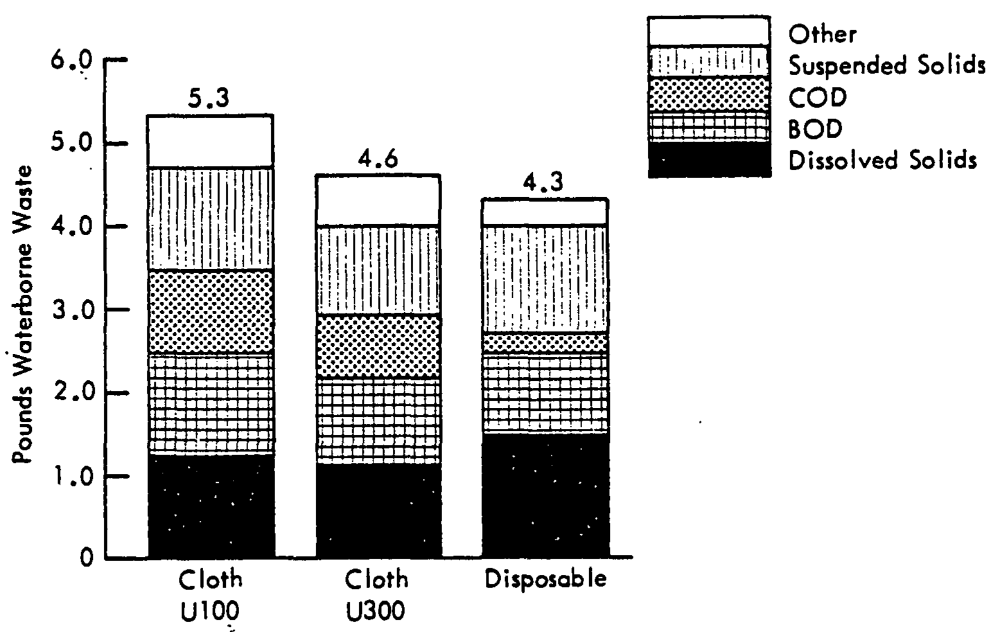


Figure 19 - Waterborne Wastes Bedding Category (1,000 Changes)

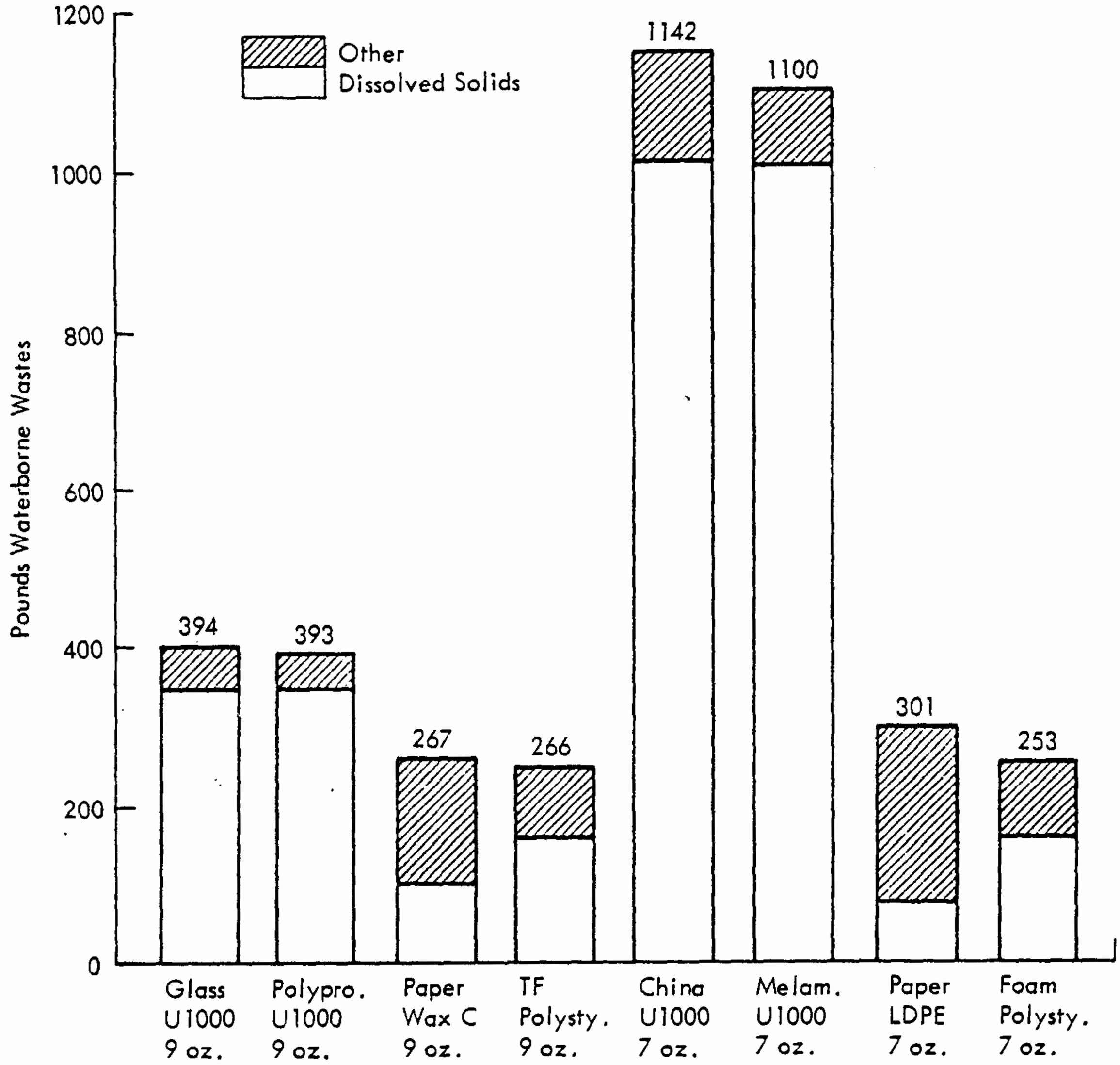


Figure 20 - Waterborne Wastes - Container Category (million servings)

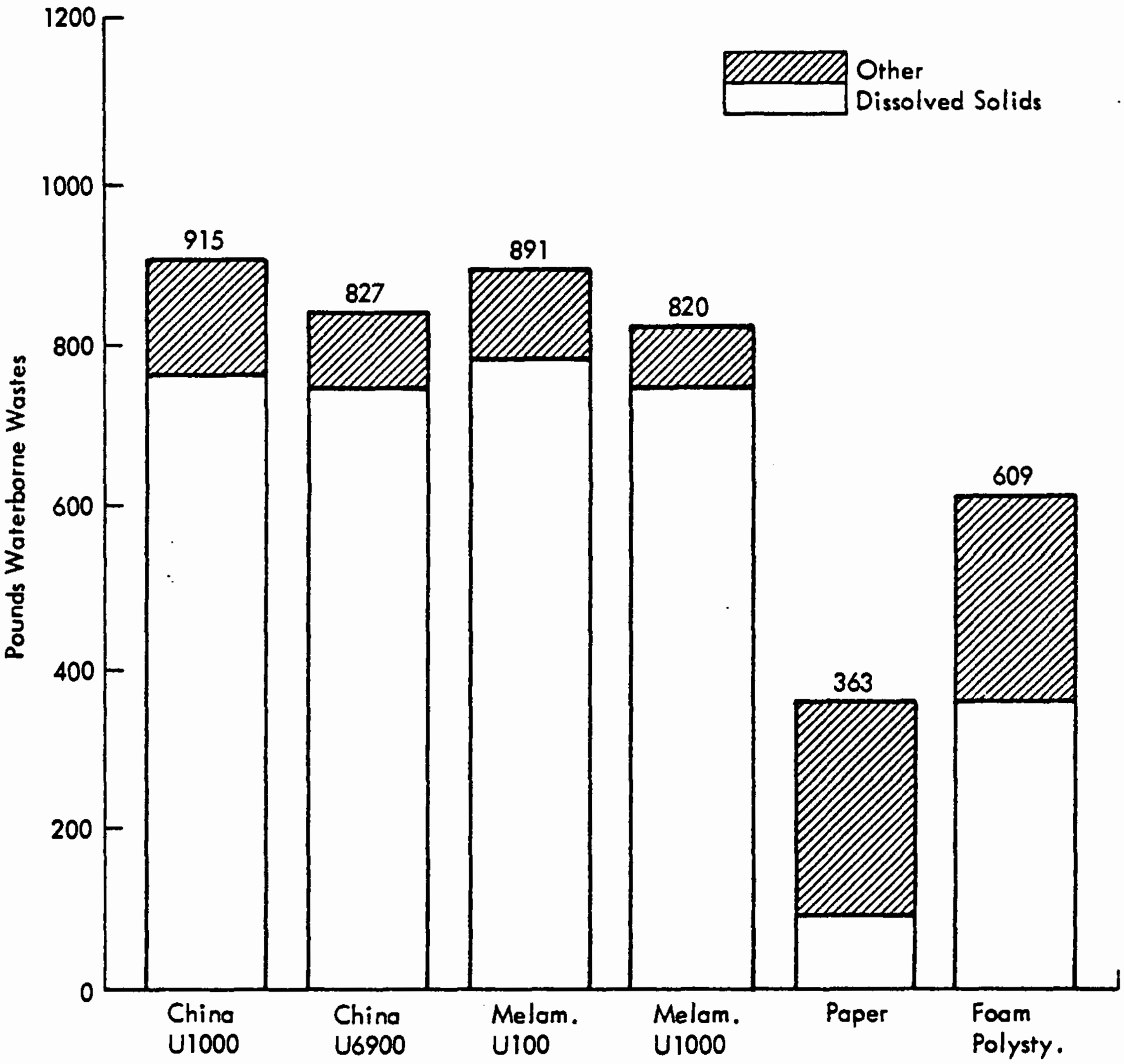


Figure 21 - Waterborne Wastes - Plate Category (million servings)

TABLE 25

WATERBORNE WASTES - TOWEL CATEGORY - 1,000 SPILLS

Pollutant	Cloth U100 L1	Cloth U100 L5	Sponge U100 L1	Sponge U100 L5	Paper Two-Ply
Dissolved Solids	0.189	0.046	0.102	0.039	0.093
BOD	0.296	0.064	0.149	0.045	0.159
COD	0.071	0.063	0.035	0.032	0.002
Suspended Solids	0.270	0.096	0.109	0.031	0.197
Alkalinity	0.001	0.000	0.000	0.000	0.000
Other	0.177				
Total	1.004	0.314	0.475	0.167	0.478

Source: MRI.

TABLE 26

WATERBORNE WASTES - NAPKIN CATEGORY - 1,000 MEALS

Pollutant	Cloth U54 Home	Cloth U100 Home	Paper One-Ply Home	Cloth U27 Commercial	Paper Two-Ply Commercial
Dissolved Solids	0.162	0.147	0.034	0.149	0.067
BOD	0.235	0.225	0.064	0.123	0.139
COD	0.163	0.092	0.001	0.216	0.001
Suspended Solids	0.200	0.182	0.071	0.253	0.171
Alkalinity	0.000	0.000	0.000	0.000	0.000
Other	0.156	0.142	0.009	0.088	0.022
Total	0.916	0.788	0.179	0.829	0.400

Source: MRI.

TABLE 27

WATERBORNE WASTES - DIAPER CATEGORY - 100 CHANGES

Pollutant	Cloth U100 Home	Cloth U50 Commercial	Disposable
Dissolved Solids	0.075	0.035	0.058
BOD	0.249	0.038	0.103
COD	0.013	0.033	0.040
Suspended Solids	0.198	0.051	0.129
Alkalinity	0.000	0.000	0.000
Other	0.066	0.020	0.026
Total	0.601	0.177	0.356

Source: MRI.

TABLE 28

WATERBORNE WASTES - BEDDING CATEGORY - 1,000 USES

Pollutant	Cloth U100	Cloth U300	Disposable
Dissolved Solids	1.286	1.177	1.467
BOD	1.123	1.085	0.923
COD	0.966	0.618	0.291
Suspended Solids	1.330	1.157	1.224
Alkalinity	0.002	0.002	0.000
Other	0.639	0.574	0.449
Total	5.346	4.613	4.354

Source: MRI.

TABLE 29

WATERBORNE WASTES - CONTAINER CATEGORY (MILLION SERVINGS)

Pollutant	Glass Tumbler U1,000 9 Fl Oz	Polypropylene Tumbler U1,000 9 Fl Oz	Paper Wax Cup 9 Fl Oz	Thermoformed Polystyrene Cup 9 Fl Oz	China Cup U1,000 7 Fl Oz	Melamine Cup U1,000 7 Fl Oz	Paper LDPE Cup 7 Fl Oz	Foam Polystyrene Cup 7 Fl Oz
Dissolved Solids	355	357	104	165	1,022	1,015	72	167
BOD	6	4	70	30	13	11	103	41
COD	6	6	2	21	19	15	2	8
Suspended Solids	9	8	69	25	41	20	101	23
Other	18	18	22	25	47	39	23	14
Total	394	393	267	266	1,142	1,100	301	253

Source: MRI.

TABLE 30

WATERBORNE WASTES - PLATE CATEGORY (MILLION SERVINGS)

Pollutant	China U1,000	China U6,900	Melamine U100	Melamine U1,000	Paper	Polystyrene
Dissolved Solids	760	743	774	743	92	356
BOD	12	9	23	10	115	90
COD	21	15	14	13	1	41
Suspended Solids	67	24	32	18	130	63
Other	55	36	49	36	22	59
Total	915	827	892	820	364	609

Source: MRI.

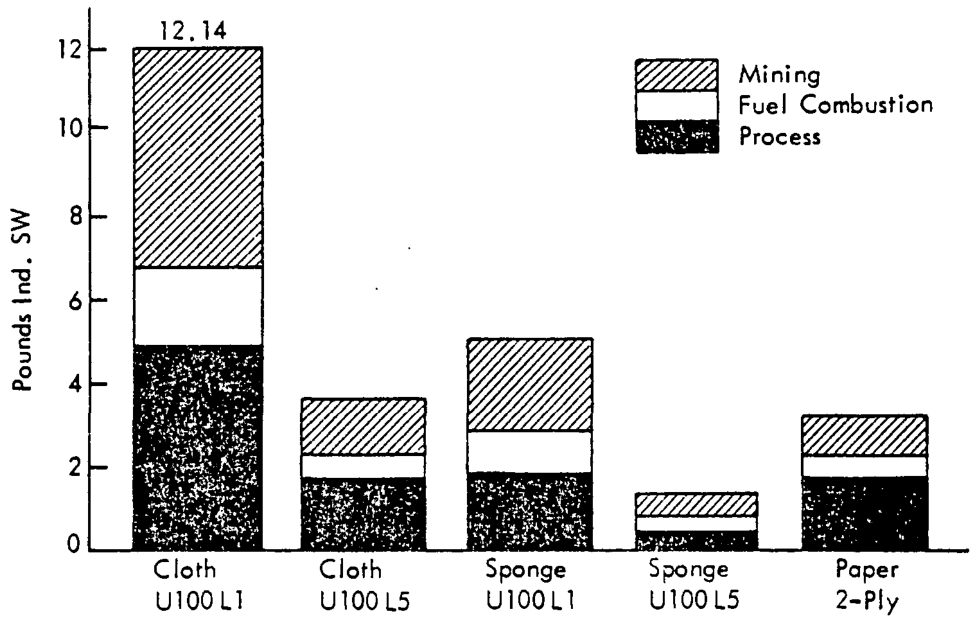


Figure 22 - Industrial Solid Waste (Pounds) Towel Category (1,000 Spills)

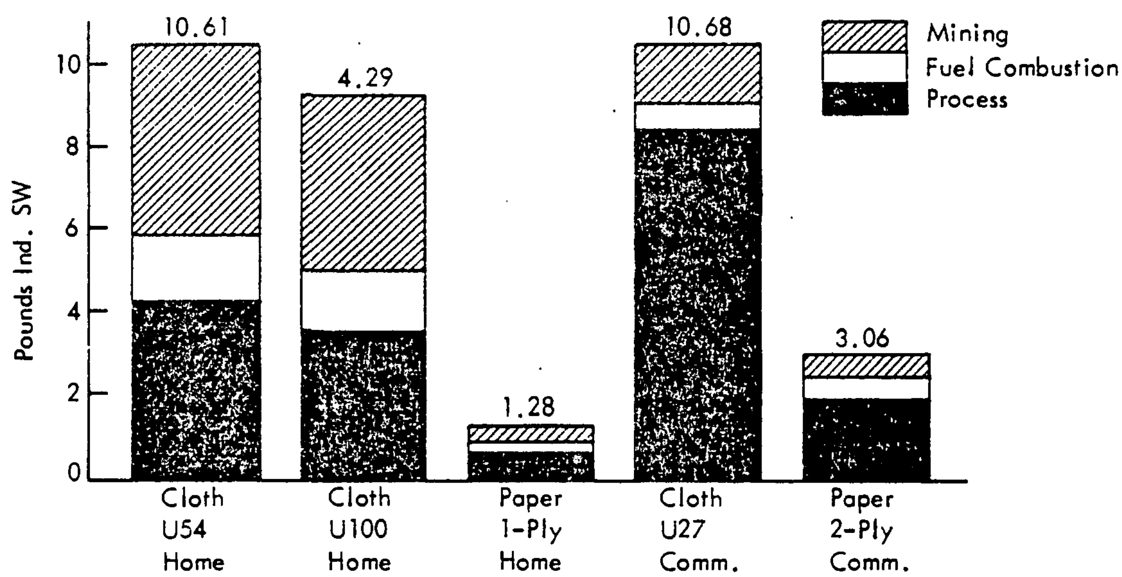


Figure 23 - Industrial Solid Waste (Pounds) Napkin Category (1,000 Meals)

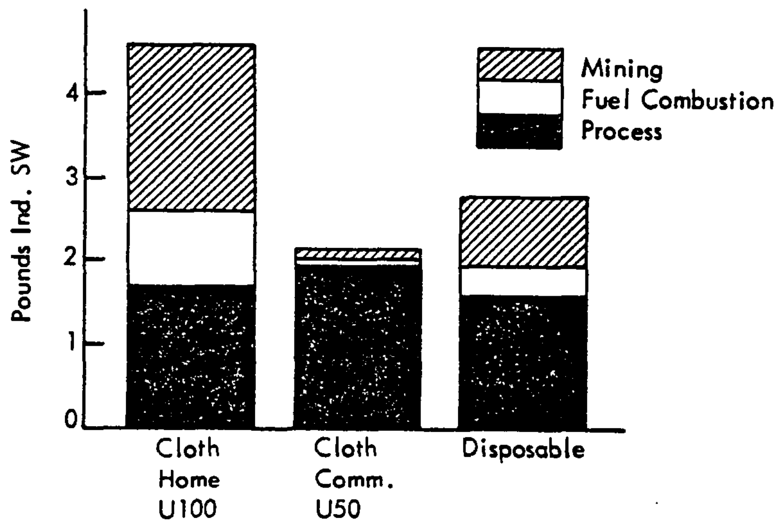


Figure 24 - Industrial Solid Waste (Pounds) Diaper Category (100 Changes)

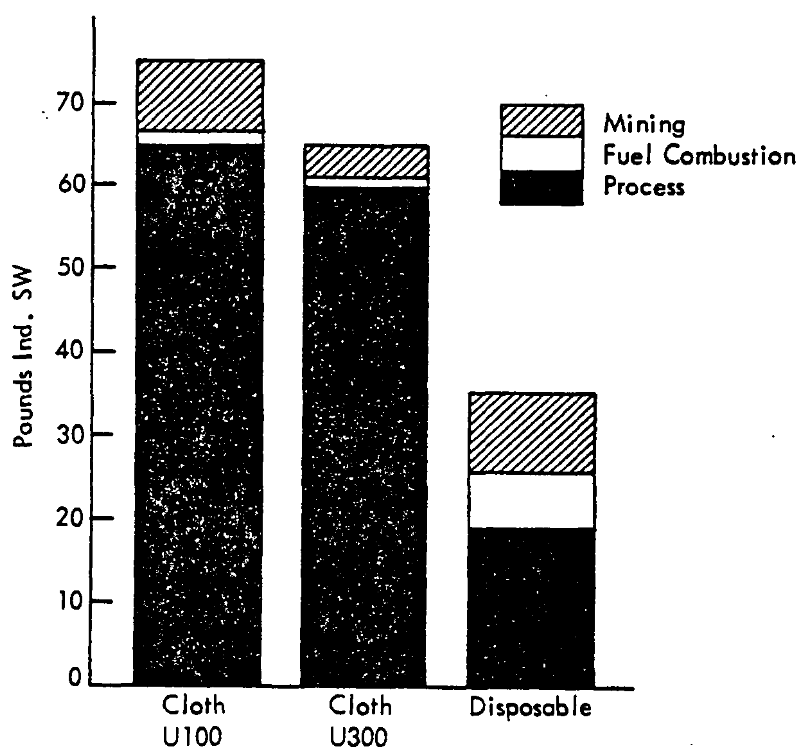


Figure 25 - Industrial Solid Waste (Pounds) Bedding Category (1,000 Changes)

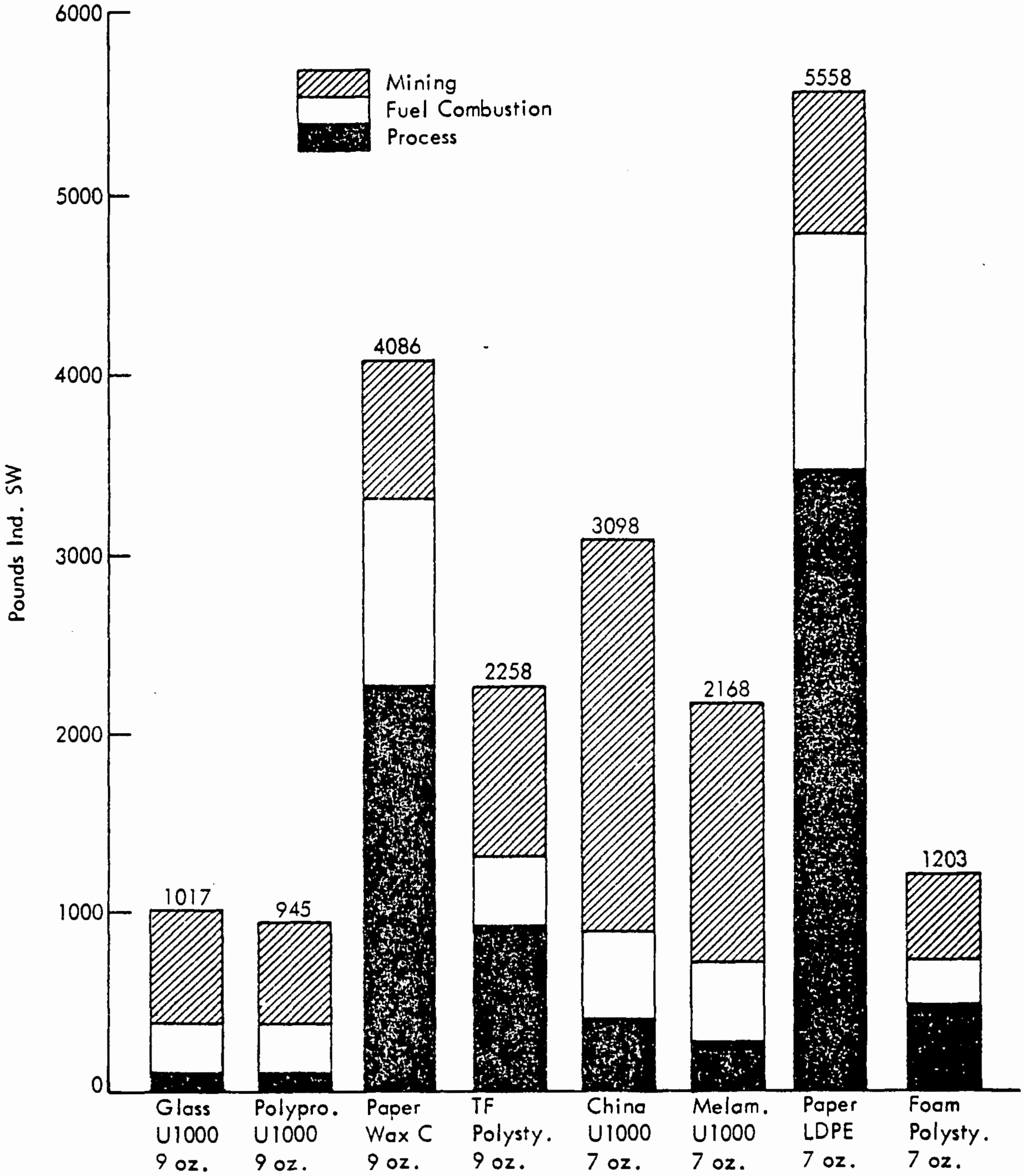


Figure. 26 - Industrial Solid Waste (Pounds) Container Category (Million Changes)

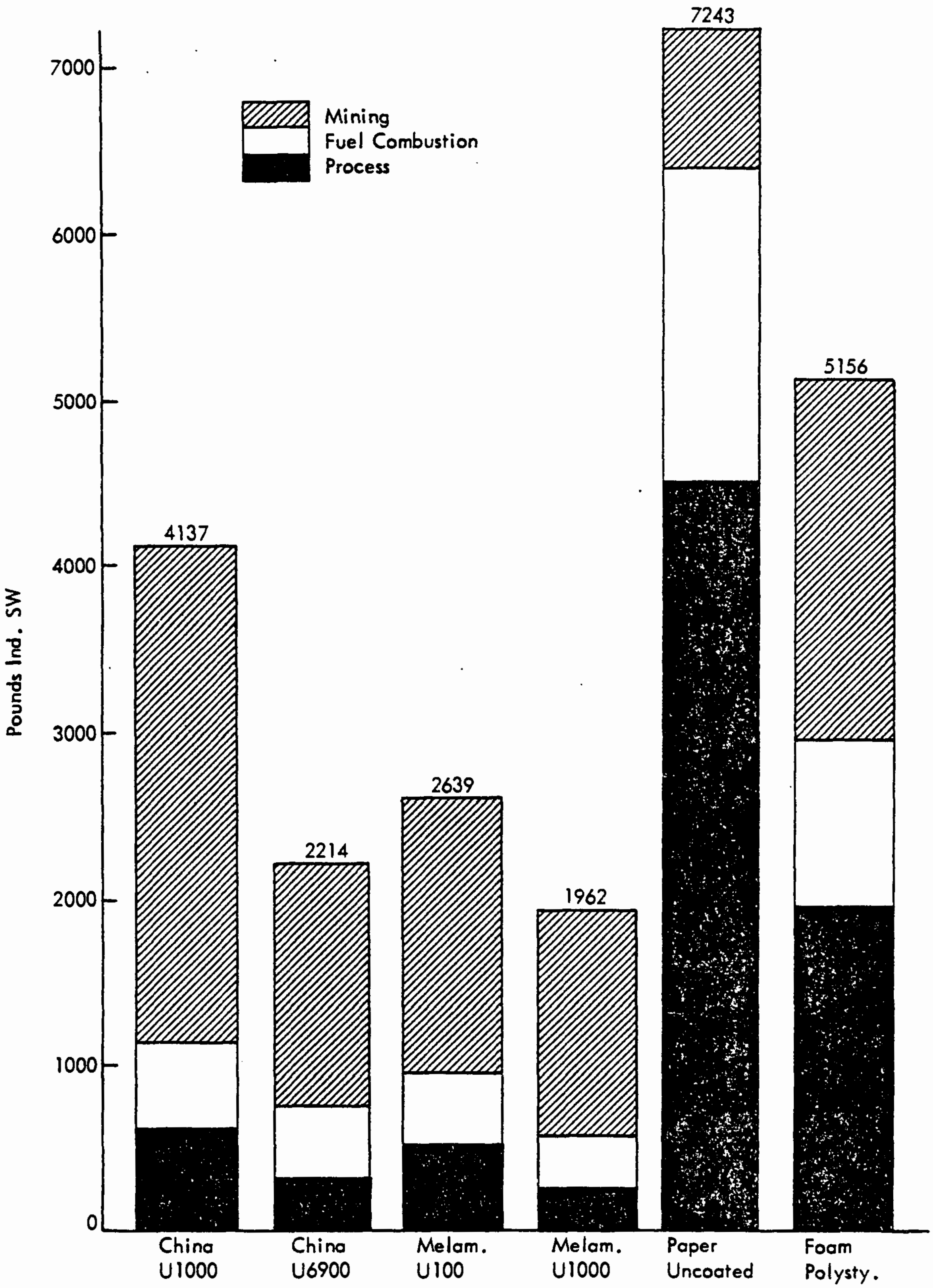


Figure 27 - Industrial Solid Waste (Pounds) Plate Category (Million Servings)

TABLE 31

INDUSTRIAL SOLID WASTE - TOWEL CATEGORY (1,000 SPILLS)

Solid Waste Type	Cloth U100 L1	Cloth U100 L5	Sponge U100 L1	Sponge U100 L5	Paper Two-Ply
Process (lb)	4.92	1.84	1.94	0.56	1.86
Fuel Combustion (lb)	1.91	0.50	0.86	0.23	0.46
Mining/Extraction (lb)	5.31	1.43	2.39	0.65	1.06
Total (lb)	12.14	3.77	5.19	1.44	3.38
Total (cu ft)	0.16	0.05	0.07	0.02	0.02

Source: MRI.

TABLE 32

INDUSTRIAL SOLID WASTE - NAPKIN CATEGORY (1,000 MEALS)

Solid Waste Type	Cloth U54 Home	Cloth U100 Home	Paper One-Ply Home	Cloth U27 Commercial	Cloth Two-Ply Commercial
Process (lb)	4.20	3.58	0.78	8.55	1.92
Fuel Combustion (lb)	1.63	1.48	0.16	0.53	0.35
Mining/Extraction (lb)	4.78	4.23	0.34	1.60	0.79
Total (lb)	10.61	9.29	1.28	10.68	3.06
Total (cu ft)	0.14	0.12	0.02	0.75	0.37

Source: MRI.

TABLE 33

INDUSTRIAL SOLID WASTE - DIAPER CATEGORY (100 CHANGES)

Solid Waste Type	Cloth U100 Home	Cloth U50 Commercial	Disposables
Processes (lb)	1.81	1.99	1.58
Fuel Combustion (lb)	0.77	0.07	0.39
Mining/Extraction (lb)	2.13	0.21	0.85
Total (lb)	4.71	2.27	2.82
Total (cu ft)	0.64	0.03	0.04

Source: MRI.

TABLE 34

INDUSTRIAL SOLID WASTE - BEDDING CATEGORY (1,000 USES)

Solid Waste Type	Cloth U100	Cloth U300	Disposable
Process (lb)	64.50	59.49	18.80
Fuel Combustion (lb)	2.38	1.47	7.34
Mining/Extraction	7.21	4.49	19.28
Total (lb)	74.09	65.45	35.42
Total (cu ft)	1.00	0.88	0.61

Source: MRI.

TABLE 35

INDUSTRIAL SOLID WASTE - CONTAINER CATEGORY (MILLION SERVINGS)

Pollutant	Glass Tumbler U1,000 9 Fl Oz	Polypropylene Tumbler U1,000 9 Fl Oz	Paper Wax Cup 9 Fl Oz	Thermoformed Polystyrene Cup 9 Fl Oz	China Cup U1,000 7 Fl Oz	Melamine Cup U1,000 7 Fl Oz	Paper LDPE Cup 7 Fl Oz	Foam Polystyrene Cup 7 Fl Oz
Process (lb)	113	102	2,280	920	421	246	3,432	437
Fuel Combustion (lb)	213	210	1,031	396	483	476	1,355	280
Mining/Extraction (lb)	690	632	775	942	2,195	1,446	771	486
Total (lb)	1,016	944	4,086	2,258	3,099	2,916	5,558	1,203
Total (cu ft)	13.7	12.8	55.16	30.50	41.8	29.3	75.03	16.23

Source: MRI.

TABLE 36

INDUSTRIAL SOLID WASTE - PLATE CATEGORY (MILLION SERVINGS)

Solid Waste Type	China U1,000	China U6,900	Melamine U100	Melamine U1,000	Paper	Foam Polystyrene
Process (lb)	653	272	404	227	4,503	1,952
Fuel Combustion (lb)	446	419	573	430	1,883	978
Mining/Extraction (lb)	3,038	1,522	1,662	1,305	857	2,226
Total (lb)	4,137	2,213	2,639	1,962	7,243	5,156
Total (cu ft)	55.8	29.9	35.6	26.5	97.78	69.60

Source: MRI.

Figure 24 shows a different profile for the home and commercial diaper systems, which is attributed to the larger quantity of detergents per pound of home laundry than for commercial laundry. In Figure 25, the high ratio of process wastes for cloth bedding is attributed to the raw materials required in the washing process. Figures 26 and 27 show a high ratio of mining wastes for the glass and china products.

4. Postconsumer Solid Waste:[1,2,3,4,5,6] Table 37 contains the postconsumer solid waste data for each product. The first column shows the rounded values for the weight of one product item, in pounds. The second column shows the pounds of packaging material associated with one product item. Corrugated materials were assumed to be recycled and therefore not considered to enter the solid waste stream. In most instances, packaging represents plastic wrapping film, with a small amount of paper wrapping and paper cartons. The comparison basis describes the number of use situations selected to compare the products; and the use factor shows the number of times the product is used before entering the PCSW stream. The pounds of PCSW as product is obtained by multiplying the weight per product item times the number of items required in the comparison. The pounds of packaging entering the PCSW stream is found by multiplying the items for comparison by the pounds of PCSW packaging per product item.

The total pounds column is the sum of the product and packaging contribution to PCSW. The volume figures are taken from the computer printout, and represent the estimated landfill volume associated with each product, with the comparison basis and use factor values taken into consideration. Since density values for the products vary from source to source, and compaction values are only estimates, the PCSW volumes represent best estimates as to the actual landfill volume experienced.

1/ See comments No. 8-9 Appendix B, pages 7-8.
2/ See comment No. 11 Appendix B, page 8.
3/ See comment No. 1 Appendix B, page 23.
4/ See comments Appendix C, pages 2-3.
5/ See comment No. 3 Appendix J, page 2.
6/ See comments Appendix J, pages 4 and 33.

TABLE 37

SUMMARY OF POST CONSUMER SOLID WASTE DATA

	Pounds Per One Product	Pounds PCSW Package Per One Product	Comparison Basis	Use Factor	Items Per Comparison	Pounds PCSW As Product	Pounds PCSW As Package	Total Pounds PCSW	Volume PCSW Cu ft
Towels			1,000 Spills						
Cloth	0.132	0.002		100	10	1.32	0.02	1.34	0.026
Sponge	0.059	0.0044		100	10	0.59	0.04	0.63	0.009
Paper	0.010	0.00015		1	1,860[a]	18.60	0.28	18.88	0.266
Napkins			1,000 Meals						
H Cloth	0.097	0.002		54	18.5	1.79	0.04	1.83	0.035
H Cloth	0.097	0.002		100	10	0.97	0.02	0.99	0.019
H Paper	0.0053	0.00012		1	1,000	5.30	0.12	5.42	0.089
C Cloth	0.100	0.002		27	37.0	3.7	0.07	3.77	0.073
C Paper	0.0137	0.0002		1	1,000	13.7	0.20	13.90	0.221
Diapers			100 Changes						
H Cloth	0.137	0.0013		100	1.47[b]	0.20	0.00	0.20	0.004
C Cloth	0.137	0.0013		50	2.94	0.40	0.00	0.40	0.008
Disposable	0.105	0.028		1	103[c]	10.82	2.88	13.70	0.190
Bedding			1,000 Changes						
Cloth	1.124	0.0234		100	10	11.24	0.23	11.47	0.220
Cloth	1.124	0.0234		300	3.3	3.75	0.08	3.83	0.073
Disposable	0.238	-0-		1	1,000	238.0	-0-	238.0	3.737
Containers			Million Servings						
Cold									
Glass	0.291	-0-		1,000	1,000	291.0	-0-	291	1.833
Polypropylene	0.088	0.008		1,000	1,000	88	8.0	96	1.413
Paper-Wax	0.0146	0.00016		1	Million	14,600	160	14,760	241.4
Thermoformed Polystyrene	0.0140	0.00012		1	Million	14,000	120	14,120	186.8
Hot									
China	0.64	-0-		1,000	1,000	640	-0-	640	3.26
Melamine	0.266	-0-		1,000	1,000	266	-0-	266	3.52
Paper LDPE	0.01465	0.00039		1	Million	14,650	390	15,040	236.9
Foam Polystyrene	0.0044	0.00028		1	Million	4,400	280	4,680	761.2
Plates									
China	1.51	-0-		1,000	1,000	1,510	-0-	1,510	7.70
China	1.51	-0-		6,900	145	219	-0-	219	1.12
Melamine	0.453	-0-		100	10,000	4,530	-0-	4,530	60.0
Melamine	0.453	-0-		1,000	1,000	453	-0-	453	6.0
Paper	0.0234	0.00010		1	Million	23,400	100	23,500	367.7
Foam Polystyrene	0.0261	0.00035		1	Million	26,100	350	26,450	4,582.5

a/ 1.86 paper towels are used per spill.
b/ 147 diapers are required for 100 changes due to double diapering, etc.
c/ 1.03 disposable diapers per change is average practice.

TABLE 38

VOLUME CALCULATIONS FOR POSTCONSUMER SOLID WASTE

Product/Material	Density Pound Per Cu Ft[a/]	Pounds To Landfill Per 1,000 lb PCSW[b/]	Percent Compaction Assumed	Cubic Feet in Landfill
Paper Cup	58-72	910	100	15.7
Cloth Products	45-52	910	100	19.9
Thermoformed Polystyrene Cup	68.7	910	100	13.2
Foam Polystyrene Plate Cup	2.65[1]	910	50[c/]	172.0
Polypropylene Tumbler	56.8	910	100	16.0
Melamine, Plate, Cup	92.4	1,000	100	10.8
Sponge (Cellulose)	90.0	910	100	10.1
China Plate, Cup	196.6	1,000	100	5.1
Glass	158.0	1,000	100	6.3
Polyethylene	56.8	910	100	16.0

a/ Density values given in the open literature and those obtained from industry sources show wide variations. Therefore, the landfill volume attributed to the products as shown in this report, are only approximations to actual landfill volume

b/ Approximately 9 percent of the combustible products are incinerated.

c/ Estimate only.

1/ See comment No. 8 Appendix J, page 39.

CHAPTER 5

REPA PROFILE ANALYSIS FOR EACH PRODUCT CATEGORY

This chapter presents materials flow diagrams, detailed REPA computer tables, and brief discussions of the product profiles. The following paragraph explains the data format in the computer tables.

A. Interpretation of REPA Computer Tables

The REPA profile tables present the inputs, outputs, summary values, and environmental index values for each product type. For example, Table 39 represents REPA data for a cloth towel profile with a use factor of 32 and laundry factor of 1. The input section shows the quantities of raw materials, energy, and water required by the particular scenarios under discussion. The output section identifies and quantifies the primary air, water, and solid waste pollutants associated with the product profile. In the summary section, the components of each impact category are combined and expressed as the total quantity of a particular impact category. For example, the sum of the 14 air emission pollutants is shown under air emission.

The index values represent the percent contribution a process in the total profile has relative to the total value of a particular impact category. For example, in Table 39 the total values for each product profile are presented in the last column "Cotton Towel Sys, Tot, 32 Uses." The total amount of raw materials is 10.310 pounds, the total energy is 1.188 million Btu, etc. The energy contribution for the towel wash process (5th column) is 0.941 million Btu. Under the index section, the percent contribution of the towel wash process (79.2) to the total cloth towel system energy (1.188 million Btu) is calculated by dividing the wash process energy by the system total energy and converting to percent $(0.941 \div 1.188) \times 100 = 79.2$ percent. The index section is a valuable analysis aid, since the reader can rapidly pick out the processes in the total profile which contribute the highest or lowest percentages in each impact category.

The detailed analyses of the tables are left to the reader. This study involves 23 separate products with numerous scenarios presented for the reusable items. An in-depth analysis of each product or product scenario is beyond the intended scope of the contract. The important aspects of the study results are presented in the summary chapter (Chapter 2). The detailed computer printouts are presented in Chapter 5 to enable the reader to obtain the analysis detail desired. These data can be used with the very detailed appendix data to study the total system profiles in-depth.

In general, the washing or laundering impacts for the reusable items account for the majority of the impacts in their REPA profiles. Regarding the disposable paper products, the pulp manufacturing and papermaking steps generally account for around 75 percent of the impacts. The transportation processes for the disposable products account for 2 to 6 percent of the total system energy, with 2 or 3 percent being the most common. The profiles for the disposable plastic products show that the resin systems account for the majority of the impacts. The manufacturing energy becomes an important part of the profile of the foam plastic products.

The material flow diagrams and the REPA computer data for the product profiles, are presented in Figures 28 through 50 and Tables 39 through 62.

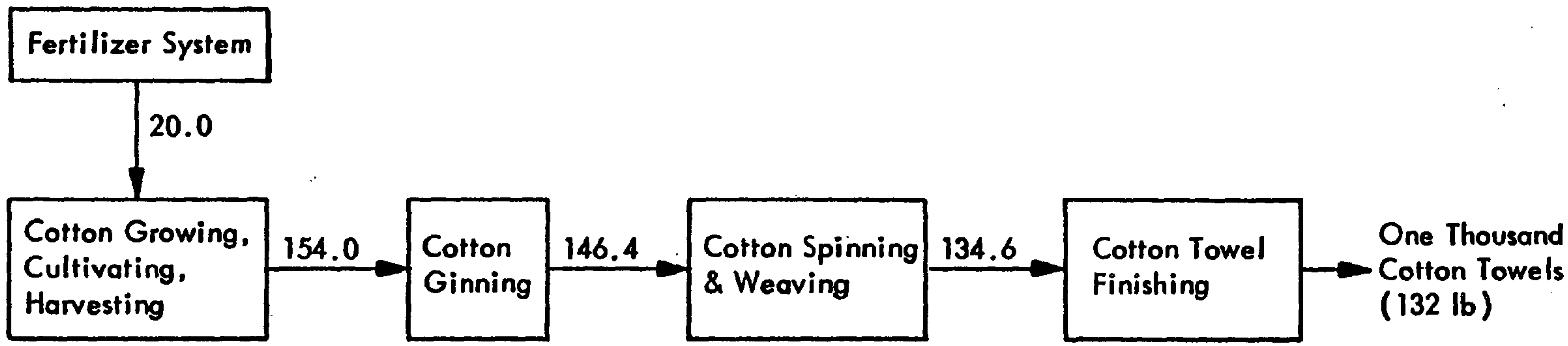


Figure 28 - Flow Diagram for Cotton Towel System (1,000 Towels) (Pounds)

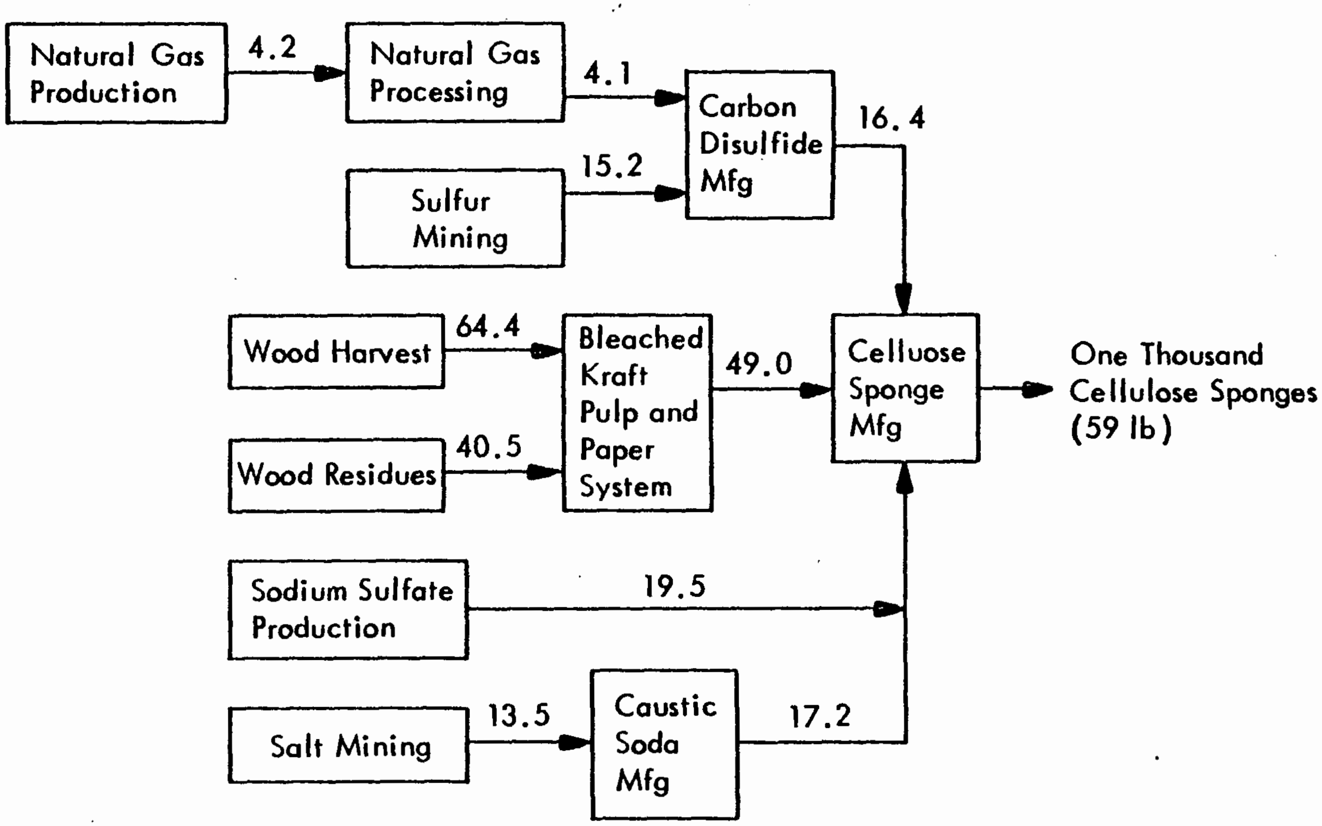
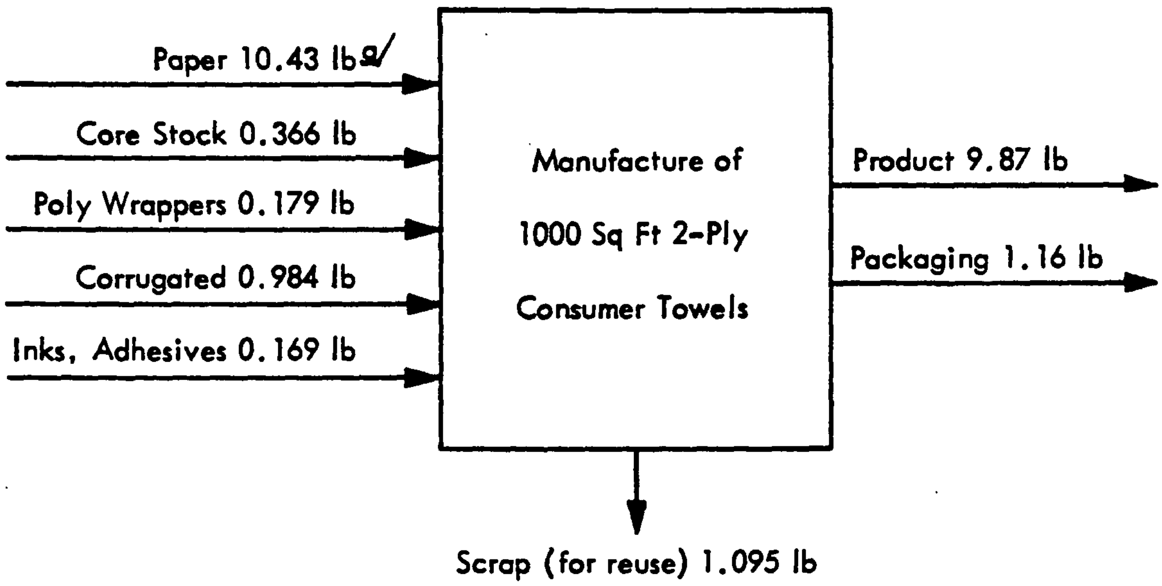


Figure 29 - Flow Diagram for Cellulose Sponge System (1,000 Sponges)
(Pounds)



a/ Includes approximately 5 percent moisture.

Figure 30 - Materials Requirements for 1,000 Square Feet, Two-Ply Consumer Towels

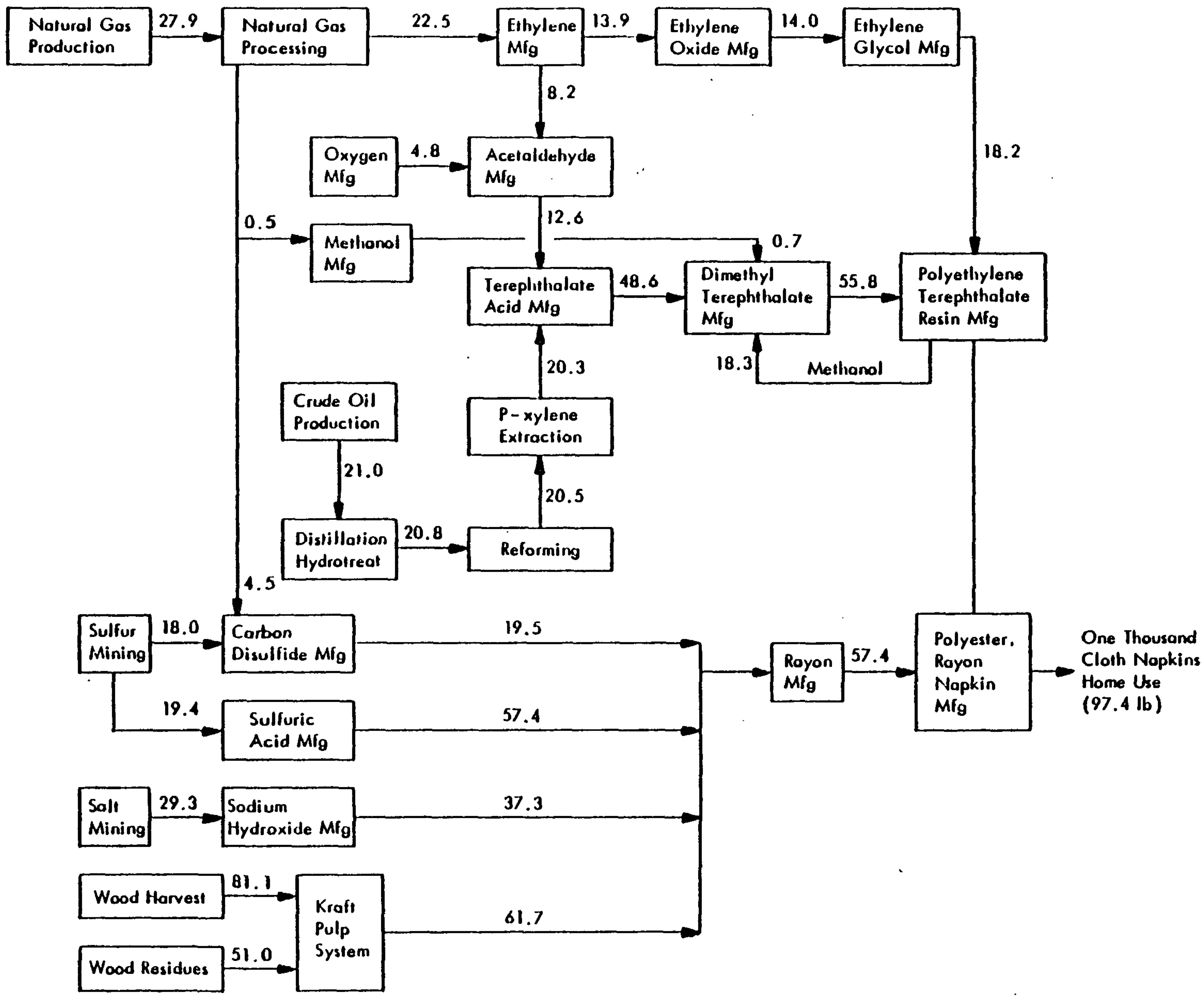
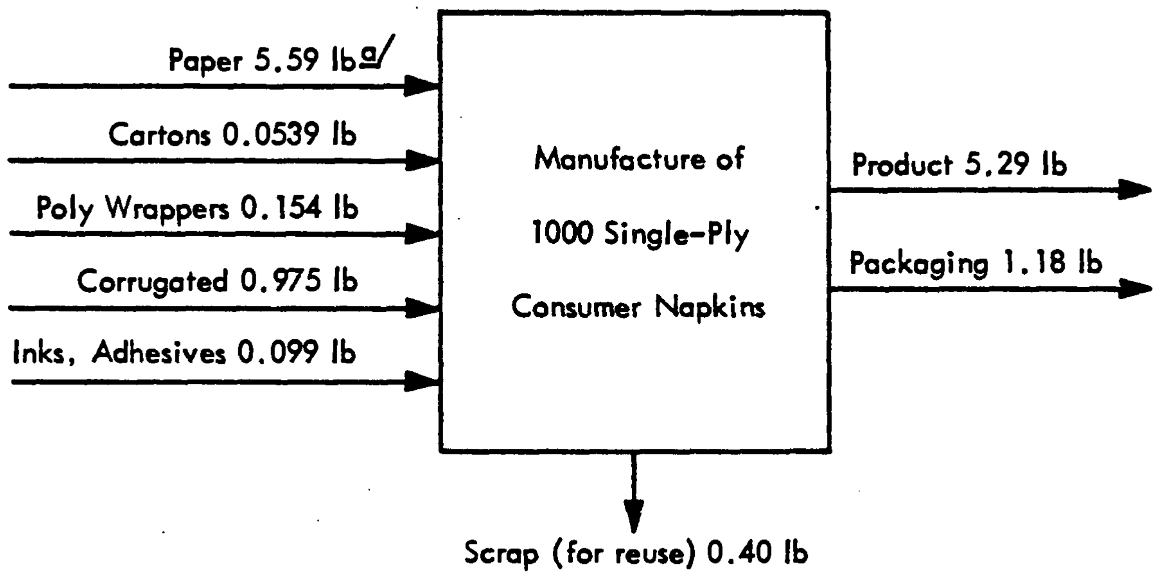


Figure 31 - Flow Diagram for Polyester-Rayon Home Napkin System (1,000 Napkins)
(Pounds)



a/ Includes approximately 5 percent moisture.

Figure 32 - Materials Requirements for 1,000 Single-Ply Consumer Napkins

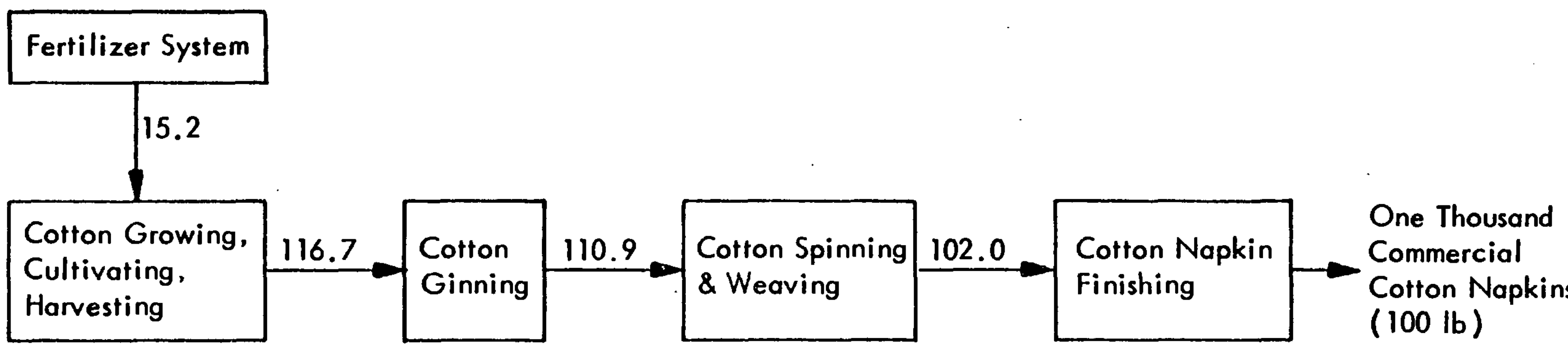
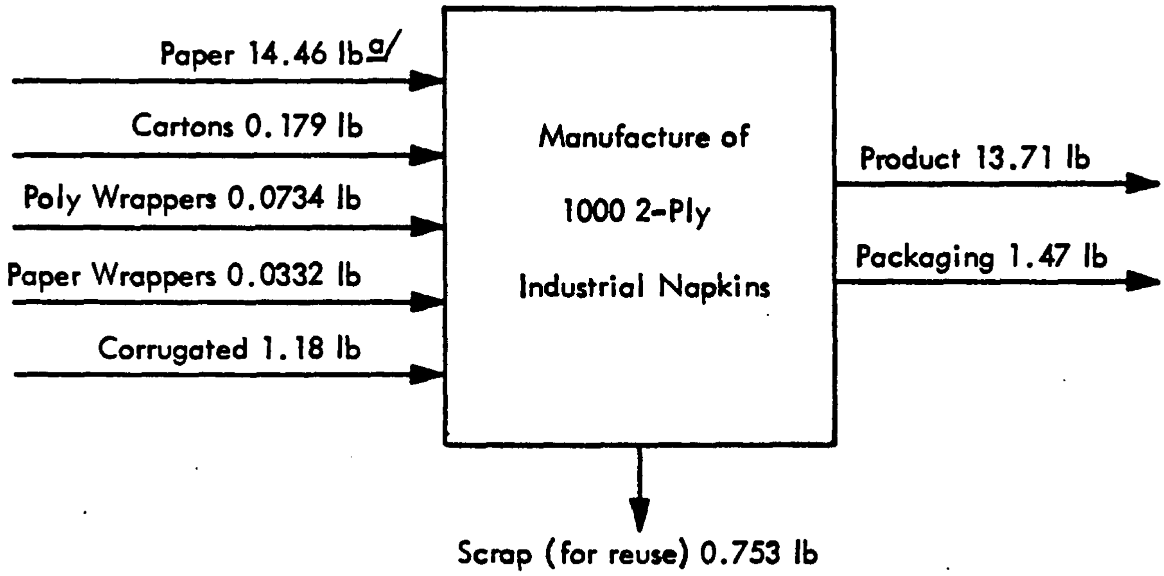


Figure 33 - Flow Diagram for Commercial Cotton Napkin System (1,000 Napkins)
(Pounds)



a/ Includes approximately 5 percent moisture

Figure 34 - Materials Requirements for 1,000 Two-Ply Industrial Napkins

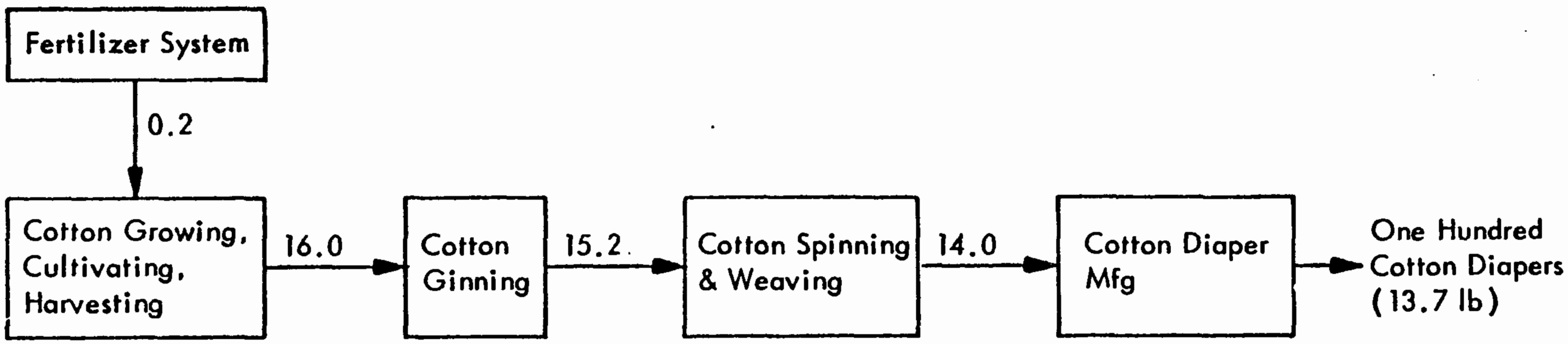
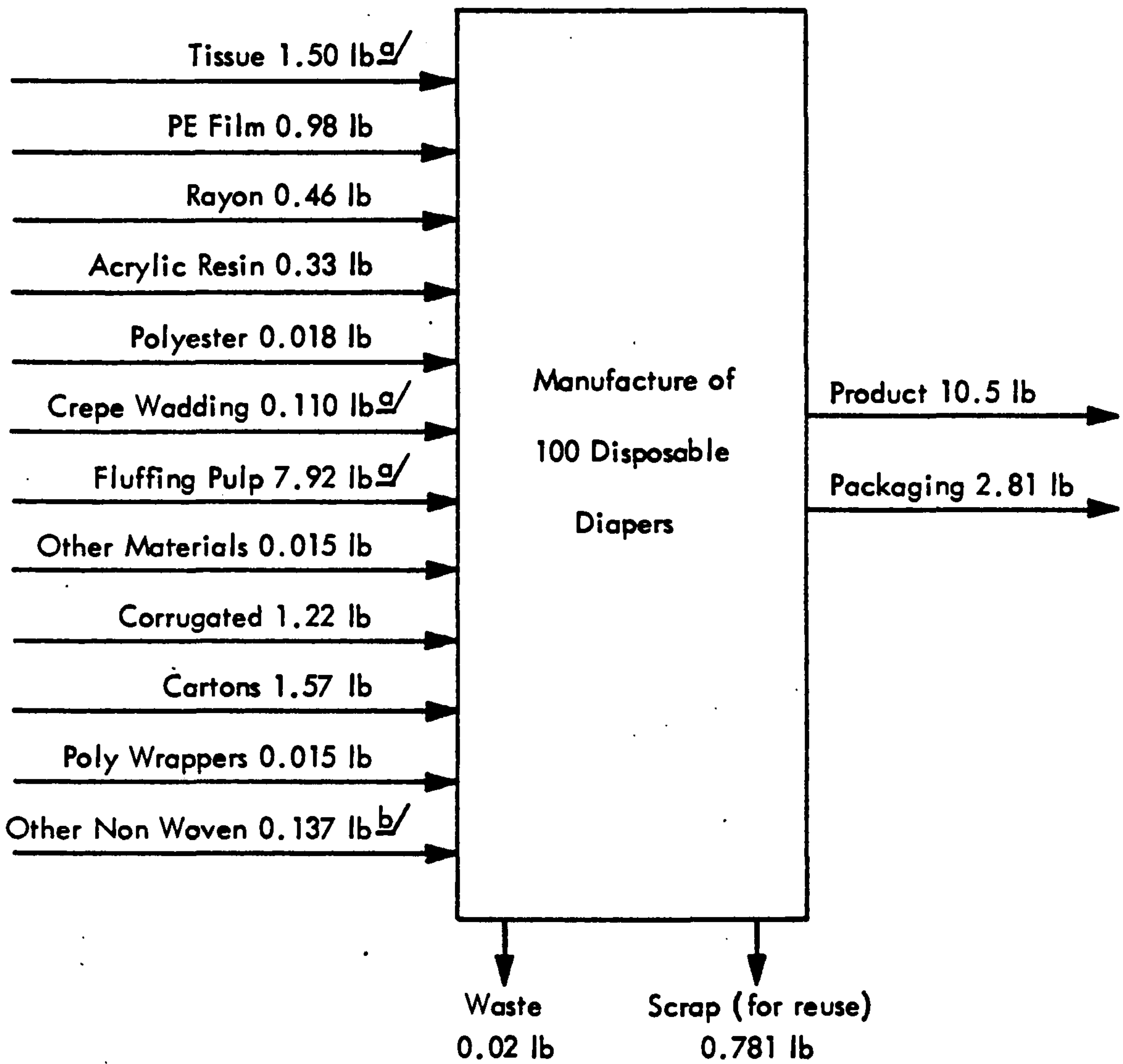


Figure 35 - Flow Diagram for Cotton Cloth Diaper System (100 Diapers)
(Pounds)



a/ Includes approximately 5 percent moisture.
b/ Includes sulfite fiber, cotton, and nylon thread.

Figure 36 - Materials Requirements for 100 Disposable Diapers

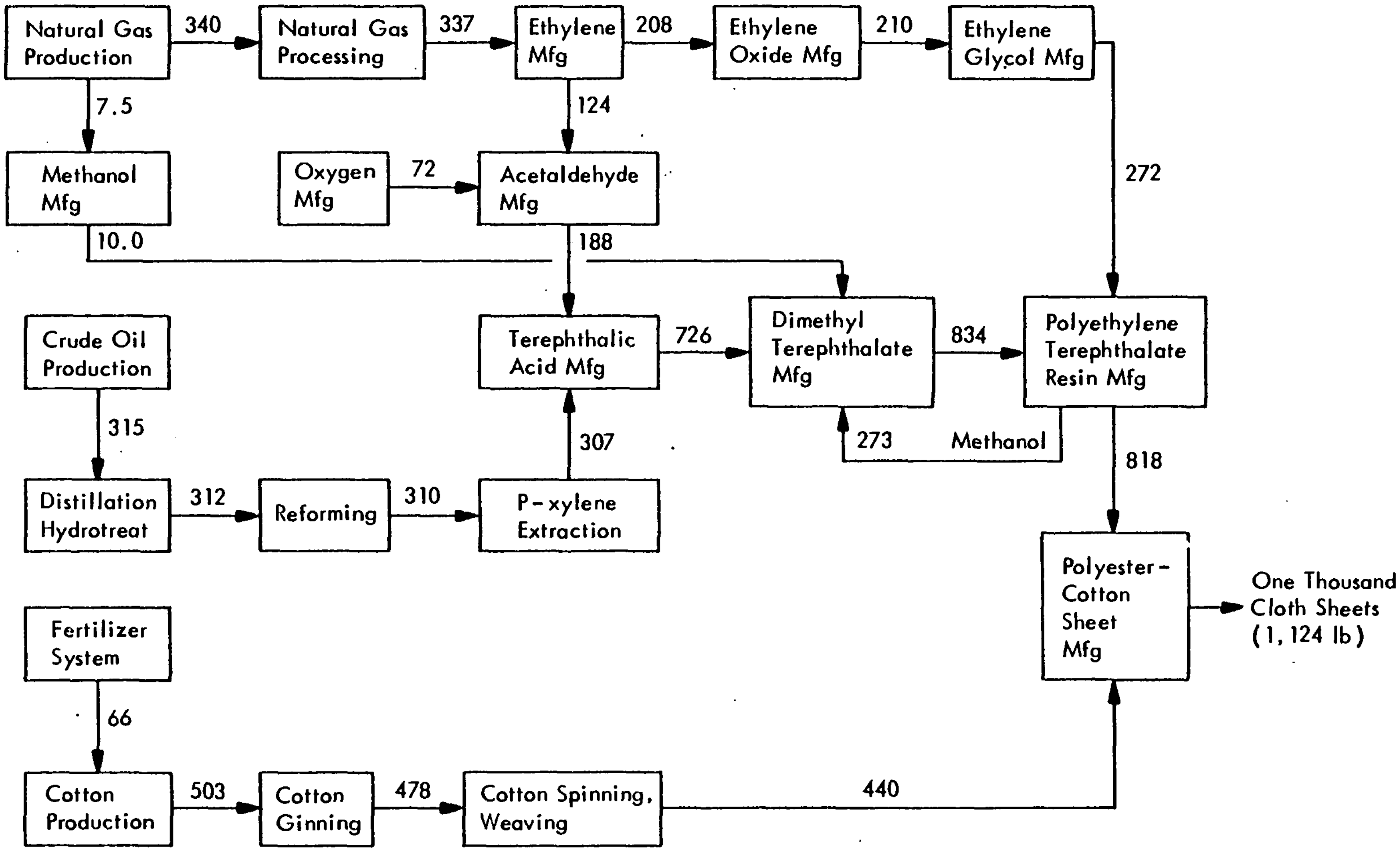


Figure 37 - Flow Diagram for Polyester-Cotton Sheet System (1,000 Sheets)
(Pounds)

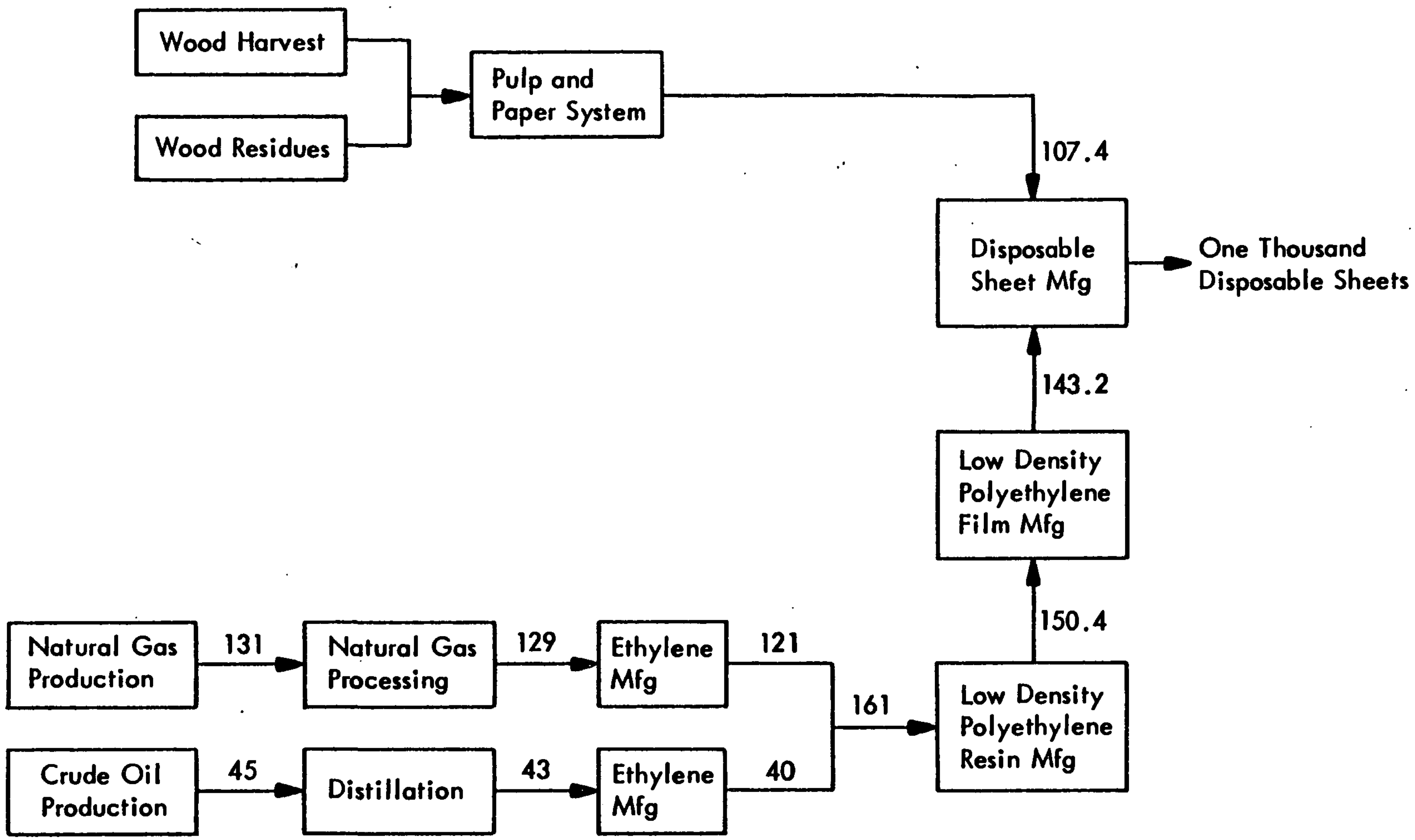


Figure 38 - Flow Diagram for Disposable Sheet System (1,000 Sheets)
(Pounds)

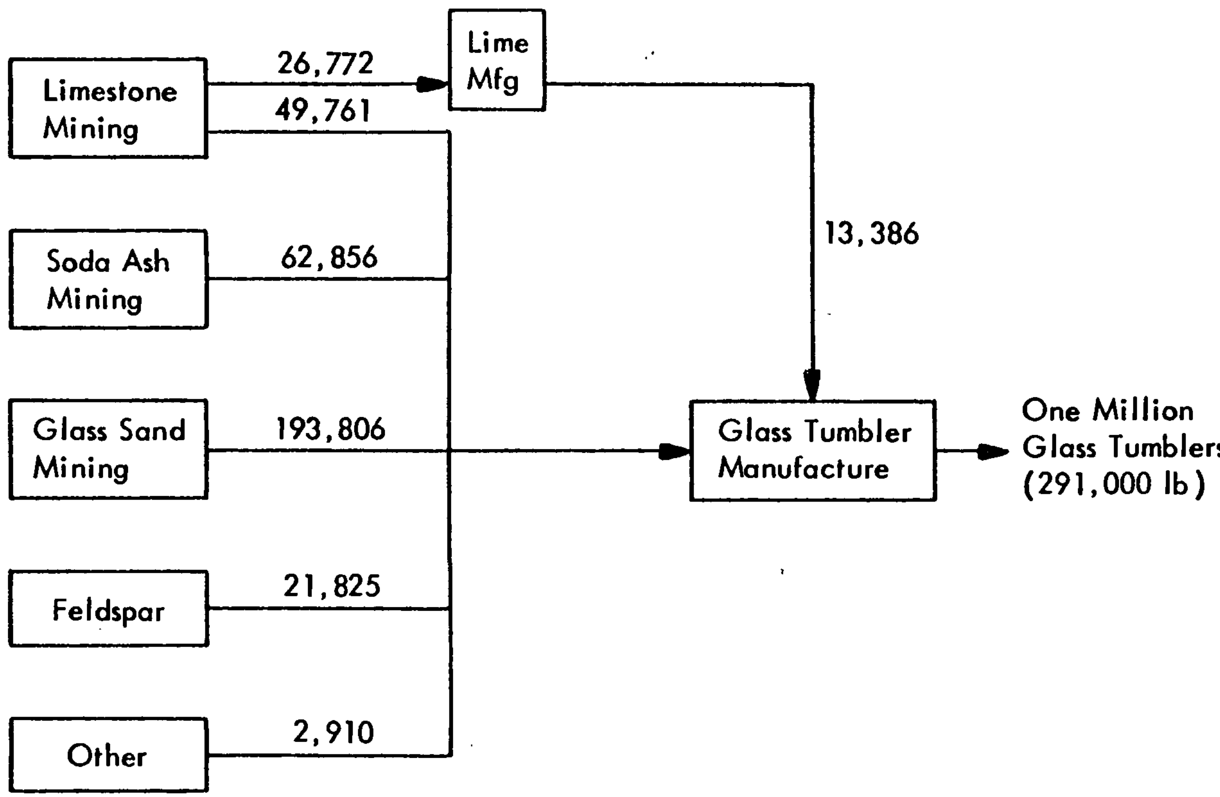


Figure 39 - Flow Diagram for 9 Fluid Ounce Glass Tumbler System (Million Tumblers) (Pounds)

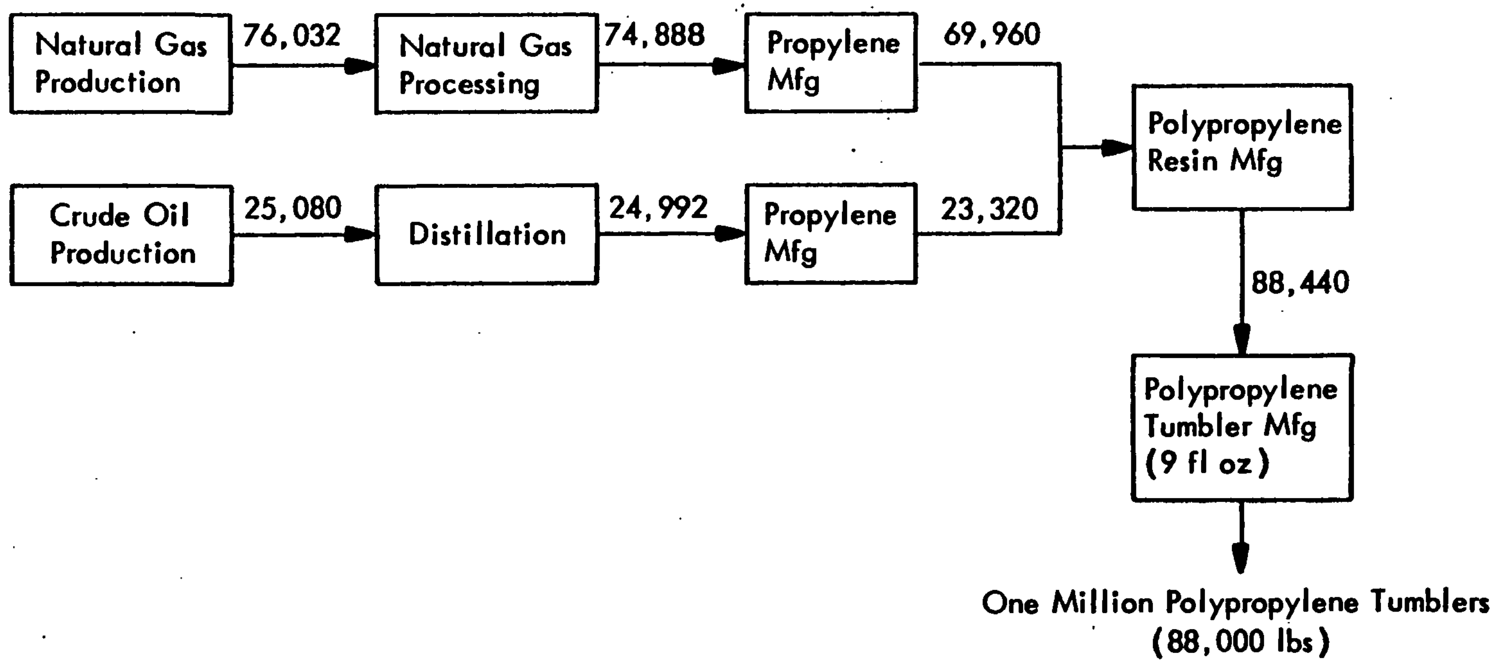


Figure 40 - Flow Diagram for 9 Fluid Ounce Polypropylene Tumbler System (Million Tumblers) (Pounds)

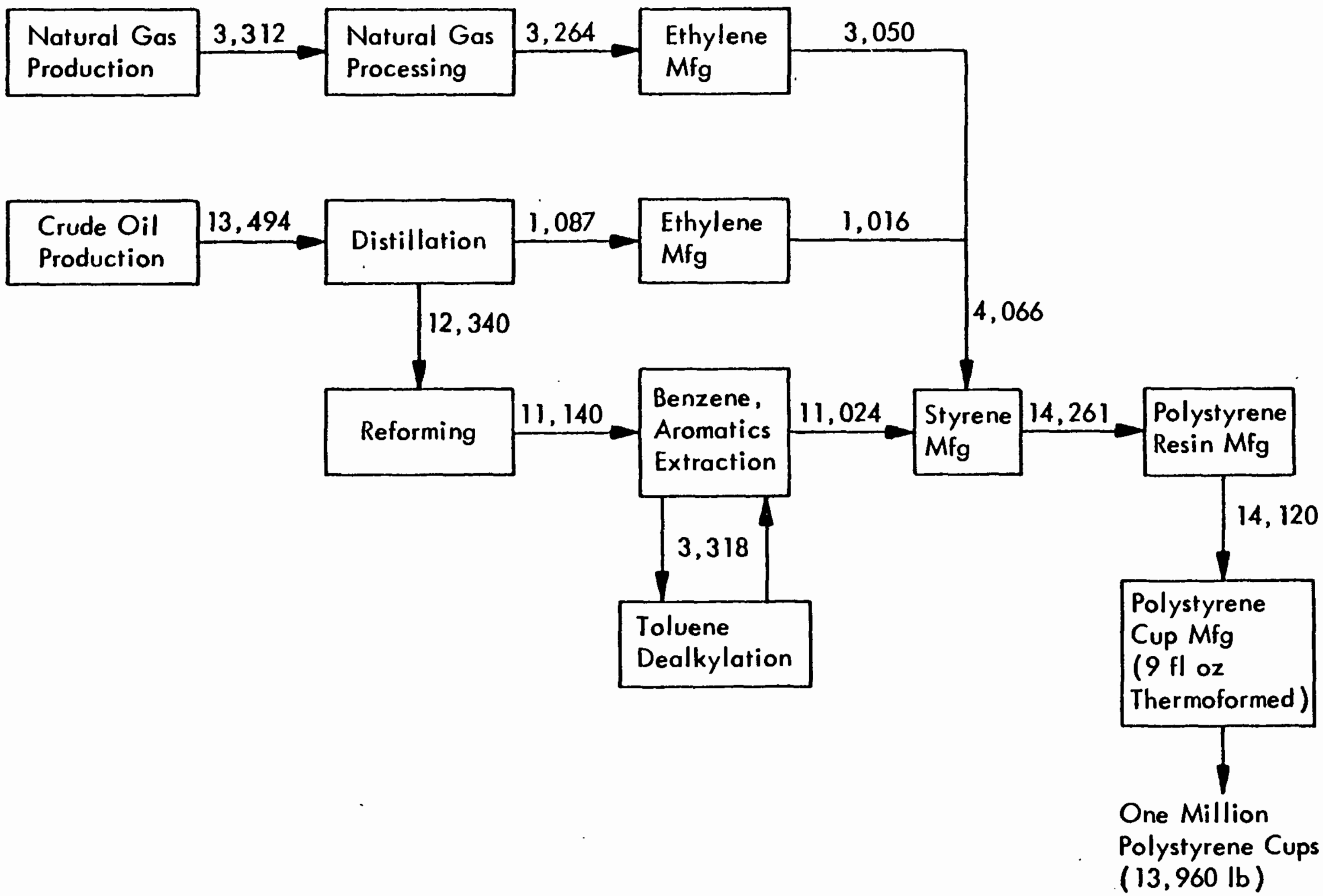


Figure 41 - Flow Diagram for 9 Fluid Ounce Thermoformed Polystyrene Cup System (Million Cups) (Pounds)

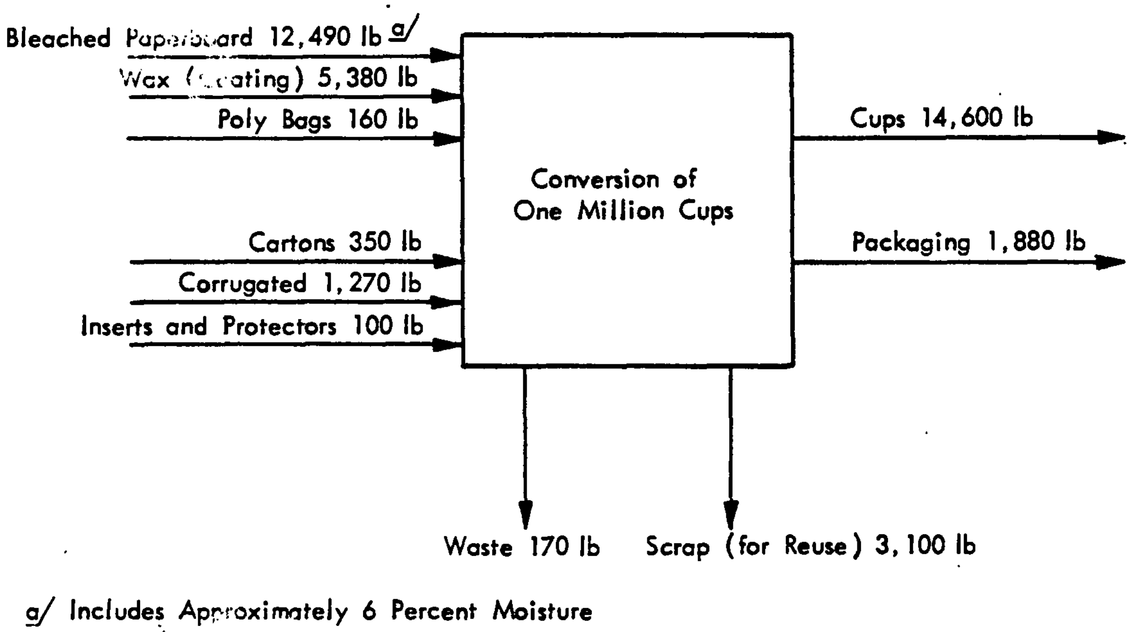


Figure 42 - Materials Requirements for 9 Fluid Ounce Wax Coated Paper Cold Drink Cups (Million Cups)

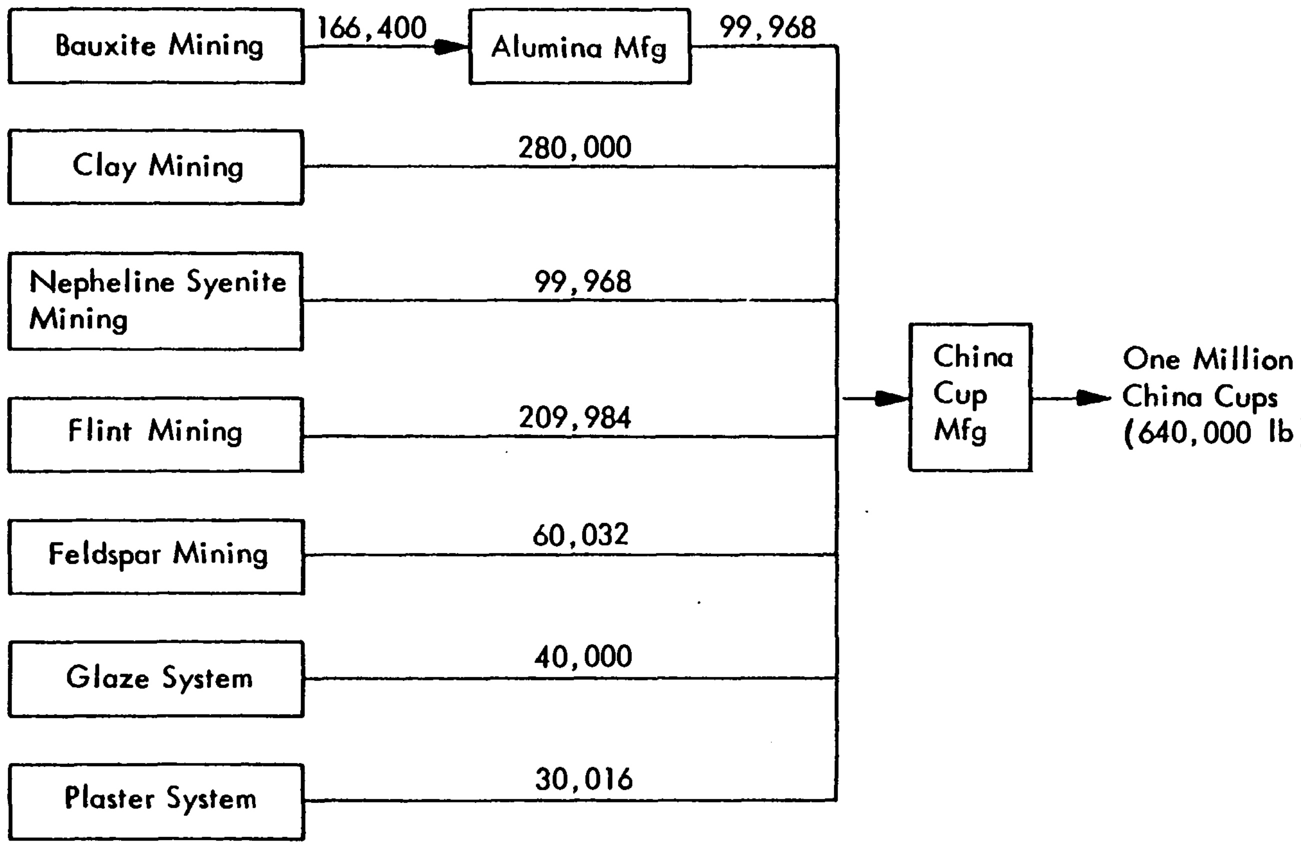


Figure 43 - Flow Diagram for 7 Fluid Ounce China Cup System (Million Cups)[1]
(Pounds)

1/ See comments Appendix I, pages 3, 19 and 21.

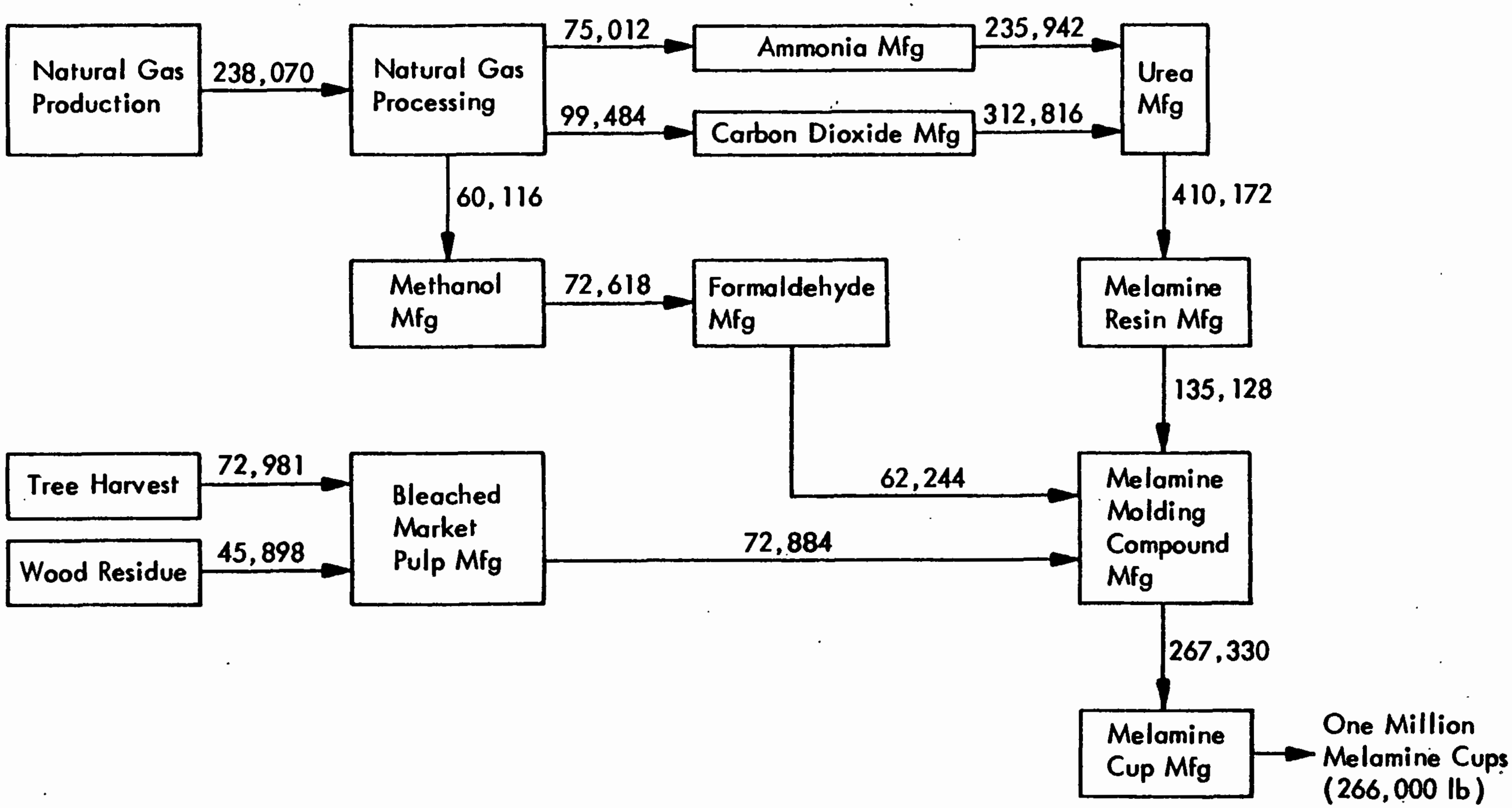


Figure 44 - Flow Diagram for 7 Fluid Ounce Melamine Cup System (Million Cups) (Pounds)

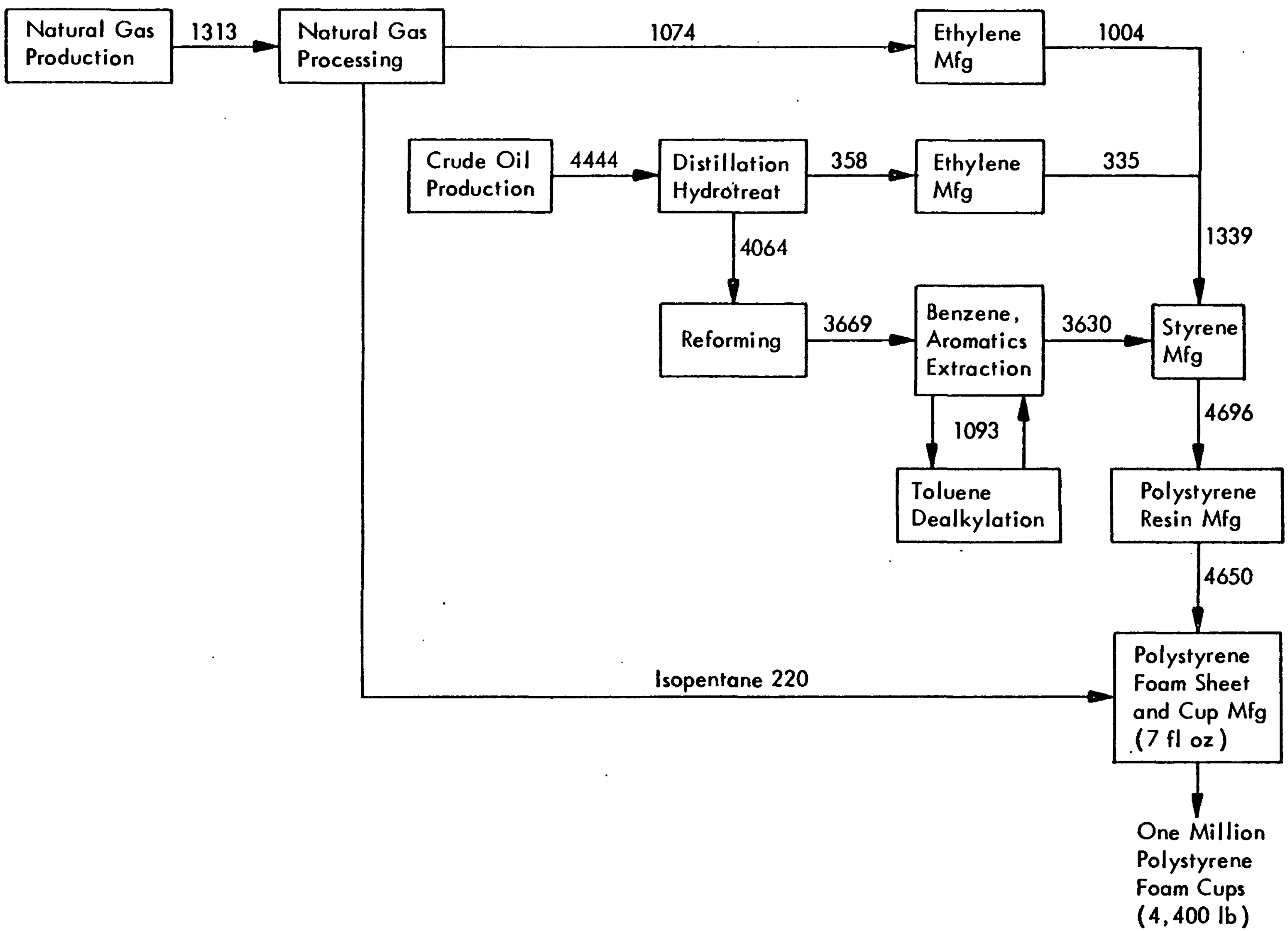
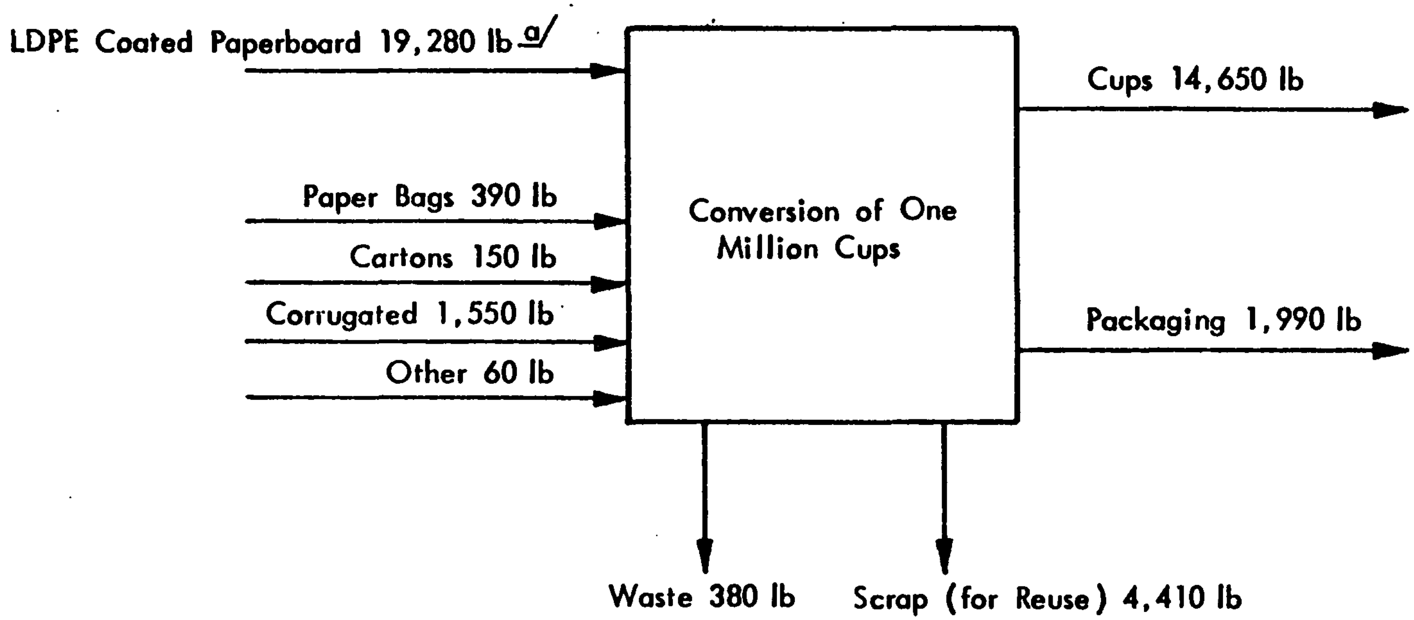


Figure 45 - Flow Diagram for 7 Fluid Ounce Foam Polystyrene Cup System (Million Cups) (Pounds)



a/ Paperboard is Approximately 6 Percent Moisture

Figure 46 - Material Requirements for 7 Fluid Ounce LDPE Lined Paper Hot Drink Cups (Million Cups)

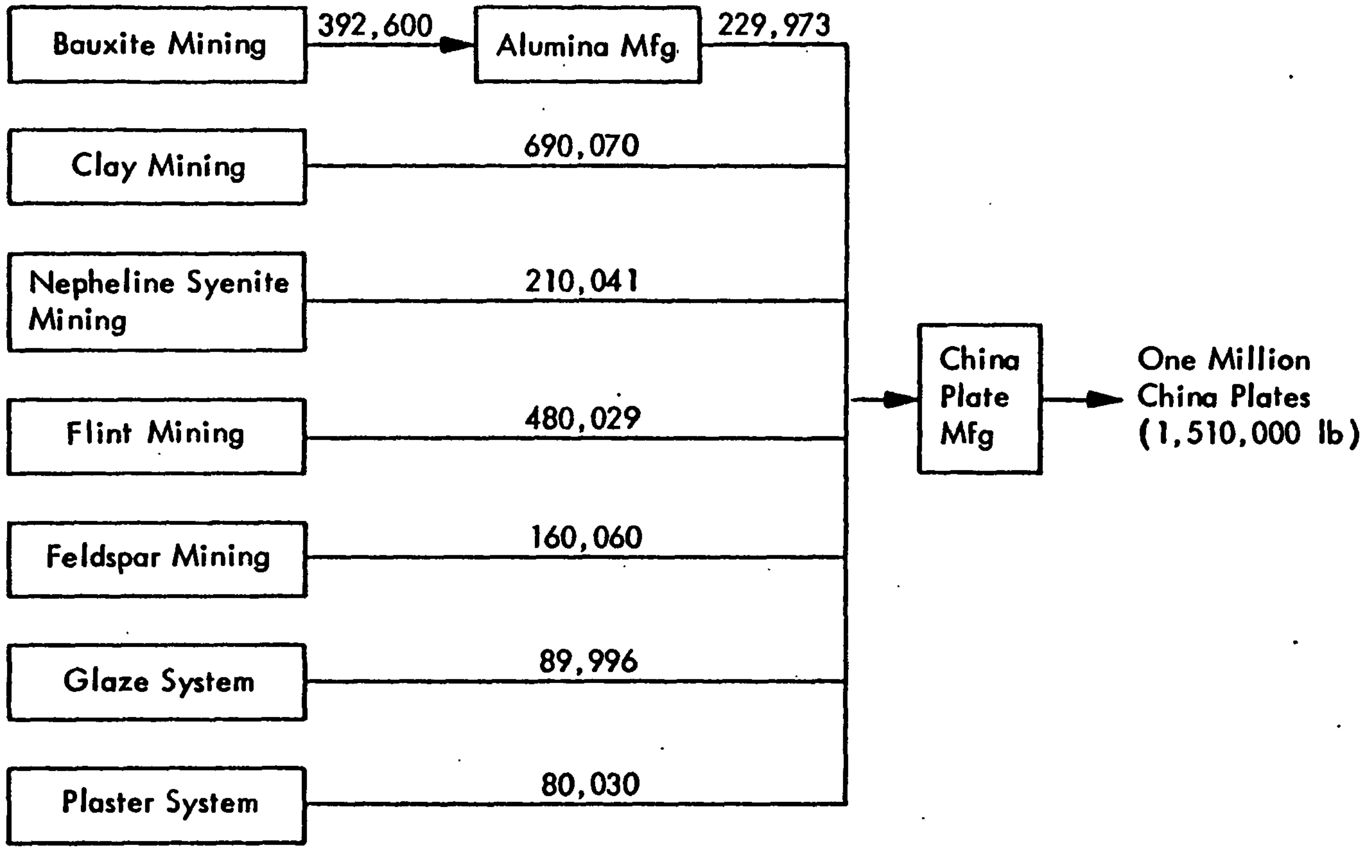


Figure 47 - Flow Diagram for China Plate System (Million Plates)
(Pounds)

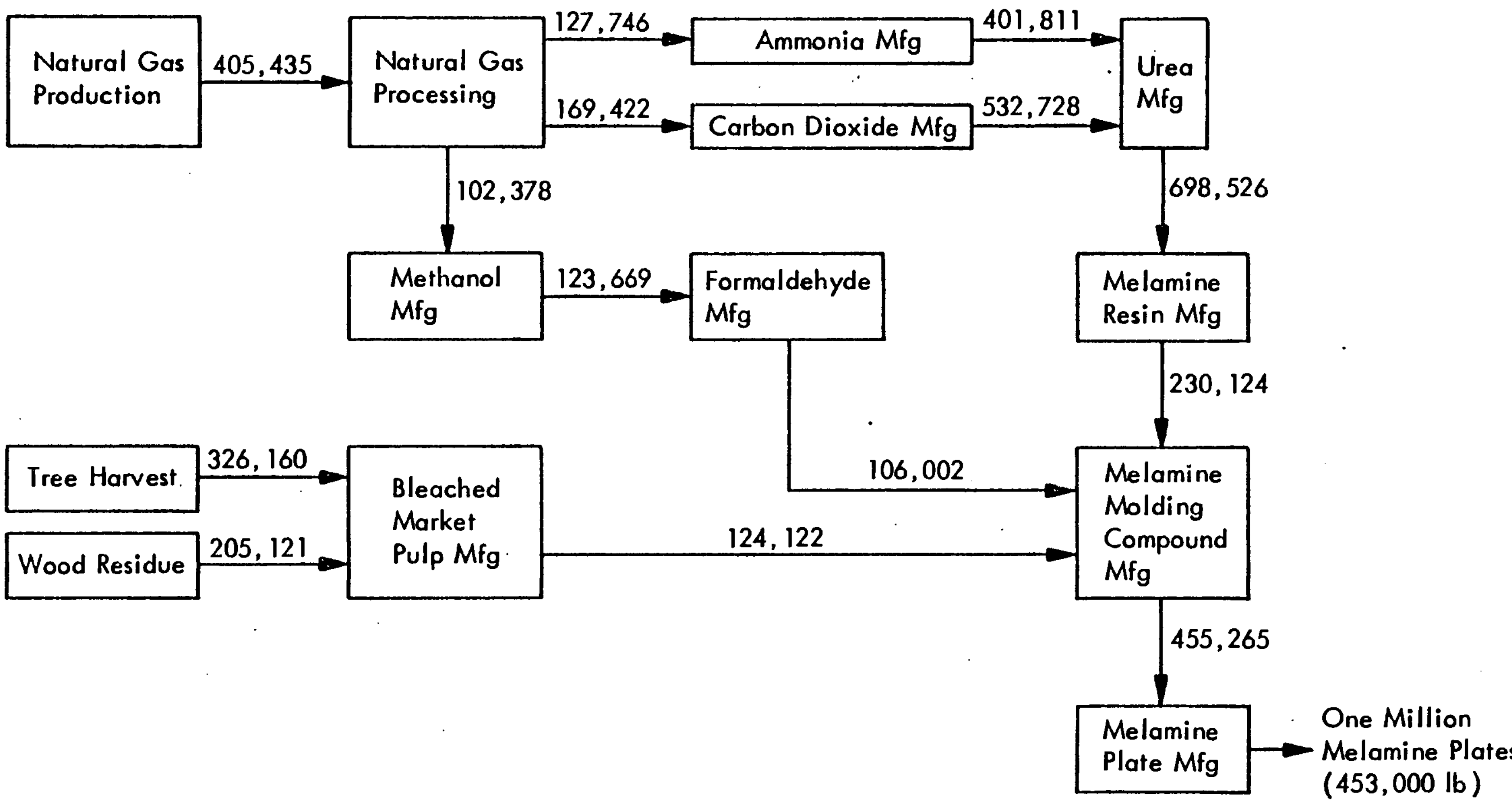


Figure 48 - Flow Diagram for Melamine Plate System (Million Plates)
(Pounds)

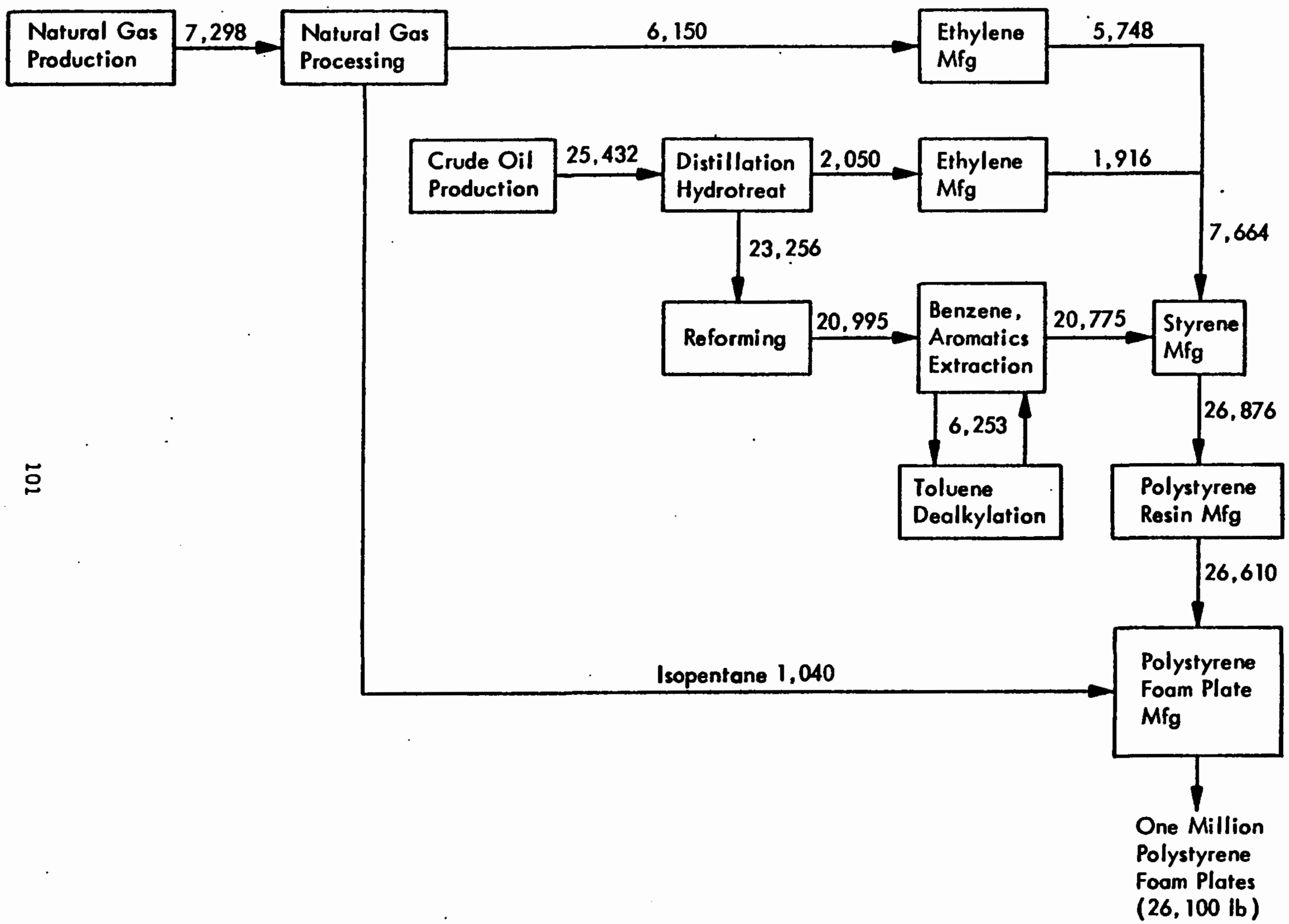


Figure 49 - Flow Diagram for Polystyrene Foam Plate System (Million Plates)

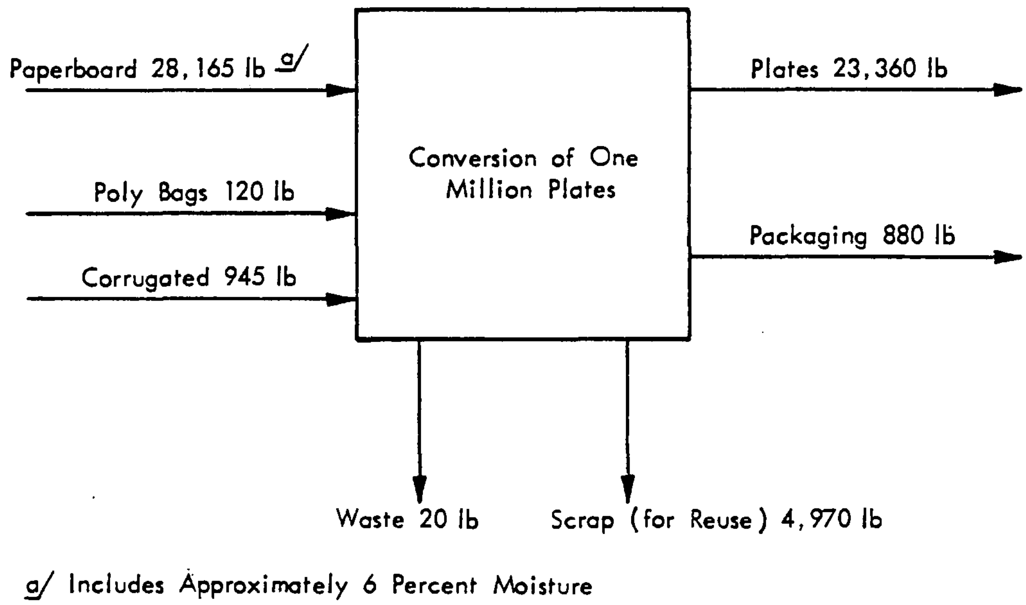


Figure 50 - Material Requirements for 9-Inch Round Clay Coated Pressed Paper Plates (Million Plates)

TABLE 39

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE THOU CLOTH TOWELS USE 32 LI

INPUTS TO SYSTEMS

NAME	UNITS	COTTON TOWEL FIBER SY 32 USES	COTTON TOWEL MFG 32 USES	COTTON TOWEL PKG 32 USES	COTTON TOWEL TRAN 32 USES	COTTON TOWEL WASH 32 USES	COTTON TOWEL PCSW 32 USES	COTTON TOWEL SYS TOT 32 USES
MATERIAL COTTON	POUND	4.913	0.000	0.000	0.000	0.000	0.000	4.913
MATERIAL SULFATE BRINE	POUND	0.000	0.000	0.000	0.000	.900	0.000	.900
MATERIAL WOOD FIBER	POUND	0.000	0.000	.063	0.000	0.000	0.000	.063
MATERIAL LIMESTONE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	0.000	1.711	0.000	0.000	1.141	0.000	2.852
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000	.394	0.000	.394
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000	.348	0.000	.348
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	0.000	.042	0.000	0.000	.103	0.000	.145
ENERGY SOURCE PETROLEUM	MILL BTU	.022	.039	.001	.006	.188	.000	.258
ENERGY SOURCE NAT GAS	MILL BTU	.007	.060	.002	0.000	.388	0.000	.457
ENERGY SOURCE COAL	MILL BTU	.001	.090	.001	0.000	.298	0.000	.389
ENERGY SOURCE MISC	MILL BTU	.000	.015	.000	0.000	.067	0.000	.083
ENERGY SOURCE WOOD FIBER	MILL BTU	0.000	0.000	.001	0.000	.000	0.000	.001
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	.001	0.000	0.000	0.000	0.000	0.000	.001
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	.046	.248	.008	0.000	.393	0.000	.695
ENERGY PROCESS	MIL BTU	.027	.205	.003	0.000	.934	0.000	1.169
ENERGY TRANSPORT	MIL BTU	.000	0.000	.000	.006	.000	.000	.007
ENERGY OF MATL RESOURCE	MIL BTU	.004	0.000	.002	0.000	.006	0.000	.011
WATER VOLUME	THOU GAL	.005	.084	.000	.000	.555	.000	.645

OUTPUTS FROM SYSTEMS

NAME	UNITS	COTTON TOWEL FIBER SY 32 USES	COTTON TOWEL MFG 32 USES	COTTON TOWEL PKG 32 USES	COTTON TOWEL TRAN 32 USES	COTTON TOWEL WASH 32 USES	COTTON TOWEL PCSW 32 USES	COTTON TOWEL SYS TOT 32 USES
SOLID WASTES PROCESS	POUND	1.135	2.189	.008	0.000	3.858	0.000	7.190
SOLID WASTES FUEL COMB	POUND	.010	.454	.006	.002	1.760	.000	2.231
SOLID WASTES MINING	POUND	.014	1.404	.008	0.000	4.855	0.000	6.282
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	0.000	0.000	0.000	.081	.081
ATMOSPHERIC PESTICIDE	POUND	.011	0.000	0.000	0.000	0.000	0.000	.011
ATMOS PARTICULATES	POUND	.025	.211	.004	.001	.390	.000	.631
ATMOS NITROGEN OXIDES	POUND	.055	.187	.003	.015	.820	.000	1.080
ATMOS HYDROCARBONS	POUND	.043	.093	.004	.005	.526	.000	.671
ATMOS SULFUR OXIDES	POUND	.013	.467	.007	.003	1.742	.000	2.230
ATMOS CARBON MONOXIDE	POUND	.055	.029	.001	.016	.123	.010	.234
ATMOS ALDEHYDES	POUND	.001	.000	.000	.000	.002	.000	.004
ATMOS OTHER ORGANICS	POUND	.002	.001	.001	.001	.003	.001	.008
ATMOS ODOROUS SULFUR	POUND	0.000	0.000	0.000	0.000	.002	0.000	.002
ATMOS AMMONIA	POUND	.001	.000	.000	.000	.001	.000	.002
ATMOS HYDROGEN FLOURIDE	POUND	.000	0.000	0.000	0.000	0.000	0.000	.000
ATMOS LEAD	POUND	.000	.000	.000	.000	.000	.000	.000
ATMOS MERCURY	POUND	.000	.000	.000	0.000	.000	0.000	.000
ATMOSPHERIC CHLORINE	POUND	0.000	.009	0.000	0.000	.010	0.000	.019
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	.007	0.000	.007
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	.012	.019	.001	.003	.170	.000	.205
WATERBORNE BOD	POUND	.000	.017	.002	.000	.290	.000	.308
WATERBORNE PHENOL	POUND	.000	.000	.000	.000	.000	.000	.000
WATERBORNE SULFIDES	POUND	.000	.000	.000	.000	.000	.000	.001
WATERBORNE OIL	POUND	.000	.000	.000	.000	.040	.000	.040
WATERBORNE COD	POUND	.000	.191	.000	.000	.010	.000	.201
WATERBORNE SUSP SOLIDS	POUND	.121	.040	.001	.000	.218	.000	.380
WATERBORNE ACID	POUND	.000	.025	.000	.000	.093	.000	.119
WATERBORNE METAL ION	POUND	.000	.006	.000	.000	.032	.000	.038
WATERBORNE CHEMICALS	POUND	.000	0.000	.000	0.000	.000	0.000	.000
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000	.001	0.000	.001
WATERBORNE CHROMIUM	POUND	0.000	.000	0.000	0.000	.000	0.000	.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	0.000	.000	0.000	0.000	.000	0.000	.000
WATERBORNE LEAD	POUND	0.000	.000	0.000	0.000	.000	0.000	.000
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE NITROGEN	POUND	.000	0.000	0.000	0.000	.002	0.000	.002
WATERBORNE PESTICIDE	POUND	.002	0.000	0.000	0.000	.000	0.000	.002

SUMMARY OF ENVIRONMENTAL IMPACTS

NAME	UNITS	COTTON TOWEL FIBER SY 32 USES	COTTON TOWEL MFG 32 USES	COTTON TOWEL PKG 32 USES	COTTON TOWEL TRAN 32 USES	COTTON TOWEL WASH 32 USES	COTTON TOWEL PCSW 32 USES	COTTON TOWEL SYS TOT 32 USES
RAW MATERIALS	POUNDS	4.960	2.001	.071	0.000	3.279	0.000	10.310
ENERGY	MIL BTU	.030	.205	.004	.006	.941	.000	1.188
WATER	THOU GAL	.005	.084	.000	.000	.555	.000	.645
INDUSTRIAL SOLID WASTES	CUBIC FT	.016	.055	.000	.000	.141	.000	.212
ATM EMMISSIONS	POUNDS	.205	.996	.019	.040	3.619	.012	4.891
WATERBORNE WASTES	POUNDS	.136	.299	.004	.003	.862	.000	1.305
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	0.000	0.000	0.000	.081	.081
ENERGY SOURCE PETROLEUM	MIL BTU	.022	.039	.001	.006	.188	.000	.258
ENERGY SOURCE NAT GAS	MIL BTU	.007	.060	.002	0.000	.388	0.000	.457
ENERGY SOURCE COAL	MIL BTU	.001	.090	.001	0.000	.298	0.000	.389
ENERGY SOURCE NUCL HYPWR	MIL BTU	.000	.015	.000	0.000	.067	0.000	.083
ENERGY SOURCE WOOD WASTE	MIL BTU	0.000	0.000	.001	0.000	.000	0.000	.001

INDEX OF ENVIRONMENTAL IMPACTS

NAME	STANDARD VALUES	COTTON TOWEL FIBER SY 32 USES	COTTON TOWEL MFG 32 USES	COTTON TOWEL PKG 32 USES	COTTON TOWEL TRAN 32 USES	COTTON TOWEL WASH 32 USES	COTTON TOWEL PCSW 32 USES	COTTON TOWEL SYS TOT 32 USES
RAW MATERIALS	10.310	48.1	19.4	.7	0.0	31.8	0.0	100.0
ENERGY	1.188	2.6	17.3	.4	.5	79.2	.0	100.0
WATER	.645	.8	13.0	.0	.1	86.0	.0	100.0
INDUSTRIAL SOLID WASTES	.212	7.4	25.8	.1	.0	66.7	.0	100.0
ATM EMMISSIONS	4.891	4.2	20.4	.4	.8	74.0	.2	100.0
WATERBORNE WASTES	1.305	10.5	22.9	.3	.3	66.1	.0	100.0
POST-CONSUMER SOL WASTE	.081	0.0	0.0	0.0	0.0	0.0	100.0	100.0
ENERGY SOURCE PETROLEUM	.258	8.7	15.3	.3	2.5	73.0	.1	100.0
ENERGY SOURCE NAT GAS	.457	1.5	13.2	.5	0.0	84.8	0.0	100.0
ENERGY SOURCE COAL	.389	.2	23.2	.1	0.0	76.5	0.0	100.0
ENERGY SOURCE NUCL HYPWR	.083	.2	18.6	.1	0.0	81.1	0.0	100.0
ENERGY SOURCE WOOD WASTE	.001	0.0	0.0	76.8	0.0	23.2	0.0	100.0

TABLE 40

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE THOU CELLULOSE SPONGE U100L1

INPUTS TO SYSTEMS

NAME	UNITS	CELLULO SPONGE RAW MAT 100 USES	CELLULO SPONGE MFG 100 USES	CELLULO SPONGE PKG 100 USES	CELLULO SPONGE TRAN 100 USES	CELLULO SPONGE WASH 100 USES	CELLULO SPONGE PCSW 100 USES	CELLULO SPONGE SYS TOT 100 USES
MATERIAL COTTON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	.246	0.000	0.000	0.000	.403	0.000	.649
MATERIAL WOOD FIBER	POUND	.396	0.000	.089	0.000	0.000	0.000	.485
MATERIAL LIMESTONE	POUND	.039	0.000	0.000	0.000	0.000	0.000	.039
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	.186	0.000	0.000	0.000	.511	0.000	.697
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000	.176	0.000	.176
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000	.156	0.000	.156
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	.005	0.000	0.000	0.000	.046	0.000	.051
ENERGY SOURCE PETROLEUM	MILL BTU	.003	.006	.001	.001	.084	.000	.095
ENERGY SOURCE NAT GAS	MILL BTU	.006	.022	.002	.000	.174	0.000	.204
ENERGY SOURCE COAL	MILL BTU	.002	.010	.001	0.000	.133	0.000	.146
ENERGY SOURCE MISC	MILL BTU	.000	.002	.000	0.000	.030	0.000	.033
ENERGY SOURCE WOOD FIBER	MILL BTU	.004	0.000	.001	0.000	.000	0.000	.005
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	.045	0.000	.010	0.000	.176	0.000	.231
ENERGY PROCESS	MIL BTU	.016	.040	.003	0.000	.418	0.000	.477
ENERGY TRANSPORT	MIL BTU	.000	0.000	.000	.001	.000	.000	.001
ENERGY OF MATL RESOURCE	MIL BTU	0.000	0.000	.001	0.000	.003	0.000	.004
WATER VOLUME	THOU GAL	.007	.073	.000	.000	.248	.000	.329

OUTPUTS FROM SYSTEMS

NAME	UNITS	CELLULO SPONGE RAW MAT 100 USES	CELLULO SPONGE MFG 100 USES	CELLULO SPONGE PKG 100 USES	CELLULO SPONGE TRAN 100 USES	CELLULO SPONGE WASH 100 USES	CELLULO SPONGE PCSW 100 USES	CELLULO SPONGE SYS TOT 100 USES
SOLID WASTES PROCESS	POUND	.105	.103	.010	0.000	1.727	0.000	1.945
SOLID WASTES FUEL COMB	POUND	.013	.057	.007	.000	.788	.000	.865
SOLID WASTES MINING	POUND	.055	.155	.009	0.000	2.173	0.000	2.392
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	0.000	0.000	0.000	.009	.009
ATMOSPHERIC PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	.007	.013	.005	.000	.175	.000	.200
ATMOS NITROGEN OXIDES	POUND	.011	.032	.003	.001	.367	.000	.414
ATMOS HYDROCARBONS	POUND	.007	.026	.004	.001	.235	.000	.273
ATMOS SULFUR OXIDES	POUND	.016	.056	.009	.000	.780	.000	.861
ATMOS CARBON MONOXIDE	POUND	.002	.005	.001	.001	.055	.001	.066
ATMOS ALDEHYDES	POUND	.000	.000	.000	.000	.001	.000	.001
ATMOS OTHER ORGANICS	POUND	.000	.000	.001	.000	.001	.000	.003
ATMOS ODOROUS SULFUR	POUND	.000	.131	0.000	0.000	.001	0.000	.132
ATMOS AMMONIA	POUND	.000	.000	.000	.000	.001	.000	.001
ATMOS HYDROGEN FLOURIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS LEAD	POUND	.000	.000	.000	.000	.000	.000	.000
ATMOS MERCURY	POUND	.000	.000	.000	0.000	.000	0.000	.000
ATMOSPHERIC CHLORINE	POUND	.001	0.000	0.000	0.000	.005	0.000	.006
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	.003	0.000	.003
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	.017	.005	.001	.000	.076	.000	.099
WATERBORNE BOD	POUND	.003	.013	.003	.000	.130	.000	.149
WATERBORNE PHENOL	POUND	.000	.000	.000	.000	.000	.000	.000
WATERBORNE SULFIDES	POUND	.000	.000	.000	.000	.000	.000	.000
WATERBORNE OIL	POUND	.000	.000	.000	.000	.018	.000	.018
WATERBORNE COD	POUND	.000	.031	.000	.000	.004	.000	.035
WATERBORNE SUSP SOLIDS	POUND	.005	.005	.001	.000	.097	.000	.109
WATERBORNE ACID	POUND	.001	.003	.000	.000	.042	.000	.046
WATERBORNE METAL ION	POUND	.000	.001	.000	.000	.014	.000	.015
WATERBORNE CHEMICALS	POUND	0.000	0.000	.000	0.000	.000	0.000	.000
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE CHROMIUM	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE LEAD	POUND	.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE NITROGEN	POUND	0.000	0.000	0.000	0.000	.001	0.000	.001
WATERBORNE PESTICIDE	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000

SUMMARY OF ENVIRONMENTAL IMPACTS

NAME	UNITS	CELLULO SPONGE RAW MAT 100 USES	CELLULO SPONGE MFG 100 USES	CELLULO SPONGE PKG 100 USES	CELLULO SPONGE TRAN 100 USES	CELLULO SPONGE WASH 100 USES	CELLULO SPONGE PCSW 100 USES	CELLULO SPONGE SYS TOT 100 USES
RAW MATERIALS	POUNDS	.918	0.000	.100	0.000	1.468	0.000	2.485
ENERGY	MIL BTU	.016	.040	.004	.001	.421	.000	.482
WATER	THOU GAL	.007	.073	.000	.000	.248	.000	.329
INDUSTRIAL SOLID WASTES	CUBIC FT	.002	.004	.000	.000	.063	.000	.070
ATM EMMISSIONS	POUNDS	.045	.262	.023	.004	1.620	.002	1.956
WATERBORNE WASTES	POUNDS	.026	.058	.005	.000	.386	.000	.475
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	0.000	0.000	0.000	.009	.009
ENERGY SOURCE PETROLEUM	MIL BTU	.003	.006	.001	.001	.084	.000	.095
ENERGY SOURCE NAT GAS	MIL BTU	.006	.022	.002	.000	.174	0.000	.204
ENERGY SOURCE COAL	MIL BTU	.002	.010	.001	0.000	.133	0.000	.146
ENERGY SOURCE NUCL HYPWR	MIL BTU	.000	.002	.000	0.000	.030	0.000	.033
ENERGY SOURCE WOOD WASTE	MIL BTU	.004	0.000	.001	0.000	.000	0.000	.005

INDEX OF ENVIRONMENTAL IMPACTS

NAME	STANDARD VALUES	CELLULO SPONGE RAW MAT 100 USES	CELLULO SPONGE MFG 100 USES	CELLULO SPONGE PKG 100 USES	CELLULO SPONGE TRAN 100 USES	CELLULO SPONGE WASH 100 USES	CELLULO SPONGE PCSW 100 USES	CELLULO SPONGE SYS TOT 100 USES
RAW MATERIALS	2.485	36.9	0.0	4.0	0.0	59.1	0.0	100.0
ENERGY	.482	3.3	8.2	.9	.1	87.5	.0	100.0
WATER	.329	2.2	22.1	.1	.0	75.6	.0	100.0
INDUSTRIAL SOLID WASTES	.070	3.3	6.0	.5	.0	90.1	.0	100.0
ATM EMMISSIONS	1.956	2.3	13.4	1.2	.2	82.8	.1	100.0
WATERBORNE WASTES	.475	5.6	12.1	1.1	.1	81.1	.0	100.0
POST-CONSUMER SOL WASTE	.009	0.0	0.0	0.0	0.0	0.0	100.0	100.0
ENERGY SOURCE PETROLEUM	.095	3.3	6.0	1.0	.7	88.9	.0	100.0
ENERGY SOURCE NAT GAS	.204	2.8	10.9	1.0	.0	85.3	0.0	100.0
ENERGY SOURCE COAL	.146	1.5	6.6	.4	0.0	91.4	0.0	100.0
ENERGY SOURCE NUCL HYPWR	.033	1.3	6.7	.2	0.0	91.8	0.0	100.0
ENERGY SOURCE WOOD WASTE	.005	83.3	0.0	15.2	0.0	1.5	0.0	100.0

TABLE 41A

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

THOU SQ FT 2 PLY TOWELS P1 OF 2

INPUTS TO SYSTEMS NAME	UNITS	DRY PULP 3.86 LB	SLUSH PULP 4.03 LB	PAPER-MAKING 10.42 LB	CONVERT THOU SQ FEET	RECYCLED PAPBOARD PACKAGE 0.366 LB	POLY WRAPPERS 0.179 LB	TOTAL
MATERIAL COTTON	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFATE BRINE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL WOOD FIBER	POUND	3.08677	3.22316	0.00000	0.00000	0.00000	0.00000	6.99577
MATERIAL LIMESTONE	POUND	.30600	.31952	0.00000	0.00000	0.00000	0.00000	.62552
MATERIAL IRON ORE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SALT	POUND	.36061	.37654	0.00000	0.00000	0.00000	0.00000	.73714
MATERIAL GLASS SAND	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL NAT SODA ASH	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL FELDSPAR	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL BAUXITE ORE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFUR	POUND	.03846	.04016	0.00000	0.00000	0.00000	0.00000	.07862
ENERGY SOURCE PETROLEUM	MILL BTU	.01907	.01432	.04160	.00190	.00104	.00138	.10187
ENERGY SOURCE NAT GAS	MILL BTU	.01451	.01156	.04571	.00757	.00108	.00590	.08919
ENERGY SOURCE COAL	MILL BTU	.00695	.00600	.02333	.00233	.00129	.00089	.04352
ENERGY SOURCE MISC	MILL BTU	.00144	.00122	.00527	.00053	.00016	.00020	.00882
ENERGY SOURCE WOOD FIBER	MILL BTU	.03209	.03351	.00762	0.00000	.00030	0.00000	.07909
ENERGY SOURCE HYDROPOWER	MILL BTU	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL POTASH	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL PHOSPHATE ROCK	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL CLAY	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL GYPSUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SILICA	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL PROCESS ADD	POUNDS	.30259	.31594	.10604	.00440	.01029	.00476	.61242
ENERGY PROCESS	MIL BTU	.07242	.06593	.12334	.00782	.00386	.00369	.29251
ENERGY TRANSPORT	MIL BTU	.00065	.00068	0.00000	.00022	0.00000	.00024	.02092
ENERGY OF MATL RESOURCE	MIL BTU	0.00000	0.00000	0.00000	.00430	0.00000	.00464	.00894
WATER VOLUME	THOU GAL	.05161	.05385	.06821	.00042	.00435	.00369	.16059

OUTPUTS FROM SYSTEMS NAME	UNITS	DRY PULP 3.86 LB	SLUSH PULP 4.03 LB	PAPER-MAKING 10.42 LB	CONVERT THOU SQ FEET	RECYCLED PAPBOARD PACKAGE 0.366 LB	POLY WRAPPERS 0.179 LB	TOTAL
SOLID WASTES PROCESS	POUND	.42351	.44222	.24279	.00398	.02393	.00449	1.20645
SOLID WASTES FUEL COMB	POUND	.04249	.03602	.14403	.01372	.00767	.00522	.29497
SOLID WASTES MINING	POUND	.10096	.09478	.37364	.03736	.01946	.01422	.64849
SOLID WASTE POST-CONSUM	CUBIC FT	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.17322
ATMOSPHERIC PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
ATMOS PARTICULATES	POUND	.03005	.02677	.03736	.00311	.00230	.00130	.14375
ATMOS NITROGEN OXIDES	POUND	.05045	.04430	.10082	.00791	.00282	.00417	.25785
ATMOS HYDROCARBONS	POUND	.02207	.01779	.06660	.01174	.00183	.00979	.15597
ATMOS SULFUR OXIDES	POUND	.04528	.05790	.21746	.01326	.00710	.00534	.42818
ATMOS CARBON MONOXIDE	POUND	.00868	.00816	.01355	.00132	.00050	.00080	.14464
ATMOS ALDEHYDES	POUND	.00009	.00008	.00041	.00001	.00001	.00001	.00143
ATMOS OTHER ORGANICS	POUND	.00024	.00024	.00037	.00003	.00001	.00001	.01598
ATMOS ODOROUS SULFUR	POUND	.00275	.00288	0.00000	0.00000	0.00000	0.00000	.00563
ATMOS AMMONIA	POUND	.00000	.00000	.00004	.00000	.00000	.00000	.00015
ATMOS HYDROGEN FLOURIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
ATMOS LEAD	POUND	.00001	.00001	.00000	.00000	.00000	.00000	.00027
ATMOS MERCURY	POUND	.00000	.00000	.00000	.00000	.00000	.00000	.00001
ATMOSPHERIC CHLORINE	POUND	.00175	.00183	0.00000	0.00000	0.00000	0.00000	.00344
WATERBORNE DIS SOLIDS	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE FLUORIDES	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE DISS SOLIDS	POUND	.01025	.00808	.02362	.00143	.00056	.00107	.06019
WATERBORNE BOD	POUND	.02680	.02798	.02333	.00006	.00475	.00005	.10316
WATERBORNE PHENOL	POUND	.00000	.00000	.00002	.00000	.00000	.00000	.00003
WATERBORNE SULFIDES	POUND	.00000	.00000	.00002	.00000	.00000	.00000	.00004
WATERBORNE OIL	POUND	.00000	.00000	.00002	.00001	.00000	.00001	.00004
WATERBORNE COD	POUND	.00001	.00001	.00018	.00034	.00000	.00037	.00104
WATERBORNE SUSP SOLIDS	POUND	.03999	.04174	.02974	.00011	.00700	.00012	.12815
WATERBORNE ACID	POUND	.00283	.00258	.00719	.00072	.00030	.00027	.01432
WATERBORNE METAL ION	POUND	.00051	.00044	.00180	.00018	.00008	.00007	.00317
WATERBORNE CHEMICALS	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.00075
WATERBORNE CYANIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALKALINITY	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE CHROMIUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE IRON	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALUMINUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE NICKEL	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE MERCURY	POUND	.00000	.00000	0.00000	0.00000	0.00000	0.00000	.00000
WATERBORNE LEAD	POUND	.00000	.00000	0.00000	0.00000	0.00000	0.00000	.00000
WATERBORNE PHOSPHATES	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ZINC	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE AMMONIA	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE NITROGEN	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

SUMMARY OF ENVIRONMENTAL IMPACTS NAME	UNITS	DRY PULP 3.86 LB	SLUSH PULP 4.03 LB	PAPER-MAKING 10.42 LB	CONVERT THOU SQ FEET	RECYCLED PAPBOARD PACKAGE 0.366 LB	POLY WRAPPERS 0.179 LB	TOTAL
RAW MATERIALS	POUNDS	4.09443	4.27534	.10604	.00440	.01029	.00476	9.24998
ENERGY	MIL BTU	.07307	.06661	.12334	.01234	.00386	.00637	.32248
WATER	THOU GAL	.05161	.05385	.06821	.00042	.00435	.00069	.16059
INDUSTRIAL SOLID WASTES	CUBIC FT	.00778	.00774	.01027	.00074	.00049	.00032	.02942
ATM EMMISSIONS	POUNDS	.18138	.16198	.43484	.03739	.01437	.02142	1.16275
WATERBORNE WASTES	POUNDS	.08041	.08086	.08591	.00283	.01269	.00194	.31092
POST-CONSUMER SOL WASTE	CUBIC FT	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.17322
ENERGY SOURCE PETROLEUM	MIL BTU	.01807	.01432	.04160	.00190	.00104	.00138	.10187
ENERGY SOURCE NAT GAS	MIL BTU	.01451	.01156	.04571	.00757	.00108	.00590	.08919
ENERGY SOURCE COAL	MIL BTU	.00698	.00600	.02333	.00232	.00129	.00089	.04342
ENERGY SOURCE NUCL HYPWR	MIL BTU	.00144	.00122	.00527	.00053	.00016	.00020	.00882
ENERGY SOURCE WOOD WASTE	MIL BTU	.03209	.03351	.00742	0.00000	.00030	0.00000	.07909

INDEX OF ENVIRONMENTAL IMPACTS NAME	STANDARD VALUES	DRY PULP 3.86 LB	SLUSH PULP 4.03 LB	PAPER-MAKING 10.42 LB	CONVERT THOU SQ FEET	RECYCLED PAPBOARD PACKAGE 0.366 LB	POLY WRAPPERS 0.179 LB	TOTAL
RAW MATERIALS	9.24998	44.3	46.2	1.1	.0	.1	.1	100.0
ENERGY	.32248	22.7	20.7	38.2	3.8	1.2	2.6	100.0
WATER	.16059	26.6	29.4	37.8	.2	2.4	.4	100.0
INDUSTRIAL SOLID WASTES	.02942	26.3	26.1	34.7	2.5	2.3	1.1	100.0
ATM EMMISSIONS	1.16275	15.6	13.9	37.4	3.2	1.2	1.8	100.0
WATERBORNE WASTES	.31192	25.9	26.0	27.6	.9	4.1	.6	100.0
POST-CONSUMER SOL WASTE	.17322	0.0	0.0	0.0	0.0	0.0	0.0	100.0
ENERGY SOURCE PETROLEUM	.10187	17.7	14.1	40.8	1.9	1.0	1.4	100.0
ENERGY SOURCE NAT GAS	.08919	16.3	13.0	51.3	8.5	1.2	6.6	100.0
ENERGY SOURCE COAL	.04352	16.0	13.8	53.6	5.4	3.0	2.0	100.0
ENERGY SOURCE NUCL HYPWR	.00882	16.3	13.8	59.6	6.0	1.8	2.3	100.0
ENERGY SOURCE WOOD WASTE	.07909	40.6	42.4	9.4	0.0	.4	0.0	100.0

TABLE 41B

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

THOU SQ FT 2 PLY TOWELS P 2

INPUTS TO SYSTEMS

NAME	UNITS	CONRUG 5.9# LB	DISPOSAL	TRANSPOR	TOTAL
MATERIAL COTTON	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFATE BRINE	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL WOOD FIBER	POUND	.68585	0.00000	0.00000	6.99577
MATERIAL LIMESTONE	POUND	0.00000	0.00000	0.00000	.62552
MATERIAL IRON ORE	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL SALT	POUND	0.00000	0.00000	0.00000	.73716
MATERIAL GLASS SAND	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL NAT SODA ASH	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL FELDSPAR	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL BAUXITE ORE	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFUR	POUND	0.00000	0.00000	0.00000	.07662
ENERGY SOURCE PETROLEUM	MILL BTU	.00451	.01049	.00855	.10187
ENERGY SOURCE NAT GAS	MILL BTU	.00285	0.00000	0.00000	.08919
ENERGY SOURCE COAL	MILL BTU	.00272	0.00000	0.00000	.04352
ENERGY SOURCE MISC	MILL BTU	0.00000	0.00000	0.00000	.30982
ENERGY SOURCE WOOD FIBER	MILL BTU	.00576	0.00000	0.00000	.07909
ENERGY SOURCE HYDROPOWER	MILL BTU	0.00000	0.00000	0.00000	0.00000
MATERIAL POTASH	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL PHOSPHATE ROCK	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL CLAY	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL GYPSUM	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL SILICA	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL PROCESS ADD	POUNDS	.05898	0.00000	0.00000	.91292
ENERGY PROCESS	MIL BTU	.01576	0.00000	0.00000	.29253
ENERGY TRANSPORT	MIL BTU	.00009	.01049	.00855	.02092
ENERGY OF MATL RESOURCE	MIL BTU	0.00000	0.00000	0.00000	.00596
WATER VOLUME	THOU GAL	.00031	.00065	.00049	.18059

OUTPUTS FROM SYSTEMS

NAME	UNITS	CONRUG 5.9# LB	DISPOSAL	TRANSPOR	TOTAL
SOLID WASTES PROCESS	POUND	.04593	0.00000	0.00000	1.20649
SOLID WASTES FUEL COMB	POUND	.04463	.00262	.00197	.29837
SOLID WASTES MINING	POUND	.03989	0.00000	0.00000	.68990
SOLID WASTE POST-CONSUM	CUBIC FT	0.00000	.17322	0.00000	.17322
ATMOSPHERIC PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000
ATMOS PARTICULATES	POUND	.03841	.00110	.00135	.14379
ATMOS NITROGEN OXIDES	POUND	.01597	.01120	.02020	.25785
ATMOS HYDROCARBONS	POUND	.00959	.01139	.00737	.15597
ATMOS SULFUR OXIDES	POUND	.05459	.00273	.00432	.42818
ATMOS CARBON MONOXIDE	POUND	.00553	.09636	.01454	.14944
ATMOS ALDEHYDES	POUND	.00008	.00090	.00034	.00193
ATMOS OTHER ORGANICS	POUND	.00796	.00653	.00059	.01598
ATMOS ODOROUS SULFUR	POUND	0.00000	0.00000	0.00000	.00563
ATMOS AMMONIA	POUND	.00001	.00003	.00002	.00015
ATMOS HYDROGEN FLOURIDE	POUND	0.00000	0.00000	0.00000	0.00000
ATMOS LEAD	POUND	.00000	.00022	.00002	.00027
ATMOS MERCURY	POUND	.00000	0.00000	0.00000	.00001
ATMOSPHERIC CHLORINE	POUND	0.00000	0.00000	0.00000	.00359
WATERBORNE DIS SOLIDS	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE FLUORIDES	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE DISS SOLIDS	POUND	.00540	.00560	.00420	.06019
WATERBORNE BOD	POUND	.02019	.00001	.00001	.10316
WATERBORNE PHENOL	POUND	.00000	.00001	.00000	.00003
WATERBORNE SULFIDES	POUND	.00000	.00001	.00000	.00004
WATERBORNE OIL	POUND	.00000	.00001	.00001	.00006
WATERBORNE COD	POUND	.00002	.00005	.00004	.00104
WATERBORNE SUSP SOLIDS	POUND	.00936	.00004	.00003	.12415
WATERBORNE ACID	POUND	.00041	.00001	.00001	.01432
WATERBORNE METAL ION	POUND	.00010	.00000	.00000	.00317
WATERBORNE CHEMICALS	POUND	.00075	0.00000	0.00000	.00075
WATERBORNE CYANIDE	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALKALINITY	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE CHROMIUM	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE IRON	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALUMINUM	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE NICKEL	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE MERCURY	POUND	0.00000	0.00000	0.00000	.00000
WATERBORNE LEAD	POUND	0.00000	0.00000	0.00000	.00000
WATERBORNE PHOSPHATES	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE ZINC	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE AMMONIA	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE NITROGEN	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000

SUMMARY OF ENVIRONMENTAL IMPACTS

NAME	UNITS	CONRUG 5.9# LB	DISPOSAL	TRANSPOR	TOTAL
RAW MATERIALS	POUNDS	.75473	0.00000	0.00000	9.24998
ENERGY	MIL BTU	.01585	.01049	.00855	.32248
WATER	THOU GAL	.00031	.00065	.00049	.18059
INDUSTRIAL SOLID WASTES	CUBIC FT	.00202	.00004	.00003	.02962
ATM EMMISSIONS	POUNDS	.13215	.13046	.04875	1.16275
WATERBORNE WASTES	POUNDS	.03623	.00574	.00431	.31092
POST-CONSUMER SOL WASTE	CUBIC FT	0.00000	.17322	0.00000	.17322
ENERGY SOURCE PETROLEUM	MIL BTU	.00451	.01049	.00855	.10187
ENERGY SOURCE NAT GAS	MIL BTU	.00285	0.00000	0.00000	.08919
ENERGY SOURCE COAL	MIL BTU	.00272	0.00000	0.00000	.04352
ENERGY SOURCE NUCL HYPWR	MIL BTU	0.00000	0.00000	0.00000	.00882
ENERGY SOURCE WOOD WASTE	MIL BTU	.00576	0.00000	0.00000	.07909

INDEX OF ENVIRONMENTAL IMPACTS

NAME	STANDARD VALUES	CONRUG 5.9# LB	DISPOSAL	TRANSPOR	TOTAL
RAW MATERIALS	9.24998	8.2	0.0	0.0	100.0
ENERGY	.32248	4.9	3.3	2.7	100.0
WATER	.18059	.2	.4	.3	100.0
INDUSTRIAL SOLID WASTES	.02962	6.8	.1	.1	100.0
ATM EMMISSIONS	1.16275	11.4	11.2	4.2	100.0
WATERBORNE WASTES	.31092	11.7	1.8	1.4	100.0
POST-CONSUMER SOL WASTE	.17322	0.0	100.0	0.0	100.0
ENERGY SOURCE PETROLEUM	.10187	4.4	10.3	8.4	100.0
ENERGY SOURCE NAT GAS	.08919	3.2	0.0	0.0	100.0
ENERGY SOURCE COAL	.04352	6.3	0.0	0.0	100.0
ENERGY SOURCE NUCL HYPWR	.00882	0.0	0.0	0.0	100.0
ENERGY SOURCE WOOD WASTE	.07909	7.3	0.0	0.0	100.0

TABLE 42

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE THOU CLOTH NAP-HOME 54 USES

INPUTS TO SYSTEMS NAME	UNITS	CLOTH NAP-HOME RAYON ST 54 USES	CLOTH NAP-HOME POLYE ST 54 USES	CLOTH NAP-HOME MFG 54 USES	CLOTH NAP-HOME PKG 54 USES	CLOTH NAP-HOME TRAN 54 USES	CLOTH NAP-HOME WASH 54 USES	CLOTH NAP-HOME PCSW 54 USES	CLOTH NAP-HOME SYS TOT 54 USES
MATERIAL COTTON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	0.000	0.000	0.000	0.000	0.000	.665	0.000	.665
MATERIAL WOOD FIBER	POUND	.848	0.000	0.000	.026	0.000	0.000	0.000	.893
MATERIAL LIMESTONE	POUND	.086	0.000	0.000	0.000	0.000	0.000	0.000	.086
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	.631	0.000	.749	0.000	0.000	.842	0.000	2.222
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000	0.000	.291	0.000	.291
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000	0.000	.257	0.000	.257
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	.349	0.000	.018	0.000	0.000	.076	0.000	.443
ENERGY SOURCE PETROLEUM	MILL BTU	.021	.019	.017	.000	.003	.139	.002	.202
ENERGY SOURCE NAT GAS	MILL BTU	.019	.010	.026	.001	.000	.246	0.000	.343
ENERGY SOURCE COAL	MILL BTU	.038	.002	.039	.000	0.000	.220	0.000	.298
ENERGY SOURCE MISC	MILL BTU	.002	.000	.007	.000	0.000	.049	0.000	.058
ENERGY SOURCE WOOD FIBER	MILL BTU	.009	0.000	0.000	.000	0.000	.000	0.000	.009
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	.125	.008	.108	.004	0.000	.290	0.000	.535
ENERGY PROCESS	MIL BTU	.088	.017	.090	.001	0.000	.690	0.000	.886
ENERGY TRANSPORT	MIL BTU	.000	.000	0.000	.000	.003	.000	.002	.006
ENERGY OF MATL RESOURCE	MIL BTU	0.000	.014	0.000	.001	0.000	.004	0.000	.019
WATER VOLUME	THOU GAL	.033	.002	.037	.000	.000	.410	.000	.442

OUTPUTS FROM SYSTEMS NAME	UNITS								
SOLID WASTES PROCESS	POUND	.369	.022	.958	.003	0.000	2.848	0.000	4.201
SOLID WASTES FUEL COMB	POUND	.117	.011	.199	.003	.001	1.299	.001	1.629
SOLID WASTES MINING	POUND	.549	.024	.616	.004	0.000	3.584	0.000	4.776
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	0.000	0.000	0.000	0.000	.035	.035
ATMOSPHERIC PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	.079	.004	.092	.002	.000	.288	.000	.465
ATMOS NITROGEN OXIDES	POUND	.063	.014	.082	.001	.006	.605	.002	.774
ATMOS HYDROCARBONS	POUND	.038	.060	.041	.002	.002	.388	.002	.525
ATMOS SULFUR OXIDES	POUND	.190	.026	.204	.003	.002	1.286	.001	1.710
ATMOS CARBON MONOXIDE	POUND	.015	.023	.013	.000	.006	.091	.019	.166
ATMOS ALDEHYDES	POUND	.000	.000	.000	.000	.000	.002	.000	.002
ATMOS OTHER ORGANICS	POUND	.000	.000	.000	.000	.000	.002	.001	.004
ATMOS ODOROUS SULFUR	POUND	.007	0.000	0.000	0.000	0.000	.001	0.000	.008
ATMOS AMMONIA	POUND	.000	.000	.000	.000	.000	.001	.000	.001
ATMOS HYDROGEN FLOURIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS LEAD	POUND	.000	.000	.000	.000	.000	.000	.000	.000
ATMOS MERCURY	POUND	.000	.000	.000	.000	0.000	.000	0.000	.000
ATMOSPHERIC CHLORINE	POUND	.003	0.000	.004	0.000	0.000	.008	0.000	.015
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	0.000	.005	0.000	.005
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	.012	.009	.008	.000	.001	.125	.001	.157
WATERBORNE BOD	POUND	.013	.001	.007	.001	.000	.214	.000	.235
WATERBORNE PHENOL	POUND	.000	.000	.000	.000	.000	.000	.000	.000
WATERBORNE SULFIDES	POUND	.000	.000	.000	.000	.000	.000	.000	.000
WATERBORNE OIL	POUND	.000	.000	.000	.000	.000	.029	.000	.029
WATERBORNE COD	POUND	.072	.000	.084	.000	.000	.007	.000	.163
WATERBORNE SUSP SOLIDS	POUND	.021	.001	.018	.000	.000	.161	.000	.200
WATERBORNE ACID	POUND	.014	.000	.011	.000	.000	.069	.000	.094
WATERBORNE METAL ION	POUND	.002	.000	.003	.000	.000	.024	.000	.028
WATERBORNE CHEMICALS	POUND	0.000	0.000	0.000	.000	0.000	.000	0.000	.000
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE CHROMIUM	POUND	0.000	.000	.000	0.000	0.000	.000	0.000	.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	.000	0.000	.000	0.000	0.000	.000	0.000	.000
WATERBORNE LEAD	POUND	.000	0.000	.000	0.000	0.000	.000	0.000	.000
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE ZINC	POUND	.001	0.000	0.000	0.000	0.000	0.000	0.000	.001
WATERBORNE AMMONIA	POUND	0.000	.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE NITROGEN	POUND	0.000	0.000	0.000	0.000	0.000	.001	0.000	.001
WATERBORNE PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	.000	0.000	.000

SUMMARY OF ENVIRONMENTAL IMPACTS NAME	UNITS								
RAW MATERIALS	POUNDS	2.050	.000	.075	.079	0.000	2.420	0.000	5.391
ENERGY	MIL BTU	.088	.031	.090	.002	.003	.695	.002	.911
WATER	THOU GAL	.033	.002	.037	.000	.000	.410	.000	.442
INDUSTRIAL SOLID WASTES	CUBIC FT	.014	.001	.024	.000	.000	.104	.000	.143
ATM EMMISSIONS	POUNDS	.385	.127	.436	.009	.016	2.672	.026	3.671
WATERBORNE WASTES	POUNDS	.134	.011	.131	.002	.001	.636	.001	.916
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	0.000	0.000	0.000	0.000	.035	.035
ENERGY SOURCE PETROLEUM	MIL BTU	.021	.019	.017	.000	.003	.139	.002	.202
ENERGY SOURCE NAT GAS	MIL BTU	.019	.010	.026	.001	.000	.246	0.000	.343
ENERGY SOURCE COAL	MIL BTU	.038	.002	.039	.000	0.000	.220	0.000	.298
ENERGY SOURCE NUCL HYPWR	MIL BTU	.002	.000	.007	.000	0.000	.049	0.000	.058
ENERGY SOURCE WOOD WASTE	MIL BTU	.009	0.000	0.000	.000	0.000	.000	0.000	.009

INDEX OF ENVIRONMENTAL IMPACTS NAME	STANDARD VALUES								
RAW MATERIALS	5.391	38.2	.1	16.2	.5	0.0	44.9	0.0	100.0
ENERGY	.911	9.7	3.4	9.9	.3	.3	76.2	.2	100.0
WATER	.442	6.8	.4	7.7	.0	.0	85.1	.0	100.0
INDUSTRIAL SOLID WASTES	.143	9.8	.5	16.7	.1	.0	72.9	.0	100.0
ATM EMMISSIONS	3.671	10.5	3.5	11.9	.3	.4	72.8	.7	100.0
WATERBORNE WASTES	.916	14.6	1.2	14.3	.2	.1	69.4	.1	100.0
POST-CONSUMER SOL WASTE	.035	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
ENERGY SOURCE PETROLEUM	.202	10.5	9.6	8.6	.2	1.3	68.8	1.1	100.0
ENERGY SOURCE NAT GAS	.343	5.5	3.0	7.7	.4	.0	83.4	0.0	100.0
ENERGY SOURCE COAL	.298	12.6	.5	13.2	.1	0.0	73.6	0.0	100.0
ENERGY SOURCE NUCL HYPWR	.058	2.7	.6	11.8	.1	0.0	85.0	0.0	100.0
ENERGY SOURCE WOOD WASTE	.009	96.4	0.0	0.0	2.3	0.0	1.3	0.0	100.0

TABLE 43A

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

THOU SINGLE PLY CONS NAP PI OF 2

INPUTS TO SYSTEMS

NAME	UNITS	DRY PULP 1.51 LB	SLUSH PULP 2.26 LB	NAPKINS PAPERMAK 5.59 LB	NAPKINS CONVERT THOU NAP	CARTONS 0.054 LB	POLY WRAPPERS 0.134	TOTAL
MATERIAL COTTON	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFATE BRINE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL WOOD FIBER	POUND	1.13948	1.73505	0.00000	0.00000	.02857	0.00000	3.58349
MATERIAL LIMESTONE	POUND	.11296	.17200	0.00000	0.00000	.00431	0.00000	.24935
MATERIAL IRON ORE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SALT	POUND	.13312	.20269	0.00000	0.00000	.01285	0.00000	.34876
MATERIAL GLASS SAND	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL NAT SODA ASH	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL FELDSPAR	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL BAUXITE ORE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFUR	POUND	.01420	.02162	0.00000	0.00000	.00054	0.00000	.03637
ENERGY SOURCE PETROLEUM	MILL BTU	.00667	.00771	.02182	.00124	.00038	.00119	.05535
ENERGY SOURCE NAT GAS	MILL BTU	.00536	.00622	.02059	.00520	.00072	.00507	.04549
ENERGY SOURCE COAL	MILL BTU	.00297	.00323	.01070	.00130	.00028	.00076	.02156
ENERGY SOURCE MISC	MILL BTU	.00053	.00066	.00242	.00029	.00002	.00017	.00409
ENERGY SOURCE WOOD FIBER	MILL BTU	.01185	.01804	.00561	0.00000	.00051	0.00000	.04173
ENERGY SOURCE HYDROPOWER	MILL BTU	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL POTASH	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL PHOSPHATE ROCK	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL CLAY	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL GYPSUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SILICA	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL PROCESS ADD	POUNDS	.11170	.17008	.03929	.00258	.00464	.00409	.43073
ENERGY PROCESS	MIL BTU	.02673	.03549	.06114	.00539	.00139	.00300	.14878
ENERGY TRANSPORT	MIL BTU	.00024	.00037	0.00000	.00013	.00001	.00020	.01241
ENERGY OF MATL RESOURCE	MIL BTU	0.00000	0.00000	0.00000	.00252	0.00000	.00399	.00651
WATER VOLUME	THOU GAL	.01905	.02899	.04767	.00026	.00058	.00060	.09820

OUTPUTS FROM SYSTEMS

NAME	UNITS	DRY PULP 1.51 LB	SLUSH PULP 2.26 LB	NAPKINS PAPERMAK 5.59 LB	NAPKINS CONVERT THOU NAP	CARTONS 0.054 LB	POLY WRAPPERS 0.134	TOTAL
SOLID WASTES PROCESS	POUND	.15634	.23805	.30692	.00233	.00799	.00346	.78093
SOLID WASTES FUEL COMB	POUND	.01568	.01939	.06663	.00768	.00316	.00469	.16417
SOLID WASTES MINING	POUND	.04059	.05102	.17135	.02092	.00166	.01223	.33626
SOLID WASTE POST-CONSUM	CUBIC FT	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.08875
ATMOSPHERIC PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
ATMOS PARTICULATES	POUND	.01109	.01548	.01912	.00178	.00052	.00112	.08763
ATMOS NITROGEN OXIDES	POUND	.01862	.02385	.05081	.00500	.00063	.00359	.13533
ATMOS HYDROCARBONS	POUND	.00815	.00958	.03031	.00762	.00037	.00842	.08612
ATMOS SULFUR OXIDES	POUND	.02410	.03117	.04762	.00767	.00118	.00459	.22453
ATMOS CARBON MONOXIDE	POUND	.00320	.00439	.00681	.00046	.00021	.00069	.09854
ATMOS ALDEHYDES	POUND	.00003	.00005	.00021	.00001	.00000	.00001	.00125
ATMOS OTHER ORGANICS	POUND	.00009	.00013	.00019	.00002	.00001	.00001	.01286
ATMOS ODOROUS SULFUR	POUND	.00102	.00155	0.00000	0.00000	.00002	0.00000	.00259
ATMOS AMMONIA	POUND	.00000	.00000	.00004	.00000	.00000	.00000	.00004
ATMOS HYDROGEN FLOURIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
ATMOS LEAD	POUND	.00000	.00001	.00000	.00000	.00000	.00000	.00020
ATMOS MERCURY	POUND	.00000	.00000	.00000	.00000	.00000	.00000	.00000
ATMOSPHERIC CHLORINE	POUND	.00065	.00099	0.00000	0.00000	.00003	0.00000	.00167
WATERBORNE DIS SOLIDS	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE FLUORIDES	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE DISS SOLIDS	POUND	.00375	.00435	.01201	.00104	.00022	.00092	.03395
WATERBORNE BOD	POUND	.00989	.01506	.01898	.00003	.00024	.00004	.05426
WATERBORNE PHENOL	POUND	.00000	.00000	.00001	.00000	.00000	.00000	.00002
WATERBORNE SULFIDES	POUND	.00000	.00000	.00001	.00000	.00000	.00000	.00002
WATERBORNE OIL	POUND	.00000	.00000	.00001	.00001	.00000	.00001	.00004
WATERBORNE COD	POUND	.00001	.00001	.00010	.00020	.00000	.00032	.00071
WATERBORNE SUSP SOLIDS	POUND	.01476	.02248	.02390	.00007	.00042	.00010	.07106
WATERBORNE ACID	POUND	.00105	.00139	.00330	.00040	.00007	.00023	.00686
WATERBORNE METAL ION	POUND	.00019	.00023	.00087	.00010	.00001	.00006	.00153
WATERBORNE CHEMICALS	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.00074
WATERBORNE CYANIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALKALINITY	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE CHROMIUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE IRON	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALUMINUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE NICKEL	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE MERCURY	POUND	.00000	.00000	0.00000	0.00000	.00000	0.00000	.00000
WATERBORNE LEAD	POUND	.00000	.00000	0.00000	0.00000	.00000	0.00000	.00000
WATERBORNE PHOSPHATES	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ZINC	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE AMMONIA	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE NITROGEN	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

SUMMARY OF ENVIRONMENTAL IMPACTS

NAME	UNITS	DRY PULP 1.51 LB	SLUSH PULP 2.26 LB	NAPKINS PAPERMAK 5.59 LB	NAPKINS CONVERT THOU NAP	CARTONS 0.054 LB	POLY WRAPPERS 0.134	TOTAL
RAW MATERIALS	POUNDS	1.51146	2.30145	.03929	.00258	.05092	.00409	4.65870
ENERGY	MIL BTU	.02697	.03586	.06114	.00803	.00141	.00720	.16820
WATER	THOU GAL	.01905	.02899	.04767	.00026	.00058	.00060	.09820
INDUSTRIAL SOLID WASTES	CUBIC FT	.00287	.00416	.00734	.00042	.00017	.00028	.01730
ATM EMMISSIONS	POUNDS	.06696	.08720	.20409	.02246	.00296	.01843	.45078
WATERBORNE WASTES	POUNDS	.02968	.04353	.05914	.00183	.00097	.00168	.17909
POST-CONSUMER SOL WASTE	CUBIC FT	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.08875
ENERGY SOURCE PETROLEUM	MIL BTU	.00667	.00771	.02182	.00124	.00038	.00119	.05535
ENERGY SOURCE NAT GAS	MIL BTU	.00536	.00622	.02059	.00520	.00022	.00507	.04549
ENERGY SOURCE COAL	MIL BTU	.00297	.00323	.01070	.00130	.00028	.00076	.02156
ENERGY SOURCE NUCL HYPWR	MIL BTU	.00053	.00066	.00242	.00029	.00002	.00017	.00409
ENERGY SOURCE WOOD WASTE	MIL BTU	.01185	.01804	.00561	0.00000	.00051	0.00000	.04173

INDEX OF ENVIRONMENTAL IMPACTS

NAME	STANDARD VALUES	DRY PULP 1.51 LB	SLUSH PULP 2.26 LB	NAPKINS PAPERMAK 5.59 LB	NAPKINS CONVERT THOU NAP	CARTONS 0.054 LB	POLY WRAPPERS 0.134	TOTAL
RAW MATERIALS	4.65870	32.4	49.4	.8	.1	1.1	.1	100.0
ENERGY	.16820	16.0	21.3	36.3	4.8	.8	4.3	100.0
WATER	.09820	19.4	29.5	48.5	.3	.6	.6	100.0
INDUSTRIAL SOLID WASTES	.01730	16.6	24.1	42.5	2.4	1.0	1.6	100.0
ATM EMMISSIONS	.45078	10.3	13.4	31.4	3.5	.5	2.8	100.0
WATERBORNE WASTES	.17909	16.6	24.3	33.0	1.0	.5	.9	100.0
POST-CONSUMER SOL WASTE	.08875	0.0	0.0	0.0	0.0	0.0	0.0	100.0
ENERGY SOURCE PETROLEUM	.05535	12.1	13.9	39.4	2.2	.7	2.2	100.0
ENERGY SOURCE NAT GAS	.04549	11.8	13.7	45.3	11.4	.5	11.2	100.0
ENERGY SOURCE COAL	.02156	11.9	15.0	49.7	6.0	1.3	3.5	100.0
ENERGY SOURCE NUCL HYPWR	.00409	13.0	16.0	59.1	7.2	.5	4.2	100.0
ENERGY SOURCE WOOD WASTE	.04173	28.4	43.2	13.5	0.0	1.2	0.0	100.0

TABLE 43B

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

THOU SINGLE PLY CONS NAP PP

NAME	UNITS	CORRUG 8.979 LB	DISPOSAL	TRANSPOR	TOTAL
INPUTS TO SYSTEMS					
MATERIAL COTTON	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFATE BRINE	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL WOOD FIBER	POUND	.67957	0.00000	0.00000	3.58349
MATERIAL LIMESTONE	POUND	0.00000	0.00000	0.00000	.28935
MATERIAL IRON ORE	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL SALT	POUND	0.00000	0.00000	0.00000	.34876
MATERIAL GLASS SAND	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL NAT SODA ASH	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL FELDSPAR	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL BAUXITE ORE	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFUR	POUND	0.00000	0.00000	0.00000	.03677
ENERGY SOURCE PETROLEUM	MILL BTU	.00447	.00855	.00331	.05535
ENERGY SOURCE NAT GAS	MILL BTU	.00283	0.00000	0.00000	.04549
ENERGY SOURCE COAL	MILL BTU	.00270	0.00000	0.00000	.02154
ENERGY SOURCE MISC	MILL BTU	0.00000	0.00000	0.00000	.00409
ENERGY SOURCE WOOD FIBER	MILL BTU	.00571	0.00000	0.00000	.04173
ENERGY SOURCE HYDROPOWER	MILL BTU	0.00000	0.00000	0.00000	0.00000
MATERIAL POTASH	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL PHOSPHATE ROCK	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL CLAY	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL GYPSUM	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL SILICA	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL PROCESS ADD	POUNDS	.06425	0.00000	0.00000	.40073
ENERGY PROCESS	MIL BTU	.01562	0.00000	0.00000	.14878
ENERGY TRANSPORT	MIL BTU	.00009	.00855	.00331	.01291
ENERGY OF MATL RESOURCE	MIL BTU	0.00000	0.00000	0.00000	.00651
WATER VOLUME	THOU GAL	.00031	.00053	.00019	.09820
OUTPUTS FROM SYSTEMS					
SOLID WASTES PROCESS	POUND	.06532	0.00000	0.00000	.78093
SOLID WASTES FUEL COMB	POUND	.04422	.00214	.00076	.16417
SOLID WASTES MINING	POUND	.03853	0.00000	0.00000	.33424
SOLID WASTE POST-CONSUM	CUBIC FT	0.00000	.08875	0.00000	.08875
ATMOSPHERIC PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000
ATMOS PARTICULATES	POUND	.03806	.00090	.00055	.08763
ATMOS NITROGEN OXIDES	POUND	.01582	.00913	.00787	.13533
ATMOS HYDROCARBONS	POUND	.00951	.00420	.00287	.08612
ATMOS SULFUR OXIDES	POUND	.05409	.00223	.00198	.22453
ATMOS CARBON MONOXIDE	POUND	.00548	.07221	.05469	.09854
ATMOS ALDEHYDES	POUND	.00008	.00073	.00013	.00125
ATMOS OTHER ORGANICS	POUND	.00789	.00432	.00020	.01284
ATMOS ODOROUS SULFUR	POUND	0.00000	0.00000	0.00000	.00259
ATMOS AMMONIA	POUND	.00001	.00002	.00001	.00009
ATMOS HYDROGEN FLUORIDE	POUND	0.00000	0.00000	0.00000	0.00000
ATMOS LEAD	POUND	.00000	.00019	.00000	.00020
ATMOS MERCURY	POUND	.00000	0.00000	0.00000	.00000
ATMOSPHERIC CHLORINE	POUND	0.00000	0.00000	0.00000	.00167
WATERBORNE DIS SOLIDS	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE FLUORIDES	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE DISS SOLIDS	POUND	.00535	.00456	.00162	.03385
WATERBORNE BOD	POUND	.01999	.00001	.00008	.06676
WATERBORNE PHENOL	POUND	.00000	.00000	.00000	.00002
WATERBORNE SULFIDES	POUND	.00000	.00081	.00000	.00002
WATERBORNE OIL	POUND	.00000	.00001	.00000	.00004
WATERBORNE COD	POUND	.00002	.00085	.00002	.00071
WATERBORNE SUSP SOLIDS	POUND	.00928	.00403	.00001	.07106
WATERBORNE ACID	POUND	.00041	.00001	.00000	.00686
WATERBORNE METAL ION	POUND	.00010	.00000	.00000	.00153
WATERBORNE CHEMICALS	POUND	.00074	0.00000	0.00000	.00076
WATERBORNE CYANIDE	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALKALINITY	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE CHROMIUM	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE IRON	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALUMINUM	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE NICKEL	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE MERCURY	POUND	0.00000	0.00000	0.00000	.00000
WATERBORNE LEAD	POUND	0.00000	0.00000	0.00000	.00000
WATERBORNE PHOSPHATES	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE ZINC	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE AMMONIA	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE NITROGEN	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000
SUMMARY OF ENVIRONMENTAL IMPACTS					
RAW MATERIALS	POUNDS	.74782	0.00000	0.00000	4.65870
ENERGY	MIL BTU	.01570	.00855	.00331	.16820
WATER	THOU GAL	.00031	.00053	.00019	.09820
INDUSTRIAL SOLID WASTES	CUBIC FT	.00200	.00003	.00001	.01730
ATM EMMISSIONS	POUNDS	.13094	.09900	.01819	.65078
WATERBORNE WASTES	POUNDS	.03590	.00468	.00166	.17909
POST-CONSUMER SOL WASTE	CUBIC FT	0.00000	.08875	0.00000	.08875
ENERGY SOURCE PETROLEUM	MIL BTU	.00447	.00855	.00331	.05535
ENERGY SOURCE NAT GAS	MIL BTU	.00283	0.00000	0.00000	.04549
ENERGY SOURCE COAL	MIL BTU	.00270	0.00000	0.00000	.02154
ENERGY SOURCE NUCL HYPWR	MIL BTU	0.00000	0.00000	0.00000	.00409
ENERGY SOURCE WOOD WASTE	MIL BTU	.00571	0.00000	0.00000	.04173

INDEX OF ENVIRONMENTAL IMPACTS

NAME	STANDARD VALUES	CORRUG 8.979 LB	DISPOSAL	TRANSPOR	TOTAL
RAW MATERIALS	4.65870	16.1	0.0	0.0	100.0
ENERGY	.16820	9.3	5.1	2.0	100.0
WATER	.09820	.3	.5	.2	100.0
INDUSTRIAL SOLID WASTES	.01730	11.6	.2	.1	100.0
ATM EMMISSIONS	.65078	20.1	15.2	2.8	100.0
WATERBORNE WASTES	.17909	20.0	2.6	.9	100.0
POST-CONSUMER SOL WASTE	.08875	0.0	100.0	0.0	100.0
ENERGY SOURCE PETROLEUM	.05535	8.1	15.5	6.0	100.0
ENERGY SOURCE NAT GAS	.04549	6.2	0.0	0.0	100.0
ENERGY SOURCE COAL	.02154	12.5	0.0	0.0	100.0
ENERGY SOURCE NUCL HYPWR	.00409	0.0	0.0	0.0	100.0
ENERGY SOURCE WOOD WASTE	.04173	13.7	0.0	0.0	100.0

TABLE 44

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE THOU CLOTH NAP-COMM 27 USES

INPUTS TO SYSTEMS NAME	UNITS	CLOTH NAP-COMM FIBER SY 27 USES	CLOTH NAP-COMM MFG 27 USES	CLOTH NAP-COMM PKG 27 USES	CLOTH NAP-COMM TRAN 27 USES	CLOTH NAP-COMM WASH 27 USES	CLOTH NAP-COMM PCSW 27 USES	CLOTH NAP-COMM SYS TOT 27 USES
MATERIAL COTTON	POUND	4.411	0.000	0.000	0.000	0.000	0.000	4.411
MATERIAL SULFATE BRINE	POUND	0.000	0.000	0.000	0.000	.305	0.000	.305
MATERIAL WOOD FIBER	POUND	0.000	0.000	.052	0.000	0.000	0.000	.052
MATERIAL LIMESTONE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	0.000	1.537	0.000	0.000	1.013	0.000	2.550
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000	.162	0.000	.162
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000	.143	0.000	.143
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	0.000	.038	0.000	0.000	.036	0.000	.073
ENERGY SOURCE PETROLEUM	MILL BTU	.020	.035	.001	.006	.013	.004	.080
ENERGY SOURCE NAT GAS	MILL BTU	.006	.054	.003	.000	.490	0.000	.553
ENERGY SOURCE COAL	MILL BTU	.001	.081	.001	0.000	.018	0.000	.100
ENERGY SOURCE MISC	MILL BTU	.000	.014	.000	0.000	.004	0.000	.018
ENERGY SOURCE WOOD FIBER	MILL BTU	0.000	0.000	.000	0.000	.000	0.000	.000
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	.001	0.000	0.000	0.000	0.000	0.000	.001
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	.041	.223	.007	0.000	.302	0.000	.573
ENERGY PROCESS	MIL BTU	.024	.184	.003	0.000	.521	0.000	.732
ENERGY TRANSPORT	MIL BTU	.000	0.000	.000	.006	.002	.004	.013
ENERGY OF MATL RESOURCE	MIL BTU	.003	0.000	.002	0.000	.002	0.000	.007
WATER VOLUME	THOU GAL	.005	.076	.000	.000	.382	.000	.463

OUTPUTS FROM SYSTEMS NAME	UNITS	FIBER SY	MFG	PKG	TRAN	WASH	PCSW	SYS TOT
SOLID WASTES PROCESS	POUND	1.019	1.946	.007	0.000	5.560	0.000	8.552
SOLID WASTES FUEL COMB	POUND	.009	.408	.006	.001	.103	.001	.528
SOLID WASTES MINING	POUND	.012	1.261	.009	0.000	.321	0.000	1.603
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	0.000	0.000	0.000	.073	.073
ATMOSPHERIC PESTICIDE	POUND	.010	0.000	0.000	0.000	0.000	0.000	.010
ATMOS PARTICULATES	POUND	.022	.189	.003	.001	.035	.000	.251
ATMOS NITROGEN OXIDES	POUND	.050	.168	.003	.013	.295	.005	.533
ATMOS HYDROCARBONS	POUND	.039	.084	.005	.005	.475	.005	.612
ATMOS SULFUR OXIDES	POUND	.011	.419	.006	.002	.109	.001	.549
ATMOS CARBON MONOXIDE	POUND	.050	.025	.001	.020	.076	.038	.210
ATMOS ALDEHYDES	POUND	.001	.000	.000	.000	.001	.000	.003
ATMOS OTHER ORGANICS	POUND	.001	.000	.001	.001	.003	.002	.009
ATMOS ODOROUS SULFUR	POUND	0.000	0.000	0.000	0.000	.008	0.000	.008
ATMOS AMMONIA	POUND	.001	.000	.000	.000	.006	.000	.007
ATMOS HYDROGEN FLOURIDE	POUND	.000	0.000	0.000	0.000	0.000	0.000	.000
ATMOS LEAD	POUND	.000	.000	.000	.000	.000	.000	.000
ATMOS MERCURY	POUND	.000	.000	.000	0.000	.000	0.000	.000
ATMOSPHERIC CHLORINE	POUND	0.000	.008	0.000	0.000	.009	0.000	.017
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	.006	0.000	.006
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	.011	.017	.001	.003	.110	.002	.143
WATERBORNE BOD	POUND	.000	.015	.002	.000	.106	.000	.123
WATERBORNE PHENOL	POUND	.000	.000	.000	.000	.000	.000	.000
WATERBORNE SULFIDES	POUND	.000	.000	.000	.000	.000	.000	.000
WATERBORNE OIL	POUND	.000	.000	.000	.000	.030	.000	.030
WATERBORNE COD	POUND	.080	.172	.000	.000	.044	.000	.216
WATERBORNE SUSP SOLIDS	POUND	.109	.036	.001	.000	.107	.000	.253
WATERBORNE ACID	POUND	.000	.023	.000	.000	.006	.000	.029
WATERBORNE METAL ION	POUND	.000	.005	.000	.000	.008	.000	.014
WATERBORNE CHEMICALS	POUND	.000	0.000	.000	0.000	.000	0.000	.000
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE CHROMIUM	POUND	0.000	.000	0.000	0.000	.000	0.000	.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	0.000	.000	0.000	0.000	.000	0.000	.000
WATERBORNE LEAD	POUND	0.000	.000	0.000	0.000	.000	0.000	.000
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000	.001	0.000	.001
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE NITROGEN	POUND	.000	0.000	0.000	0.000	.010	0.000	.010
WATERBORNE PESTICIDE	POUND	.002	0.000	0.000	0.000	.000	0.000	.002

SUMMARY OF ENVIRONMENTAL IMPACTS NAME	UNITS	FIBER SY	MFG	PKG	TRAN	WASH	PCSW	SYS TOT
RAW MATERIALS	POUNDS	4.453	1.797	.059	0.000	1.962	0.000	8.270
ENERGY	MIL BTU	.027	.184	.005	.006	.525	.004	.752
WATER	THOU GAL	.005	.076	.000	.000	.382	.000	.463
INDUSTRIAL SOLID WASTES	CUBIC FT	.014	.049	.000	.000	.081	.000	.144
ATM EMMISSIONS	POUNDS	.184	.898	.019	.041	1.017	.052	2.208
WATERBORNE WASTES	POUNDS	.122	.269	.006	.003	.428	.002	.829
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	0.000	0.000	0.000	.073	.073
ENERGY SOURCE PETROLEUM	MIL BTU	.020	.035	.001	.006	.013	.004	.080
ENERGY SOURCE NAT GAS	MIL BTU	.006	.054	.003	.000	.490	0.000	.553
ENERGY SOURCE COAL	MIL BTU	.001	.081	.001	0.000	.018	0.000	.100
ENERGY SOURCE NUCL HYPWR	MIL BTU	.000	.014	.000	0.000	.004	0.000	.018
ENERGY SOURCE WOOD WASTE	MIL BTU	0.000	0.000	.000	0.000	.000	0.000	.000

INDEX OF ENVIRONMENTAL IMPACTS NAME	STANDARD VALUES	FIBER SY	MFG	PKG	TRAN	WASH	PCSW	SYS TOT
RAW MATERIALS	8.270	53.8	21.7	.7	0.0	23.7	0.0	100.0
ENERGY	.752	3.6	24.5	.6	.8	69.8	.6	100.0
WATER	.463	1.1	16.3	.1	.1	82.4	.1	100.0
INDUSTRIAL SOLID WASTES	.144	9.7	34.0	.2	.0	56.0	.0	100.0
ATM EMMISSIONS	2.208	8.4	40.5	.9	1.9	46.1	2.3	100.0
WATERBORNE WASTES	.829	14.8	32.4	.4	.4	51.7	.3	100.0
POST-CONSUMER SOL WASTE	.073	0.0	0.0	0.0	0.0	0.0	100.0	100.0
ENERGY SOURCE PETROLEUM	.080	25.0	44.1	1.1	7.6	16.7	5.4	100.0
ENERGY SOURCE NAT GAS	.553	1.1	9.8	.5	.0	88.6	0.0	100.0
ENERGY SOURCE COAL	.100	.8	80.6	.6	0.0	18.1	0.0	100.0
ENERGY SOURCE NUCL HYPWR	.018	1.0	77.4	.5	0.0	21.2	0.0	100.0
ENERGY SOURCE WOOD WASTE	.000	0.0	0.0	88.8	0.0	11.2	0.0	100.0

TABLE 45A

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

THOU 2PLY INDUST NAPKINS P1 OF 2

INPUTS TO SYSTEMS

NAME	UNITS	DRY PULP 3.96 LB	SLUSH PULP 5.86 LB	PAPERMKR 14.64 LB	CONVERT	CARTONS 0.170 LB	POLY WRAPPERS 0.0734	TOTAL
MATERIAL COTTON	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFATE AMINE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL WOOD FIBER	POUND	3.94958	4.49095	0.00000	0.00000	.09487	0.00000	8.38037
MATERIAL LIMESTONE	POUND	.29240	.44520	0.00000	0.00000	.01432	0.00000	.75148
MATERIAL IRON ORE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SALT	POUND	.34458	.52465	0.00000	0.00000	.04269	0.00000	.91147
MATERIAL GLASS SAND	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL NAT SODA ASH	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL FELDSPAR	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL BAUXITE ORE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFUR	POUND	.03675	.05596	0.00000	0.00000	.00181	0.00000	.09451
ENERGY SOURCE PETROLEUM	MILL BTU	.01727	.01995	.05646	.00140	.00125	.00057	.11393
ENERGY SOURCE NAT GAS	MILL BTU	.01387	.01611	.05327	.00842	.00072	.00242	.09835
ENERGY SOURCE COAL	MILL BTU	.00664	.00836	.02769	.00339	.00093	.00036	.05075
ENERGY SOURCE MISC	MILL BTU	.00137	.00170	.00626	.00077	.00007	.00008	.01025
ENERGY SOURCE WOOD FIBER	MILL BTU	.03067	.04469	.01452	0.00000	.00171	0.00000	.10073
ENERGY SOURCE HYDROPOWER	MILL BTU	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL POTASH	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL PHOSPHATE ROCK	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL CLAY	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL GYPSUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SILICA	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL PROCESS ADD	POUNDS	.29914	.44024	.10144	0.00000	.01942	.00195	.33332
ENERGY PROCESS	MIL BTU	.08920	.09107	.19819	.01397	.00463	.00143	.39841
ENERGY TRANSPORT	MIL BTU	.00062	.00095	0.00000	0.00000	.00005	.00010	.01327
ENERGY OF MATL RESOURCE	MIL BTU	0.00000	0.00000	0.00000	0.00000	0.00000	.00190	.00190
WATER VOLUME	THOU GAL	.04932	.07503	.12335	.00023	.00193	.00028	.25121

OUTPUTS FROM SYSTEMS

NAME	UNITS	DRY PULP	SLUSH PULP	PAPERMKR	CONVERT	CARTONS	POLY WRAPPERS	TOTAL
SOLID WASTES PROCESS	POUND	.40649	.61617	.79417	0.00000	.02654	.00184	1.92464
SOLID WASTES FUEL COMB	POUND	.04040	.05019	.17742	.01992	.01050	.00214	.35392
SOLID WASTES MINING	POUND	.10507	.13206	.44338	.05426	.00553	.00583	.74613
SOLID WASTE POST-CONSUM	CUBIC FT	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.22097
ATMOSPHERIC PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
ATMOS PARTICULATES	POUND	.02871	.04000	.06688	.00435	.00171	.00053	.17145
ATMOS NITROGEN OXIDES	POUND	.04821	.06173	.13148	.01102	.00204	.00171	.29733
ATMOS HYDROCARBONS	POUND	.02109	.02479	.07463	.00949	.00124	.00401	.16236
ATMOS SULFUR OXIDES	POUND	.06238	.08068	.25259	.01670	.00392	.00219	.43232
ATMOS CARBON MONOXIDE	POUND	.00829	.01137	.01761	.00171	.00069	.00033	.11546
ATMOS ALDEHYDES	POUND	.00004	.00012	.00055	.00003	.00001	.00000	.00155
ATMOS OTHER ORGANICS	POUND	.00023	.00034	.00066	.00005	.00002	.00000	.01704
ATMOS ODOROUS SULFUR	POUND	.00253	.00401	0.00000	0.00000	.00007	0.00000	.00571
ATMOS AMMONIA	POUND	.00000	.00000	.00011	0.00000	.00000	.00000	.00014
ATMOS HYDROGEN FLUORIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
ATMOS LEAD	POUND	.00001	.00002	.00000	0.00000	.00000	.00000	.00014
ATMOS MERCURY	POUND	.00000	.00000	.00000	.00000	.00000	.00000	.00001
ATMOSPHERIC CHLORINE	POUND	.00148	.00256	0.00000	0.00000	.00011	0.00000	.00474
WATERBORNE DIS SOLIDS	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE FLUORIDES	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00006
WATERBORNE DISS SOLIDS	POUND	.00979	.01124	.03108	.00163	.00075	.00044	.05763
WATERBORNE BOD	POUND	.02561	.03099	.04911	.00000	.00079	.00002	.13941
WATERBORNE PHENOL	POUND	.00000	.00000	.00002	.00000	.00000	.00000	.00003
WATERBORNE SULFIDES	POUND	.00000	.00000	.00003	.00000	.00000	.00000	.00004
WATERBORNE OIL	POUND	.00000	.00000	.00007	.00000	.00000	.00000	.00009
WATERBORNE COD	POUND	.00001	.00002	.00029	.00000	.00000	.00015	.00052
WATERBORNE SUSP SOLIDS	POUND	.03822	.05019	.06109	.00000	.00141	.00005	.17167
WATERBORNE ACID	POUND	.00271	.00359	.00853	.00104	.00023	.00011	.01673
WATERBORNE METAL ION	POUND	.00049	.00061	.00213	.00026	.00005	.00003	.00369
WATERBORNE CHEMICALS	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.00043
WATERBORNE CYANIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALKALINITY	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE CHROMIUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE IRON	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALUMINUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE NICKEL	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE MERCURY	POUND	.00000	.00000	0.00000	0.00000	.00000	0.00000	.00000
WATERBORNE LEAD	POUND	.00000	.00000	0.00000	0.00000	.00000	0.00000	.00000
WATERBORNE PHOSPHATES	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ZINC	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE AMMONIA	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE NITROGEN	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

SUMMARY OF ENVIRONMENTAL IMPACTS

NAME	UNITS	DRY PULP	SLUSH PULP	PAPERMKR	CONVERT	CARTONS	POLY WRAPPERS	TOTAL
RAW MATERIALS	POUNDS	3.91246	5.95700	.10168	0.00000	.16910	.00195	11.07195
ENERGY	MIL BTU	.06982	.09281	.19819	.01397	.00468	.00343	.37401
WATER	THOU GAL	.04932	.07503	.12335	.00023	.00193	.00028	.25121
INDUSTRIAL SOLID WASTES	CUBIC FT	.00743	.01070	.01903	.00100	.00057	.00013	.04148
ATM EMISSIONS	POUNDS	.17332	.22569	.52810	.04535	.00986	.00078	1.26904
WATERBORNE WASTES	POUNDS	.07683	.11266	.15304	.00294	.00322	.00040	.40032
POST-CONSUMER SOL WASTE	CUBIC FT	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.22097
ENERGY SOURCE PETROLEUM	MIL BTU	.01727	.01995	.05646	.00140	.00125	.00057	.11393
ENERGY SOURCE NAT GAS	MIL BTU	.01387	.01611	.05327	.00842	.00072	.00242	.09035
ENERGY SOURCE COAL	MIL BTU	.00664	.00836	.02769	.00339	.00093	.00036	.05075
ENERGY SOURCE NUCL HYPWR	MIL BTU	.00137	.00170	.00626	.00077	.00007	.00000	.01025
ENERGY SOURCE WOOD WASTE	MIL BTU	.03067	.04469	.01452	0.00000	.00171	0.00000	.10073

INDEX OF ENVIRONMENTAL IMPACTS

NAME	STANDARD VALUES	DRY PULP	SLUSH PULP	PAPERMKR	CONVERT	CARTONS	POLY WRAPPERS	TOTAL
RAW MATERIALS	11.07195	35.3	53.8	.9	0.0	1.5	.0	100.0
ENERGY	.37401	18.7	24.8	42.3	3.7	1.3	.9	100.0
WATER	.25121	19.6	29.9	49.1	.1	.8	.1	100.0
INDUSTRIAL SOLID WASTES	.04148	17.9	26.0	45.9	2.4	1.4	.3	100.0
ATM EMISSIONS	1.26904	13.7	17.8	41.6	3.6	.8	.7	100.0
WATERBORNE WASTES	.40032	19.2	28.1	38.2	.7	.8	.2	100.0
POST-CONSUMER SOL WASTE	.22097	0.0	0.0	0.0	0.0	0.0	0.0	100.0
ENERGY SOURCE PETROLEUM	.11393	15.2	17.5	49.6	1.2	1.1	.5	100.0
ENERGY SOURCE NAT GAS	.09835	14.1	16.4	54.2	8.6	.7	2.5	100.0
ENERGY SOURCE COAL	.05075	13.1	16.5	54.6	6.7	1.8	.7	100.0
ENERGY SOURCE NUCL HYPWR	.01025	13.4	16.6	61.1	7.5	.7	.8	100.0
ENERGY SOURCE WOOD WASTE	.10073	30.4	44.4	14.4	0.0	1.7	0.0	100.0

TABLE 45B

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

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INPUTS TO SYSTEMS NAME	UNITS	PAPER WRAPPERS 0.0332	CORRUG 1.18 LB	DISPOSAL	TRANSPOR	TOTAL
MATERIAL COTTON	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFATE BRINE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL WOOD FIBER	POUND	.02287	.02244	0.00000	0.00000	8.38037
MATERIAL LIMESTONE	POUND	0.00000	0.00000	0.00000	0.00000	.75100
MATERIAL IRON ORE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SALT	POUND	0.00000	0.00000	0.00000	0.00000	.91187
MATERIAL GLASS SAND	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL NAT SODA ASH	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL FELDSPAR	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL BAUXITE ORE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFUR	POUND	0.00000	0.00000	0.00000	0.00000	.09451
ENERGY SOURCE PETROLEUM	MILL BTU	.00018	.00541	.00477	.00668	.11393
ENERGY SOURCE NAT GAS	MILL BTU	.00012	.00342	0.00000	0.00000	.09835
ENERGY SOURCE COAL	MILL BTU	.00011	.00326	0.00000	0.00000	.05075
ENERGY SOURCE MISC	MILL BTU	0.00000	0.00000	0.00000	0.00000	.01025
ENERGY SOURCE WOOD FIBER	MILL BTU	.00025	.00691	0.00000	0.00000	.10073
ENERGY SOURCE HYDROPOWER	MILL BTU	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL POTASH	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL PHOSPHATE ROCK	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL CLAY	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL GYPSUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SILICA	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL PROCESS ADD	POUNDS	.00232	.08260	0.00000	0.00000	.93332
ENERGY PROCESS	MIL BTU	.00065	.01890	0.00000	0.00000	.35883
ENERGY TRANSPORT	MIL BTU	.00000	.00011	.00477	.00668	.01327
ENERGY OF MATL RESOURCE	MIL BTU	0.00000	0.00000	0.00000	0.00000	.00190
WATER VOLUME	THOU GAL	.00001	.00037	.00030	.00038	.25121

OUTPUTS FROM SYSTEMS NAME	UNITS	PAPER WRAPPERS 0.0332	CORRUG 1.18 LB	DISPOSAL	TRANSPOR	TOTAL
SOLID WASTES PROCESS	POUND	.00222	.07906	0.00000	0.00000	1.92464
SOLID WASTES FUEL COMB	POUND	.00190	.05352	.00119	.00153	.35392
SOLID WASTES MINING	POUND	.00158	.04683	0.00000	0.00000	.79431
SOLID WASTE POST-CONSUM	CUBIC FT	0.00000	0.00000	.22097	0.00000	.22097
ATMOSPHERIC PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
ATMOS PARTICULATES	POUND	.00146	.04607	.00050	.00115	.17145
ATMOS NITROGEN OXIDES	POUND	.00062	.01915	.00909	.01625	.29733
ATMOS HYDROCARBONS	POUND	.00039	.01150	.00518	.00594	.16206
ATMOS SULFUR OXIDES	POUND	.00134	.06547	.00124	.00381	.49232
ATMOS CARBON MONOXIDE	POUND	.00021	.00663	.04102	.00808	.11594
ATMOS ALDEHYDES	POUND	.00000	.00010	.00041	.00026	.00155
ATMOS OTHER ORGANICS	POUND	.00015	.00955	.00569	.00036	.01704
ATMOS ODOROUS SULFUR	POUND	0.00000	0.00000	0.00000	0.00000	.00671
ATMOS AMMONIA	POUND	.00000	.00001	.00001	.00002	.00016
ATMOS HYDROGEN FLUORIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
ATMOS LEAD	POUND	.00000	.00000	.00010	.00001	.00014
ATMOS MERCURY	POUND	.00000	.00000	0.00000	0.00000	.00001
ATMOSPHERIC CHLORINE	POUND	0.00000	0.00000	0.00000	0.00000	.00434
WATERBORNE DIS SOLIDS	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE FLUORIDES	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE DISS SOLIDS	POUND	.00021	.00647	.00294	.00328	.06743
WATERBORNE BOD	POUND	.00048	.02420	.00001	.00001	.13941
WATERBORNE PHENOL	POUND	.00000	.00000	.00000	.00000	.00003
WATERBORNE SULFIDES	POUND	.00000	.00000	.00000	.00000	.00004
WATERBORNE OIL	POUND	.00000	.00000	.00000	.00000	.00005
WATERBORNE COD	POUND	.00000	.00003	.00003	.00003	.00092
WATERBORNE SUSP SOLIDS	POUND	.00050	.01123	.00002	.00002	.17147
WATERBORNE ACID	POUND	.00002	.00050	.00001	.00001	.01673
WATERBORNE METAL ION	POUND	.00000	.00012	.00000	.00000	.00349
WATERBORNE CHEMICALS	POUND	.00003	.00090	0.00000	0.00000	.00093
WATERBORNE CYANIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALKALINITY	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE CHROMIUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE IRON	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALUMINUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE NICKEL	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE MERCURY	POUND	0.00000	0.00000	0.00000	0.00000	.00000
WATERBORNE LEAD	POUND	0.00000	0.00000	0.00000	0.00000	.00000
WATERBORNE PHOSPHATES	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ZINC	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE AMMONIA	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE NITROGEN	POUND	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000

SUMMARY OF ENVIRONMENTAL IMPACTS NAME	UNITS	PAPER WRAPPERS 0.0332	CORRUG 1.18 LB	DISPOSAL	TRANSPOR	TOTAL
RAW MATERIALS	POUNDS	.02520	.90506	0.00000	0.00000	11.07195
ENERGY	MIL BTU	.00065	.01900	.00477	.00668	.37401
WATER	THOU GAL	.00001	.00037	.00030	.00038	.25121
INDUSTRIAL SOLID WASTES	CUBIC FT	.00008	.00242	.00002	.00002	.04144
ATM EMMISSIONS	POUNDS	.00438	.15847	.07924	.03588	1.26904
WATERBORNE WASTES	POUNDS	.00144	.04345	.00261	.00334	.40032
POST-CONSUMER SOL WASTE	CUBIC FT	0.00000	0.00000	.22097	0.00000	.22097
ENERGY SOURCE PETROLEUM	MIL BTU	.00018	.00541	.00477	.00668	.11393
ENERGY SOURCE NAT GAS	MIL BTU	.00012	.00342	0.00000	0.00000	.09835
ENERGY SOURCE COAL	MIL BTU	.00011	.00326	0.00000	0.00000	.05075
ENERGY SOURCE NUCL HYPWR	MIL BTU	0.00000	0.00000	0.00000	0.00000	.01025
ENERGY SOURCE WOOD WASTE	MIL BTU	.00025	.00691	0.00000	0.00000	.10073

INDEX OF ENVIRONMENTAL IMPACTS NAME	STANDARD VALUES	PAPER WRAPPERS 0.0332	CORRUG 1.18 LB	DISPOSAL	TRANSPOR	TOTAL
RAW MATERIALS	11.07195	.2	8.2	0.0	0.0	100.0
ENERGY	.37401	.2	5.1	1.3	1.8	100.0
WATER	.25121	.0	.1	.1	.2	100.0
INDUSTRIAL SOLID WASTES	.04144	.2	5.8	.0	.0	100.0
ATM EMMISSIONS	1.26904	.3	12.5	6.2	2.8	100.0
WATERBORNE WASTES	.40032	.4	10.9	.7	.8	100.0
POST-CONSUMER SOL WASTE	.22097	0.0	0.0	100.0	0.0	100.0
ENERGY SOURCE PETROLEUM	.11393	.2	4.8	4.2	5.9	100.0
ENERGY SOURCE NAT GAS	.09835	.1	3.5	0.0	0.0	100.0
ENERGY SOURCE COAL	.05075	.2	6.4	0.0	0.0	100.0
ENERGY SOURCE NUCL HYPWR	.01025	0.0	0.0	0.0	0.0	100.0
ENERGY SOURCE WOOD WASTE	.10073	.2	6.9	0.0	0.0	100.0

TABLE 46

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

100 CHANGES CLOTH DIAP HLAUNU100

INPUTS TO SYSTEMS

NAME	UNITS	COTTON FIBER BY 0.204 LB	COTTON DIAPER MFG 0.200 LB	COTTON DIAPER PKG	COTTON DIAPER TRAN	COTTON DIAPER WASH 100 CHGE	COTTON DIAPER PCSW	COTTON DIAPER SYS TOT
MATERIAL COTTON	POUND	.233	0.000	0.000	0.000	0.000	0.000	.238
MATERIAL SULFATE BRINE	POUND	0.000	0.000	0.000	0.000	.385	0.000	.385
MATERIAL WOOD FIBER	POUND	0.000	0.000	.006	0.000	0.000	0.000	.006
MATERIAL LIMESTONE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	0.000	.003	0.000	0.000	.205	0.000	.208
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000	.168	0.000	.168
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000	.149	0.000	.149
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	0.000	.002	0.000	0.000	.044	0.000	.046
ENERGY SOURCE PETROLEUM	MILL BTU	.001	.002	.000	.000	.081	.000	.084
ENERGY SOURCE NAT GAS	MILL BTU	.000	.003	.000	0.000	.165	0.000	.169
ENERGY SOURCE COAL	MILL BTU	.000	.004	.000	0.000	.126	0.000	.131
ENERGY SOURCE MISC	MILL BTU	.000	.001	.000	0.000	.028	0.000	.029
ENERGY SOURCE WOOD FIBER	MILL BTU	0.000	0.000	.000	0.000	.000	0.000	.000
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	.000	0.000	0.000	0.000	0.000	0.000	.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	.002	.012	.001	0.000	.151	0.000	.166
ENERGY PROCESS	MIL BTU	.001	.010	.000	0.000	.399	0.000	.410
ENERGY TRANSPORT	MIL BTU	.000	0.000	.000	.000	.000	.000	.001
ENERGY OF MATL RESOURCE	MIL BTU	.000	0.000	.000	0.000	.003	0.000	.003
WATER VOLUME	THOU GAL	.000	.004	.000	.000	.505	.000	.510

OUTPUTS FROM SYSTEMS

NAME	UNITS	COTTON FIBER BY 0.204 LB	COTTON DIAPER MFG 0.200 LB	COTTON DIAPER PKG	COTTON DIAPER TRAN	COTTON DIAPER WASH 100 CHGE	COTTON DIAPER PCSW	COTTON DIAPER SYS TOT
SOLID WASTES PROCESS	POUND	.094	.106	.001	0.000	1.640	0.000	1.810
SOLID WASTES FUEL COMB	POUND	.000	.022	.000	.000	.748	.000	.771
SOLID WASTES MINING	POUND	.001	.068	.000	0.000	2.063	0.000	2.133
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	0.000	0.000	0.000	.004	.004
ATMOSPHERIC PESTICIDE	POUND	.001	0.000	0.000	0.000	0.000	0.000	.001
ATMOS PARTICULATES	POUND	.001	.010	.000	.000	.166	.000	.178
ATMOS NITROGEN OXIDES	POUND	.003	.009	.000	.001	.350	.000	.362
ATMOS HYDROCARBONS	POUND	.002	.005	.000	.000	.224	.000	.231
ATMOS SULFUR OXIDES	POUND	.001	.023	.001	.000	.742	.000	.766
ATMOS CARBON MONOXIDE	POUND	.003	.001	.000	.001	.053	.000	.058
ATMOS ALDEHYDES	POUND	.000	.000	.000	.000	.001	.000	.001
ATMOS OTHER ORGANICS	POUND	.000	.000	.000	.000	.001	.000	.002
ATMOS ODOROUS SULFUR	POUND	0.000	0.000	0.000	0.000	.001	0.000	.001
ATMOS AMMONIA	POUND	.000	.000	.000	.000	.001	.000	.001
ATMOS HYDROGEN FLOURIDE	POUND	.000	0.000	0.000	0.000	0.000	0.000	.000
ATMOS LEAD	POUND	.000	.000	.000	.000	.000	.000	.000
ATMOS MERCURY	POUND	.000	.000	.000	0.000	.000	0.000	.000
ATMOSPHERIC CHLORINE	POUND	0.000	.000	0.000	0.000	.002	0.000	.002
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	.001	0.000	.001
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	.001	.001	.000	.000	.073	.000	.074
WATERBORNE BOD	POUND	.000	.001	.000	.000	.249	.000	.249
WATERBORNE PHENOL	POUND	.000	.000	.000	.000	.000	.000	.000
WATERBORNE SULFIDES	POUND	.000	.000	.000	.000	.000	.000	.000
WATERBORNE OIL	POUND	.000	.000	.000	.000	.018	.000	.018
WATERBORNE COD	POUND	.000	.009	.000	.000	.004	.000	.013
WATERBORNE SUSP SOLIDS	POUND	.000	.002	.000	.000	.190	.000	.190
WATERBORNE ACID	POUND	.000	.001	.000	.000	.040	.000	.041
WATERBORNE METAL ION	POUND	.000	.000	.000	.000	.012	.000	.012
WATERBORNE CHEMICALS	POUND	.000	0.000	.000	0.000	.000	0.000	.000
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE CHROMIUM	POUND	0.000	.000	0.000	0.000	.000	0.000	.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	0.000	.000	0.000	0.000	.000	0.000	.000
WATERBORNE LEAD	POUND	0.000	.000	0.000	0.000	.000	0.000	.000
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE NITROGEN	POUND	.000	0.000	0.000	0.000	.001	0.000	.001
WATERBORNE PESTICIDE	POUND	.000	0.000	0.000	0.000	.000	0.000	.000

SUMMARY OF ENVIRONMENTAL IMPACTS

NAME	UNITS	COTTON FIBER BY 0.204 LB	COTTON DIAPER MFG 0.200 LB	COTTON DIAPER PKG	COTTON DIAPER TRAN	COTTON DIAPER WASH 100 CHGE	COTTON DIAPER PCSW	COTTON DIAPER SYS TOT
RAW MATERIALS	POUNDS	.236	.097	.006	0.000	1.101	0.000	1.445
ENERGY	MIL BTU	.001	.010	.000	.000	.402	.000	.413
WATER	THOU GAL	.000	.004	.000	.000	.505	.000	.510
INDUSTRIAL SOLID WASTES	CUBIC FT	.001	.003	.000	.000	.060	.000	.064
ATM EMMISSIONS	POUNDS	.010	.048	.001	.002	1.540	.001	1.602
WATERBORNE WASTES	POUNDS	.006	.015	.000	.000	.579	.000	.601
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	0.000	0.000	0.000	.004	.004
ENERGY SOURCE PETROLEUM	MIL BTU	.001	.002	.000	.000	.081	.000	.084
ENERGY SOURCE NAT GAS	MIL BTU	.000	.003	.000	0.000	.165	0.000	.169
ENERGY SOURCE COAL	MIL BTU	.000	.004	.000	0.000	.126	0.000	.131
ENERGY SOURCE NUCL HYPWR	MIL BTU	.000	.001	.000	0.000	.028	0.000	.029
ENERGY SOURCE WOOD WASTE	MIL BTU	0.000	0.000	.000	0.000	.000	0.000	.000

INDEX OF ENVIRONMENTAL IMPACTS

NAME	STANDARD VALUES	COTTON FIBER BY 0.204 LB	COTTON DIAPER MFG 0.200 LB	COTTON DIAPER PKG	COTTON DIAPER TRAN	COTTON DIAPER WASH 100 CHGE	COTTON DIAPER PCSW	COTTON DIAPER SYS TOT
RAW MATERIALS	1.445	16.3	6.7	.4	0.0	76.2	0.0	100.0
ENERGY	.413	.3	2.4	.1	.1	97.1	.0	100.0
WATER	.510	.1	.8	.0	.0	99.1	.0	100.0
INDUSTRIAL SOLID WASTES	.064	1.2	4.2	.0	.0	94.6	.0	100.0
ATM EMMISSIONS	1.602	.6	3.0	.1	.1	96.1	.0	100.0
WATERBORNE WASTES	.601	1.1	2.4	.1	.0	96.4	.0	100.0
POST-CONSUMER SOL WASTE	.004	0.0	0.0	0.0	0.0	0.0	100.0	100.0
ENERGY SOURCE PETROLEUM	.084	1.3	2.3	.1	.4	96.0	.0	100.0
ENERGY SOURCE NAT GAS	.169	.2	1.7	.1	0.0	98.0	0.0	100.0
ENERGY SOURCE COAL	.131	.0	3.3	.0	0.0	96.6	0.0	100.0
ENERGY SOURCE NUCL HYPWR	.029	.0	2.6	.0	0.0	97.4	0.0	100.0
ENERGY SOURCE WOOD WASTE	.000	0.0	0.0	40.8	0.0	59.2	0.0	100.0

TABLE 47

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

100 CHANGES CLOTH DIAP CLAUN USO

NAME	UNITS	COTTON FIBER SY 0.41 LB	COTTON DIAPER MFG .40 LB	COTTON DIAPER PKG	COTTON DIAPER TRAN	COTTON DIAPER WASH	COTTON DIAPER PCSW	COTTON DIAPER SYS TOT
INPUTS TO SYSTEMS								
NAME	UNITS							
MATERIAL COTTON	POUND	.478	0.000	0.000	0.000	0.000	0.000	.478
MATERIAL SULFATE BRINE	POUND	0.000	0.000	0.000	0.000	.098	0.000	.098
MATERIAL WOOD FIBER	POUND	0.000	0.000	.011	0.000	0.000	0.000	.011
MATERIAL LIMESTONE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	0.000	.166	0.000	0.000	.141	0.000	.307
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000	.052	0.000	.052
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000	.046	0.000	.046
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	0.000	.004	0.000	0.000	.011	0.000	.015
ENERGY SOURCE PETROLEUM	MILL BTU	.002	.004	.000	.001	.003	.000	.010
ENERGY SOURCE NAT GAS	MILL BTU	.001	.006	.000	0.000	.133	0.000	.139
ENERGY SOURCE COAL	MILL BTU	.000	.009	.000	0.000	.004	0.000	.013
ENERGY SOURCE MISC	MILL BTU	.000	.001	.000	0.000	.001	0.000	.002
ENERGY SOURCE WOOD FIBER	MILL BTU	0.000	0.000	.000	0.000	.000	0.000	.000
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	.000	0.000	0.000	0.000	0.000	0.000	.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	.004	.024	.001	0.000	.086	0.000	.116
ENERGY PROCESS	MIL BTU	.003	.020	.000	0.000	.139	0.000	.162
ENERGY TRANSPORT	MIL BTU	.000	0.000	.000	.001	.001	.000	.001
ENERGY OF MATL RESOURCE	MIL BTU	.000	0.000	.000	0.000	.001	0.000	.001
WATER VOLUME	THOU GAL	.001	.008	.000	.000	.120	.000	.129
OUTPUTS FROM SYSTEMS								
NAME	UNITS							
SOLID WASTES PROCESS	POUND	.111	.213	.001	0.000	1.664	0.000	1.988
SOLID WASTES FUEL COMB	POUND	.001	.044	.001	.000	.021	.000	.067
SOLID WASTES MINING	POUND	.001	.136	.001	0.000	.068	0.000	.207
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	0.000	0.000	0.000	.008	.008
ATMOSPHERIC PESTICIDE	POUND	.001	0.000	0.000	0.000	0.000	0.000	.001
ATMOS PARTICULATES	POUND	.002	.020	.001	.000	.008	.000	.032
ATMOS NITROGEN OXIDES	POUND	.005	.018	.000	.001	.077	.000	.103
ATMOS HYDROCARBONS	POUND	.004	.009	.000	.000	.128	.000	.142
ATMOS SULFUR OXIDES	POUND	.001	.045	.001	.000	.023	.000	.070
ATMOS CARBON MONOXIDE	POUND	.005	.003	.000	.002	.021	.001	.032
ATMOS ALDEHYDES	POUND	.000	.000	.000	.000	.000	.000	.000
ATMOS OTHER ORGANICS	POUND	.000	.000	.000	.000	.001	.000	.001
ATMOS ODOROUS SULFUR	POUND	0.000	0.000	0.000	0.000	.003	0.000	.003
ATMOS AMMONIA	POUND	.000	.000	.000	.000	.002	.000	.002
ATMOS HYDROGEN FLOURIDE	POUND	.000	0.000	0.000	0.000	0.000	0.000	.000
ATMOS LEAD	POUND	.000	.000	.000	.000	.000	.000	.000
ATMOS MERCURY	POUND	.000	.000	.000	0.000	.000	0.000	.000
ATMOSPHERIC CHLORINE	POUND	0.000	.001	0.000	0.000	.001	0.000	.002
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	.001	0.000	.001
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	.001	.002	.000	.000	.031	.000	.034
WATERBORNE BOD	POUND	.000	.002	.000	.000	.036	.000	.038
WATERBORNE PHENOL	POUND	.000	.000	.000	.000	.000	.000	.000
WATERBORNE SULFIDES	POUND	.000	.000	.000	.000	.000	.000	.000
WATERBORNE OIL	POUND	.000	.000	.000	.000	.009	.000	.009
WATERBORNE COD	POUND	.000	.019	.000	.000	.014	.000	.033
WATERBORNE SUSP SOLIDS	POUND	.012	.004	.000	.000	.036	.000	.051
WATERBORNE ACID	POUND	.000	.002	.000	.000	.001	.000	.004
WATERBORNE METAL ION	POUND	.000	.001	.000	.000	.002	.000	.003
WATERBORNE CHEMICALS	POUND	.000	0.000	.000	0.000	.000	0.000	.000
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE CHROMIUM	POUND	0.000	.000	0.000	0.000	.000	0.000	.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	0.000	.000	0.000	0.000	.000	0.000	.000
WATERBORNE LEAD	POUND	0.000	.000	0.000	0.000	.000	0.000	.000
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE NITROGEN	POUND	.000	0.000	0.000	0.000	.003	0.000	.003
WATERBORNE PESTICIDE	POUND	.000	0.000	0.000	0.000	.000	0.000	.000
SUMMARY OF ENVIRONMENTAL IMPACTS								
NAME	UNITS							
RAW MATERIALS	POUNDS	.483	.194	.013	0.000	.434	0.000	1.124
ENERGY	MIL BTU	.003	.020	.000	.001	.140	.000	.164
WATER	THOU GAL	.001	.008	.000	.000	.120	.000	.129
INDUSTRIAL SOLID WASTES	CUBIC FT	.002	.005	.000	.000	.024	.000	.031
ATM ENMISSIONS	POUNDS	.020	.097	.003	.004	.264	.001	.388
WATERBORNE WASTES	POUNDS	.013	.029	.001	.000	.133	.000	.177
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	0.000	0.000	0.000	.008	.008
ENERGY SOURCE PETROLEUM	MIL BTU	.002	.004	.000	.001	.003	.000	.010
ENERGY SOURCE NAT GAS	MIL BTU	.001	.006	.000	0.000	.133	0.000	.139
ENERGY SOURCE COAL	MIL BTU	.000	.009	.000	0.000	.004	0.000	.013
ENERGY SOURCE NUCL HYPWR	MIL BTU	.000	.001	.000	0.000	.001	0.000	.002
ENERGY SOURCE WOOD WASTE	MIL BTU	0.000	0.000	.000	0.000	.000	0.000	.000
INDEX OF ENVIRONMENTAL IMPACTS								
NAME	STANDARD VALUES							
RAW MATERIALS	1.124	43.0	17.3	1.1	0.0	38.6	0.0	100.0
ENERGY	.164	1.8	12.1	.3	.4	85.4	.0	100.0
WATER	.129	.4	6.3	.0	.0	93.2	.0	100.0
INDUSTRIAL SOLID WASTES	.031	5.0	17.4	.1	.0	77.5	.0	100.0
ATM ENMISSIONS	.388	5.2	24.9	.7	1.0	68.0	.3	100.0
WATERBORNE WASTES	.177	7.5	16.4	.4	.2	75.5	.0	100.0
POST-CONSUMER SOL WASTE	.008	0.0	0.0	0.0	0.0	0.0	100.0	100.0
ENERGY SOURCE PETROLEUM	.010	21.7	38.0	1.0	6.2	32.8	.2	100.0
ENERGY SOURCE NAT GAS	.139	.5	4.2	.1	0.0	95.2	0.0	100.0
ENERGY SOURCE COAL	.013	.7	69.9	.5	0.0	29.0	0.0	100.0
ENERGY SOURCE NUCL HYPWR	.002	.8	66.1	.2	0.0	32.8	0.0	100.0
ENERGY SOURCE WOOD WASTE	.000	0.0	0.0	84.5	0.0	15.5	0.0	100.0

TABLE 48A

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE HUNDRED DISP DIAPERS P1 OF 2

INPUTS TO SYSTEMS

NAME	UNITS	DIAPER TISSUE 1.61 LB	PE FILM 0.98 LB	RAYON 0.46 LB	RESIN 0.10 LB	POLYESTR 0.19 LB	FLUFF PULP 7.92 LB	TOTAL
MATERIAL COTTON	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFATE BRINE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL WOOD FIBER	POUND	1.05321	0.00000	.39006	0.00000	0.00000	6.08478	9.21949
MATERIAL LIMESTONE	POUND	.10441	0.00000	.01956	0.00000	0.00000	.60320	.87277
MATERIAL IRON ORE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SALT	POUND	.12384	0.00000	.29009	0.00000	0.00000	.71084	1.49837
MATERIAL GLASS SAND	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL NAT SODA ASH	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL FELDSPAR	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL BAUXITE ORE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFUR	POUND	.01312	0.00000	.16045	0.00000	0.00000	.07582	.26524
ENERGY SOURCE PETROLEUM	MILL BTU	.00868	.00748	.00972	.00193	.00018	.03563	.09239
ENERGY SOURCE NAT GAS	MILL BTU	.01514	.03183	.00872	.01160	.00012	.02861	.10942
ENERGY SOURCE COAL	MILL BTU	.00598	.00484	.01728	.00030	.00002	.01370	.06059
ENERGY SOURCE MISC	MILL BTU	.00131	.00109	.00073	.00007	.00000	.00284	.00823
ENERGY SOURCE WOOD FIBER	MILL BTU	.01095	0.00000	.00415	0.00000	0.00000	.06326	.10066
ENERGY SOURCE HYDROPOWER	MILL BTU	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL POTASH	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL PHOSPHATE ROCK	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL CLAY	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL GYPSUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SILICA	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL PROCESS ADD	POUNDS	.12772	.02567	.05759	.00430	.00006	.59649	1.03291
ENERGY PROCESS	MIL BTU	.04183	.01892	.04051	.00394	.00019	.14276	.32281
ENERGY TRANSPORT	MIL BTU	.00022	.00128	.00008	.00045	.00000	.00129	.01318
ENERGY OF MATL RESOURCE	MIL BTU	0.00000	.02504	0.00000	.00979	.00014	0.00000	.03539
WATER VOLUME	THOU GAL	.02501	.00376	.01499	.00257	.00003	.10174	.16628

OUTPUTS FROM SYSTEMS

NAME	UNITS	DIAPER TISSUE 1.61 LB	PE FILM 0.98 LB	RAYON 0.46 LB	RESIN 0.10 LB	POLYESTR 0.19 LB	FLUFF PULP 7.92 LB	TOTAL
SOLID WASTES PROCESS	POUND	.20540	.02811	.16992	.00791	.00022	.83484	1.58131
SOLID WASTES FUEL COMB	POUND	.03595	.02846	.05360	.00176	.00014	.08375	.39393
SOLID WASTES MINING	POUND	.09537	.07749	.25238	.00478	.00033	.21675	.85494
SOLID WASTE POST-CONSUM	CUBIC FT	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.18981
ATMOSPHERIC PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
ATMOS PARTICULATES	POUND	.01506	.00708	.03612	.00044	.00005	.05923	.14071
ATMOS NITROGEN OXIDES	POUND	.03014	.02261	.02881	.00501	.00016	.09945	.26068
ATMOS HYDROCARBONS	POUND	.01914	.05283	.01361	.01725	.00054	.04359	.18450
ATMOS SULFUR OXIDES	POUND	.04415	.02905	.08728	.00245	.00029	.12869	.43659
ATMOS CARBON MONOXIDE	POUND	.00502	.00435	.00669	.00118	.00019	.01711	.09041
ATMOS ALDEHYDES	POUND	.00007	.00004	.00010	.00001	.00000	.00017	.00095
ATMOS OTHER ORGANICS	POUND	.00014	.00007	.00011	.00002	.00000	.00047	.01524
ATMOS ODOROUS SULFUR	POUND	.00094	0.00000	.00316	0.00000	0.00000	.00543	.01016
ATMOS AMMONIA	POUND	.00000	.00000	.00002	.00014	.00000	.00001	.00020
ATMOS HYDROGEN FLOURIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
ATMOS LEAD	POUND	.00000	.00000	.00000	.00000	.00000	.00003	.00007
ATMOS MERCURY	POUND	.00000	.00000	.00000	.00000	.00000	.00000	.00001
ATMOSPHERIC CHLORINE	POUND	.00040	0.00000	.00145	0.00000	0.00000	.00344	.00644
WATERBORNE DIS SOLIDS	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE FLUORIDES	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE DISS SOLIDS	POUND	.00590	.00576	.00594	.00193	.00009	.02020	.05812
WATERBORNE BOD	POUND	.01141	.00026	.00577	.00093	.00001	.05283	.10317
WATERBORNE PHENOL	POUND	.00000	.00000	.00000	.00000	.00000	.00000	.00002
WATERBORNE SULFIDES	POUND	.00000	.00000	.00001	.00000	.00000	.00000	.00002
WATERBORNE OIL	POUND	.00000	.00006	.00000	.00002	.00000	.00000	.00011
WATERBORNE COD	POUND	.00002	.00198	.03315	.00455	.00009	.00003	.03996
WATERBORNE SUSP SOLIDS	POUND	.01555	.00064	.00974	.00039	.00001	.07884	.12917
WATERBORNE ACID	POUND	.00208	.00140	.00643	.00009	.00001	.00559	.02033
WATERBORNE METAL ION	POUND	.00045	.00037	.00078	.00002	.00000	.00100	.00370
WATERBORNE CHEMICALS	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.00043
WATERBORNE CYANIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALKALINITY	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE CHROMIUM	POUND	0.00000	0.00000	0.00000	0.00000	.00000	0.00000	.00000
WATERBORNE IRON	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALUMINUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE NICKEL	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE MERCURY	POUND	.00000	0.00000	.00000	0.00000	0.00000	.00000	.00000
WATERBORNE LEAD	POUND	.00000	0.00000	.00000	0.00000	0.00000	.00000	.00000
WATERBORNE PHOSPHATES	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ZINC	POUND	0.00000	0.00000	.00025	0.00000	0.00000	0.00000	.00025
WATERBORNE AMMONIA	POUND	0.00000	0.00000	0.00000	.00001	.00000	0.00000	.00001
WATERBORNE NITROGEN	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE PESTIC. E	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

SUMMARY OF ENVIRONMENTAL IMPACTS

NAME	UNITS	DIAPER TISSUE 1.61 LB	PE FILM 0.98 LB	RAYON 0.46 LB	RESIN 0.10 LB	POLYESTR 0.19 LB	FLUFF PULP 7.92 LB	TOTAL
RAW MATERIALS	POUNDS	1.42150	.02567	.94676	.00430	.00006	8.07112	12.88878
ENERGY	MIL BTU	.04206	.04525	.04060	.01409	.00033	.14404	.37109
WATER	THOU GAL	.02501	.00376	.01499	.00257	.00003	.10174	.16628
INDUSTRIAL SOLID WASTES	CUBIC FT	.00455	.00181	.00642	.00020	.00001	.01533	.03820
ATM EMMISSIONS	POUNDS	.11527	.11603	.17727	.02649	.00123	.35754	1.19597
WATERBORNE WASTES	POUNDS	.03541	.01055	.06167	.00795	.00021	.15850	.35577
POST-CONSUMER SOL WASTE	CUBIC FT	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.18981
ENERGY SOURCE PETROLEUM	MIL BTU	.00868	.00748	.00972	.00193	.00018	.03563	.09239
ENERGY SOURCE NAT GAS	MIL BTU	.01514	.03183	.00872	.01160	.00012	.02861	.10942
ENERGY SOURCE COAL	MIL BTU	.00598	.00484	.01728	.00030	.00002	.01370	.06059
ENERGY SOURCE NUCL HYPWR	MIL BTU	.00131	.00109	.00073	.00007	.00000	.00284	.00823
ENERGY SOURCE WOOD WASTE	MIL BTU	.01095	0.00000	.00415	0.00000	0.00000	.06326	.10046

INDEX OF ENVIRONMENTAL IMPACTS

NAME	STANDARD VALUES	DIAPER TISSUE 1.61 LB	PE FILM 0.98 LB	RAYON 0.46 LB	RESIN 0.10 LB	POLYESTR 0.19 LB	FLUFF PULP 7.92 LB	TOTAL
RAW MATERIALS	12.88878	11.0	.2	7.3	.0	.0	62.6	100.0
ENERGY	.37109	11.3	12.2	10.9	3.8	.1	38.8	100.0
WATER	.16628	15.0	2.3	9.0	1.5	.0	61.2	100.0
INDUSTRIAL SOLID WASTES	.03820	11.9	4.7	16.8	.5	.0	40.1	100.0
ATM EMMISSIONS	1.19597	9.6	9.7	14.8	2.2	.1	29.9	100.0
WATERBORNE WASTES	.35577	10.0	3.0	17.3	2.2	.1	44.6	100.0
POST-CONSUMER SOL WASTE	.18981	0.0	0.0	0.0	0.0	0.0	0.0	100.0
ENERGY SOURCE PETROLEUM	.09239	9.4	8.1	10.5	2.1	.2	38.6	100.0
ENERGY SOURCE NAT GAS	.10942	13.8	29.1	8.0	10.6	.1	26.1	100.0
ENERGY SOURCE COAL	.06059	9.9	8.0	28.5	.5	.0	22.6	100.0
ENERGY SOURCE NUCL HYPWR	.00823	15.9	13.3	8.9	.8	.1	34.5	100.0
ENERGY SOURCE WOOD WASTE	.10046	10.9	0.0	4.1	0.0	0.0	63.0	100.0

TABLE 48B

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE HUNDRED DISP DIAPERS #2

NAME	UNITS	CORRUGAT 1.22 LB	CARTONS 1.47 LB	POLY WRAPPERS 0.015 LB	CONVERT	DISPOSAL	TRANSPOR	TOTAL
INPUTS TO SYSTEMS								
MATERIAL COTTON	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFATE BRINE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL WOOD FIBER	POUND	.85034	.83210	0.00000	0.00000	0.00000	0.00000	9.21949
MATERIAL LIMESTONE	POUND	0.00000	.12560	0.00000	0.00000	0.00000	0.00000	.87277
MATERIAL IRON ORE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SALT	POUND	0.00000	.37448	0.00000	0.00000	0.00000	0.00000	1.49837
MATERIAL GLASS SAND	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL NAT SODA ASH	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL FELDSPAR	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL BAUXITE ORE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFUR	POUND	0.00000	.01588	0.00000	0.00000	0.00000	0.00000	.26524
ENERGY SOURCE PETROLEUM	MILL BTU	.00560	.01096	.00012	.00292	.00065	.00736	.09239
ENERGY SOURCE NAT GAS	MILL BTU	.00354	.00629	.00049	.00244	0.00000	0.00000	.10942
ENERGY SOURCE COAL	MILL BTU	.00338	.00818	.00007	.00684	0.00000	0.00000	.06059
ENERGY SOURCE MISC	MILL BTU	0.00000	.00062	.00002	.00155	0.00000	0.00000	.00823
ENERGY SOURCE WOOD FIBER	MILL BTU	.00714	.01496	0.00000	0.00000	0.00000	0.00000	.10046
ENERGY SOURCE HYDROPOWER	MILL BTU	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL POTASH	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL PHOSPHATE ROCK	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL CLAY	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL GYPSUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SILICA	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL PROCESS ADD	POUNDS	.08540	.13526	.00040	.00001	0.00000	0.00000	1.03291
ENERGY PROCESS	MIL BTU	.01954	.04058	.00029	.01404	0.00000	0.00000	.32291
ENERGY TRANSPORT	MIL BTU	.00011	.00044	.00002	0.00000	.00065	.00736	.01319
ENERGY OF MATL RESOURCE	MIL BTU	0.00000	0.00000	.00039	0.00000	0.00000	0.00000	.03539
WATER VOLUME	THOU GAL	.00039	.01697	.00006	.00022	.00004	.00042	.16628
OUTPUTS FROM SYSTEMS								
SOLID WASTES PROCESS	POUND	.08174	.23277	.00038	.02000	0.00000	0.00000	1.58131
SOLID WASTES FUEL COMB	POUND	.05533	.09214	.00044	.04022	.00016	.00148	.39393
SOLID WASTES MINING	POUND	.04821	.04850	.00119	.10952	0.00000	0.00000	.45456
SOLID WASTE POST-CONSUM	CUBIC FT	0.00000	0.00000	0.00000	0.00009	.18981	0.00000	.18981
ATMOSPHERIC PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
ATMOS PARTICULATES	POUND	.04763	.01501	.00011	.00851	.00007	.00127	.19071
ATMOS NITROGEN OXIDES	POUND	.01980	.01821	.00035	.01480	.00069	.01803	.26068
ATMOS HYDROCARBONS	POUND	.01149	.01086	.00082	.00576	.00070	.00659	.18450
ATMOS SULFUR OXIDES	POUND	.06769	.03440	.00045	.03760	.00017	.00402	.43659
ATMOS CARBON MONOXIDE	POUND	.00645	.00604	.00007	.00183	.02743	.00917	.09041
ATMOS ALDEHYDES	POUND	.00010	.00005	.00000	.00002	.00006	.00028	.00095
ATMOS OTHER ORGANICS	POUND	.00987	.00015	.00000	.00003	.00383	.00041	.01526
ATMOS ODOROUS SULFUR	POUND	0.00000	.00063	0.00000	0.00000	0.00000	0.00000	.01016
ATMOS AMMONIA	POUND	.00001	.00000	.00000	0.00000	.00000	.00002	.00020
ATMOS HYDROGEN FLOURIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
ATMOS LEAD	POUND	.00000	.00001	.00000	0.00000	.00001	.00001	.00007
ATMOS MERCURY	POUND	.00000	.00000	.00000	.00000	0.00000	0.00000	.00001
ATMOSPHERIC CHLORINE	POUND	0.00000	.00093	0.00000	0.00000	0.00000	0.00000	.00644
WATERBORNE DIS SOLIDS	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE FLUORIDES	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE DISS SOLIDS	POUND	.00669	.00694	.00009	.00041	.00035	.00359	.05812
WATERBORNE BOD	POUND	.02502	.00692	.00000	.00000	.00000	.00001	.10317
WATERBORNE PHENOL	POUND	.00000	.00000	.00000	.00000	.00000	.00000	.00002
WATERBORNE SULFIDES	POUND	.00000	.00000	.00000	.00000	.00000	.00000	.00002
WATERBORNE OIL	POUND	.00000	.00000	.00004	.00000	.00000	.00000	.00011
WATERBORNE COD	POUND	.00003	.00001	.00003	.00001	.00000	.00004	.03996
WATERBORNE SUSP SOLIDS	POUND	.01161	.01235	.00001	.00001	.00000	.00002	.12917
WATERBORNE ACID	POUND	.00051	.00201	.00002	.00210	.00000	.00001	.02033
WATERBORNE METAL ION	POUND	.00013	.00041	.00001	.00052	.00000	.00000	.00370
WATERBORNE CHEMICALS	POUND	.00093	0.00000	0.00000	0.00000	0.00000	0.00000	.00093
WATERBORNE CYANIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALKALINITY	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE CHROMIUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.00000
WATERBORNE IRON	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALUMINUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE NICKEL	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE MERCURY	POUND	0.00000	.00000	0.00000	0.00000	0.00000	0.00000	.00000
WATERBORNE LEAD	POUND	0.00000	.00000	0.00000	0.00000	0.00000	0.00000	.00000
WATERBORNE PHOSPHATES	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ZINC	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.00025
WATERBORNE AMMONIA	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.00001
WATERBORNE NITROGEN	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE PESTICID	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
SUMMARY OF ENVIRONMENTAL IMPACTS								
RAW MATERIALS	POUNDS	.93574	1.48320	.00040	.00001	0.00000	0.00000	12.88878
ENERGY	MIL BTU	.01965	.04102	.00070	.01404	.00065	.00736	.37109
WATER	THOU GAL	.00039	.01697	.00006	.00022	.00004	.00042	.16628
INDUSTRIAL SOLID WASTES	CUBIC FT	.00250	.00504	.00003	.00229	.00000	.00002	.03820
ATM EMMISSIONS	POUNDS	.16385	.08629	.00179	.06857	.03316	.03981	1.19597
WATERBORNE WASTES	POUNDS	.04492	.02823	.00016	.00345	.00035	.00368	.35577
POST-CONSUMER SOL WASTE	CUBIC FT	0.00000	0.00000	0.00000	0.00000	.18981	0.00000	.18981
ENERGY SOURCE PETROLEUM	MIL BTU	.00560	.01096	.00012	.00292	.00065	.00736	.09239
ENERGY SOURCE NAT GAS	MIL BTU	.00354	.00629	.00049	.00244	0.00000	0.00000	.10942
ENERGY SOURCE COAL	MIL BTU	.00338	.00818	.00007	.00684	0.00000	0.00000	.06059
ENERGY SOURCE NUCL HYPWR	MIL BTU	0.00000	.00062	.00002	.00155	0.00000	0.00000	.00823
ENERGY SOURCE WOOD WASTE	MIL BTU	.00714	.01496	0.00000	0.00000	0.00000	0.00000	.10046
INDEX OF ENVIRONMENTAL IMPACTS	STANDARD VALUES							
RAW MATERIALS	12.88878	7.3	11.5	.0	.0	0.0	0.0	100.0
ENERGY	.37109	5.3	11.1	.2	3.8	.2	2.0	100.0
WATER	.16628	.2	10.2	.0	.1	.0	.3	100.0
INDUSTRIAL SOLID WASTES	.03820	6.5	13.2	.1	6.0	.0	.1	100.0
ATM EMMISSIONS	1.19597	13.7	7.2	.2	5.7	2.8	3.3	100.0
WATERBORNE WASTES	.35577	12.6	7.9	.0	1.0	.1	1.0	100.0
POST-CONSUMER SOL WASTE	.18981	0.0	0.0	0.0	0.0	100.0	0.0	100.0
ENERGY SOURCE PETROLEUM	.09239	6.1	11.9	.1	3.0	.7	8.0	100.0
ENERGY SOURCE NAT GAS	.10942	3.2	5.7	.5	2.6	0.0	0.0	100.0
ENERGY SOURCE COAL	.06059	5.6	13.5	.1	11.3	0.0	0.0	100.0
ENERGY SOURCE NUCL HYPWR	.00823	0.0	7.6	.2	18.8	0.0	0.0	100.0
ENERGY SOURCE WOOD WASTE	.10046	7.1	14.9	0.0	0.0	0.0	0.0	100.0

TABLE 49

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE THOU CLOTH SHEETS 100 USES

NAME	UNITS	CLOTH SHEET COTTN ST 100 USES	CLOTH SHEET POLYE SY 100 USES	CLOTH SHEET MFG 100 USES	CLOTH SHEET PKG 100 USES	CLOTH SHEET TRAN 100 USES	CLOTH SHEET WASH 100 USES	CLOTH SHEET PCSW 100 USES	CLOTH SHEET SYS TOT 100 USES
INPUTS TO SYSTEMS									
MATERIAL COTTON	POUND	5.777	0.000	0.000	0.000	0.000	0.000	0.000	5.777
MATERIAL SULFATE BRINE	POUND	0.000	0.000	0.000	0.000	0.000	3.073	0.000	3.073
MATERIAL WOOD FIBER	POUND	0.000	0.000	0.000	.163	0.000	0.000	0.000	.163
MATERIAL LIMESTONE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	0.000	0.000	4.651	0.000	0.000	4.640	0.000	9.291
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000	0.000	1.635	0.000	1.635
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000	0.000	1.445	0.000	1.445
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	0.000	0.000	.114	0.000	0.000	.352	0.000	.465
ENERGY SOURCE PETROLEUM	MILL BTU	.026	.178	.107	.003	.017	.138	.014	.475
ENERGY SOURCE NAT GAS	MILL BTU	.008	.093	.164	.008	.000	4.902	0.000	5.177
ENERGY SOURCE COAL	MILL BTU	.001	.014	.245	.002	0.000	.176	0.000	.438
ENERGY SOURCE MISC	MILL BTU	.000	.003	.042	.000	0.000	.037	0.000	.083
ENERGY SOURCE WOOD FIBER	MILL BTU	0.000	0.000	0.000	.001	0.000	.001	0.000	.002
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	.001	0.000	0.000	0.000	0.000	0.000	0.000	.001
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	.054	.070	.674	.023	0.000	2.723	0.000	3.543
ENERGY PROCESS	MIL BTU	.031	.157	.558	.008	0.000	5.205	0.000	5.960
ENERGY TRANSPORT	MIL BTU	.000	.004	0.000	.000	.017	.020	.014	.055
ENERGY OF MATL RESOURCE	MIL BTU	.004	.128	0.000	.006	0.000	.021	0.000	.159
WATER VOLUME	THOU GAL	.006	.018	.229	.001	.001	3.677	.001	3.933
OUTPUTS FROM SYSTEMS									
SOLID WASTES PROCESS	POUND	1.335	.205	5.952	.022	0.000	56.991	0.000	64.503
SOLID WASTES FUEL COMB	POUND	.012	.101	1.234	.017	.004	1.009	.003	2.381
SOLID WASTES MINING	POUND	.016	.223	3.818	.028	0.000	3.129	0.000	7.214
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	0.000	0.000	0.000	0.000	.220	.220
ATMOSPHERIC PESTICIDE	POUND	.013	0.000	0.000	0.000	0.000	0.000	0.000	.013
ATMOS PARTICULATES	POUND	.029	.037	.573	.011	.002	.341	.001	.994
ATMOS NITROGEN OXIDES	POUND	.065	.131	.509	.009	.037	2.943	.015	3.708
ATMOS HYDROCARBONS	POUND	.051	.548	.253	.015	.015	4.756	.015	5.653
ATMOS SULFUR OXIDES	POUND	.015	.237	1.268	.020	.007	1.057	.004	2.607
ATMOS CARBON MONOXIDE	POUND	.065	.210	.078	.002	.056	.757	.119	1.289
ATMOS ALDEHYDES	POUND	.001	.001	.001	.000	.001	.011	.001	.016
ATMOS OTHER ORGANICS	POUND	.002	.001	.001	.002	.002	.029	.008	.045
ATMOS ODOROUS SULFUR	POUND	0.000	0.000	0.000	0.000	0.000	.084	0.000	.084
ATMOS AMMONIA	POUND	.001	.000	.000	.000	.000	.058	.000	.059
ATMOS HYDROGEN FLOURIDE	POUND	.000	0.000	0.000	0.000	0.000	0.000	0.000	.000
ATMOS LEAD	POUND	.000	.000	.000	.000	.000	.000	.000	.001
ATMOS MERCURY	POUND	.000	.000	.000	.000	0.000	.000	0.000	.000
ATMOSPHERIC CHLORINE	POUND	0.000	0.000	.073	0.000	0.000	.040	0.000	.063
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	0.000	.026	0.000	.026
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	.014	.079	.052	.003	.009	1.097	.007	1.260
WATERBORNE BOD	POUND	.000	.007	.045	.005	.000	1.065	.000	1.123
WATERBORNE PHENOL	POUND	.000	.000	.001	.000	.000	.000	.000	.001
WATERBORNE SULFIDES	POUND	.000	.000	.001	.000	.000	.000	.000	.001
WATERBORNE OIL	POUND	.000	.001	.000	.000	.000	.294	.000	.295
WATERBORNE COD	POUND	.000	.001	.520	.000	.000	.444	.000	.966
WATERBORNE SUSP SOLIDS	POUND	.143	.005	.110	.002	.000	1.071	.000	1.330
WATERBORNE ACID	POUND	.000	.004	.068	.000	.000	.060	.000	.133
WATERBORNE METAL ION	POUND	.000	.001	.016	.000	.000	.081	.000	.098
WATERBORNE CHEMICALS	POUND	.000	0.000	0.000	.000	0.000	.000	0.000	.001
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000	0.000	.002	0.000	.002
WATERBORNE CHROMIUM	POUND	0.000	.000	.001	0.000	0.000	.000	0.000	.001
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	0.000	0.000	.000	0.000	0.000	.000	0.000	.000
WATERBORNE LEAD	POUND	0.000	0.000	.000	0.000	0.000	.000	0.000	.000
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000	0.000	.005	0.000	.005
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	.000	.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE NITROGE	POUND	.000	0.000	0.000	0.000	0.000	.101	0.000	.101
WATERBORNE PESTICIDE	POUND	.003	0.000	0.000	0.000	0.000	.001	0.000	.003
SUMMARY OF ENVIRONMENTAL IMPACTS									
RAW MATERIALS	POUNDS	5.832	.070	5.430	.186	0.000	13.068	0.000	25.394
ENERGY	MIL BTU	.036	.288	.558	.015	.017	5.246	.014	6.174
WATER	THOU GAL	.006	.018	.229	.001	.001	3.677	.001	3.933
INDUSTRIAL SOLID WASTES	CUBIC FT	.018	.007	.149	.001	.008	.825	.000	1.000
ATM EMMISSIONS	POUNDS	.242	1.164	2.708	.059	.120	10.077	.163	14.532
WATERBORNE WASTES	POUNDS	.160	.099	.813	.011	.009	4.246	.007	5.346
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	0.000	0.000	0.000	0.000	.220	.220
ENERGY SOURCE PETROLEUM	MIL BTU	.026	.178	.107	.003	.017	.138	.014	.475
ENERGY SOURCE NAT GAS	MIL BTU	.008	.093	.164	.008	.000	4.902	0.000	5.177
ENERGY SOURCE COAL	MIL BTU	.001	.014	.245	.002	0.000	.176	0.000	.438
ENERGY SOURCE NUCL HYPWR	MIL BTU	.000	.003	.042	.000	0.000	.037	0.000	.083
ENERGY SOURCE WOOD WASTE	MIL BTU	0.000	0.000	0.000	.001	0.000	.001	0.000	.002
INDEX OF ENVIRONMENTAL IMPACTS	**STANDARD VALUES**								
RAW MATERIALS	25.394	23.0	.3	21.4	.7	0.0	54.6	0.0	100.0
ENERGY	6.174	.6	4.7	9.0	.2	.3	85.0	.2	100.0
WATER	3.933	.2	.5	5.8	.0	.0	93.5	.0	100.0
INDUSTRIAL SOLID WASTES	1.000	1.8	.7	14.8	.1	.0	82.5	.0	100.0
ATM EMMISSIONS	14.532	1.7	8.0	18.6	.4	.8	69.3	1.1	100.0
WATERBORNE WASTES	5.346	3.0	1.8	15.2	.2	.2	79.4	.1	100.0
POST-CONSUMER SOL WASTE	.220	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
ENERGY SOURCE PETROLEUM	.475	5.6	37.5	22.6	.6	3.6	27.3	2.9	100.0
ENERGY SOURCE NAT GAS	5.177	.2	1.8	3.2	.2	.0	94.7	0.0	100.0
ENERGY SOURCE COAL	.438	.2	3.2	56.0	.4	0.0	40.2	0.0	100.0
ENERGY SOURCE NUCL HYPWR	.083	.3	3.8	50.5	.3	0.0	45.1	0.0	100.0
ENERGY SOURCE WOOD WASTE	.002	0.0	0.0	0.0	71.4	0.0	28.6	0.0	100.0

TABLE 50

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE THOUSAND DISPOSABLE SHEETS

INPUTS TO SYSTEMS

NAME	UNITS	LDPE FILM SYS 143.2 LB	NONWOVEN FIBER SYS 107.4 LB	DISPOS SHEET MFG 1120 LB	DISPOS SHEET SYS PKG 4.1 LB	DISPOS SHEET SYS PCSW 238 LB	DISPOS SHEET SYS TRAN M SHEETS	DISPOS SHEET SYS TOT M SHEETS
MATERIAL COTTON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	0.000	0.000	.000	0.000	0.000	0.000	.000
MATERIAL WOOD FIBER	POUND	0.000	73.931	0.000	2.858	0.000	0.000	76.789
MATERIAL LIMESTONE	POUND	0.000	7.329	0.000	0.000	0.000	0.000	7.329
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	0.000	8.637	0.000	0.000	0.000	0.000	8.637
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	0.000	.921	0.000	0.000	0.000	0.000	.921
ENERGY SOURCE PETROLEUM	MILL BTU	1.094	.609	.032	.019	.013	.262	2.025
ENERGY SOURCE NAT GAS	MILL BTU	4.651	1.063	.032	.012	0.000	.014	5.768
ENERGY SOURCE COAL	MILL BTU	.707	.420	.077	.011	0.000	0.000	1.207
ENERGY SOURCE MISC	MILL BTU	.160	.092	.017	0.000	0.000	0.000	.267
ENERGY SOURCE WOOD FIBER	MILL BTU	0.000	.769	0.000	.024	0.000	0.000	.793
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	3.751	8.966	0.000	.287	0.000	0.000	13.004
ENERGY PROCESS	MIL BTU	2.765	2.937	.157	.066	0.000	0.000	5.907
ENERGY TRANSPORT	MIL BTU	.188	.016	0.000	.000	.013	.276	.492
ENERGY OF MATL RESOURCE	MIL BTU	3.659	0.000	0.000	0.000	0.000	0.000	3.659
WATER VOLUME	THOU GAL	.549	1.756	.002	.001	.001	.015	2.325

OUTPUTS FROM SYSTEMS

NAME	UNITS	LDPE FILM SYS 143.2 LB	NONWOVEN FIBER SYS 107.4 LB	DISPOS SHEET MFG 1120 LB	DISPOS SHEET SYS PKG 4.1 LB	DISPOS SHEET SYS PCSW 238 LB	DISPOS SHEET SYS TRAN M SHEETS	DISPOS SHEET SYS TOT M SHEETS
SOLID WASTES PROCESS	POUND	4.108	14.418	.002	.275	0.000	0.000	18.803
SOLID WASTES FUEL COMB	POUND	4.159	2.524	.450	.186	.003	.061	7.335
SOLID WASTES MINING	POUND	11.323	6.695	1.227	.162	0.000	0.000	19.275
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	0.000	0.000	3.737	0.000	3.737
ATMOSPHERIC PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	1.034	1.057	.095	.160	.001	.038	2.375
ATMOS NITROGEN OXIDES	POUND	3.304	2.116	.166	.067	.014	.677	6.325
ATMOS HYDROCARBONS	POUND	7.720	1.343	.065	.040	.014	.240	9.415
ATMOS SULFUR OXIDES	POUND	4.245	3.099	.421	.227	.003	.120	8.071
ATMOS CARBON MONOXIDE	POUND	.636	.353	.021	.023	.544	.594	2.168
ATMOS ALDEHYDES	POUND	.005	.005	.000	.000	.001	.011	.022
ATMOS OTHER ORGANICS	POUND	.010	.010	.000	.033	.075	.022	.150
ATMOS ODOROUS SULFUR	POUND	0.000	.066	0.000	0.000	0.000	0.000	.066
ATMOS AMMONIA	POUND	.000	.000	0.000	.000	.000	.001	.001
ATMOS HYDROGEN FLOURIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS LEAD	POUND	.000	.000	0.000	.000	.000	.001	.002
ATMOS MERCURY	POUND	.000	.000	.000	.000	0.000	0.000	.000
ATMOSPHERIC CHLORINE	POUND	0.000	.042	0.000	0.000	0.000	0.000	.042
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	.841	.414	.009	.022	.007	.132	1.425
WATERBORNE BOD	POUND	.038	.801	.000	.084	.000	.000	.923
WATERBORNE PHENOL	POUND	.000	.000	.000	.000	.000	.000	.000
WATERBORNE SULFIDES	POUND	.000	.000	.000	.000	.000	.000	.000
WATERBORNE OIL	POUND	.009	.000	.000	.000	.000	.000	.009
WATERBORNE COD	POUND	.289	.001	.000	.000	.000	.001	.291
WATERBORNE SUSP SOLIDS	POUND	.093	1.092	.000	.039	.000	.001	1.224
WATERBORNE ACID	POUND	.217	.146	.023	.002	.000	.000	.386
WATERBORNE METAL ION	POUND	.054	.032	.006	.000	.000	.000	.092
WATERBORNE CHEMICALS	POUND	0.000	0.000	0.000	.003	0.000	0.000	.003
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE CHROMIUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	0.000	.000	0.000	0.000	0.000	0.000	.000
WATERBORNE LEAD	POUND	0.000	.000	0.000	0.000	0.000	0.000	.000
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NITROGE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE PESTICI--	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000

SUMMARY OF ENVIRONMENTAL IMPACTS

NAME	UNITS	LDPE FILM SYS 143.2 LB	NONWOVEN FIBER SYS 107.4 LB	DISPOS SHEET MFG 1120 LB	DISPOS SHEET SYS PKG 4.1 LB	DISPOS SHEET SYS PCSW 238 LB	DISPOS SHEET SYS TRAN M SHEETS	DISPOS SHEET SYS TOT M SHEETS
RAW MATERIALS	POUNDS	3.751	99.784	.000	3.145	0.000	0.000	106.680
ENERGY	MIL BTU	6.612	2.952	.157	.066	.013	.276	10.059
WATER	THOU GAL	.549	1.756	.002	.001	.001	.015	2.325
INDUSTRIAL SOLID WASTES	CUBIC FT	.264	.319	.023	.008	.000	.001	.613
ATM EMMISSIONS	POUNDS	16.994	8.092	.768	.551	.653	1.702	28.637
WATERBORNE WASTES	POUNDS	1.541	2.486	.039	.151	.007	.135	4.354
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	0.000	0.000	3.737	0.000	3.737
ENERGY SOURCE PETROLEUM	MIL BTU	1.094	.609	.032	.019	.013	.262	2.025
ENERGY SOURCE NAT GAS	MIL BTU	4.651	1.063	.032	.012	0.000	.014	5.768
ENERGY SOURCE COAL	MIL BTU	.707	.420	.077	.011	0.000	0.000	1.207
ENERGY SOURCE NUCL HYPWR	MIL BTU	.160	.092	.017	0.000	0.000	0.000	.267
ENERGY SOURCE WOOD WASTE	MIL BTU	0.000	.769	0.000	.024	0.000	0.000	.793

INDEX OF ENVIRONMENTAL IMPACTS

NAME	STANDARD VALUES	LDPE FILM SYS 143.2 LB	NONWOVEN FIBER SYS 107.4 LB	DISPOS SHEET MFG 1120 LB	DISPOS SHEET SYS PKG 4.1 LB	DISPOS SHEET SYS PCSW 238 LB	DISPOS SHEET SYS TRAN M SHEETS	DISPOS SHEET SYS TOT M SHEETS
RAW MATERIALS	106.680	3.5	93.5	.0	2.9	0.0	0.0	100.0
ENERGY	10.059	65.7	29.3	1.6	.7	.1	2.7	100.0
WATER	2.325	23.6	75.5	.1	.1	.0	.7	100.0
INDUSTRIAL SOLID WASTES	.613	43.1	52.0	3.7	1.4	.0	.1	100.0
ATM EMMISSIONS	28.637	59.2	28.3	2.7	1.9	2.3	5.9	100.0
WATERBORNE WASTES	4.354	35.4	57.1	.9	3.5	.2	3.1	100.0
POST-CONSUMER SOL WASTE	3.737	0.0	0.0	0.0	0.0	100.0	0.0	100.0
ENERGY SOURCE PETROLEUM	2.025	54.0	30.1	1.6	.9	.6	12.9	100.0
ENERGY SOURCE NAT GAS	5.768	80.6	18.4	.6	.2	0.0	.2	100.0
ENERGY SOURCE COAL	1.207	58.6	34.8	6.3	.9	0.0	0.0	100.0
ENERGY SOURCE NUCL HYPWR	.267	59.8	34.4	6.5	0.0	0.0	0.0	100.0
ENERGY SOURCE WOOD WASTE	.793	0.0	97.0	0.0	3.0	0.0	0.0	100.0

TABLE 51

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE MILLION GLASS TUMB 1000 USES

INPUTS TO SYSTEMS NAME	UNITS	GLASS TUMBLER RAW MAT 1000 USE	GLASS TUMBLER MFG 1000 USE	GLASS TUMBLER PKG 1000 USE	GLASS TUMBLER TRAN SYS 1000 USE	GLASS TUMBLER WASH	GLASS TUMBLER PCSW 1000 USE	GLASS TUMBLER SYS TOT 1000 USE
MATERIAL COTTON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	0.000	0.000	0.000	0.000	637.056	0.000	637.056
MATERIAL WOOD FIBER	POUND	0.000	0.000	81.549	0.000	0.000	0.000	81.549
MATERIAL LIMESTONE	POUND	26.772	0.000	0.000	0.000	0.000	0.000	26.772
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	0.000	0.000	0.000	0.000	64.246	0.000	64.246
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000	278.488	0.000	278.488
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000	246.150	0.000	246.150
MATERIAL FELDSPAR	POUND	22.371	0.000	0.000	0.000	0.000	0.000	22.371
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	0.000	0.000	0.000	0.000	71.937	0.000	71.937
ENERGY SOURCE PETROLEUM	MILL BTU	.120	.167	.537	.130	20.115	.006	21.075
ENERGY SOURCE NAT GAS	MILL BTU	.266	1.558	.339	.000	116.484	0.000	118.648
ENERGY SOURCE COAL	MILL BTU	.047	.190	.324	0.000	35.222	0.000	35.783
ENERGY SOURCE MISC	MILL BTU	.003	.043	0.000	0.000	7.869	0.000	7.914
ENERGY SOURCE WOOD FIBER	MILL BTU	0.000	0.000	.685	0.000	.114	0.000	.798
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	0.000	2.910	8.190	0.000	233.548	0.000	244.648
ENERGY PROCESS	MIL BTU	.434	1.958	1.874	0.000	175.165	0.000	179.431
ENERGY TRANSPORT	MIL BTU	.002	0.000	.011	.130	.349	.006	.497
ENERGY OF MATL RESOURCE	MIL BTU	0.000	0.000	0.000	0.000	4.291	0.000	4.291
WATER VOLUME	THOU GAL	.278	.108	.037	.007	86.091	.000	86.522

OUTPUTS FROM SYSTEMS NAME	UNITS	GLASS TUMBLER RAW MAT 1000 USE	GLASS TUMBLER MFG 1000 USE	GLASS TUMBLER PKG 1000 USE	GLASS TUMBLER TRAN SYS 1000 USE	GLASS TUMBLER WASH	GLASS TUMBLER PCSW 1000 USE	GLASS TUMBLER SYS TOT 1000 USE
SOLID WASTES PROCESS	POUND	2.436	3.783	7.839	0.000	98.983	0.000	113.041
SOLID WASTES FUEL COMB	POUND	.179	1.136	5.307	.030	206.769	.001	213.421
SOLID WASTES MINING	POUND	54.664	3.041	4.624	0.000	628.546	0.000	690.875
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	0.000	0.000	0.000	1.833	1.833
ATMOSPHERIC PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	1.284	.570	4.567	.017	49.486	.001	55.926
ATMOS NITROGEN OXIDES	POUND	.266	1.245	1.898	.287	130.730	.006	134.433
ATMOS HYDROCARBONS	POUND	.302	1.589	1.141	.104	129.874	.006	133.016
ATMOS SULFUR OXIDES	POUND	.310	1.441	6.491	.057	200.270	.002	208.569
ATMOS CARBON MONOXIDE	POUND	.066	.228	.657	.319	26.689	.042	28.001
ATMOS ALDEHYDES	POUND	.002	.004	.010	.005	.350	.001	.372
ATMOS OTHER ORGANICS	POUND	.002	.008	.946	.012	.729	.002	1.699
ATMOS ODOROUS SULFUR	POUND	0.000	0.000	0.000	0.000	1.184	0.000	1.184
ATMOS AMMONIA	POUND	.000	.000	.001	.000	.821	.000	.824
ATMOS HYDROGEN FLOURIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS LEAD	POUND	.000	.000	.000	.001	.006	.000	.007
ATMOS MERCURY	POUND	.000	.000	.000	0.000	.003	0.000	.003
ATMOSPHERIC CHLORINE	POUND	0.000	0.000	0.000	0.000	.323	0.000	.323
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	.103	.322	.641	.064	353.608	.003	354.742
WATERBORNE BOD	POUND	.000	.000	2.399	.000	4.072	.000	6.471
WATERBORNE PHENOL	POUND	.000	.000	.000	.000	.004	.000	.005
WATERBORNE SULFIDES	POUND	.000	.000	.000	.000	.006	.000	.006
WATERBORNE OIL	POUND	.000	.000	.000	.000	.077	.000	.077
WATERBORNE COD	POUND	.001	.001	.003	.001	6.387	.000	6.391
WATERBORNE SUSP SOLIDS	POUND	.097	.021	1.113	.000	7.956	.000	9.188
WATERBORNE ACID	POUND	.009	.058	.049	.000	12.231	.000	12.348
WATERBORNE METAL ION	POUND	.002	.015	.012	.000	2.685	.000	2.714
WATERBORNE CHEMICALS	POUND	0.000	0.000	.089	0.000	.009	0.000	.098
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000	.380	0.000	.380
WATERBORNE CHROMIUM	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE LEAD	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000	.074	0.000	.074
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	0.000	0.000	0.000	0.000	.005	0.000	.005
WATERBORNE NITROGEN	POUND	0.000	0.000	0.000	0.000	1.427	0.000	1.427
WATERBORNE PESTICIDE	POUND	0.000	0.000	0.000	0.000	.008	0.000	.008

SUMMARY OF ENVIRONMENTAL IMPACTS NAME	UNITS	GLASS TUMBLER RAW MAT 1000 USE	GLASS TUMBLER MFG 1000 USE	GLASS TUMBLER PKG 1000 USE	GLASS TUMBLER TRAN SYS 1000 USE	GLASS TUMBLER WASH	GLASS TUMBLER PCSW 1000 USE	GLASS TUMBLER SYS TOT 1000 USE
RAW MATERIALS	POUNDS	49.143	2.910	89.739	0.000	1531.424	0.000	1673.216
ENERGY	MIL BTU	.436	1.958	1.884	.130	179.804	.006	184.218
WATER	THOU GAL	.278	.108	.037	.007	86.091	.000	86.522
INDUSTRIAL SOLID WASTES	CUBIC FT	.773	.107	.240	.000	12.613	.000	13.734
ATM EMMISSIONS	POUNDS	2.233	5.084	15.713	.802	540.465	.060	564.357
WATERBORNE WASTES	POUNDS	.213	.416	4.308	.066	388.927	.003	393.933
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	0.000	0.000	0.000	1.833	1.833
ENERGY SOURCE PETROLEUM	MIL BTU	.120	.167	.537	.130	20.115	.006	21.075
ENERGY SOURCE NAT GAS	MIL BTU	.266	1.558	.339	.000	116.484	0.000	118.648
ENERGY SOURCE COAL	MIL BTU	.047	.190	.324	0.000	35.222	0.000	35.783
ENERGY SOURCE NUCL HYPWR	MIL BTU	.003	.043	0.000	0.000	7.869	0.000	7.914
ENERGY SOURCE WOOD WASTE	MIL BTU	0.000	0.000	.685	0.000	.114	0.000	.798

INDEX OF ENVIRONMENTAL IMPACTS NAME	STANDARD VALUES	GLASS TUMBLER RAW MAT 1000 USE	GLASS TUMBLER MFG 1000 USE	GLASS TUMBLER PKG 1000 USE	GLASS TUMBLER TRAN SYS 1000 USE	GLASS TUMBLER WASH	GLASS TUMBLER PCSW 1000 USE	GLASS TUMBLER SYS TOT 1000 USE
RAW MATERIALS	1673.216	2.9	.2	5.4	0.0	91.5	0.0	100.0
ENERGY	184.218	.2	1.1	1.0	.1	97.6	.0	100.0
WATER	86.522	.3	.1	.0	.0	99.5	.0	100.0
INDUSTRIAL SOLID WASTES	13.734	5.6	.8	1.7	.0	91.8	.0	100.0
ATM EMMISSIONS	564.357	.4	.9	2.8	.1	95.8	.0	100.0
WATERBORNE WASTES	393.933	.1	.1	1.1	.0	98.7	.0	100.0
POST-CONSUMER SOL WASTE	1.833	0.0	0.0	0.0	0.0	0.0	100.0	100.0
ENERGY SOURCE PETROLEUM	21.075	.6	.8	2.5	.6	95.4	.0	100.0
ENERGY SOURCE NAT GAS	118.648	.2	1.3	.3	.0	98.2	0.0	100.0
ENERGY SOURCE COAL	35.783	.1	.5	.9	0.0	98.4	0.0	100.0
ENERGY SOURCE NUCL HYPWR	7.914	.0	.5	0.0	0.0	99.4	0.0	100.0
ENERGY SOURCE WOOD WASTE	.798	0.0	0.0	85.8	0.0	14.2	0.0	100.0

TABLE 52

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE MILLN POLYPROP TUMB 1000 USE

INPUTS TO SYSTEMS

NAME	UNITS	POLYPROP TUMBLER RESIN SY 1000 USE	POLYPROP TUMBLER MFG 1000 USE	POLYPROP TUMBLER PKG 1000 USE	POLYPROP TUMBLER TRAN 1000 USE	POLYPROP TUMBLER WASH 1000 USE	POLYPROP TUMBLER PCSW 1000 USE	POLYPROP TUMBLER SYS TOT 1000 USE
MATERIAL COTTON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	0.000	0.000	0.000	0.000	637.056	0.000	637.056
MATERIAL WOOD FIBER	POUND	0.000	0.000	5.808	0.000	0.000	0.000	5.808
MATERIAL LIMESTONE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	0.000	0.000	0.000	0.000	64.246	0.000	64.246
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000	278.488	0.000	278.488
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000	246.150	0.000	246.150
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	0.000	0.000	0.000	0.000	71.937	0.000	71.937
ENERGY SOURCE PETROLEUM	MILL BTU	.057	.046	.045	.043	20.115	4.856	25.163
ENERGY SOURCE NAT GAS	MILL BTU	3.557	.047	.052	.004	116.484	0.000	120.143
ENERGY SOURCE COAL	MILL BTU	.134	.113	.027	0.000	35.222	0.000	35.496
ENERGY SOURCE MISC	MILL BTU	.030	.025	.001	0.000	7.869	0.000	7.926
ENERGY SOURCE WOOD FIBER	MILL BTU	0.000	0.000	.049	0.000	.114	0.000	.162
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	4.102	0.000	.605	0.000	233.548	0.000	238.255
ENERGY PROCESS	MIL BTU	1.406	.232	.150	0.000	175.165	0.000	176.952
ENERGY TRANSPORT	MIL BTU	.136	0.000	.002	.047	.349	4.856	5.389
ENERGY OF MATL RESOURCE	MIL BTU	2.237	0.000	.022	0.000	4.291	0.000	6.549
WATER VOLUME	THOU GAL	.311	.161	.006	.003	86.091	.302	86.873

OUTPUTS FROM SYSTEMS

NAME	UNITS	RESIN SY	MFG	PKG	TRAN	WASH	PCSW	SYS TOT
SOLID WASTES PROCESS	POUND	2.311	.441	.579	0.000	98.983	0.000	102.314
SOLID WASTES FUEL COMB	POUND	.790	.663	.402	.010	206.769	1.213	209.847
SOLID WASTES MINING	POUND	2.150	1.806	.395	0.000	628.546	0.000	632.898
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	0.000	0.000	0.000	1.413	1.413
ATMOSPHERIC PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	.191	.140	.331	.006	49.486	.509	50.663
ATMOS NITROGEN OXIDES	POUND	1.672	.244	.159	.117	130.730	5.184	138.102
ATMOS HYDROCARBONS	POUND	6.655	.095	.127	.041	129.874	5.271	142.062
ATMOS SULFUR OXIDES	POUND	1.012	.620	.487	.018	200.270	1.263	203.670
ATMOS CARBON MONOXIDE	POUND	.380	.030	.051	.115	26.689	35.061	62.326
ATMOS ALDEHYDES	POUND	.003	.000	.001	.002	.350	.416	.771
ATMOS OTHER ORGANICS	POUND	.006	.001	.067	.004	.729	1.518	2.325
ATMOS ODOROUS SULFUR	POUND	0.000	0.000	0.000	0.000	1.184	0.000	1.184
ATMOS AMMONIA	POUND	.000	0.000	.000	.000	.821	.013	.835
ATMOS HYDROGEN FLOURIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS LEAD	POUND	.000	0.000	.000	.000	.006	.101	.106
ATMOS MERCURY	POUND	.000	.000	.000	0.000	.003	0.000	.003
ATMOSPHERIC CHLORINE	POUND	0.000	0.000	0.000	0.000	.323	0.000	.323
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	.430	.013	.051	.022	353.608	2.590	356.715
WATERBORNE BOD	POUND	.043	.000	.171	.000	4.072	.007	4.292
WATERBORNE PHENOL	POUND	.000	.000	.000	.000	.004	.002	.007
WATERBORNE SULFIDES	POUND	.000	.000	.000	.000	.006	.003	.009
WATERBORNE OIL	POUND	.004	.000	.000	.000	.077	.003	.084
WATERBORNE COD	POUND	.186	.000	.002	.000	6.387	.027	6.602
WATERBORNE SUSP SOLIDS	POUND	.111	.000	.080	.000	7.956	.017	8.164
WATERBORNE ACID	POUND	.041	.035	.005	.000	12.231	.005	12.317
WATERBORNE METAL ION	POUND	.010	.009	.001	.000	2.685	.001	2.707
WATERBORNE CHEMICALS	POUND	0.000	0.000	.006	0.000	.009	0.000	.015
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000	.380	0.000	.380
WATERBORNE CHROMIUM	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE LEAD	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000	.074	0.000	.074
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	0.000	0.000	0.000	0.000	.005	0.000	.005
WATERBORNE NITROGEN	POUND	0.000	0.000	0.000	0.000	1.427	0.000	1.427
WATERBORNE PESTICIDE	POUND	0.000	0.000	0.000	0.000	.008	0.000	.008

SUMMARY OF ENVIRONMENTAL IMPACTS

NAME	UNITS	RESIN SY	MFG	PKG	TRAN	WASH	PCSW	SYS TOT
RAW MATERIALS	POUNDS	4.102	0.000	6.414	0.000	1531.424	0.000	1541.940
ENERGY	MIL BTU	3.779	.232	.173	.047	179.804	4.856	188.890
WATER	THOU GAL	.311	.161	.006	.003	86.091	.302	86.873
INDUSTRIAL SOLID WASTES	CUBIC FT	.071	.039	.019	.000	12.613	.016	12.758
ATM EMMISSIONS	POUNDS	9.919	1.131	1.219	.302	540.465	49.336	602.370
WATERBORNE WASTES	POUNDS	.826	.057	.316	.023	388.927	2.656	392.804
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	0.000	0.000	0.000	1.413	1.413
ENERGY SOURCE PETROLEUM	MIL BTU	.057	.046	.045	.043	20.115	4.856	25.163
ENERGY SOURCE NAT GAS	MIL BTU	3.557	.047	.052	.004	116.484	0.000	120.143
ENERGY SOURCE COAL	MIL BTU	.134	.113	.027	0.000	35.222	0.000	35.496
ENERGY SOURCE NUCL HYPWR	MIL BTU	.030	.025	.001	0.000	7.869	0.000	7.926
ENERGY SOURCE WOOD WASTE	MIL BTU	0.000	0.000	.049	0.000	.114	0.000	.162

INDEX OF ENVIRONMENTAL IMPACTS

NAME	STANDARD VALUES	RESIN SY	MFG	PKG	TRAN	WASH	PCSW	SYS TOT
RAW MATERIALS	1541.940	.3	0.0	.4	0.0	99.3	0.0	100.0
ENERGY	188.890	2.0	.1	.1	.0	95.2	2.6	100.0
WATER	86.873	.4	.2	.0	.0	99.1	.3	100.0
INDUSTRIAL SOLID WASTES	12.758	.6	.3	.1	.0	98.9	.1	100.0
ATM EMMISSIONS	602.370	1.6	.2	.2	.1	89.7	8.2	100.0
WATERBORNE WASTES	392.804	.2	.0	.1	.0	99.0	.7	100.0
POST-CONSUMER SOL WASTE	1.413	0.0	0.0	0.0	0.0	0.0	100.0	100.0
ENERGY SOURCE PETROLEUM	25.163	.2	.2	.2	.2	79.9	19.3	100.0
ENERGY SOURCE NAT GAS	120.143	3.0	.0	.0	.0	97.0	0.0	100.0
ENERGY SOURCE COAL	35.496	.4	.3	.1	0.0	99.2	0.0	100.0
ENERGY SOURCE NUCL HYPWR	7.926	.4	.3	.0	0.0	99.3	0.0	100.0
ENERGY SOURCE WOOD WASTE	.162	0.0	0.0	30.1	0.0	69.9	0.0	100.0

TABLE 53

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE MILLION THERMOFORMED 9OZ CUP

INPUTS TO SYSTEMS NAME	UNITS	POLYSTY RESIN SY 14120 LB	POLYSTY THERMO F 9OZ CUP MFG	POLYSTY THERMO F 9OZ CUP PKG	POLYSTY THERMO F 9OZ CUP TRAN	POLYSTY THERMO F 9OZ CUP PCSW	POLYSTY THERMO F 9OZ CUP SYS TOT
MATERIAL COTTON	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL SULFATE BRINE	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL WOOD FIBER	POUND	0.00	0.00	710.94	0.00	0.00	710.94
MATERIAL LIMESTONE	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL IRON ORE	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL SALT	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL GLASS SAND	POUND	0.00	0.00	0.00	0.00	0.00	0 00
MATERIAL NAT SODA ASH	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL FELDSPAR	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL BAUXITE ORE	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL SULFUR	POUND	0.00	0.00	0.00	0.00	0.00	0.00
ENERGY SOURCE PETROLEUM	MILL BTU	319.58	17.95	5.61	25.41	7.25	375.81
ENERGY SOURCE NAT GAS	MILL BTU	216.77	18.12	6.91	1.31	0.00	243.11
ENERGY SOURCE COAL	MILL BTU	12.16	43.59	3.42	0.00	0.00	59.16
ENERGY SOURCE MISC	MILL BTU	2.75	9.85	.13	0.00	0.00	12.74
ENERGY SOURCE WOOD FIBER	MILL BTU	0.00	0.00	5.97	0.00	0.00	5.97
ENERGY SOURCE HYDROPOWER	MILL BTU	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL POTASH	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL PHOSPHATE ROCK	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL CLAY	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL GYPSUM	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL SILICA	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL PROCESS ADD	POUNDS	698.68	0.00	74.59	0.00	0.00	773.27
ENERGY PROCESS	MIL BTU	201.28	89.51	18.68	0.00	0.00	309.46
ENERGY TRANSPORT	MIL BTU	9.17	0.00	.25	26.73	7.25	43.40
ENERGY OF MATL RESOURCE	MIL BTU	340.81	0.00	3.11	0.00	0.00	343.93
WATER VOLUME	THOU GAL	46.77	1.42	.79	1.48	.45	50.91

OUTPUTS FROM SYSTEMS NAME	UNITS	POLYSTY RESIN SY 14120 LB	POLYSTY THERMO F 9OZ CUP MFG	POLYSTY THERMO F 9OZ CUP PKG	POLYSTY THERMO F 9OZ CUP TRAN	POLYSTY THERMO F 9OZ CUP PCSW	POLYSTY THERMO F 9OZ CUP SYS TOT
SOLID WASTES PROCESS	POUND	658.95	190.00	71.34	0.00	0.00	920.30
SOLID WASTES FUEL COMB	POUND	82.46	256.34	49.76	5.86	1.81	396.24
SOLID WASTES MINING	POUND	194.68	698.06	49.84	0.00	0.00	942.58
SOLID WASTE POST-CONSUM	CUBIC FT	0.00	0.00	0.00	0.00	186.75	186.75
ATMOSPHERIC PESTICIDE	POUND	0.00	0.00	0.00	0.00	0.00	0.00
ATMOS PARTICULATES	POUND	30.05	54.28	40.69	3.33	.76	129.11
ATMOS NITROGEN OXIDES	POUND	177.75	94.36	19.35	66.26	7.75	365.46
ATMOS HYDROCARBONS	POUND	490.97	36.74	16.51	21.15	7.88	573.25
ATMOS SULFUR OXIDES	POUND	167.25	239.65	60.17	11.29	1.89	480.24
ATMOS CARBON MONOXIDE	POUND	242.87	11.69	6.27	55.15	78.89	394.87
ATMOS ALDEHYDES	POUND	.78	.16	.09	.91	.62	2.56
ATMOS OTHER ORGANICS	POUND	.80	.21	8.26	1.74	6.45	17.47
ATMOS ODOROUS SULFUR	POUND	0.00	0.00	0.00	0.00	0.00	0.00
ATMOS AMMONIA	POUND	.12	0.00	.01	.06	.02	.22
ATMOS HYDROGEN FLOURIDE	POUND	0.00	0.00	0.00	0.00	0.00	0.00
ATMOS LEAD	POUND	.00	0.00	.00	.07	.15	.23
ATMOS MERCURY	POUND	.00	.00	.00	0.00	0.00	.01
ATMOSPHERIC CHLORINE	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE DIS SOLIDS	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE FLUORIDES	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE DISS SOLIDS	POUND	136.78	5.16	6.31	12.74	3.87	164.86
WATERBORNE BOD	POUND	8.53	.01	20.99	.03	.01	29.56
WATERBORNE PHENOL	POUND	.02	.00	.00	.01	.00	.05
WATERBORNE SULFIDES	POUND	.03	.01	.00	.01	.00	.06
WATERBORNE OIL	POUND	1.77	.01	.01	.02	.01	1.81
WATERBORNE COD	POUND	21.00	.05	.27	.13	.04	21.49
WATERBORNE SUSP SOLIDS	POUND	14.98	.03	9.78	.08	.03	24.91
WATERBORNE ACID	POUND	3.77	13.37	.61	.02	.01	17.79
WATERBORNE METAL ION	POUND	.94	3.34	.15	.01	.00	4.45
WATERBORNE CHEMICALS	POUND	0.00	0.00	.78	0.00	0.00	.78
WATERBORNE CYANIDE	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE ALKALINITY	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE CHROMIUM	POUND	.02	0.00	0.00	0.00	0.00	.02
WATERBORNE IRON	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE ALUMINUM	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE NICKEL	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE MERCURY	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE LEAD	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE PHOSPHATES	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE ZINC	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE AMMONIA	POUND	.24	0.00	0.00	0.00	0.00	.24
WATERBORNE NITROGEN	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE PESTICIDE	POUND	0.00	0.00	0.00	0.00	0.00	0.00

SUMMARY OF ENVIRONMENTAL IMPACTS NAME	UNITS	POLYSTY RESIN SY 14120 LB	POLYSTY THERMO F 9OZ CUP MFG	POLYSTY THERMO F 9OZ CUP PKG	POLYSTY THERMO F 9OZ CUP TRAN	POLYSTY THERMO F 9OZ CUP PCSW	POLYSTY THERMO F 9OZ CUP SYS TOT
RAW MATERIALS	POUNDS	698.68	0.00	785.53	0.00	0.00	1484.21
ENERGY	MIL BTU	551.26	89.51	22.04	26.73	7.25	696.79
WATER	THOU GAL	46.77	1.42	.79	1.48	.45	50.91
INDUSTRIAL SOLID WASTES	CUBIC FT	12.64	15.45	2.31	.08	.02	30.50
ATM EMMISSIONS	POUNDS	1110.60	437.08	181.34	159.98	104.40	1963.40
WATERBORNE WASTES	POUNDS	188.18	21.99	38.86	13.06	3.97	265.98
POST-CONSUMER SOL WASTE	CUBIC FT	0.00	0.00	0.00	0.00	186.75	186.75
ENERGY SOURCE PETROLEUM	MIL BTU	319.58	17.95	5.61	25.41	7.25	375.81
ENERGY SOURCE NAT GAS	MIL BTU	216.77	18.12	6.91	1.31	0.00	243.11
ENERGY SOURCE COAL	MIL BTU	12.16	43.59	3.42	0.00	0.00	59.16
ENERGY SOURCE NUCL HYPWR	MIL BTU	2.75	9.85	.13	0.00	0.00	12.74
ENERGY SOURCE WOOD WASTE	MIL BTU	0.00	0.00	5.97	0.00	0.00	5.97

INDEX OF ENVIRONMENTAL IMPACTS NAME	STANDARD VALUES	POLYSTY RESIN SY 14120 LB	POLYSTY THERMO F 9OZ CUP MFG	POLYSTY THERMO F 9OZ CUP PKG	POLYSTY THERMO F 9OZ CUP TRAN	POLYSTY THERMO F 9OZ CUP PCSW	POLYSTY THERMO F 9OZ CUP SYS TOT
RAW MATERIALS	1484.21	47.1	0.0	52.9	0.0	0.0	100.0
ENERGY	696.79	79.1	12.8	3.2	3.8	1.0	100.0
WATER	50.91	91.9	2.8	1.5	2.9	.9	100.0
INDUSTRIAL SOLID WASTES	30.50	41.4	50.7	7.6	.3	.1	100.0
ATM EMMISSIONS	1963.40	56.6	22.3	7.7	8.1	5.3	100.0
WATERBORNE WASTES	265.98	70.7	8.3	14.6	4.9	1.5	100.0
POST-CONSUMER SOL WASTE	186.75	0.0	0.0	0.0	0.0	100.0	100.0
ENERGY SOURCE PETROLEUM	375.81	85.0	4.8	1.5	6.8	1.9	100.0
ENERGY SOURCE NAT GAS	243.11	89.2	7.5	2.8	.5	0.0	100.0
ENERGY SOURCE COAL	59.16	20.5	73.7	5.8	0.0	0.0	100.0
ENERGY SOURCE NUCL HYPWR	12.74	21.6	77.4	1.1	0.0	0.0	100.0
ENERGY SOURCE WOOD WASTE	5.97	0.0	0.0	100.0	0.0	0.0	100.0

TABLE 54A

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

MIL 9 OZ PAP-WAX CD CUPS P1 OF 2

INPUTS TO SYSTEMS NAME	UNITS	PULPWOOD HARVEST 14000 LB	PULP AND MATERIAL 12490 LB	PULP MAN 12490 LB	WAX 5340 LB	CONVERT	POLY BAGS 160 LB	TOTAL
MATERIAL COTTON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL WOOD FIBER	POUND	0.000	0.000	8829.320	0.000	0.000	0.000	9500.010
MATERIAL LIMESTONE	POUND	0.000	915.720	0.000	0.000	0.000	0.000	943.720
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	0.000	1398.704	0.000	0.000	0.000	0.000	1482.168
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	0.000	118.648	0.000	0.000	0.000	0.000	121.941
ENERGY SOURCE PETROLEUM	MILL BTU	2.063	5.174	31.997	120.204	22.181	1.237	218.085
ENERGY SOURCE NAT GAS	MILL BTU	0.000	6.960	74.224	8.679	18.388	5.271	118.586
ENERGY SOURCE COAL	MILL BTU	0.000	9.731	54.228	2.613	22.916	.796	97.619
ENERGY SOURCE MISC	MILL BTU	0.000	1.719	1.981	.591	5.180	.179	9.789
ENERGY SOURCE WOOD FIBER	MILL BTU	0.000	0.000	109.076	0.000	0.000	0.000	119.845
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	0.000	60.977	880.500	17.200	100.000	4.254	1181.983
ENERGY PROCESS	MIL BTU	0.000	23.561	273.504	22.051	68.665	3.119	420.288
ENERGY TRANSPORT	MIL BTU	2.063	.003	0.000	1.839	0.000	.213	31.240
ENERGY OF MATL RESOURCE	MIL BTU	0.000	0.000	0.000	108.198	0.000	4.150	112.347
WATER VOLUME	THOU GAL	.128	.625	125.973	10.655	1.568	.619	165.481

OUTPUTS FROM SYSTEMS NAME	UNITS	PULPWOOD HARVEST 14000 LB	PULP AND MATERIAL 12490 LB	PULP MAN 12490 LB	WAX 5340 LB	CONVERT	POLY BAGS 160 LB	TOTAL
SOLID WASTES PROCESS	POUND	0.000	291.286	1667.080	10.769	170.000	4.007	2260.102
SOLID WASTES FUEL COMB	POUND	.515	50.119	735.942	17.700	137.448	4.669	1031.031
SOLID WASTES MINING	POUND	0.000	152.169	140.369	41.856	367.004	12.711	775.041
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	0.000	0.000	0.000	0.000	241.357
ATMOSPHERIC PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	2.456	28.626	65.738	6.305	30.746	1.162	141.416
ATMOS NITROGEN OXIDES	POUND	2.273	21.253	103.851	25.070	62.269	3.730	243.470
ATMOS HYDROCARBONS	POUND	2.240	10.835	84.753	82.400	31.994	8.748	240.446
ATMOS SULFUR OXIDES	POUND	.537	59.164	233.639	34.841	167.218	4.769	565.344
ATMOS CARBON MONOXIDE	POUND	14.878	3.238	19.960	48.736	8.305	.719	241.949
ATMOS ALDEHYDES	POUND	.177	.054	.032	.117	.205	.006	2.231
ATMOS OTHER ORGANICS	POUND	.436	.046	.062	.077	.198	.011	20.344
ATMOS ODOROUS SULFUR	POUND	0.000	0.000	.453	0.000	0.000	0.000	1.553
ATMOS AMMONIA	POUND	.006	.005	0.000	.026	.030	.000	.142
ATMOS HYDROGEN FLUORIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS LEAD	POUND	.043	.000	0.000	.001	.000	.000	.316
ATMOS MERCURY	POUND	0.000	.002	.001	.000	.002	.000	.000
ATMOSPHERIC CHLORINE	POUND	0.000	4.835	0.000	0.000	0.000	0.000	7.0[illegible]
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	0.000	0.000	3.000
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	1.101	2.493	26.456	40.134	10.063	.953	103.764
WATERBORNE BOD	POUND	.003	.075	62.384	.170	.022	.043	70.317
WATERBORNE PHENOL	POUND	.001	.002	.001	.005	.009	.000	.032
WATERBORNE SULFIDES	POUND	.001	.002	.001	.007	.010	.000	.041
WATERBORNE OIL	POUND	.001	.002	.001	.555	.011	.010	.711
WATERBORNE COD	POUND	.011	.015	.011	.464	.348	.327	1.[illegible]
WATERBORNE SUSP SOLIDS	POUND	.007	.756	52.719	.121	.055	.104	66.649
WATERBORNE ACID	POUND	.002	5.107	2.668	.811	7.461	.243	14.901
WATERBORNE METAL ION	POUND	.001	.464	.672	.203	1.740	.041	3.552
WATERBORNE CHEMICALS	POUND	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE CHROMIUM	POUND	0.000	0.000	0.000	.003	0.000	0.000	.003
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	0.000	.000	0.000	0.000	0.000	0.000	.000
WATERBORNE LEAD	POUND	0.000	.003	0.000	0.000	0.000	0.000	.003
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	0.000	0.000	0.000	.041	0.000	0.000	.041
WATERBORNE NITROGEN	POUND	0.000	0.000	0.000	0.000	0.000	0.000	[illegible]
WATERBORNE PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000

SUMMARY OF ENVIRONMENTAL IMPACTS NAME	UNITS	PULPWOOD HARVEST 14000 LB	PULP AND MATERIAL 12490 LB	PULP MAN 12490 LB	WAX 5340 LB	CONVERT	POLY BAGS 160 LB	TOTAL
RAW MATERIALS	POUNDS	0.000	2493.849	9309.820	17.200	100.000	4.254	13229.863
ENERGY	MIL BTU	2.063	23.564	273.506	132.087	68.665	7.441	563.925
WATER	THOU GAL	.128	.625	125.903	10.655	1.568	.618	165.481
INDUSTRIAL SOLID WASTES	CUBIC FT	.007	6.663	34.336	.949	9.106	.249	55.164
ATM EMMISSIONS	POUNDS	23.123	130.077	516.270	218.571	280.958	19.145	1414.363
WATERBORNE WASTES	POUNDS	1.129	9.123	125.344	43.187	19.057	1.763	266.696
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	0.000	0.000	0.000	0.000	241.357
ENERGY SOURCE PETROLEUM	MIL BTU	2.063	5.174	31.997	120.204	22.181	1.237	218.085
ENERGY SOURCE NAT GAS	MIL BTU	0.000	6.940	74.224	8.679	18.388	5.271	118.586
ENERGY SOURCE COAL	MIL BTU	0.000	9.731	54.229	2.613	22.916	.796	97.619
ENERGY SOURCE NUCL HYPWR	MIL BTU	0.000	1.719	1.981	.591	5.180	.174	9.789
ENERGY SOURCE WOOD WASTE	MIL BTU	0.000	0.000	109.076	0.000	0.000	0.000	119.845

INDEX OF ENVIRONMENTAL IMPACTS NAME	STANDARD VALUES	PULPWOOD HARVEST 14000 LB	PULP AND MATERIAL 12490 LB	PULP MAN 12490 LB	WAX 5340 LB	CONVERT	POLY BAGS 160 LB	TOTAL
RAW MATERIALS	13229.863	0.0	18.9	70.4	.1	.8	.0	100.0
ENERGY	563.925	.4	4.2	48.5	23.4	12.2	1.3	100.0
WATER	165.481	.1	.4	88.5	7.5	1.1	.4	100.0
INDUSTRIAL SOLID WASTES	55.164	.0	12.1	62.2	1.7	16.5	.5	100.0
ATM EMMISSIONS	1414.363	1.4	8.1	32.0	13.5	17.4	1.2	100.0
WATERBORNE WASTES	266.696	.4	3.4	47.0	16.2	7.1	.7	100.0
POST-CONSUMER SOL WASTE	241.357	0.0	0.0	0.0	0.0	0.0	0.0	100.0
ENERGY SOURCE PETROLEUM	218.085	.9	2.4	14.7	55.1	10.2	.6	100.0
ENERGY SOURCE NAT GAS	118.586	0.0	5.9	62.6	7.3	15.5	4.4	100.0
ENERGY SOURCE COAL	97.619	0.0	10.0	57.6	2.7	23.5	.8	100.0
ENERGY SOURCE NUCL HYPWR	9.789	0.0	17.6	20.2	6.0	52.9	1.8	100.0
ENERGY SOURCE WOOD WASTE	119.845	0.0	0.0	91.0	0.0	0.0	0.0	100.0

TABLE 54B

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

MIL 9 OZ PAP-WAX CD CUPS P 2

INPUTS TO SYSTEMS NAME	UNITS	CARTONS 390 LB	CORRUG 1270 LB	DISPOSAL	TRANSPOR	TOTAL
MATERIAL COTTON	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL WOOD FIBER	POUND	189.900	885.190	0.000	0.000	9500.010
MATERIAL LIMESTONE	POUND	28.000	0.000	0.000	0.000	963.720
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	93.465	0.000	0.000	0.000	1482.169
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	3.533	0.000	0.000	0.000	121.981
ENERGY SOURCE PETROLEUM	MILL BTU	2.444	5.825	9.625	17.332	218.085
ENERGY SOURCE NAT GAS	MILL BTU	1.402	3.693	0.000	0.000	118.586
ENERGY SOURCE COAL	MILL BTU	1.423	3.513	0.000	0.000	97.619
ENERGY SOURCE MISC	MILL BTU	.139	0.000	0.000	0.000	9.789
ENERGY SOURCE WOOD FIBER	MILL BTU	3.335	7.433	0.000	0.000	119.845
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	30.153	48.900	0.000	0.000	1181.983
ENERGY PROCESS	MIL BTU	9.046	20.340	0.000	0.000	420.288
ENERGY TRANSPORT	MIL BTU	.097	.114	9.425	17.332	31.299
ENERGY OF MATL RESOURCE	MIL BTU	0.000	0.000	0.000	0.000	112.367
WATER VOLUME	THOU GAL	3.783	.403	.998	.998	145.681

OUTPUTS FROM SYSTEMS NAME	UNITS	CARTONS 390 LB	CORRUG 1270 LB	DISPOSAL	TRANSPOR	TOTAL
SOLID WASTES PROCESS	POUND	51.891	45.090	0.000	0.000	2290.102
SOLID WASTES FUEL COMB	POUND	20.940	57.601	2.405	4.016	1031.031
SOLID WASTES MINING	POUND	10.811	90.190	0.000	0.000	775.091
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	241.357	0.000	241.357
ATMOSPHERIC PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	3.367	49.579	1.010	2.441	191.416
ATMOS NITROGEN OXIDES	POUND	4.059	20.607	10.776	39.149	293.670
ATMOS HYDROCARBONS	POUND	2.421	12.382	10.449	14.239	240.666
ATMOS SULFUR OXIDES	POUND	7.664	74.461	2.504	7.739	564.366
ATMOS CARBON MONOXIDE	POUND	1.347	7.135	98.374	39.305	261.949
ATMOS ALDEHYDES	POUND	.011	.106	.826	.700	2.231
ATMOS OTHER ORGANICS	POUND	.034	19.273	7.567	1.474	20.366
ATMOS ODOROUS SULFUR	POUND	.140	0.000	0.000	0.000	8.593
ATMOS AMMONIA	POUND	.000	.015	.027	.044	.152
ATMOS HYDROGEN FLUORIDE	POUND	0.000	0.000	0.000	0.000	0.000
ATMOS LEAD	POUND	.002	.002	.149	.046	.314
ATMOS MERCURY	POUND	.000	.000	0.000	0.000	.006
ATMOSPHERIC CHLORINE	POUND	.207	0.000	0.000	0.000	7.062
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	1.497	4.943	5.135	8.576	102.746
WATERBORNE BOD	POUND	1.562	26.042	.013	.022	70.317
WATERBORNE PHENOL	POUND	.000	.003	.005	.009	.032
WATERBORNE SULFIDES	POUND	.000	.003	.006	.010	.041
WATERBORNE OIL	POUND	.000	.004	.007	.011	.713
WATERBORNE COD	POUND	.002	.029	.053	.049	1.593
WATERBORNE SUSP SOLIDS	POUND	2.793	12.083	.033	.059	68.699
WATERBORNE ACID	POUND	.467	.536	.010	.017	16.901
WATERBORNE METAL ION	POUND	.042	.133	.003	.004	3.592
WATERBORNE CHEMICALS	POUND	0.000	.965	0.000	0.000	.965
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE CHROMIUM	POUND	0.000	0.000	0.000	0.000	.003
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	.000	0.000	0.000	0.000	.000
WATERBORNE LEAD	POUND	.000	0.000	0.000	0.000	.003
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	0.000	0.000	0.000	0.000	.041
WATERBORNE NITROGEN	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000

SUMMARY OF ENVIRONMENTAL IMPACTS NAME	UNITS	CARTONS 390 LB	CORRUG 1270 LB	DISPOSAL	TRANSPOR	TOTAL
RAW MATERIALS	POUNDS	330.650	974.090	0.000	0.000	13229.863
ENERGY	MIL BTU	9.143	20.456	9.425	17.332	563.925
WATER	THOU GAL	3.783	.403	.998	.998	145.681
INDUSTRIAL SOLID WASTES	CUBIC FT	1.124	2.604	.032	.054	55.164
ATM EMMISSIONS	POUNDS	19.237	170.561	131.230	105.155	1614.363
WATERBORNE WASTES	POUNDS	6.294	46.760	5.264	8.792	266.696
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	241.357	0.000	241.357
ENERGY SOURCE PETROLEUM	MIL BTU	2.444	5.825	9.625	17.332	218.085
ENERGY SOURCE NAT GAS	MIL BTU	1.402	3.643	0.000	0.000	118.586
ENERGY SOURCE COAL	MIL BTU	1.423	3.513	0.000	0.000	97.619
ENERGY SOURCE NUCL HYPWR	MIL BTU	.139	0.000	0.000	0.000	9.789
ENERGY SOURCE WOOD WASTE	MIL BTU	3.335	7.433	0.000	0.000	119.845

INDEX OF ENVIRONMENTAL IMPACTS NAME	STANDARD VALUES	CARTONS 390 LB	CORRUG 1270 LB	DISPOSAL	TRANSPOR	TOTAL
RAW MATERIALS	13229.863	2.5	7.4	0.0	0.0	100.0
ENERGY	563.925	1.6	3.6	1.7	3.1	100.0
WATER	145.681	2.6	.3	.4	.7	100.0
INDUSTRIAL SOLID WASTES	55.164	2.0	4.7	.1	.1	100.0
ATM EMMISSIONS	1614.363	1.2	10.6	8.1	6.5	100.0
WATERBORNE WASTES	266.696	2.4	17.5	2.0	3.3	100.0
POST-CONSUMER SOL WASTE	241.357	0.0	0.0	100.0	0.0	100.0
ENERGY SOURCE PETROLEUM	218.085	1.1	2.7	4.4	7.9	100.0
ENERGY SOURCE NAT GAS	118.586	1.2	3.1	0.0	0.0	100.0
ENERGY SOURCE COAL	97.619	1.5	3.6	0.0	0.0	100.0
ENERGY SOURCE NUCL HYPWR	9.789	1.4	0.0	0.0	0.0	100.0
ENERGY SOURCE WOOD WASTE	119.845	2.8	6.2	0.0	0.0	100.0

TABLE 55

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE MILLION CHINA CUPS 1000 USES

NAME	UNITS	CHINA CUP 70Z RAW MAT 1000 USE	CHINA CUP 70Z MFG 1000 USE	CHINA CUP 70Z PKG 1000 USE	CHINA CUP 70Z TRAN 1000 USE	CHINA CUP 70Z WASH 1000 USE	CHINA CUP 70Z PCSW 1000 USE	CHINA CUP 70Z SYS TOT 1000 USE
INPUTS TO SYSTEMS								
MATERIAL COTTON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	0.000	0.000	0.000	0.000	1504.168	0.000	1504.168
MATERIAL WOOD FIBER	POUND	37.638	0.000	37.638	0.000	0.000	0.000	75.276
MATERIAL LIMESTONE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	0.000	0.000	0.000	0.000	151.691	0.000	151.691
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000	657.541	0.000	657.541
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000	581.187	0.000	581.187
MATERIAL FELDSPAR	POUND	164.000	0.000	0.000	0.000	0.000	0.000	164.000
MATERIAL BAUXITE ORE	POUND	319.483	0.000	0.000	0.000	0.000	0.000	319.483
MATERIAL SULFUR	POUND	0.000	0.000	0.000	0.000	169.852	0.000	169.852
ENERGY SOURCE PETROLEUM	MILL BTU	1.335	.516	.240	1.176	45.949	10.201	59.425
ENERGY SOURCE NAT GAS	MILL BTU	.894	9.861	.157	.000	263.393	0.000	274.305
ENERGY SOURCE COAL	MILL BTU	.613	1.253	.149	0.000	79.409	0.000	81.425
ENERGY SOURCE MISC	MILL BTU	.058	.283	0.000	0.000	17.730	0.000	18.072
ENERGY SOURCE WOOD FIBER	MILL BTU	.316	0.000	.316	0.000	.268	0.000	.900
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	304.920	0.000	0.000	0.000	0.000	0.000	304.920
MATERIAL GYPSUM	POUND	32.327	0.000	0.000	0.000	0.000	0.000	32.327
MATERIAL SILICA	POUND	251.234	0.000	0.000	0.000	0.000	0.000	251.234
MATERIAL PROCESS ADD	POUNDS	10.778	0.000	3.780	0.000	551.432	0.000	565.989
ENERGY PROCESS	MIL BTU	3.111	11.913	.805	0.000	395.796	0.000	411.604
ENERGY TRANSPORT	MIL BTU	.106	0.000	.005	1.176	.823	10.201	12.312
ENERGY OF MATL RESOURCE	MIL BTU	0.000	0.000	0.000	0.000	10.131	0.000	10.131
WATER VOLUME	THOU GAL	2.007	2.756	.017	.068	194.452	.634	199.934
OUTPUTS FROM SYSTEMS								
SOLID WASTES PROCESS	POUND	3.618	180.080	3.618	0.000	233.709	0.000	420.945
SOLID WASTES FUEL COMB	POUND	4.669	7.388	2.449	.274	466.127	2.548	483.436
SOLID WASTES MINING	POUND	749.287	20.064	2.134	0.000	1423.950	0.000	2195.436
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	0.000	0.000	0.000	3.264	3.264
ATMOSPHERIC PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	25.790	3.981	2.108	.149	111.972	1.078	145.078
ATMOS NITROGEN OXIDES	POUND	2.950	7.623	.876	2.508	295.243	10.891	320.090
ATMOS HYDROCARBONS	POUND	1.762	9.889	.526	.908	293.951	11.074	318.111
ATMOS SULFUR OXIDES	POUND	6.202	6.991	2.996	.518	452.109	2.654	471.471
ATMOS CARBON MONOXIDE	POUND	.774	1.402	.303	3.181	60.059	73.308	139.027
ATMOS ALDEHYDES	POUND	.021	.022	.005	.049	.793	.873	1.763
ATMOS OTHER ORGANICS	POUND	.447	.049	.437	.113	1.657	3.133	5.835
ATMOS ODOROUS SULFUR	POUND	0.000	0.000	0.000	0.000	2.796	0.000	2.796
ATMOS AMMONIA	POUND	.003	0.000	.001	.003	1.939	.028	1.974
ATMOS HYDROGEN FLOURIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS LEAD	POUND	.000	0.000	.000	.006	.014	.211	.231
ATMOS MERCURY	POUND	.000	.000	.000	0.000	.008	0.000	.008
ATMOSPHERIC CHLORINE	POUND	0.000	0.000	0.000	0.000	.763	0.000	.763
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE FLUORIDES	POUND	.024	0.000	0.000	0.000	0.000	0.000	.024
WATERBORNE DISS SOLIDS	POUND	.911	1.782	.296	.584	1012.700	5.442	1021.716
WATERBORNE BOD	POUND	1.191	.775	1.107	.002	9.612	.014	12.701
WATERBORNE PHENOL	POUND	.002	.000	.000	.001	.010	.005	.018
WATERBORNE SULFIDES	POUND	.001	.000	.000	.001	.013	.006	.021
WATERBORNE OIL	POUND	.004	.000	.000	.001	.180	.007	.193
WATERBORNE COD	POUND	1.996	1.538	.001	.006	15.075	.056	18.672
WATERBORNE SUSP SOLIDS	POUND	20.486	1.447	.514	.004	18.782	.035	41.268
WATERBORNE ACID	POUND	.134	.304	.023	.001	27.727	.011	28.200
WATERBORNE METAL ION	POUND	7.681	.096	.006	.000	6.052	.003	13.836
WATERBORNE CHEMICALS	POUND	.621	0.000	.041	0.000	.020	0.000	.682
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000	.898	0.000	.898
WATERBORNE CHROMIUM	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE LEAD	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000	.174	0.000	.174
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	0.000	0.000	0.000	0.000	.012	0.000	.012
WATERBORNE NITROGEN	POUND	0.000	0.000	0.000	0.000	3.368	0.000	3.368
WATERBORNE PESTICIDE	POUND	0.000	0.000	0.000	0.000	.018	0.000	.018
SUMMARY OF ENVIRONMENTAL IMPACTS								
RAW MATERIALS	POUNDS	1120.380	0.000	41.418	0.000	3615.863	0.000	4777.661
ENERGY	MIL BTU	3.217	11.913	.870	1.176	406.750	10.201	434.127
WATER	THOU GAL	2.007	2.756	.017	.068	194.452	.634	199.934
INDUSTRIAL SOLID WASTES	CUBIC FT	10.227	2.880	.131	.004	28.671	.034	41.848
ATM EMISSIONS	POUNDS	37.950	29.954	7.252	7.435	1222.103	103.242	1407.938
WATERBORNE WASTES	POUNDS	33.051	6.023	1.988	.599	1094.643	5.579	1141.883
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	0.000	0.000	0.000	3.264	3.264
ENERGY SOURCE PETROLEUM	MIL BTU	1.335	.516	.240	1.176	45.949	10.201	59.425
ENERGY SOURCE NAT GAS	MIL BTU	.894	9.861	.157	.000	263.393	0.000	274.305
ENERGY SOURCE COAL	MIL BTU	.613	1.253	.149	0.000	79.409	0.000	81.425
ENERGY SOURCE NUCL HYPWR	MIL BTU	.058	.283	0.000	0.000	17.730	0.000	18.072
ENERGY SOURCE WOOD WASTE	MIL BTU	.316	0.000	.316	0.000	.268	0.000	.900
INDEX OF ENVIRONMENTAL IMPACTS	STANDARD VALUES							
RAW MATERIALS	4777.661	23.5	0.0	.9	0.0	75.7	0.0	100.0
ENERGY	434.127	.7	2.7	.2	.3	93.7	2.3	100.0
WATER	199.934	1.0	1.4	.0	.0	97.3	.3	100.0
INDUSTRIAL SOLID WASTES	41.848	24.4	6.7	.3	.0	68.5	.1	100.0
ATM EMISSIONS	1407.938	2.7	2.1	.5	.5	86.8	7.3	100.0
WATERBORNE WASTES	1141.883	2.9	.5	.2	.1	95.9	.5	100.0
POST-CONSUMER SOL WASTE	3.264	0.0	0.0	0.0	0.0	0.0	100.0	100.0
ENERGY SOURCE PETROLEUM	59.425	2.2	.9	.4	2.0	77.3	17.2	100.0
ENERGY SOURCE NAT GAS	274.305	.3	3.6	.1	.0	96.0	0.0	100.0
ENERGY SOURCE COAL	81.425	.8	1.5	.2	0.0	97.5	0.0	100.0
ENERGY SOURCE NUCL HYPWR	18.072	.3	1.6	0.0	0.0	98.1	0.0	100.0
ENERGY SOURCE WOOD WASTE	.900	35.1	0.0	35.1	0.0	29.8	0.0	100.0

TABLE 56

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE MILLN MELAMINE CUP 1000 USES

		MELAMINE CUPS RAW MAT 1000 USE	MELAMINE CUPS MFG 1000 USE	MELAMINE CUPS PKG 1000 USE	MELAMINE CUPS TRAN 1000 USE	MELAMINE CUPS WASH 1000 USE	MELAMINE CUPS PCSW 1000 USE	MELAMINE CUPS SYS TOT 1000 USE
INPUTS TO SYSTEMS								
NAME	UNITS							
MATERIAL COTTON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	0.000	0.000	0.000	0.000	1504.160	0.000	1504.160
MATERIAL WOOD FIBER	POUND	58.813	0.000	18.151	0.000	0.000	0.000	76.964
MATERIAL LIMESTONE	POUND	5.830	0.000	0.000	0.000	0.000	0.000	5.830
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	6.871	0.000	0.000	0.000	151.691	0.000	158.562
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000	657.541	0.000	657.541
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000	581.187	0.000	581.187
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	.733	0.000	0.000	0.000	169.852	0.000	170.585
ENERGY SOURCE PETROLEUM	MILL BTU	1.658	.215	.119	.583	45.949	.012	48.537
ENERGY SOURCE NAT GAS	MILL BTU	9.046	.217	.076	.009	263.393	0.000	272.740
ENERGY SOURCE COAL	MILL BTU	.809	.522	.072	0.000	79.409	0.000	80.812
ENERGY SOURCE MISC	MILL BTU	.180	.118	0.000	0.000	17.730	0.000	18.029
ENERGY SOURCE WOOD FIBER	MILL BTU	.611	0.000	.152	0.000	.268	0.000	1.032
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	9.452	0.000	1.823	0.000	551.432	0.000	562.707
ENERGY PROCESS	MIL BTU	6.514	1.072	.417	0.000	395.796	0.000	403.799
ENERGY TRANSPORT	MIL BTU	.349	0.000	.002	.592	.823	.012	1.779
ENERGY OF MATL RESOURCE	MIL BTU	5.442	0.000	0.000	0.000	10.131	0.000	15.572
WATER VOLUME	THOU GAL	4.667	1.452	.008	.034	194.452	.001	200.614
OUTPUTS FROM SYSTEMS								
NAME	UNITS							
SOLID WASTES PROCESS	POUND	9.951	.531	1.745	0.000	233.709	0.000	245.936
SOLID WASTES FUEL COMB	POUND	5.008	3.070	1.181	.136	466.127	.003	475.525
SOLID WASTES MINING	POUND	12.927	8.360	1.029	0.000	1423.950	0.000	1446.267
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	0.000	0.000	0.000	3.517	3.517
ATMOSPHERIC PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	1.732	.650	1.017	.071	111.972	.001	115.443
ATMOS NITROGEN OXIDES	POUND	6.447	1.130	.423	1.302	295.243	.013	304.557
ATMOS HYDROCARBONS	POUND	15.156	.440	.254	.468	293.951	.013	310.282
ATMOS SULFUR OXIDES	POUND	7.336	2.870	1.445	.221	452.109	.003	463.984
ATMOS CARBON MONOXIDE	POUND	6.264	.140	.146	1.710	58.859	.593	67.713
ATMOS ALDEHYDES	POUND	.018	.002	.002	.024	.793	.001	.841
ATMOS OTHER ORGANICS	POUND	.023	.003	.211	.060	1.657	.083	2.037
ATMOS ODOROUS SULFUR	POUND	.052	0.000	0.000	0.000	2.796	0.000	2.848
ATMOS AMMONIA	POUND	1.368	0.000	.000	.002	1.939	.000	3.310
ATMOS HYDROGEN FLOURIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS LEAD	POUND	.000	0.000	.000	.003	.014	.000	.017
ATMOS MERCURY	POUND	.000	.000	.000	0.000	.008	0.000	.009
ATMOSPHERIC CHLORINE	POUND	.033	0.000	0.000	0.000	.763	0.000	.796
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	1.748	.062	.143	.293	1012.700	.007	1014.952
WATERBORNE BOD	POUND	.528	.000	.534	.001	9.612	.000	10.675
WATERBORNE PHENOL	POUND	.001	.000	.000	.000	.010	.000	.011
WATERBORNE SULFIDES	POUND	.001	.000	.000	.000	.013	.000	.014
WATERBORNE OIL	POUND	.009	.000	.000	.000	.180	.000	.190
WATERBORNE COD	POUND	.046	.001	.001	.003	15.075	.000	15.126
WATERBORNE SUSP SOLIDS	POUND	.783	.000	.248	.002	18.782	.000	19.815
WATERBORNE ACID	POUND	.262	.160	.011	.001	27.727	.000	28.161
WATERBORNE METAL ION	POUND	.042	.040	.003	.000	8.052	.000	8.157
WATERBORNE CHEMICALS	POUND	0.000	0.000	.020	0.000	.020	0.000	.040
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000	.898	0.000	.898
WATERBORNE CHROMIUM	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE LEAD	POUND	.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000	.174	0.000	.174
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	.259	0.000	0.000	0.000	.012	0.000	.271
WATERBORNE NITROGEN	POUND	0.000	0.000	0.000	0.000	3.368	0.000	3.368
WATERBORNE PESTICIDE	POUND	0.000	0.000	0.000	0.000	.018	0.000	.018
SUMMARY OF ENVIRONMENTAL IMPACTS								
NAME	UNITS							
RAW MATERIALS	POUNDS	81.699	0.000	19.974	0.000	3615.863	0.000	3717.536
ENERGY	MIL BTU	12.305	1.072	.419	.592	406.750	.012	421.150
WATER	THOU GAL	4.667	1.452	.008	.034	194.452	.001	200.614
INDUSTRIAL SOLID WASTES	CUBIC FT	.376	.161	.053	.002	28.671	.000	29.264
ATM EMMISSIONS	POUNDS	36.430	5.234	3.497	3.862	1222.103	.709	1271.836
WATERBORNE WASTES	POUNDS	3.699	.263	.959	.300	1094.643	.007	1099.871
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	0.000	0.000	0.000	3.517	3.517
ENERGY SOURCE PETROLEUM	MIL BTU	1.658	.215	.119	.583	45.949	.012	48.537
ENERGY SOURCE NAT GAS	MIL BTU	9.046	.217	.076	.009	263.393	0.000	272.740
ENERGY SOURCE COAL	MIL BTU	.809	.522	.072	0.000	79.409	0.000	80.812
ENERGY SOURCE NUCL HYPWR	MIL BTU	.180	.118	0.000	0.000	17.730	0.000	18.029
ENERGY SOURCE WOOD WASTE	MIL BTU	.611	0.000	.152	0.000	.268	0.000	1.032
INDEX OF ENVIRONMENTAL IMPACTS								
NAME	STANDARD VALUES							
RAW MATERIALS	3717.536	2.2	0.0	.5	0.0	97.3	0.0	100.0
ENERGY	421.150	2.9	.3	.1	.1	96.6	.0	100.0
WATER	200.614	2.3	.7	.0	.0	96.9	.0	100.0
INDUSTRIAL SOLID WASTES	29.264	1.3	.6	.2	.0	98.0	.0	100.0
ATM EMMISSIONS	1271.836	2.9	.4	.3	.3	96.1	.1	100.0
WATERBORNE WASTES	1099.871	.3	.0	.1	.0	99.5	.0	100.0
POST-CONSUMER SOL WASTE	3.517	0.0	0.0	0.0	0.0	0.0	100.0	100.0
ENERGY SOURCE PETROLEUM	48.537	3.4	.4	.2	1.2	94.7	.0	100.0
ENERGY SOURCE NAT GAS	272.740	3.3	.1	.0	.0	96.6	0.0	100.0
ENERGY SOURCE COAL	80.812	1.0	.6	.1	0.0	98.3	0.0	100.0
ENERGY SOURCE NUCL HYPWR	18.029	1.0	.7	0.0	0.0	98.3	0.0	100.0
ENERGY SOURCE WOOD WASTE	1.032	59.3	0.0	14.8	0.0	26.0	0.0	100.0

TABLE 57

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE MILLION POLYSTY FOAM 7OZ CUP

INPUTS TO SYSTEMS NAME	UNITS	POLYSTY RESIN SY 4680 LB	POLYSTY FOAM 7OZ NO CUP MFG	POLYSTY FOAM 7OZ NO CUP PKG	POLYSTY FOAM 7OZ NO CUP TRAN	POLYSTY FOAM 7OZ NO CUP PCSW	POLYSTY FOAM 7OZ NO CUP SYS TOT
MATERIAL COTTON	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL SULFATE BRINE	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL WOOD FIBER	POUND	0.00	0.00	1289.45	0.00	0.00	1289.45
MATERIAL LIMESTONE	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL IRON ORE	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL SALT	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL GLASS SAND	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL NAT SODA ASH	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL FELDSPAR	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL BAUXITE ORE	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL SULFUR	POUND	0.00	0.00	0.00	0.00	0.00	0.00
ENERGY SOURCE PETROLEUM	MILL BTU	105.24	144.20	10.22	20.46	17.50	297.71
ENERGY SOURCE NAT GAS	MILL BTU	71.39	141.11	12.78	.44	0.00	225.71
ENERGY SOURCE COAL	MILL BTU	4.00	20.68	6.23	0.00	0.00	30.92
ENERGY SOURCE MISC	MILL BTU	.90	4.67	.25	0.00	0.00	5.83
ENERGY SOURCE WOOD FIBER	MILL BTU	0.00	0.00	10.83	0.00	0.00	10.83
ENERGY SOURCE HYDROPOWER	MILL BTU	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL POTASH	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL PHOSPHATE ROCK	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL CLAY	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL GYPSUM	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL SILICA	POUND	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL PROCESS ADD	POUNDS	230.09	0.00	135.48	0.00	0.00	365.57
ENERGY PROCESS	MIL BTU	66.28	305.09	34.01	0.00	0.00	405.39
ENERGY TRANSPORT	MIL BTU	3.02	.46	.47	20.90	17.50	42.34
ENERGY OF MATL RESOURCE	MIL BTU	112.24	5.19	5.84	0.00	0.00	123.26
WATER VOLUME	THOU GAL	15.40	10.51	1.46	1.18	1.09	29.64

OUTPUTS FROM SYSTEMS NAME	UNITS	POLYSTY RESIN SY 4680 LB	POLYSTY FOAM 7OZ NO CUP MFG	POLYSTY FOAM 7OZ NO CUP PKG	POLYSTY FOAM 7OZ NO CUP TRAN	POLYSTY FOAM 7OZ NO CUP PCSW	POLYSTY FOAM 7OZ NO CUP SYS TOT
SOLID WASTES PROCESS	POUND	217.01	90.00	129.58	0.00	0.00	436.59
SOLID WASTES FUEL COMB	POUND	27.16	152.43	90.47	4.73	4.37	279.16
SOLID WASTES MINING	POUND	64.11	331.20	90.99	0.00	0.00	486.30
SOLID WASTE POST-CONSUM	CUBIC FT	0.00	0.00	0.00	0.00	761.20	761.20
ATMOSPHERIC PESTICIDE	POUND	0.00	0.00	0.00	0.00	0.00	0.00
ATMOS PARTICULATES	POUND	9.90	44.95	73.06	2.46	1.04	133.00
ATMOS NITROGEN OXIDES	POUND	58.54	204.29	35.26	49.72	18.68	366.50
ATMOS HYDROCARBONS	POUND	101.69	344.83	30.34	15.23	19.00	571.08
ATMOS SULFUR OXIDES	POUND	55.38	268.92	109.35	8.12	4.55	446.03
ATMOS CARBON MONOXIDE	POUND	79.90	33.60	11.40	46.94	134.05	306.66
ATMOS ALDEHYDES	POUND	.26	2.31	.16	.70	1.50	4.92
ATMOS OTHER ORGANICS	POUND	.26	1.11	14.98	1.42	6.78	24.56
ATMOS ODOROUS SULFUR	POUND	0.00	0.00	0.00	0.00	0.00	0.00
ATMOS AMMONIA	POUND	.04	.34	.02	.05	.05	.50
ATMOS HYDROGEN FLOURIDE	POUND	0.00	0.00	0.30	0.00	0.00	0.00
ATMOS LEAD	POUND	.00	.00	.00	.07	.36	.43
ATMOS MERCURY	POUND	.00	.00	.00	0.00	0.00	.00
ATMOSPHERIC CHLORINE	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE DIS SOLIDS	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE FLUORIDES	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE DISS SOLIDS	POUND	45.06	90.95	11.48	10.17	9.34	166.98
WATERBORNE BOD	POUND	2.81	.18	38.00	.03	.02	41.03
WATERBORNE PHENOL	POUND	.01	.06	.00	.01	.01	.09
WATERBORNE SULFIDES	POUND	.01	.08	.00	.01	.01	.12
WATERBORNE OIL	POUND	.58	.10	.02	.01	.01	.72
WATERBORNE COD	POUND	6.92	.71	.50	.10	.10	8.33
WATERBORNE SUSP SOLIDS	POUND	4.93	.44	17.75	.07	.06	23.25
WATERBORNE ACID	POUND	1.24	4.47	1.12	.02	.02	6.87
WATERBORNE METAL ION	POUND	.31	1.62	.28	.01	.00	2.22
WATERBORNE CHEMICALS	POUND	0.00	0.00	1.41	0.00	0.00	1.41
WATERBORNE CYANIDE	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE ALKALINITY	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE CHROMIUM	POUND	.01	0.00	0.00	0.00	0.00	.01
WATERBORNE IRON	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE ALUMINUM	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE NICKEL	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE MERCURY	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE LEAD	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE PHOSPHATES	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE ZINC	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE AMMONIA	POUND	.00	0.00	0.00	0.00	0.00	.00
WATERBORNE NITROGEN	POUND	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE PESTICIDE	POUND	0.00	0.00	0.00	0.00	0.00	0.00

SUMMARY OF ENVIRONMENTAL IMPACTS NAME	UNITS	POLYSTY RESIN SY 4680 LB	POLYSTY FOAM 7OZ NO CUP MFG	POLYSTY FOAM 7OZ NO CUP PKG	POLYSTY FOAM 7OZ NO CUP TRAN	POLYSTY FOAM 7OZ NO CUP PCSW	POLYSTY FOAM 7OZ NO CUP SYS TOT
RAW MATERIALS	POUNDS	230.09	0.00	1424.93	0.00	0.00	1655.02
ENERGY	MIL BTU	181.54	310.74	40.32	20.90	17.50	571.00
WATER	THOU GAL	15.40	10.51	1.46	1.18	1.09	29.64
INDUSTRIAL SOLID WASTES	CUBIC FT	4.16	7.74	4.20	.06	.06	16.23
ATM EMMISSIONS	POUNDS	365.74	900.44	275.30	124.72	187.41	1853.69
WATERBORNE WASTES	POUNDS	61.96	100.60	70.57	10.43	9.57	253.11
POST-CONSUMER SOL WASTE	CUBIC FT	0.00	0.00	0.00	0.00	761.20	761.20
ENERGY SOURCE PETROLEUM	MIL BTU	105.24	144.20	10.22	20.46	17.50	297.71
ENERGY SOURCE NAT GAS	MIL BTU	71.39	141.11	12.78	.44	0.00	225.71
ENERGY SOURCE COAL	MIL BTU	4.00	20.68	6.23	0.00	0.00	30.92
ENERGY SOURCE NUCL HYPWR	MIL BTU	.90	4.67	.25	0.00	0.00	5.83
ENERGY SOURCE WOOD WASTE	MIL BTU	0.00	0.00	10.83	0.00	0.00	10.83

INDEX OF ENVIRONMENTAL IMPACTS NAME	STANDARD VALUES	POLYSTY RESIN SY 4680 LB	POLYSTY FOAM 7OZ NO CUP MFG	POLYSTY FOAM 7OZ NO CUP PKG	POLYSTY FOAM 7OZ NO CUP TRAN	POLYSTY FOAM 7OZ NO CUP PCSW	POLYSTY FOAM 7OZ NO CUP SYS TOT
RAW MATERIALS	1655.02	13.9	0.0	86.1	0.0	0.0	100.0
ENERGY	571.00	31.8	54.4	7.1	3.7	3.1	100.0
WATER	29.64	52.0	35.5	4.9	4.0	3.7	100.0
INDUSTRIAL SOLID WASTES	16.23	25.6	47.7	25.9	.4	.4	100.0
ATM EMMISSIONS	1853.69	19.7	48.6	14.9	6.7	10.1	100.0
WATERBORNE WASTES	253.11	24.5	39.7	27.9	4.1	3.8	100.0
POST-CONSUMER SOL WASTE	761.20	0.0	0.0	0.0	0.0	100.0	100.0
ENERGY SOURCE PETROLEUM	297.71	35.4	48.5	3.4	6.9	5.9	100.0
ENERGY SOURCE NAT GAS	225.71	31.6	62.5	5.7	.2	0.0	100.0
ENERGY SOURCE COAL	30.92	12.9	66.8	20.2	0.0	0.0	100.0
ENERGY SOURCE NUCL HYPWR	5.83	15.5	80.2	4.3	0.0	0.0	100.0
ENERGY SOURCE WOOD WASTE	10.83	0.0	0.0	100.0	0.0	0.0	100.0

TABLE 58

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

MIL 702 PAP-PE HOT DR CUPS

INPUTS TO SYSTEMS NAME	UNITS	COATED PAPBD MAN SYS 19280 LB	CONVERT	PAPER BAGS 390 LB	CARTONS 150 LB	CORRUG 1550 LB	DISPOSAL	TRANSPOR	TOTAL
MATERIAL COTTON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL WOOD FIBER	POUND	12387.525	0.000	268.710	79.500	1080.350	0.000	0.000	13816.085
MATERIAL LIMESTONE	POUND	1345.720	0.000	0.000	12.000	0.000	0.000	0.000	1357.720
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	2055.501	0.000	0.000	35.771	0.000	0.000	0.000	2091.272
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	174.049	0.000	0.000	1.514	0.000	0.000	0.000	175.563
ENERGY SOURCE PETROLEUM	MILL BTU	64.222	5.203	2.080	1.047	7.109	.808	13.529	93.999
ENERGY SOURCE NAT GAS	MILL BTU	148.750	17.132	1.415	.601	4.494	0.000	0.000	172.393
ENERGY SOURCE COAL	MILL BTU	100.307	12.632	1.297	.781	4.288	0.000	0.000	119.306
ENERGY SOURCE MISC	MILL BTU	6.200	2.856	0.000	.060	0.000	0.000	0.000	9.115
ENERGY SOURCE WOOD FIBER	MILL BTU	160.296	0.000	2.899	1.429	9.072	0.000	0.000	173.696
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	1407.738	60.000	27.300	12.923	108.500	0.000	0.000	1616.460
ENERGY PROCESS	MIL BTU	451.951	37.823	7.656	3.877	24.825	0.000	0.000	526.131
ENERGY TRANSPORT	MIL BTU	4.250	0.000	.035	.042	.139	.808	13.529	18.874
ENERGY OF MATL RESOURCE	MIL BTU	23.575	0.000	0.000	0.000	0.000	0.000	0.000	23.575
WATER VOLUME	THOU GAL	187.990	.608	.146	1.621	.492	.050	.780	191.687

OUTPUTS FROM SYSTEMS NAME	UNITS	COATED PAPBD MAN SYS 19280 LB	CONVERT	PAPER BAGS 390 LB	CARTONS 150 LB	CORRUG 1550 LB	DISPOSAL	TRANSPOR	TOTAL
SOLID WASTES PROCESS	POUND	2899.820	380.000	26.130	22.239	103.850	0.000	0.000	3432.039
SOLID WASTES FUEL COMB	POUND	1175.845	74.294	22.349	8.803	70.300	.202	3.136	1354.949
SOLID WASTES MINING	POUND	483.929	202.312	18.525	4.633	61.296	0.000	0.000	770.685
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	0.000	0.000	0.000	236.599	0.000	236.913
ATMOSPHERIC PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	147.482	15.960	17.126	1.436	60.510	.085	1.870	244.466
ATMOS NITROGEN OXIDES	POUND	205.826	33.593	7.332	1.740	25.151	.863	30.145	304.650
ATMOS HYDROCARBONS	POUND	192.514	21.403	4.582	1.038	15.111	.877	10.954	246.962
ATMOS SULFUR OXIDES	POUND	451.855	49.505	15.798	3.287	85.996	.210	6.127	632.648
ATMOS CARBON MONOXIDE	POUND	59.897	4.745	2.446	.577	8.708	34.439	31.664	142.323
ATMOS ALDEHYDES	POUND	.416	.068	.038	.005	.130	.069	.551	1.276
ATMOS OTHER ORGANICS	POUND	1.145	.115	4.160	.014	12.538	4.769	1.171	23.919
ATMOS ODOROUS SULFUR	POUND	12.422	0.000	0.000	.040	0.000	0.000	0.000	12.442
ATMOS AMMONIA	POUND	.016	0.000	.005	.000	.018	.002	.035	.076
ATMOS HYDROGEN FLOURIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS LEAD	POUND	.063	0.000	.001	.001	.003	.017	.054	.139
ATMOS MERCURY	POUND	.005	.001	.000	.000	.000	0.000	0.000	.006
ATMOSPHERIC CHLORINE	POUND	10.045	0.000	0.000	.089	0.000	0.000	0.000	10.133
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	50.045	3.575	2.517	.625	8.498	.431	6.696	72.387
WATERBORNE BOD	POUND	62.644	.004	7.998	.661	31.786	.001	.017	103.109
WATERBORNE PHENOL	POUND	.006	.001	.001	.000	.003	.000	.006	.019
WATERBORNE SULFIDES	POUND	.007	.002	.001	.000	.004	.001	.008	.023
WATERBORNE OIL	POUND	.066	.002	.001	.000	.006	.001	.009	.043
WATERBORNE COD	POUND	1.919	.015	.010	.001	.036	.004	.069	2.055
WATERBORNE SUSP SOLIDS	POUND	79.194	.010	5.857	1.180	14.747	.003	.043	101.036
WATERBORNE ACID	POUND	12.494	3.875	.197	.192	.652	.001	.013	17.424
WATERBORNE METAL ION	POUND	2.222	.969	.049	.039	.163	.000	.003	3.444
WATERBORNE CHEMICALS	POUND	0.000	0.000	.343	0.000	1.178	0.000	0.000	1.521
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE CHROMIUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	.000	0.000	0.000	.000	0.000	0.000	0.000	.000
WATERBORNE LEAD	POUND	.005	0.000	0.000	.000	0.000	0.000	0.000	.005
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NITROGEN	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

SUMMARY OF ENVIRONMENTAL IMPACTS NAME	UNITS	COATED PAPBD MAN SYS 19280 LB	CONVERT	PAPER BAGS 390 LB	CARTONS 150 LB	CORRUG 1550 LB	DISPOSAL	TRANSPOR	TOTAL
RAW MATERIALS	POUNDS	17370.552	60.000	296.010	141.707	1188.850	0.000	0.000	19057.119
ENERGY	MIL BTU	479.776	37.823	7.691	3.919	24.964	.808	13.529	568.510
WATER	THOU GAL	187.990	.608	.146	1.621	.492	.050	.780	191.687
INDUSTRIAL SOLID WASTES	CUBIC FT	61.555	8.864	.905	.482	3.178	.003	.042	75.028
ATM EMMISSIONS	POUNDS	1081.288	145.950	51.478	8.245	208.164	41.331	82.572	1619.080
WATERBORNE WASTES	POUNDS	208.603	8.453	16.974	2.697	57.070	.442	6.865	301.104
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	0.000	0.000	0.000	236.599	0.000	236.913
ENERGY SOURCE PETROLEUM	MIL BTU	64.222	5.203	2.080	1.047	7.109	.808	13.529	93.999
ENERGY SOURCE NAT GAS	MIL BTU	148.750	17.132	1.415	.601	4.494	0.000	0.000	172.393
ENERGY SOURCE COAL	MIL BTU	100.307	12.632	1.297	.781	4.288	0.000	0.000	119.306
ENERGY SOURCE NUCL HYPWR	MIL BTU	6.200	2.856	0.000	.060	0.000	0.000	0.000	9.115
ENERGY SOURCE WOOD WASTE	MIL BTU	160.296	0.000	2.899	1.429	9.072	0.000	0.000	173.696

INDEX OF ENVIRONMENTAL IMPACTS NAME	STANDARD VALUES	COATED PAPBD MAN SYS 19280 LB	CONVERT	PAPER BAGS 390 LB	CARTONS 150 LB	CORRUG 1550 LB	DISPOSAL	TRANSPOR	TOTAL
RAW MATERIALS	19057.119	91.1	.3	1.6	.7	6.2	0.0	0.0	100.0
ENERGY	568.510	84.4	6.7	1.4	.7	4.4	.1	2.4	100.0
WATER	191.687	98.1	.3	.1	.8	.3	.0	.4	100.0
INDUSTRIAL SOLID WASTES	75.028	82.0	11.8	1.2	.6	4.2	.0	.1	100.0
ATM EMMISSIONS	1619.080	66.8	9.0	3.2	.5	12.9	2.6	5.1	100.0
WATERBORNE WASTES	301.104	69.3	2.8	5.6	.9	19.0	.1	2.3	100.0
POST-CONSUMER SOL WASTE	236.913	0.0	0.0	0.0	0.0	0.0	99.9	0.0	100.0
ENERGY SOURCE PETROLEUM	93.999	68.3	5.5	2.2	1.1	7.6	.9	14.4	100.0
ENERGY SOURCE NAT GAS	172.393	86.3	9.9	.8	.3	2.6	0.0	0.0	100.0
ENERGY SOURCE COAL	119.306	84.1	10.6	1.1	.7	3.6	0.0	0.0	100.0
ENERGY SOURCE NUCL HYPWR	9.115	68.0	31.3	0.0	.7	0.0	0.0	0.0	100.0
ENERGY SOURCE WOOD WASTE	173.696	92.3	0.0	1.7	.8	5.2	0.0	0.0	100.0

TABLE 59

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE MILLION CHINA PLATE 6900 USE

INPUTS TO SYSTEMS NAME	UNITS	CHINA PLATES RAW MAT 6900 USE	CHINA PLATES MFG 6900 USE	CHINA PLATES PKG 6900 USE	CHINA PLATES TRAN 6900 USE	CHINA PLATES WASH 6900 USE	CHINA PLATES PCSW 6900 USE	CHINA PLATES SYS TOT 6900 USE
MATERIAL COTTON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	0.000	0.000	0.000	0.000	1336.040	0.000	1336.040
MATERIAL WOOD FIBER	POUND	0.000	0.000	7.580	0.000	0.000	0.000	7.580
MATERIAL LIMESTONE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	0.000	0.000	0.000	0.000	134.738	0.000	134.738
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000	504.051	0.000	504.051
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000	516.231	0.000	516.231
MATERIAL FELDSPAR	POUND	55.019	0.000	0.000	0.000	0.000	0.000	55.019
MATERIAL BAUXITE ORE	POUND	100.022	0.000	0.000	0.000	0.000	0.000	100.022
MATERIAL SULFUR	POUND	0.000	0.000	0.000	0.000	150.860	0.000	150.860
ENERGY SOURCE PETROLEUM	MILL BTU	.366	.171	.050	.401	40.034	3.491	45.313
ENERGY SOURCE NAT GAS	MILL BTU	.254	3.260	.032	.000	234.109	0.000	237.655
ENERGY SOURCE COAL	MILL BTU	.156	.416	.030	0.000	70.504	0.000	71.106
ENERGY SOURCE MISC	MILL BTU	.020	.094	0.000	0.000	15.760	0.000	15.874
ENERGY SOURCE WOOD FIBER	MILL BTU	0.000	0.000	.064	0.000	.238	0.000	.302
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	100.990	0.000	0.000	0.000	0.000	0.000	100.990
MATERIAL GYPSUM	POUND	12.501	0.000	0.000	0.000	0.000	0.000	12.501
MATERIAL SILICA	POUND	63.006	0.000	0.000	0.000	0.000	0.000	63.006
MATERIAL PROCESS ADD	POUNDS	2.335	0.000	.761	0.000	489.001	0.000	492.097
ENERGY PROCESS	MIL BTU	.761	3.942	.174	0.000	351.795	0.000	356.673
ENERGY TRANSPORT	MIL BTU	.035	0.000	.021	.401	.731	3.491	4.458
ENERGY OF MATL RESOURCE	MIL BTU	0.000	0.000	0.000	0.000	0.990	0.000	0.998
WATER VOLUME	THOU GAL	.675	.929	.003	.023	172.617	.217	174.465

OUTPUTS FROM SYSTEMS NAME	UNITS	CHINA PLATES RAW MAT 6900 USE	CHINA PLATES MFG 6900 USE	CHINA PLATES PKG 6900 USE	CHINA PLATES TRAN 6900 USE	CHINA PLATES WASH 6900 USE	CHINA PLATES PCSW 6900 USE	CHINA PLATES SYS TOT 6900 USE
SOLID WASTES PROCESS	POUND	0.000	63.014	.729	0.000	207.509	0.000	272.132
SOLID WASTES FUEL COMB	POUND	.740	2.449	.493	.093	414.322	.072	418.978
SOLID WASTES MINING	POUND	249.977	6.664	.430	0.000	1265.598	0.000	1522.673
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	0.000	0.000	0.000	1.117	1.117
ATMOSPHERIC PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	8.407	1.345	.425	.051	99.522	.366	110.115
ATMOS NITROGEN OXIDES	POUND	.701	2.524	.176	.055	262.423	3.727	270.407
ATMOS HYDROCARBONS	POUND	.421	3.270	.196	.318	261.266	3.709	269.163
ATMOS SULFUR OXIDES	POUND	1.079	2.323	.603	.176	401.854	.008	406.944
ATMOS CARBON MONOXIDE	POUND	.160	.464	.061	1.082	54.000	25.005	80.930
ATMOS ALDEHYDES	POUND	.006	.007	.001	.017	.705	.299	1.034
ATMOS OTHER ORGANICS	POUND	.003	.016	.000	.038	1.473	1.072	2.691
ATMOS ODOROUS SULFUR	POUND	0.000	0.000	0.000	0.000	2.483	0.000	2.483
ATMOS AMMONIA	POUND	.001	0.000	.000	.001	1.722	.010	1.734
ATMOS HYDROGEN FLOURIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS LEAD	POUND	.000	0.000	.000	.002	.012	.072	.086
ATMOS MERCURY	POUND	.000	.000	.000	0.000	.007	0.000	.007
ATMOSPHERIC CHLORINE	POUND	0.000	0.000	0.000	0.000	.677	0.000	.677
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE FLUORIDES	POUND	.000	0.000	0.000	0.000	0.000	0.000	.000
WATERBORNE DISS SOLIDS	POUND	.290	.509	.060	.199	739.663	1.862	742.581
WATERBORNE BOD	POUND	.020	.200	.223	.001	8.530	.005	9.075
WATERBORNE PHENOL	POUND	.001	.000	.000	.000	.009	.002	.012
WATERBORNE SULFIDES	POUND	.000	.000	.000	.000	.011	.002	.014
WATERBORNE OIL	POUND	.001	.000	.000	.000	.160	.002	.164
WATERBORNE COD	POUND	.665	.476	.000	.002	13.390	.019	14.553
WATERBORNE SUSP SOLIDS	POUND	6.643	.504	.163	.001	16.643	.012	23.967
WATERBORNE ACID	POUND	.037	.120	.005	.000	24.643	.004	24.817
WATERBORNE METAL ION	POUND	2.561	.332	.001	.000	5.380	.001	7.975
WATERBORNE CHEMICALS	POUND	.193	0.000	.008	0.000	.018	0.000	.220
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000	.798	0.000	.798
WATERBORNE CHROMIUM	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE LEAD	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000	.154	0.000	.154
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	0.000	0.000	0.000	0.000	.010	0.000	.010
WATERBORNE NITROGEN	POUND	0.000	0.000	0.000	0.000	2.992	0.000	2.992
WATERBORNE PESTICIDE	POUND	0.000	0.000	0.000	0.000	.016	0.000	.016

SUMMARY OF ENVIRONMENTAL IMPACTS NAME	UNITS	CHINA PLATES RAW MAT 6900 USE	CHINA PLATES MFG 6900 USE	CHINA PLATES PKG 6900 USE	CHINA PLATES TRAN 6900 USE	CHINA PLATES WASH 6900 USE	CHINA PLATES PCSW 6900 USE	CHINA PLATES SYS TOT 6900 USE
RAW MATERIALS	POUNDS	369.953	0.000	8.341	0.000	3211.737	0.000	3590.031
ENERGY	MIL BTU	.796	3.942	.175	.401	361.525	3.491	370.329
WATER	THOU GAL	.675	.929	.003	.023	172.617	.217	174.465
INDUSTRIAL SOLID WASTES	CUBIC FT	3.385	.905	.022	.001	25.481	.012	29.886
ATM EMISSIONS	POUNDS	10.776	9.950	1.461	2.533	1086.230	35.326	1146.279
WATERBORNE WASTES	POUNDS	10.367	2.089	.400	.206	812.467	1.909	827.357
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	0.000	0.000	0.000	1.117	1.117
ENERGY SOURCE PETROLEUM	MIL BTU	.366	.171	.050	.401	40.034	3.491	45.313
ENERGY SOURCE NAT GAS	MIL BTU	.254	3.260	.032	.000	234.109	0.000	237.655
ENERGY SOURCE COAL	MIL BTU	.156	.416	.030	0.000	70.504	0.000	71.106
ENERGY SOURCE NUCL HYPWR	MIL BTU	.020	.094	0.000	0.000	15.760	0.000	15.874
ENERGY SOURCE WOOD WASTE	MIL BTU	0.000	0.000	.064	0.000	.238	0.000	.302

INDEX OF ENVIRONMENTAL IMPACTS NAME	STANDARD VALUES	CHINA PLATES RAW MAT 6900 USE	CHINA PLATES MFG 6900 USE	CHINA PLATES PKG 6900 USE	CHINA PLATES TRAN 6900 USE	CHINA PLATES WASH 6900 USE	CHINA PLATES PCSW 6900 USE	CHINA PLATES SYS TOT 6900 USE
RAW MATERIALS	3590.031	10.3	0.0	.2	0.0	89.5	0.0	100.0
ENERGY	370.329	.2	1.1	.0	.1	97.6	.9	100.0
WATER	174.465	.4	.5	.0	.0	98.9	.1	100.0
INDUSTRIAL SOLID WASTES	29.886	11.3	3.3	.1	.0	85.3	.0	100.0
ATM EMISSIONS	1146.279	.9	.9	.1	.2	94.8	3.1	100.0
WATERBORNE WASTES	827.357	1.3	.2	.0	.0	98.2	.2	100.0
POST-CONSUMER SOL WASTE	1.117	0.0	0.0	0.0	0.0	0.0	100.0	100.0
ENERGY SOURCE PETROLEUM	45.313	.8	.4	.1	.9	90.1	7.7	100.0
ENERGY SOURCE NAT GAS	237.655	.1	1.4	.0	.0	98.5	0.0	100.0
ENERGY SOURCE COAL	71.106	.2	.6	.0	0.0	99.2	0.0	100.0
ENERGY SOURCE NUCL HYPWR	15.874	.1	.6	0.0	0.0	99.3	0.0	100.0
ENERGY SOURCE WOOD WASTE	.302	0.0	0.0	21.1	0.0	78.9	0.0	100.0

TABLE 60

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE MILLN MELAMINE PLTE 1000 USE

INPUTS TO SYSTEMS NAME	UNITS	MELAMINE PLATE RAW MAT 1000 USE	MELAMINE PLATE MFG 1000 USE	MELAMINE PLATE PKG 1000 USE	MELAMINE PLATE TRAN 1000 USE	MELAMINE PLATE WASH 1000 USE	MELAMINE PLATE PCSW 1000 USE	MELAMINE PLATE SYS TOT 1000 USE
MATERIAL COTTON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	0.000	0.000	0.000	0.000	1336.048	0.000	1336.048
MATERIAL WOOD FIBER	POUND	100.328	0.000	18.151	0.000	0.000	0.000	118.479
MATERIAL LIMESTONE	POUND	9.946	0.000	0.000	0.000	0.000	0.000	9.946
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	11.721	0.000	0.000	0.000	134.730	0.000	146.450
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000	584.051	0.000	584.051
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000	516.231	0.000	516.231
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	1.250	0.000	0.000	0.000	150.868	0.000	152.118
ENERGY SOURCE PETROLEUM	MILL BTU	2.829	.426	.119	.258	40.834	.021	44.487
ENERGY SOURCE NAT GAS	MILL BTU	15.431	.430	.076	0.000	234.109	0.000	250.046
ENERGY SOURCE COAL	MILL BTU	1.380	1.035	.072	0.000	70.584	0.000	73.070
ENERGY SOURCE MISC	MILL BTU	.308	.234	0.000	0.000	15.760	0.000	16.301
ENERGY SOURCE WOOD FIBER	MILL BTU	1.043	0.000	.152	0.000	.238	0.000	1.434
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	16.125	0.000	1.823	0.000	489.801	0.000	507.749
ENERGY PROCESS	MIL BTU	11.112	2.125	.417	0.000	351.795	0.000	365.449
ENERGY TRANSPORT	MIL BTU	.595	0.000	.002	.258	.731	.021	1.608
ENERGY OF MATL RESOURCE	MIL BTU	9.283	0.000	0.000	0.000	8.998	0.000	18.281
WATER VOLUME	THOU GAL	7.961	2.474	.008	.015	172.617	.001	183.077

OUTPUTS FROM SYSTEMS NAME	UNITS	RAW MAT	MFG	PKG	TRAN	WASH	PCSW	SYS TOT
SOLID WASTES PROCESS	POUND	16.976	.873	1.745	0.000	207.509	0.000	227.102
SOLID WASTES FUEL COMB	POUND	8.943	6.085	1.181	.060	414.322	.005	430.197
SOLID WASTES MINING	POUND	22.053	16.570	1.029	0.000	1265.598	0.000	1305.250
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	0.000	0.000	0.000	5.999	5.999
ATMOSPHERIC PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	2.955	1.288	1.017	.030	99.522	.002	104.813
ATMOS NITROGEN OXIDES	POUND	10.997	2.248	.423	.543	262.423	.022	276.648
ATMOS HYDROCARBONS	POUND	25.854	.872	.254	.196	281.266	.023	288.465
ATMOS SULFUR OXIDES	POUND	12.514	5.689	1.445	.092	401.854	.005	421.598
ATMOS CARBON MONOXIDE	POUND	7.274	.277	.146	.807	54.086	1.012	63.602
ATMOS ALDEHYDES	POUND	.030	.004	.002	.011	.705	.002	.754
ATMOS OTHER ORGANICS	POUND	.040	.005	.211	.028	1.473	.142	1.899
ATMOS ODOROUS SULFUR	POUND	.090	0.000	0.000	0.000	2.483	0.000	2.573
ATMOS AMMONIA	POUND	2.334	0.000	.000	.001	1.722	.000	4.058
ATMOS HYDROGEN FLOURIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS LEAD	POUND	.000	0.000	.000	.007	.012	.000	.015
ATMOS MERCURY	POUND	.000	.000	.000	0.000	.007	0.000	.007
ATMOSPHERIC CHLORINE	POUND	.057	0.000	0.000	0.000	.677	0.000	.735
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	2.941	.123	.143	.129	739.663	.011	743.050
WATERBORNE BOD	POUND	.901	.000	.534	.000	8.538	.000	9.973
WATERBORNE PHENOL	POUND	.001	.000	.000	.000	.009	.000	.010
WATERBORNE SULFIDES	POUND	.001	.000	.000	.000	.011	.000	.013
WATERBORNE OIL	POUND	.016	.000	.000	.000	.160	.000	.177
WATERBORNE COD	POUND	.079	.001	.001	.001	13.390	.000	13.473
WATERBORNE SUSP SOLIDS	POUND	1.335	.001	.248	.001	16.683	.000	18.268
WATERBORNE ACID	POUND	.448	.317	.011	.000	24.643	.000	25.420
WATERBORNE METAL ION	POUND	.105	.079	.003	.000	5.380	.000	5.567
WATERBORNE CHEMICALS	POUND	0.000	0.000	.020	0.000	.018	0.000	.038
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000	.798	0.000	.798
WATERBORNE CHROMIUM	POUND	0.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE LEAD	POUND	.000	0.000	0.000	0.000	.000	0.000	.000
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000	.154	0.000	.154
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	.442	0.000	0.000	0.000	.010	0.000	.452
WATERBORNE NITROGEN	POUND	0.000	0.000	0.000	0.000	2.992	0.000	2.992
WATERBORNE PESTICIDE	POUND	0.000	0.000	0.000	0.000	.016	0.000	.016

SUMMARY OF ENVIRONMENTAL IMPACTS NAME	UNITS	RAW MAT	MFG	PKG	TRAN	WASH	PCSW	SYS TOT
RAW MATERIALS	POUNDS	139.369	0.000	19.974	0.000	3211.737	0.000	3371.080
ENERGY	MIL BTU	20.990	2.125	.419	.258	361.525	.021	385.338
WATER	THOU GAL	7.961	2.474	.008	.015	172.617	.001	183.077
INDUSTRIAL SOLID WASTES	CUBIC FT	.642	.318	.053	.000	25.481	.000	26.496
ATM EMMISSIONS	POUNDS	62.146	10.375	3.497	1.709	1086.230	1.210	1165.166
WATERBORNE WASTES	POUNDS	6.310	.522	.959	.132	812.467	.011	820.401
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	0.000	0.000	0.000	5.999	5.999
ENERGY SOURCE PETROLEUM	MIL BTU	2.829	.426	.119	.258	40.834	.021	44.487
ENERGY SOURCE NAT GAS	MIL BTU	15.431	.430	.076	0.000	234.109	0.000	250.046
ENERGY SOURCE COAL	MIL BTU	1.380	1.035	.072	0.000	70.584	0.000	73.070
ENERGY SOURCE NUCL HYPWR	MIL BTU	.308	.234	0.000	0.000	15.760	0.000	16.301
ENERGY SOURCE WOOD WASTE	MIL BTU	1.043	0.000	.152	0.000	.238	0.000	1.434

INDEX OF ENVIRONMENTAL IMPACTS NAME	STANDARD VALUES	RAW MAT	MFG	PKG	TRAN	WASH	PCSW	SYS TOT
RAW MATERIALS	3371.080	4.1	0.0	.6	0.0	95.3	0.0	100.0
ENERGY	385.338	5.4	.6	.1	.1	93.8	.0	100.0
WATER	183.077	4.3	1.4	.0	.0	94.3	.0	100.0
INDUSTRIAL SOLID WASTES	26.496	2.4	1.2	.2	.0	96.2	.0	100.0
ATM EMMISSIONS	1165.166	5.3	.9	.3	.1	93.2	.1	100.0
WATERBORNE WASTES	820.401	.8	.1	.1	.0	99.0	.0	100.0
POST-CONSUMER SOL WASTE	5.999	0.0	0.0	0.0	0.0	0.0	100.0	100.0
ENERGY SOURCE PETROLEUM	44.487	6.4	1.0	.3	.6	91.8	.0	100.0
ENERGY SOURCE NAT GAS	250.046	6.2	.2	.0	0.0	93.6	0.0	100.0
ENERGY SOURCE COAL	73.070	1.9	1.4	.1	0.0	96.6	0.0	100.0
ENERGY SOURCE NUCL HYPWR	16.301	1.9	1.4	0.0	0.0	96.7	0.0	100.0
ENERGY SOURCE WOOD WASTE	1.434	72.8	0.0	10.6	0.0	16.6	0.0	100.0

TABLE 61

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE MILLION POLYSTY FOAM PLATES

NAME	UNITS	POLYSTY RESIN ST 26010 LB	ISOPENT SYS 1840 LB	POLYSTY FOAM PLATE MFG	POLYSYY FOAM PLATE PKG	POLYSTY FOAM PLATE TRAN	POLYSTY FOAM PLATE PCSW	POLYSTY FOAM PLATE SYS TOT
INPUTS TO SYSTEMS								
MATERIAL COTTON	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL SULFATE BRINE	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL WOOD FIBER	POUND	0.00	0.00	0.00	2509.20	0.00	0.00	2509.20
MATERIAL LIMESTONE	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL IRON ORE	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL SALT	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL GLASS SAND	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL NAT SODA ASH	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL FELDSPAR	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL BAUXITE ORE	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL SULFUR	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENERGY SOURCE PETROLEUM	MILL BTU	602.27	.04	43.43	19.22	87.29	33.54	785.78
ENERGY SOURCE NAT GAS	MILL BTU	408.51	26.03	43.83	21.97	2.53	0.00	502.87
ENERGY SOURCE COAL	MILL BTU	22.91	.04	105.44	11.70	0.00	0.00	140.09
ENERGY SOURCE MISC	MILL BTU	5.18	.01	23.84	.39	0.00	0.00	29.42
ENERGY SOURCE WOOD FIBER	MILL BTU	0.00	0.00	0.00	21.07	0.00	0.00	21.07
ENERGY SOURCE HYDROPOWER	MILL BTU	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL POTASH	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL PHOSPHATE ROCK	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL CLAY	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL GYPSUM	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL SILICA	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL PROCESS ADD	POUNDS	1316.71	0.00	0.00	261.30	0.00	0.00	1578.02
ENERGY PROCESS	MIL BTU	379.32	.09	216.54	64.48	0.00	0.00	660.43
ENERGY TRANSPORT	MIL BTU	17.27	1.49	0.00	.79	89.81	33.54	142.91
ENERGY OF MATL RESOURCE	MIL BTU	642.28	24.54	0.00	9.08	0.00	0.00	675.90
WATER VOLUME	THOU GAL	88.14	.35	3.43	2.50	5.04	2.08	101.55
OUTPUTS FROM SYSTEMS								
SOLID WASTES PROCESS	POUND	1241.84	0.00	440.00	249.96	0.00	0.00	1951.80
SOLID WASTES FUEL COMB	POUND	155.40	.26	628.16	173.49	20.11	0.38	977.77
SOLID WASTES MINING	POUND	366.89	.69	1688.72	170.08	0.00	0.00	2226.37
SOLID WASTE POST-CONSUM	CUBIC FT	0.00	0.00	0.00	0.00	0.00	4582.52	4582.52
ATMOSPHERIC PESTICIDE	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ATMOS PARTICULATES	POUND	56.63	.06	131.30	143.08	10.65	3.52	345.24
ATMOS NITROGEN OXIDES	POUND	334.98	8.72	228.26	66.57	219.32	35.81	893.66
ATMOS HYDROCARBONS	POUND	925.26	40.24	358.88	54.23	65.29	36.41	1480.31
ATMOS SULFUR OXIDES	POUND	315.19	3.01	579.74	210.17	35.69	8.73	1152.52
ATMOS CARBON MONOXIDE	POUND	457.71	2.36	28.28	21.80	185.40	292.24	987.78
ATMOS ALDEHYDES	POUND	1.47	.00	.38	.31	2.85	2.87	7.89
ATMOS OTHER ORGANICS	POUND	1.51	.00	.50	29.15	5.38	18.39	54.93
ATMOS ODOROUS SULFUR	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ATMOS AMMONIA	POUND	.23	.00	0.00	.04	.22	.09	.58
ATMOS HYDROGEN FLOURIDE	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ATMOS LEAD	POUND	.00	.00	0.00	.01	.23	.69	.93
ATMOS MERCURY	POUND	.00	.00	.01	.00	0.00	0.00	.01
ATMOSPHERIC CHLORINE	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE DIS SOLIDS	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE FLUORIDES	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE DISS SOLIDS	POUND	257.77	2.38	12.49	21.82	43.38	17.89	355.74
WATERBORNE BOD	POUND	16.08	.00	.03	73.91	.11	.05	90.19
WATERBORNE PHENOL	POUND	.05	.00	.01	.01	.04	.02	.12
WATERBORNE SULFIDES	POUND	.06	.00	.01	.01	.05	.02	.15
WATERBORNE OIL	POUND	3.33	.04	.02	.03	.06	.02	3.50
WATERBORNE COD	POUND	39.57	.00	.13	.80	.44	.19	41.13
WATERBORNE SUSP SOLIDS	POUND	28.24	.00	.08	34.48	.28	.12	63.19
WATERBORNE ACID	POUND	7.11	.01	32.34	2.05	.08	.04	41.64
WATERBORNE METAL ION	POUND	1.78	.00	8.09	.51	.02	.01	10.41
WATERBORNE CHEMICALS	POUND	0.00	0.00	0.00	2.74	0.00	0.00	2.74
WATERBORNE CYANIDE	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE ALKALINITY	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE CHROMIUM	POUND	.04	0.00	0.00	0.00	0.00	0.00	.04
WATERBORNE IRON	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE ALUMINUM	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE NICKEL	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE MERCURY	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE LEAD	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE PHOSPHATES	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE ZINC	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE AMMONIA	POUND	.45	0.00	0.00	0.00	0.00	0.00	.45
WATERBORNE NITROGEN	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE PESTICIDE	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUMMARY OF ENVIRONMENTAL IMPACTS								
RAW MATERIALS	POUNDS	1316.71	0.00	0.00	2770.50	0.00	0.00	4087.22
ENERGY	MIL BTU	1038.87	26.12	216.54	74.35	89.81	33.54	1479.23
WATER	THOU GAL	88.14	.35	3.43	2.50	5.04	2.08	101.55
INDUSTRIAL SOLID WASTES	CUBIC FT	23.82	.01	37.38	8.01	.27	.11	69.61
ATM EMISSIONS	POUNDS	2092.90	54.39	1327.36	525.36	525.03	398.74	4923.87
WATERBORNE WASTES	POUNDS	354.40	2.44	53.21	136.36	44.46	18.36	609.30
POST-CONSUMER SOL WASTE	CUBIC FT	0.00	0.00	0.00	0.00	0.00	4582.52	4582.52
ENERGY SOURCE PETROLEUM	MIL BTU	602.27	.04	43.43	19.22	87.29	33.54	785.78
ENERGY SOURCE NAT GAS	MIL BTU	408.51	26.03	43.83	21.97	2.53	0.00	502.87
ENERGY SOURCE COAL	MIL BTU	22.91	.04	105.44	11.70	0.00	0.00	140.09
ENERGY SOURCE NUCL HYPWR	MIL BTU	5.18	.01	23.84	.39	0.00	0.00	29.42
ENERGY SOURCE WOOD WASTE	MIL BTU	0.00	0.00	0.00	21.07	0.00	0.00	21.07

INDEX OF ENVIRONMENTAL IMPACTS

NAME	STANDARD VALUES	POLYSTY RESIN ST 26010 LB	ISOPENT SYS 1840 LB	POLYSTY FOAM PLATE MFG	POLYSYY FOAM PLATE PKG	POLYSTY FOAM PLATE TRAN	POLYSTY FOAM PLATE PCSW	POLYSTY FOAM PLATE SYS TOT
RAW MATERIALS	4087.22	32.2	0.0	0.0	67.8	0.0	0.0	100.0
ENERGY	1479.23	70.2	1.8	14.6	5.0	6.1	2.3	100.0
WATER	101.55	86.8	.3	3.4	2.5	5.0	2.1	100.0
INDUSTRIAL SOLID WASTES	69.61	34.2	.0	53.7	11.5	.4	.2	100.0
ATM EMISSIONS	4923.87	42.5	1.1	27.0	10.7	10.7	8.1	100.0
WATERBORNE WASTES	609.30	58.2	.4	8.7	22.4	7.3	3.0	100.0
POST-CONSUMER SOL WASTE	4582.52	0.0	.0	0.0	0.0	0.0	100.0	100.0
ENERGY SOURCE PETROLEUM	785.78	76.6	.0	5.5	2.4	11.1	4.3	100.0
ENERGY SOURCE NAT GAS	502.87	81.2	5.2	8.7	4.4	.5	0.0	100.0
ENERGY SOURCE COAL	140.09	16.4	.0	75.3	8.3	0.0	0.0	100.0
ENERGY SOURCE NUCL HYPWR	29.42	17.6	.0	81.0	1.3	0.0	0.0	100.0
ENERGY SOURCE WOOD WASTE	21.07	0.0	0.0	0.0	100.0	0.0	0.0	100.0

TABLE 62

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

MIL 9IN PAPBD PLATES

INPUTS TO SYSTEMS

NAME	UNITS	PAPBD SYSTEM 28168 LB	CONVERT	POLY BAGS 120 LB	CORRUG 945 LB	DISPOSAL	TRANSPOR	TOTAL
MATERIAL COTTON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL WOOD FIBER	POUND	19009.050	0.000	0.000	658.665	0.000	0.000	19667.715
MATERIAL LIMESTONE	POUND	2065.050	0.000	0.000	0.000	0.000	0.000	2065.050
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	3154.231	0.000	0.000	0.000	0.000	0.000	3154.231
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000	0.000	0.00.	0.000
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	267.114	0.000	0.000	0.000	0.000	0.000	267.114
ENERGY SOURCE PETROLEUM	MILL BTU	88.484	3.870	.928	4.334	7.857	25.553	131.026
ENERGY SOURCE NAT GAS	MILL BTU	183.033	3.906	3.953	2.740	0.000	0.000	193.632
ENERGY SOURCE COAL	MILL BTU	148.746	9.396	.595	2.614	0.000	0.000	161.351
ENERGY SOURCE MISC	MILL BTU	8.344	2.124	.135	0.000	0.000	0.000	10.602
ENERGY SOURCE WOOD FIBER	MILL BTU	245.979	0.000	0.000	5.531	0.000	0.000	251.510
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	2123.134	0.000	3.190	66.150	0.000	0.000	2192.474
ENERGY PROCESS	MIL BTU	669.919	19.296	2.339	15.135	0.000	0.000	706.688
ENERGY TRANSPORT	MIL BTU	4.668	0.000	.160	.085	7.857	25.553	38.322
ENERGY OF MATL RESOURCE	MIL BTU	0.000	0.000	3.112	0.000	0.000	0.000	3.112
WATER VOLUME	THOU GAL	285.626	.306	.464	.300	.488	1.472	288.655

OUTPUTS FROM SYSTEMS

NAME	UNITS	PAPBD SYSTEM 28168 LB	CONVERT	POLY BAGS 120 LB	CORRUG 945 LB	DISPOSAL	TRANSPOR	TOTAL
SOLID WASTES PROCESS	POUND	4416.331	20.000	3.005	63.315	0.000	0.000	4502.651
SOLID WASTES FUEL COMB	POUND	1773.900	55.260	3.502	42.860	1.963	5.920	1883.405
SOLID WASTES MINING	POUND	659.661	150.480	9.533	37.366	0.000	0.000	857.020
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	0.000	0.000	367.730	0.000	367.730
ATMOSPHERIC PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	218.350	11.700	.472	36.891	.824	3.584	272.221
ATMOS NITROGEN OXIDES	POUND	287.099	20.340	2.797	15.334	8.388	57.466	391.424
ATMOS HYDROCARBONS	POUND	220.622	7.920	6.561	9.213	8.529	20.894	273.740
ATMOS SULFUR OXIDES	POUND	661.065	51.660	3.577	52.430	2.044	11.527	782.303
ATMOS CARBON MONOXIDE	POUND	85.806	2.520	.539	5.309	100.958	58.289	253.422
ATMOS ALDEHYDES	POUND	.593	.034	.004	.079	.672	1.035	2.419
ATMOS OTHER ORGANICS	POUND	1.670	.045	.098	7.644	9.439	2.177	20.944
ATMOS ODOROUS SULFUR	POUND	19.042	0.000	0.000	0.000	0.000	0.000	19.042
ATMOS AMMONIA	POUND	.024	0.000	.000	.011	.022	.065	.122
ATMOS HYDROGEN FLOURIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS LEAD	POUND	.097	0.000	.000	.002	.153	.094	.340
ATMOS MERCURY	POUND	.007	.001	.000	.000	0.000	0.000	.008
ATMOSPHERIC CHLORINE	POUND	15.414	0.000	0.000	0.000	0.000	0.000	15.414
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	68.695	1.113	.715	5.191	4.191	12.642	92.537
WATERBORNE BOD	POUND	95.756	.003	.032	19.378	.011	.033	115.213
WATERBORNE PHENOL	POUND	.008	.001	.000	.002	.004	.011	.026
WATERBORNE SULFIDES	POUND	.010	.001	.000	.002	.005	.015	.034
WATERBORNE OIL	POUND	.012	.001	.008	.003	.005	.016	.045
WATERBORNE COD	POUND	.093	.012	.244	.022	.043	.131	.546
WATERBORNE SUSP SOLIDS	POUND	120.608	.007	.079	8.991	.027	.082	129.794
WATERBORNE ACID	POUND	17.584	2.882	.183	.397	.008	.025	21.080
WATERBORNE METAL ION	POUND	3.013	.721	.046	.099	.002	.006	3.887
WATERBORNE CHEMICALS	POUND	0.000	0.000	0.000	.718	0.000	0.000	.718
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE CHROMIUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	.000	0.000	0.000	0.000	0.000	0.000	.000
WATERBORNE LEAD	POUND	.007	0.000	0.000	0.000	0.000	0.000	.007
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NITROGEN	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000

SUMMARY OF ENVIRONMENTAL IMPACTS

NAME	UNITS	PAPBD SYSTEM 28168 LB	CONVERT	POLY BAGS 120 LB	CORRUG 945 LB	DISPOSAL	TRANSPOR	TOTAL
RAW MATERIALS	POUNDS	26618.580	0.000	3.190	724.815	0.000	0.000	27346.585
ENERGY	MIL BTU	674.586	19.296	5.611	15.220	7.857	25.553	748.122
WATER	THOU GAL	285.626	.306	.464	.300	.488	1.472	288.655
INDUSTRIAL SOLID WASTES	CUBIC FT	92.474	3.047	.217	1.938	.026	.080	97.782
ATM EMMISSIONS	POUNDS	1509.809	94.220	14.359	126.913	131.039	155.136	2031.477
WATERBORNE WASTES	POUNDS	305.786	4.741	1.308	34.794	4.297	12.961	363.887
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	0.000	0.000	367.730	0.000	367.730
ENERGY SOURCE PETROLEUM	MIL BTU	88.484	3.870	.928	4.334	7.857	25.553	131.026
ENERGY SOURCE NAT GAS	MIL BTU	183.033	3.906	3.953	2.740	0.000	0.000	193.632
ENERGY SOURCE COAL	MIL BTU	148.746	9.396	.595	2.614	0.000	0.000	161.351
ENERGY SOURCE NUCL HYPWR	MIL BTU	8.344	2.124	.135	0.000	0.000	0.000	10.602
ENERGY SOURCE WOOD WASTE	MIL BTU	245.979	0.000	0.000	5.531	0.000	0.000	251.510

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NAME	STANDARD VALUES	PAPBD SYSTEM 28168 LB	CONVERT	POLY BAGS 120 LB	CORRUG 945 LB	DISPOSAL	TRANSPOR	TOTAL
RAW MATERIALS	27346.585	97.3	0.0	.0	2.7	0.0	0.0	100.0
ENERGY	748.122	90.2	2.6	.7	2.0	1.1	3.4	100.0
WATER	288.655	99.0	.1	.2	.1	.2	.5	100.0
INDUSTRIAL SOLID WASTES	97.782	94.6	3.1	.2	2.0	.0	.1	100.0
ATM EMMISSIONS	2031.477	74.3	4.6	.7	6.2	6.5	7.6	100.0
WATERBORNE WASTES	363.887	84.0	1.3	.4	9.6	1.2	3.6	100.0
POST-CONSUMER SOL WASTE	367.730	0.0	0.0	0.0	0.0	100.0	0.0	100.0
ENERGY SOURCE PETROLEUM	131.026	67.5	3.0	.7	3.3	6.0	19.5	100.0
ENERGY SOURCE NAT GAS	193.632	94.5	2.0	2.0	1.4	0.0	0.0	100.0
ENERGY SOURCE COAL	161.351	92.2	5.8	.4	1.6	0.0	0.0	100.0
ENERGY SOURCE NUCL HYPWR	10.602	78.7	20.0	1.3	0.0	0.0	0.0	100.0
ENERGY SOURCE WOOD WASTE	251.510	97.8	0.0	0.0	2.2	0.0	0.0	100.0

APPENDIX A

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

The following sets of appendices present the basic raw data used to develop the resource and environmental profile analysis of the disposables and reusables within the basic categories: towels, napkins, diapers, bedding, drinking containers and plates.

Appendix B discusses the basic fuel factors used in this study and identifies the impacts associated with the combustion of a unit quantity of fuel, and the impacts for generating and delivering electric energy. The impacts associated with the various modes of transportation are also included.

Appendix C discusses the disposable systems: paper towels, paper napkins (home and commercial), disposable diapers, nonwoven sheets, cold drink containers (paper and thermoformed polystyrene), hot drink containers (paper and foam polystyrene), and plates (paper and foam polystyrene).

Appendix D discusses the reusable systems: cotton cloth towels, cloth napkins (home and commercial), cotton cloth diapers, cotton and polyester sheets, glass and polypropylene tumblers, ceramic and melamine hot cups, and ceramic and melamine plates.

In Appendices D and E, the subsystems and processes of each system are enumerated. Also, the environmental impacts associated with 1,000 pounds or specified unit (e.g., 1,000 sheets, 1 million drinking containers) of each process are presented.

Appendix F presents computer tables showing the total impacts of each system and process.

APPENDIX B

BASIC FUEL FACTORS

This section contains data and information used to convert raw fuel and electric energy input values into corresponding environmental impact parameters. The basic factors are discussed in three sections:

1. Mobile and Stationary Sources;

2. Electric Energy; and

3. Transportation.

I. Mobile and Stationary Sources

A set of atmospheric emission factors resulting from the combustion of fuels has been developed by the authors of this report in cooperation with staff in the Physical Sciences Division of Midwest Research Institute (MRI). They are reported in Table B-1. These data represent both a comprehensive literature search and data collected from a nationwide telephone survey. The primary source was Reference 6, but numerous other literature sources were also used. The factors represent national average emissions after pollution controls have been applied. They are representative of projections of levels which were experienced in 1975.

The total impacts associated with using a given quantity of a fuel are composed of: (1) precombustion impacts and (2) combustion impacts. Precombustion impacts refer to the resource and environmental impacts associated with extracting, refining and shipping the fuel to its location of use. Combustion impacts represent the energy content of the fuel plus the environmental pollutants (atmospheric emissions) discharged upon combustion of the fuel. The sum of the precombustion and combustion impacts are identified as "secondary impacts," and represent the basic fuel impact factors associated with burning fossil fuels.

Table B-1 contains the basic fuel factors for 12 energy resources. Tables B-2 and B-3 contain the precombustion impacts for natural gas and refined fuels.

TABLE B-1

FUEL FACTORS

	Gasoline (1000 gal.)			Diesel (1000 gal)			Fuel Oil Mobile Source (1000 gal)			Natural Gas Internal Combustion (1000 ft^3)			Natural Gas Industrial Heating (1000 ft^3)			Natural Gas Utility Heating (1000 ft^3)		
	Pre-combustion	Combustion	Total	Pre-combustion	Combustion	Total	Pre-combustion	Combustion	Total	Pre-combustion	Combustion	Total	Pre-combustion	Combustion	Total	Pre-combustion	Combustion	Total
Energy-10^6 Btu	19.9	125.0	144.9	19.9	139.0	158.9	19.9	150.0	169.9	0.056	1.03	1.086	0.056	1.03	1.086	0.056	1.03	1.086
Solid Wastes - lb	36.2		36.2	36.2		36.2	36.2		36.2									
Atmospheric Emissions - lb																		
Particulates	4.2	11.0	15.2	4.2	13.0	17.2	4.2	23.0	27.2	0.003		0.003	0.003	0.018	0.021	0.003	0.015	0.018
Nitrogen Oxides	34.7	120.0	154.7	34.7	370.0	404.7	34.7	105.0	139.7	0.357	6.0	6.357	0.357	0.214	0.571	0.357	0.600	0.957
Hydrocarbons	54.3	103.0	157.3	54.3	37.0	91.3	54.3	5.0	59.3	1.024	0.8	1.824	1.024	0.003	1.027	1.024	0.001	1.024
Sulfur Oxides	31.7	6.0	37.7	31.7	27.0	58.7	31.7	302.0	333.7	0.012		0.012	0.012		0.012	0.012		0.012
Carbon Monoxide	11.3	1030.0	1041.3	11.3	225.0	236.3	11.3	130.0	141.3	0.104	1.6	1.704	0.104	0.020	0.124	0.104	0.017	0.121
Aldehydes	0.4	12.0	12.4	0.4	3.0	3.4	0.4	10.0	10.4					0.002	0.002		0.001	0.001
Other Organics	0.5	44.0	44.5	0.5	3.0	3.5	0.5		0.5					0.005	0.005		0.003	0.003
Ammonia	0.4		0.4	0.4		0.4	0.4		0.4									
Lead	0.003	3.0	3.0	0.003		0.003	0.003		0.003									
Total Atmospheric	137.5	1454.0	1466.5	137.5	678.0	815.5	137.5	575.0	712.5	1.5	8.4	9.9	1.5	0.3	1.8	1.5	0.6	2.1
Waterborne Wastes - lb																		
Dissolved Solids (oil field brine)	80.9		80.9	80.9		80.9	80.9		80.9	0.19		0.19	0.19		0.19	0.19		0.19
Other	3.1		3.1	3.1		3.1	3.1		3.1									
Total Waterborne	84.0		84.0	84.0		84.0	84.0		84.0	0.19		0.19	0.19		0.19	0.19		0.19

	Residual Oil Industrial Heating (1000 gal.)			Fuel Oil Utility Heating (1000 gal.)			Distillate Oil Indust. Heating (1000 gal.)			Coal Industrial Heating (1000 lb)			Coal Utility Heat (1000 lb)			Diesel Locomotive (1000 gal)		
	Pre-combustion	Combustion	Total	Pre-combustion	Pre-Combustion	Total	Pre-combustion	Combustion	Total	Pre-combustion	Combustion	Total	Pre-combustion	Combustion	Total	Pre-combustion	Combustion	Total
Energy - 10^6 Btu	19.9	150.0	169.9	19.9	148.0	167.9	19.9	139.0	158.9	0.2	13.1	13.3	0.2	13.1	13.3	19.9	139.0	158.9
Solid Wastes - lb	36.2		36.2	36.2		36.2	36.2		36.2	190.0	31.0	221.0	190.0	69.0	259.0	36.2		36.2
Atmospheric Emissions - lb																		
Particulates	4.2	23.0	27.2	4.2	8.0	12.2	4.2	15.0	19.2	2.0	21.0	23.0	2.0	11.0	13.0	4.2	25.0	29.2
Nitrogen Oxides	34.7	72.0	106.7	34.7	105.0	139.7	34.7	72.0	106.7	0.5	9.0	9.5	0.5	9.0	9.5	34.7	370.0	404.7
Hydrocarbons	54.3	3.0	57.3	54.3	2.0	56.3	54.3	3.0	57.3	0.5	0.5	1.0	0.5	0.15	0.65	54.3	94.0	148.3
Sulfur Oxides	31.7	250.0	281.7	31.7	254.0	285.7	31.7	142.0	173.7	1.5	42.0	43.5	1.5	55.0	56.5	31.7	57.0	88.7
Carbon Monoxide	11.3	4.0	15.3	11.3	3.0	14.3	11.3	4.0	15.3	2.5	1.0	3.5	2.5	0.5	3.0	11.3	130.0	141.3
Aldehydes	0.4	1.0	1.4	0.4	1.0	1.4	0.4	2.0	2.4	0.01	0.003	0.013	0.01	0.003	0.013	0.4	5.5	5.9
Other Organics	0.5		0.5	0.5		0.5	0.5		0.5	0.02		0.02	0.02		0.02	0.5	7.0	7.5
Ammonia	0.4		0.4	0.4		0.4	0.4		0.4							0.4		0.4
Lead	0.003		0.003	0.003		0.003	0.003		0.003							0.003		0.003
Total Atmospheric	137.5	353.0	490.5	137.5	373.0	510.5	137.5	238.0	375.5	7.0	73.5	80.5	7.0	75.7	82.7	137.5	688.5	826.0
Waterborne Wastes - lb																		
Dissolved Solids (oil field brine)	80.9		80.9	80.9		80.9	80.9		80.9							80.9		80.9
Acid	0.2		0.2	0.2		0.2	0.2		0.2	2.0		2.0	2.0		2.0	0.2		0.2
Metal Ion	0.1		0.1	0.1		0.1	0.1		0.1	0.5		0.5	0.5		0.5	0.1		0.1
Other	0.8		2.8	2.8		2.8	2.8		2.8	0.5		0.5	0.5		0.5	2.8		2.8
Total Waterborne	84.0		84.0	84.0		84.0	84.0		84.0	3.0		3.0	3.0		3.0	84.0		84.0

TABLE B-1 (concluded)

FUEL FACTORS
(in metric units)

	Gasoline (1,000 ℓ)			Diesel (1,000 ℓ)			Fuel Oil Mobile Source (1,000 ℓ)			(1,000 cu m) Natural Gas Internal Combustion			(1,000 cu m) Natural Gas Industrial Heating			(1,000 cu m) Natural Gas Utility Heating		
	Pre-combustion	Combustion	Total	Pre-combustion	Combustion	Total	Pre-combustion	Combustion	Total	Pre-combustion	Combustion	Total	Pre-combustion	Combustion	Total	Pre-combustion	Combustion	Total
Energy - 10^9 j	5.5	34.8	40.3	5.5	38.7	44.2	5.5	41.8	47.3	2.1	38.4	40.5	2.1	38.4	40.5	2.1	38.4	40.5
Solid Wastes - kg	4.3		4.3	4.3		4.3	4.3		4.3									
Atmospheric emissions - kg																		
Particulates	0.5	1.3	1.8	0.5	1.6	2.1	0.5	2.8	3.3	0.05		0.05	0.05	0.3	0.35	0.05	0.2	0.25
Nitrogen Oxides	4.2	14.4	18.6	4.2	44.3	48.5	4.2	12.6	16.8	5.7	96.1	101.8	5.7	3.4	9.1	5.7	9.6	15.3
Hydrocarbons	6.5	12.3	18.8	6.5	4.4	10.9	6.5	0.6	7.1	16.4	12.8	29.2	16.4	0.05	16.45	16.4	0.02	16.42
Sulfur Oxides	3.8	0.7	4.5	3.8	3.2	7.0	3.8	36.2	40.0	0.2		0.2	0.2		0.2	0.2		0.2
Carbon Monoxide	1.4	123.4	124.8	1.4	27.0	28.4	1.4	15.6	17.0	1.7	25.6	27.3	1.7	0.3	2.0	1.7	0.3	2.0
Aldehydes	0.05	1.4	1.45	0.05	0.4	0.45	0.05	1.2	1.25					0.03	0.03		0.02	0.02
Other Organics	0.1	5.3	5.4	0.1	0.4	0.5	0.1		0.1					0.08	0.08		0.05	0.05
Ammonia	0.05		0.05	0.05		0.05	0.05		0.05									
Lead	0.0004	0.4	0.4004	0.0004		0.0004	0.0004		0.0004									
Total Atmospheric	16.6004	159.2	175.8004	16.6004	81.3	97.9004	16.6004	69.0	85.6004	24.05	134.5	158.55	24.05	4.16	28.21	24.05	10.19	34.24
Waterborne Wastes - kg																		
Dissolved Solids (oil field brine)	9.3		9.3	9.3		9.3	9.3		9.3	3.0		3.0	3.0		3.0	3.0		3.0
Other	1.1		1.1	1.1		1.1	1.1		1.1									
Total Waterborne	10.4		10.4	10.4		10.4	10.4		10.4	3.0		3.0	3.0		3.0	3.0		3.0

	(1,000 ℓ) Residual Oil Indust. Heating			(1,000 ℓ) Fuel Oil Utility Heating			(1,000 ℓ) Distillate Oil Industrial Heating			(1,000 ℓ) Coal Industrial Heat			Coal Utility Heat (1,000 kg)			Diesel Locomotive (1,000 ℓ)		
	Pre-combustion	Combustion	Total	Pre-combustion	Combustion	Total	Pre-combustion	Combustion	Total	Pre-combustion	Combustion	Total	Pre-combustion	Combustion	Total	Pre-combustion	Combustion	Total
Energy - 10^9 j	5.5	41.8	47.3	5.5	41.2	46.7	5.5	38.7	44.2	0.47	30.5	31.0	0.45	30.5	31.0	5.5	38.7	44.2
Solid Wastes - kg	4.3		4.3	4.3		4.3	4.3		4.3	190.0	31.0	221.0	190.0	69.0	259.0	4.3		4.3
Atmospheric emissions - kg																		
Particulates	0.5	2.8	3.3	0.5	1.0	1.5	0.5	1.8	2.3	2.0	21.0	23.0	2.0	11.0	13.0	0.5	3.0	3.5
Nitrogen Oxides	4.2	8.6	12.8	4.2	12.6	16.8	4.2	8.6	12.8	0.5	9.0	9.5	0.5	9.0	9.5	4.2	44.3	48.5
Hydrocarbons	6.5	0.4	6.9	6.5	0.2	6.7	6.5	0.4	6.9	0.5	0.5	1.0	0.5	0.2	0.7	6.5	11.3	17.8
Sulfur Oxides	3.8	30.0	33.8	3.8	30.4	34.2	3.8	17.0	20.8	1.5	42.0	43.5	1.5	55.0	56.5	3.8	6.8	10.6
Carbon Monoxide	1.4	0.5	1.9	1.4	0.4	1.8	1.4	0.5	1.9	2.5	1.0	3.5	2.5	0.5	3.0	1.4	15.6	17.0
Aldehydes	0.05	0.1	0.15	0.05	0.1	0.15	0.05	0.2	0.25	0.01	0.002	0.012	0.01	0.002	0.012	0.05	0.7	0.75
Other Organics	0.1		0.1	0.1		0.1	0.1		0.1	0.02		0.02	0.02		0.02	0.1	0.8	0.9
Ammonia	0.05		0.05	0.05		0.05	0.05		0.05							0.05		0.05
Lead	0.0004		0.0004	0.0004		0.0004	0.0004		0.0004							0.0004		0.0004
Total Atmospheric	16.6004	42.4	59.0004	16.6004	44.7	61.3004	16.6004	28.5	45.1004	7.03	73.502	80.532	7.03	75.702	82.732	16.6004	82.5	99.1004
Waterborne Wastes - kg																		
Dissolved Solids (oil field brine)	9.3		9.3	9.3		9.3	9.3		9.3							9.3		9.3
Acid										2.0		2.0	2.0		2.0			
Metal Ions										0.5		0.5	0.5		0.5			
Other	1.1		1.1	1.1		1.1	1.1		1.1	0.5		0.5	0.5		0.5	1.1		1.1
Total Waterborne	10.4		10.4	10.4		10.4	10.4		10.4	3.0		3.0	3.0		3.0	10.4		10.4

Source: Midwest Research Institute.

TABLE B-2

PRECOMBUSTION ENVIRONMENTAL IMPACTS RESULTING FROM PRODUCTION AND PROCESSING OF 1,000 CUBIC FEET OF NATURAL GAS

Impact Category	Production	Processing	Total Precombustion
Energy - 10^6 Btu	0.021	0.035	0.056
Atmopsheric emissions - lb			
Particulates	0.002	0.001	0.003
Nitrogen oxides	0.119	0.238	0.357
Hydrocarbons	0.495	0.529	1.024
Sulfur oxides	0.010	0.002	0.012
Carbon monoxide	0.038	0.066	0.104
Total atmopsheric	0.66	0.84	1.50
Waterborne wastes - lb			
Dissolved solids (oil field brine)	0.184	0.007	0.19

Source: Midwest Research Institute.

TABLE B-3

PRECOMBUSTION ENVIRONMENTAL IMPACTS RESULTING FROM PRODUCTION, REFINING AND DELIVERY OF 1,000 GALLONS OF LIQUID HYDROCARBON FUEL

Impact Category	Production	Refining	Transportation	Total
Energy - 10^6 Btu	1.4	17.5	1.0	19.9
Solid wastes - lb				
Process	4.2	--	--	4.2
Fuel combustion	2.6	10.2	0.06	12.9
Mining	3.9	15.2	--	19.1
Total	10.7	25.4	0.06	36.2
Atmospheric emissions - lb				
Particulate	0.34	3.82	0.07	4.2
Nitrogen oxides	3.02	27.16	4.53	34.7
Hydrocarbon	10.83	42.16	1.34	54.3
Sulfur oxide	2.14	29.12	0.48	31.7
Carbon monoxide	1.63	7.75	1.92	11.3
Aldehydes	0.04	0.38	0.02	0.4
Other organics	0.01	0.43	0.01	0.5
Ammonia	--	0.42	--	0.4
Lead	--	--	0.003	0.0
Total atmospheric	18.0	111.2	8.4	137.6
Waterborne wastes - lb				
Dissolved solids (oil field brine)	77.33	3.23	0.31	80.9
Suspended solids	--	0.63	--	0.6
BOD	--	0.36	--	0.4
COD	--	1.12	--	1.1
Phenol	--	0.10	--	0.1
Sulfide	--	0.13	--	0.1
Oil	--	0.21	--	0.2
Acid	0.04	0.15	--	0.2
Metal ion	0.01	0.04	--	0.1
Total waterborne	77.4	6.0	0.3	84.0

Source: Midwest Research Institute.

II. Electric Energy

The environmental impacts associated with use of electrical energy are summarized in Table B-4. The impacts were calculated on the basis of a composite kilowatt-hour (kw-hr). A composite kilowatt-hour is defined as 1 kilowatt-hour generated by the U.S. national average mix of fossil fuels and hydroelectric power. Data were obtained from the Edison Electric Institute for 1974 (Reference 84).

Hydropower was assigned an energy equivalent of 3,413 Btu per kilowatt-hour and nuclear energy was assigned an energy equivalent of 21,330 Btu per kilowatt-hour. The amounts of fuel required are the total 1974 U.S. fuel requirements for electric utilities, divided by the total number of kilowatt-hours sold to customers. Impact factors from Table B-1 were combined with the fuel quantities to arrive at the impact values in Table B-4.

III. Transportation

Environmental impacts occur when goods are transported as a result of the consumption of fossil fuels to provide the necessary energy. In this study, the modes of transportation included are rail, truck, pipeline, and barge. These impacts were calculated by determining the kinds and amounts of fuels used by each mode on a national average basis. Impacts were then calculated for 1,000 ton-miles by mode.

A. Rail

A complete set of fuel consumption data indicates that diesel fuel accounted for 98 percent of the energy expended by railroads in 1968 (Reference 85). We assumed that 100 percent of the energy was supplied by diesel fuel and that 5.63×10^{14} Btu of fuel were used. This fuel use resulted in 7.68×10^{11} ton-miles of transportation (Reference 86). The corresponding fuel consumption was 5.25 gallons per 1,000 ton-miles. This value was combined with information in Table B-1 to yield the impacts presented in Table B-5.

B. Truck

In 1967, a total of 9.29×10^{9} miles were traveled by trucks engaged in intercity highway hauling. This resulted in 1.10×10^{11} ton-miles of transportation (Reference 87). It is estimated that 35 percent of these miles were traveled by gasoline engine trucks while 65 percent were traveled by diesel-fueled trucks (Reference 85). National average fuel mileage data are not available, but a reasonable assumption based on actual experience is that this type of truck travel results in fuel consumption rates of about 5 miles per gallon for either type of fuel. Thus,

TABLE B-4

ENVIRONMENTAL IMPACTS RESULTING FROM GENERATION AND DELIVERY OF
1,000 COMPOSITE KILOWATT-HOURS OF ELECTRICITY, 1972

Impact Category	Coal	Oil	Natural gas[a]	Other	Total
Quantity	0.23[a] ton	13.1[a] gal.	1,999[a] cu ft		
Percent of Btu	48.7	20.1	20.2	11.0	100
Impacts					
Energy - 10 6 Btu[a]	5.22	2.15	2.17	1.18	10.72
Solid wastes - lb					
Mining	83.6	-	-	-	83.6
Fuel combustion	30.4	0.3	-	-	30.7
Atmospheric emissions - lb					
Particulates	5.7	0.2	0.6		6.5
Nitrogen oxides	4.2	1.6	5.5		11.3
Hydrocarbons	0.3	0.6	3.5		4.4
Sulfur oxides	24.9	3.7	0.1		28.7
Carbon monoxide	1.3	0.1			1.4
Other	0.01	0.03	0.01		0.05
Total atmospheric	36.4	6.3	9.2	-	52.0
Waterborne wastes - lb					
Acid	0.96	0.06	0.58		1.6
Metal ion	0.24	0.01	0.11		0.4
Other	0.20	0.60	0.59		1.4
Total waterborne	1.4	0.7	1.3	-	3.4

Source: Midwest Research Institute.
a/ These values were derived from: Monthly Energy Review, Federal Energy Administration, August 1975.

TABLE B-5

FUEL CONSUMPTION AND ENVIRONMENTAL IMPACTS RESULTING FROM 1,000 TON-MILES OF TRANSPORTATION BY EACH MODE

Impact Category	Rail	Truck	Barge	Pipeline
Fuel				
Gasoline - gal.		5.9		
Diesel - gal.	5.3	10.9	1.4	
Fuel oil - gal.			6.1	
Natural gas - cu ft				670
Energy - 10^6 Btu	0.8	2.5	1.2	0.7
Solid wastes (fuel combustion) - lb	0.13	0.40	0.18	
Atmospheric emissions - lb				
Particulates	0.17	0.32	0.21	0.01
Nitrogen oxides	2.05	5.08	1.31	5.09
Hydrocarbon	0.72	1.73	0.41	1.47
Sulfur oxides	0.46	0.83	2.11	0.01
Carbon monoxide	0.45	8.66	1.17	1.41
Aldehydes	0.03	0.12	0.07	
Other organics	0.04	0.07	0.01	
Ammonia				
Lead		0.02		
Total atmospheric	3.9	16.8	5.3	8.0
Waterborne wastes - lb				
Dissolved solids (oil field brine)	0.394	1.260	0.562	0.147
COD	0.004	0.013	0.006	
Acid	0.001	0.003	0.001	
Metal ion		0.001		
Other	0.005	0.016	0.008	
Total waterborne	0.40	1.29	0.57	0.15

Source: Midwest Research Institute.

6.5×10^8 gallons of gasoline and 1.20×10^9 gallons of diesel fuel were used in 1967. From this, it was calculated that 5.9 gallons of gasoline and 10.9 gallons of diesel fuel were consumed per 1,000 ton-miles. Using data in Table B-1, impacts were calculated and reported in Table B-5.

C. Barge

During 1966, barge traffic resulted in 5.0×10^{11} ton-miles of transportation (Reference 88). Fuel consumption was 6.99×10^8 gallons of diesel fuel and 3.09×10^9 gallons of residual. Therefore, 1.4 gallons of diesel fuel and 6.1 gallons of residual were consumed per 1,000 ton-miles. Impacts were calculated and are listed in Table B-5.

D. Crude Oil and Products Pipeline

Sources in the pipeline industry report that, on the average, about 30 cubic feet of natural gas fuel are required to transport one barrel of oil 300 miles through a pipeline. This requirement translates to 30 cubic feet for 45 ton-miles, or 0.67 cubic feet of natural gas per ton-mile of crude petroleum transportation. This factor, combined with information from Table B-1, gives the data necessary to calculate the impacts for 1,000 ton-miles of pipeline transportation. Pipeline transportation impacts for moving other types of liquids of interest in this study were assumed to be approximately the same as for crude oil.

According to the data in Table B-5, transportation by truck has the greatest environmental impacts of the four transportation modes. This is a result of the relative inefficiency of the gasoline engine. Truck transportation ranks highest in every impact category. Computer analysis comparing the four transport modes shows that the impacts for trucks are more than double that of barge transportation, greater than triple that of rail transportation, and nearly five times higher than pipeline transport. Despite these rather high values for trucks, transportation per se is usually only a small percent (e.g., 10 percent) of he total impact of a particular product system.

APPENDIX C

DISPOSABLES

I. Paper Towels

The processes necessary to accomplish the manufacture of paper towels are: (1) pulpwood harvesting; (2) bleached kraft and sulfite pulp production; (3) salt mining; (4) chlorine manufacturing; (5) caustic manufacturing; (6) limestone mining; (7) lime manufacturing; (8) sulfur mining; (9) sulfuric acid manufacturing; (10) tissue papermaking; and, (11) paper towel conversion. A brief description of the steps in each process will be given, along with environmental impact data. (Also, sources and assumptions will be enumerated when necessary.)

A. Pulpwood Harvesting

Impacts incurred during logging activities were determined from specific company operating data (Reference 89). The primary impacts incurred are related to fuels required for the cutting of timber and hauling it to a landing. The timber is then transported directly to a paper mill, or in many cases, to a concentration point which serves as a point of origin for shipping logs to the mill gathered from several landings.

Impacts were considered here only from roundwood consumption. The wood delivered to mills surveyed by the American Paper Institute for this study is 61 percent roundwood, the remainder being wood chips or wastes obtained from other types of wood processing mills. However, in past years, chips and other wastes were burned, rather than used, so they are treated here as being a waste by-product from another industry. Hence, less environmental impact is attributed to wood harvesting than if the wood was all supplied as roundwood. The impacts of harvesting wood which ends up as chips is allocated to the primary product for which it was harvested. Thus, wood ending up as sawdust is allocated to lumber products and is not included here. In addition, in the case of the mills studied, these residues were generated on-site or close by so the transport of the residues was negligible.

Table C-1 summarizes the data pertaining to pulpwood harvesting. The gasoline represents the fuel used for cutting and hauling the logs. The atmospheric emissions were derived by estimating the effluents from the burning of wood wastes left in the forest. The factors used were as follows: (Reference 90)

TABLE C-1

DATA FOR HARVESTING 1,000 POUNDS OF PULPWOOD

Impact Category	Quantities	Sources
Energy		89
Gasoline	0.89 gal.	
Atmospheric Emissions	0.14 lb	89

1. Ten percent of the harvested roundwood is left in the woods as a residue.

2. Seven percent of the amount left is presently burned.

3. Two percent of the amount burned is emitted into the atmosphere as a particulate emission.

Thus, for 1,000 pounds wood harvested, there is 100 pounds of waste, 7 pounds of which is burned. Of this 7 pounds, 2 percent, or 0.14 pound is emitted to the atmosphere.

One item of possible significance is omitted from Table C-1. An unknown amount of water pollution in the form of suspended solids results from run-off of harvested forests. However, at present, it is not possible to accurately estimate to what extent these solids actually reach streams. Although perhaps 7 pounds of suspended solids are generated, their final deposition is probably at other locations in the forest, and not in streams. Therefore, this category was not included at this time because the amount of stream pollution from this source is quite likely very small (Source: Franklin Associates, Ltd.).

B. Bleached Kraft and Sulfite Pulp (for tissue manufacture)

Tissue products (such as towels, napkins and portions of disposable diapers) are manufactured from wood pulp. Most of the wood pulp utilized in these products is prepared by the kraft process, with the remainder being prepared by the sulfite process.

The raw materials required for pulp manufacture are shown in Figure C-1.* The predominant raw material is wood, which comes from two

* These data are based on actual materials requirements for pulp used in manufacture of towels, napkins and disposable diapers (see Reference 89).

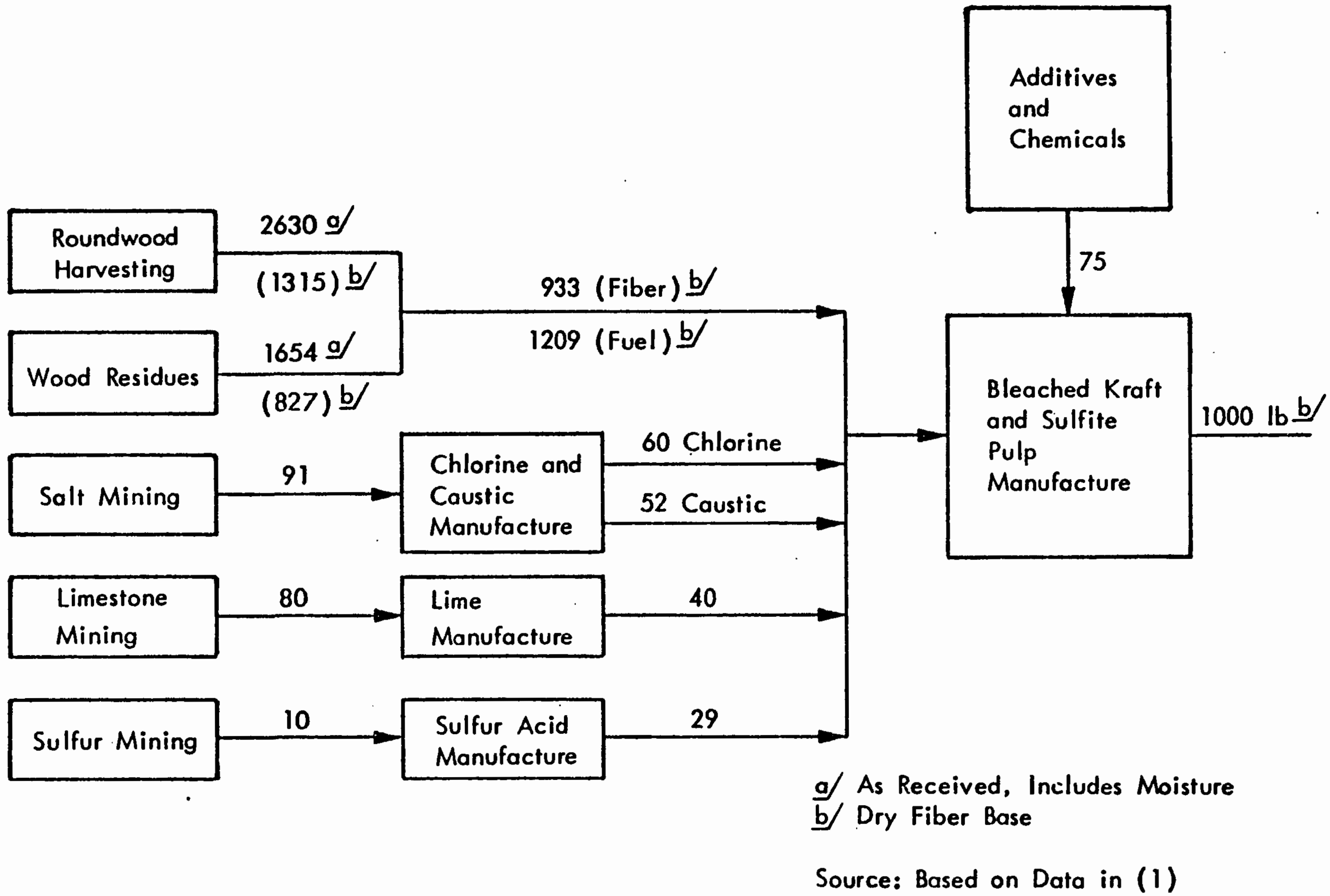


Figure C-1 - Materials Flow for Pulp Manufacture
(Pounds)

sources: trees and wood residues. Sixty-one percent of the wood required for pulp manufacture comes directly from trees, while 39 percent comes from by-products of other wood processing facilities. Typical of the wood residues used are sawdust and trim from saw mills.

The remaining raw materials are chemicals required to carry out the wood pulping and bleaching but which are not, for the most part, intended to become part of the finished product. The impacts of manufacture of these chemicals are discussed elsewhere in this report.

Kraft pulping hinges on the chemical digestion of wood. The digester is a closed container which holds wood chips and digestion liquors. The liquor is mainly an aqueous solution of sodium sulfide. In order for digestion to take place, heat and pressure are applied to the mixture of wood and liquor. The digestion process delignifies the wood and removes other chemical components which hinder paper forming. After pulp is "blown" from the digester by the steam used in the process, it is washed free of the chemicals, screened and refined for entry into the paper forming section of the mill. Sulfite pulp is made in a similar fashion, although the chemical composition of the digestion liquor varies, depending on the particular sulfite process employed.

One of the most desirable features of the kraft (and some sulfite) pulping processes is that the used digestion liquor is burned. The liquor contains a high percentage of flammable wood components and so it burns readily. The digestion chemicals are recovered and heat is released from the organic components. Liquor combustion, plus the use of the bark removed from the incoming logs as a fuel results in wood providing a significant amount of the energy required for a pulp mill. Auxiliary energy is usually needed, and comes primarily from fuel oil, natural gas, coal, and electricity.

A survey of operating mills was undertaken by the American Paper Institute (API) to determine the extent to which pulp types were used in the products studied, and to determine the environmental impacts of manufacture. In addition, various literature sources and other paper industry organizations were utilized for consultation and sources of data. The results of this survey were combined with other confidential data on energy use and environmental impacts routinely reported to API and the National Council on Air and Stream Improvement (NCASI) in order to develop data to be used in this study. The data were combined into a wood pulp module which includes both kraft and sulfite in the proportion actually used by the industry. The survey was conducted for the 1975 production year and included 27 pulp mills. The production composite was 74 percent kraft pulp, 20 percent sulfite pulp and 6 percent listed as other.

Figure C-1 shows the materials required for pulp manufacture as determined by API, while Table C-2 contains the impact data for the kraft and sulfite pulp. The unit selected is 1,000 pounds of market pulp which is a dried and baled form of wood pulp. Market pulp is commonly used by the tissue manufacturers. However, in many cases papermaking equipment is located adjacent to a pulp mill, so pulp is used in the "slush" form, avoiding the pulp drying stage. Revised energy values for slush pulp are shown on Table C-2, reflecting the saving of 2 million Btu per 1,000 pounds which results from using slush pulp.

Air pollutants generated from pulp manufacture are of two types: on-site pollutants and off-site pollutants. Table C-3 summarizes the on-site pollutants which are actual measurements obtained from the API survey (Reference 89). In addition to the on-site generation, pollutants (and other impacts) result from secondary processes, such as transporting, mining and refining of fuels. The impacts from these secondary off-site sources are summarized in Table C-4 for the fuels consumed at the pulp mills. The impacts associated with electricity generation are reported elsewhere.

C. Salt Mining

Salt (sodium chloride) is obtained primarily by the following three methods:

- Pumping water into salt deposits and recovering the salt as brine.
- Mining rock salt.
- Solar evaporation of seawater.

The first method uses water to dissolve the salt and bring it to the surface. About 320 gallons of water will dissolve 1,000 pounds of salt. The saturated solution is removed from an adjacent well or by means of an annular pipe. The brine will contain sodium chloride, calcium chloride and magnesium chloride plus traces of hydrogen sulfide and ferrous ions. The purification required will vary and depends on the purity of the deposits.

Rock salt is "mined" by blasting the mineral and removing the salt crystals. The crystals are crushed in the mine and then again at the surface. The remaining processes consist of grinding and screening operations. The product is not as pure as salt from brine wells.

Seawater contains about 3.7 percent solids of which about 77.8 percent is sodium chloride. The water is evaporated to various degrees in several ponds. The evaporation steps serve to precipitate most of the

TABLE C-2

DATA FOR MANUFACTURE OF 1,000 POUNDS (DRY BASIS) BLEACHED KRAFT/SULPHITE MARKET PULP

Impact Category	Quantities	Sources
Raw Materials		89,90
Roundwood (Trees)	2,630 lb	
(Dry Weight)	1,315 lb	
Wood Residues (Sawdust, etc.)	1,654 lb	
(Dry Weight)	807 lb	
Chlorine	60 lb	
Caustic	52 lb	
Lime	40 lb	
Sulfuric Acid	29 lb	
Other Chemicals and Additives	75 lb	
Energy (Purchased)[a/]		91
Electricity	221 kw-hr (161)	
Residual[b/]	21.5 gal. (15.7)	
Distillate	0.6 gal. (0.44)	
LPG	0.1 gal. (0.073)	
Natural Gas	2,539 cu ft (1,853)	
Coal	0.5 lb (0.36)	
Energy (Self-Generated)[a/]		
Wood Wastes (Million Btu)	8.39 Btu (8.39)	
Water Volume	13,400 gal.	92
Industrial Solid Wastes	89 lb	96
Process Air Pollutants[c/]		92
Particulates	2.07 lb	
Sulfur Oxides	0.86 lb	
TRS (Total Reduced Sulfur)	0.72 lb	
Water Pollutants		92
Suspended Solids	10.4 lb	
BOD	7.0 lb	

a/ Values without parentheses are for dry pulp. Values in parentheses are for slush pulp.

b/ Includes 13.4 pounds of purchased steam at 150,000 Btu per gallon residual oil and 1,400 Btu per pound for steam.

c/ See Table C-3 for more detail on the sources of air pollution.

Source: Reference 89.

TABLE C-3

EMISSIONS TO THE ATMOSPHERE FROM MILL SITES FOR MANUFACTURE OF 1,000 POUNDS BLEACHED KRAFT/SULPHITE PULP

	Power Sources[a]	Kraft/Sulphite Process	Total[a]
Particulates	1.82 (1.58)	2.07	3.89 (3.65)
Sulfur Oxides	5.00 (4.35)	0.86	5.86 (5.21)
Nitrogen Oxides	7.39 (6.43)	--	7.39 (6.43)
TRS	--	0.72	0.72 (0.72)

a/ The first values are for dry pulp. The second values (in parentheses) are for slush pulp.
Source: Reference 89.

TABLE C-4

ENERGY AND SECONDARY IMPACT FACTORS FOR FUEL PURCHASED AND CONSUMED ON-SITE FOR MANUFACTURE OF 1,000 POUNDS OF BLEACHED KRAFT/SULPHITE PULP[a]

Impact Category	Quantities	Sources
Energy		90
Fuel Oils (22.1 gal.)	3.75 gal.	
Natural Gas and LPG (2,625 cu ft)	2.85 cu ft	
Coal (0.5 lb)	0.0067 lb	
Total	6.607	
Solid Wastes (Secondary)	0.91 lb	90
Air Pollutants (Secondary)[a]		90
Particulates	0.10 lb	
Nitrogen Oxides	1.70 lb	
Hydrocarbons	3.89 lb	
Sulfur Oxides	0.73 lb	
Carbon Monoxide	0.52 lb	
Water Pollutants (Secondary)		90
Dissolved Solids	2.29 lb	

a/ Energy is total energy from Table C-2. Pollutants are from secondary sources which occur on-site in Tables C-2 and C-3.

compounds other than sodium chloride. After the final evaporation step, the salt solids are crushed and washed with salt brine to produce an industrial grade material. Additional steps can be incorporated to produce high purity salt.

Table C-5 shows the data pertaining to mining 1,000 pounds of salt. The values are, in most, national averages and include impacts from each salt mining process.

TABLE C-5

DATA FOR MINING 1,000 POUNDS OF SALT

Impact Category	Quantities	Sources
Raw Materials		19
Salt Mineral	1,036.00 lb	
Additives	43.0 lb	
Energy		98
Electricity	11.7 kw-hr	
Steam	270.0 lb	
Mining Solid Wastes	360.0 lb	98

The raw materials category shows that 1,026 pounds of mineral must be mined to ship 1,000 pounds of salt. The rock salt mining phase of the industry experiences its losses in the form of fines. Some mines have as much as 20 percent waste. The water-brine type of mine will experience losses from water discharge. The average purity of salt deposits is around 98.5 percent.

D. Chlorine Manufacture

Approximately 97 percent of the chlorine produced in the United States is manufactured by electrolytic caust-chlorine processes (Figure C-2). The remainder comes from a nitrosyl chloride process, electrolysis of hydrochloric acid, and as a by-product from the electrolytic production of caustic potash, magnesium, and metallic sodium.

The electrolysis of sodium chloride is performed by two processes: (1) mercury cathode cells; and (2) diaphragm cell. The mercury cell produces about 24.2 percent of the electrolytic chlorine while the diaphragm cell accounts for about 75.8 percent.

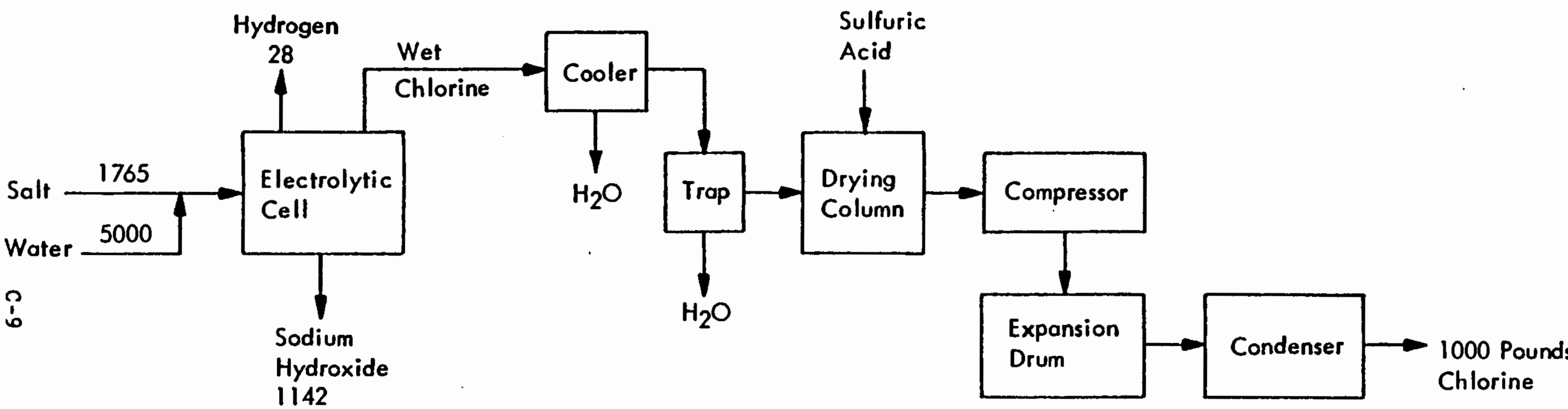


Figure C-2. Manufacture of 1,000 pounds of chlorine and by-products, diaphragm cell.

The mercury cathode cell process can be described as follows:

$$NaCl + xHg = 1/2\ Cl_2 + Na\ (Hg)x \text{ and}$$

$$Na(Hg)x + H_2O = NaOH + 1/2\ H_2 + xHg$$

The salt is electrolyzed, producing chlorine gas at the graphite (or metal) anodes; metallic sodium, released by the passage of current, reacts with the mercury cathode to produce an amalgam. The amalgam is sent to another compartment of the cell where it reacts with water to produce hydrogen and very pure sodium hydroxide. The outstanding feature of the mercury cell is the high grade and concentration of the caustic liquor, which may be used in other industries without further purification. The disadvantages of the mercury cell are its higher energy requirements and loss of mercury. Some of the methods by which mercury can escape the plant are (Reference 101):

1. Carryover in the hydrogen gas stream;
2. Cell room ventilation air;
3. Washing water from cell rooms;
4. Purging of the brine loop;
5. Disposal of brine sludges; and
6. End box fumes.

Close attention to product and effluent stream is necessary to keep the mercury loss at a minimum. The average mercury consumption from this type of plant in 1972 was 0.183 pound per 1,000 pounds of chlorine produced (Reference 102). This value is based on the 1972 production of chlorine from mercury cells, which was 2,389,356 short tons, and mercury purchases of 11,519 flasks (875,444 pounds).

The diaphragm cell uses graphite anodes and steel cathodes. The brine solution is passed to the anode compartment where chlorine gas is formed and taken off through a pipe at the top of the cell. The other ions in solution flow through an asbestos diaphragm and react at the cathode to form sodium hydroxide and hydrogen. The diaphragm prevents back diffusion of the cathode reaction products. The caustic-brine solution containing hydrogen is removed from the cathode compartment and processed to recover hydrogen and caustic. The chlorine from the anode compartment is cooled and then dried in a sulfuric acid scrubber. The gas is compressed and cooled to form liquid chlorine. Shipment of chlorine is generally by rail and barge.

Table C-6 shows the data pertaining to the manufacture of chlorine. The manufacturing data are a combination derived by adding 24.2 percent of the mercury cathode cell impacts to 75.8 percent of the diaphragm cell impacts.

TABLE C-6

DATA FOR MANUFACTURE OF 1,000 POUNDS OF CHLORINE

Impact Category	Quantities	Sources
Raw Materials		98
Salt	786 lb	
Process Additives	1.68 lb.	
Sulfuric Acid	12.5 lb	
Energy		98
Electric	823 kw-hr	
Steam	229 lb	
Water Volume	237.0 gal.	98
Process Solid Wastes (Mercury - 0.019)	80.0 lb	19,99
Process Atmospheric Emissions		19,99,100
Mercury Vapor	0.0007 lb	
Chlorine	4.1 lb	
Waterborne Wastes		19,99,100
Mercury	0.000035 lb	
Suspended Solids	0.32 lb	
Lead	0.019 lb	
Transportation		19
Rail	400 ton-miles	
Barge	400 ton-miles	

The largest impact is the amount of electrical energy required to operate the cells. About 21 million Btu are required for the 2,170 pounds of products. The amount allocated to chlorine is about 9.5 million Btu.

The solids value was estimated by calculating the amount of sludge produced during the manufacturing process. The brine sludges contain about 50 parts per million mercury.

The sodium content of the slat raw material represents part of the by-product sodium hydroxide, and should not be counted as a raw material for chlorine.

E. Sodium Hydroxide Manufacture

The electrolytic method for manufacture of sodium hydroxide (caustic soda) accounts for more than 90 percent of the total U.S. production. The caustic is actually a by-product of the chlorine manufacturing process described in the previous section.

Table C-7 contains the basic impacts for the production of 1,000 pounds of caustic.

F. Limestone Mining

Limestone is used by the glass industry as a source of calcium oxide in glass furnace operations. The limestone is heated in the furnace so that carbon dioxide is released, leaving calcium oxide behind. Calcium oxides act as a chemical stabilizer in the finished glass product.

Limestone is quarried primarily from open pits. The most economical method of recovering the stone has been blasting, followed by mechanical crushing and screening. According to the Bureau of Mines, environmental problems are greater for crushed-stone producers than for any other mineral industry operation except sand and gravel (Reference: Mineral Facts and Problems, U.S. Department of Interior, 1970). The reason for this is that limestone typically is mined quite close to the ultimate consumer, which frequently dictates that the mining operation be near, or even within, heavily populated areas. Hence, environmental problems are accentuated because of high visibility.

The environmental consequences of limestone mining include: noise from heavy equipment and from blasting; dust from mining, crushing and screening; solid residues not properly disposed of; general unsightliness; and occasional contamination of streams. None of these problems is insurmountable, and many quarries are presently operated in an environmentally acceptable fashion.

TABLE C-7

DATA FOR MANUFACTURE OF 1,000 POUNDS OF SODIUM HYDROXIDE

Impact Category	Quantities	Sources
Raw Materials		98
Salt	786 lb	
Additives	1.82 lb	
Energy		98
Electricity	886.0 kw-hr	
Steam	4,302.0 lb	
Water Volume	237 gal.	98
Process Solid Wastes	80.0 lb	37,69,19, 99
Process Atmospheric Emissions		37,69,71, 19,99,100
Mercury Vapor	0.0007 lb	
Chlorine	4.10 lb	
Waterborne Wastes		19,99,100
Mercury	0.000035 lb	
Suspended Solids	0.32 lb	
Lead	0.0019 lb	
Transportation		19
Rail	109 ton-miles	
Barge	57 ton-miles	
Truck	12 ton-miles	

Data concerning the quantifiable environmental impacts of limestone mining are summarized in Table C-8. Even though the quarrying operations may be objectionable as a neighborhood problem, they produce relatively low impacts on a tonnage basis (partly because of the inherently high density of the stone). The major problem is dust, i.e., particulates. However, compared to the other operations in the glass container system, the impacts of limestone mining are quite small.

TABLE C-8

DATA FOR MINING OF 1,000 POUNDS OF LIMESTONE

Impact Category	Quantities	Sources
Energy		103
Coal	0.12 lb	
Distillate	0.08 gal.	
Natural Gas	4.65 cu ft	
Gasoline	0.02 gal.	
Electricity	1.0 kw-hr	
Water Volume	45 gal.	104
Process Atmospheric Emissions		105
Particulates	6.5 lb	

G. Lime Manufacture

Lime is produced by calcining limestone. Limestone (calcium carbonate) is heated in a kiln to a high temperature so that any water present is driven off and the carbonate is broken up by the evolution of carbon dioxide. The product remaining is lime (calcium oxide). Significant environmental impacts occur as a result of fuel combustion and material losses. For 1,000 pounds of lime produced, approximately 800 pounds of carbon dioxide are released. An additional 200 pounds of material impacts on the environment in the form of solid waste and as dust (particulate emission). The data are summarized in Table C-9. This table was derived from U.S. Census of Manufactures data for the year 1972, with the energy values adjusted downward to reflect energy conservation through 1980. Energy use was assumed to decline at a compound rate of 1.4 percent per year from the base year to 1980 (Reference 10).

TABLE C-9

DATA FOR MANUFACTURE OF 1,000 POUNDS OF LIME

Impact Category	Quantities	Sources
Raw Materials	2,000 lb	106
Energy		19
Coal	113 lb	
Distillate	0.63 gal.	
Residual	0.27 gal.	
Natural Gas	1,186 cu ft	
Electricity	19.4 kw-hr	
Water Volume	135 gal.	107
Solid Wastes	182 lb	105,106
Process Atmospheric Emissions		105,106
Particulates	16 lb	

H. Sulfur Mining

The Frasch process of mining sulfur is the most common type of operation employed in the United States. In consists basically of sulfur being forced to the surface through a well shaft by superheated water that has been previously injected into a sulfur-bearing rock formation. The major requirements for mining sulfur by the Frasch process are a large supply of water and fuel, a power plant to produce steam, compressed air, electricity and a drilling apparatus.

Environmental impacts generated from sulfur mining are due largely to the use of fuels as an energy source for steam generation.

Sulfur is considered one of the most versatile elements. Its consumption, along with that of sulfuric acid for which sulfur is the basic raw material, is often used as a measure of economic activity in the U.S. Table C-10 lists the data used in the study for the mining of 1,000 pounds of sulfur. The significant impacts are the large quantity of natural gas consumed, the water used, the solid wastes, and the particulate air emissions.

TABLE C-10

DATA FOR MINING OF 1,000 POUNDS OF SULFUR

Impact Category	Quantities	Sources
Energy		8,37,108, 109
Electricity	1.39 kw-hr	
Gas	2,757.0	
Water Volume	800.0 gal.	3,37,108, 109
Solid Wastes	205 lb	19
Process Atmospheric Emissions	10 lb	19
Transportation		13,14,86, 88
Rail	262 ton-miles	
Water	340 ton-miles	
Truck	25 ton-miles	

I. Sulfuric Acid Manufacture

There are two basic methods for manufacturing sulfuric acid--the chamber process and the contact process. Both methods utilize sulfur, which is most often obtained from mineral sulfides, smelter gas, gypsum, petroleum or other sulfur-bearing compounds. The sulfur is burned to yield sulfur dioxide (SO_2) which is further oxidized to sulfur trioxide (SO_3) which is absorbed in weak sulfuric acid (H_2SO_4) or water to form sulfuric acid.

In the chamber process the oxidation of sulfur dioxide to sulfur trioxide is carried out by the catalytic action of nitrogen oxides, whereas in the contact process the oxidation is performed by the catalytic (contact) action of various catalysts such as platinum, palladium, iron and various vanadium oxides.

Since more than 97 percent of the sulfuric acid produced in the U.S. is made by the contact process and elemental sulfur is the raw material used in most of these plants, a sulfur burning contact method of manufacture is assumed for the study. Table C-11 presents the raw data for sulfuric acid manufacture.

TABLE C-11

DATA FOR MANUFACTURE OF 1,000 POUNDS OF SULFURIC ACID

Impact Category	Quantities	Sources
Raw Materials		19
Sulfur	338 lb	
Energy		109
Electricity	12.0 kw-hr	
Steam (Credit)	500.0 lb (credit)	
Water Volume	3,200.0 gal.	109
Solid Wastes	3.5 lb	19
Atmospheric Emissions		6,110
Particulate and Acid Mist	1.7 lb	
SO_2	20.0 lb	
Waterborne Wastes		19
BOD	0.2 lb	
Suspended Solids	0.6 lb	
Acid	7.0 lb	
Transportation		86,88
Water	6.0 ton-miles	
Rail	55.0 ton-miles	
Truck	13.0 ton-miles	

The major sources of pollution generated from sulfuric acid manufacture are sulfur oxides and waste acid contained in the absorber exit gases. Even though elaborate control methods are employed on absorber stacks at most plants, approximately 2 pounds of acid per 1,000 pounds of acid produced is released to the atmosphere which, along with hydrated sulfur trioxide emissions, may form a visible plume of acid mist above the absorber stacks. Sulfur dioxide is also contained in the absorber exit gases although the amount that is released is somewhat dependent upon the amount of oleum (fuming acid) produced by the plant. Sulfur dioxide emissions average approximately 20 pounds of SO_2 per 1,000 pounds of acid produced.

Waterborne acid wastes, averaging 7 pounds acid per 1,000 pounds acid produced, result primarily from equipment washdowns, handling losses and spills, and constitute the majority of the waterborne wastes from contact plants.

J. Tissue Papermaking

After wood pulp has been produced (and bleached to achieve a specified brightness) it is either dried, or sent to a papermaking machine in slush form. If it is dried, it is baled and transported to a papermaking site, where it is defibered and beaten into a slush pulp by mixing with water in a large pulping device. In any event, the input material for a paper machine is a slush pulp.

Papermaking equipment consists of a paper machine which utilizes an endless wire or plastic mesh screen, sets of water removal devices, and dryers. The slush pulp is placed on the rapidly moving screen where water drains out of the pulp and leaves a fiber mat on the screen. The fiber mat is picked up on rolls, and in subsequent operations additional water is removed. The paper is then dried on steam heated rolls until it is dry enough to wind into large rolls. These rolls of finished paper are the final product of the papermaking operation.

Table C-12 presents the impact data for manufacturing the paper to be used in towels. These data were obtained from a survey of paper mills (Reference 89), which represents 89 percent of the U.S. towel production. The data are complete except for values of air pollutants, which were not available for all mills. The values given in the tables are based on the percent of total production given in parentheses. However, these values for air pollution were proportionately increased so as to represent all mills by assuming that air pollutants from mills not reporting is the same as from those reporting air pollution.

K. Conversion of Paper to Consumer Paper Towels

Rolls of paper are transported to converting sites for manufacture into final products. In many cases the converting site is located quite close to the papermaking site, but sometimes the rolls are transported for a long distance. In any event, at the converting site, materials are assembled for the converting operation.

The converting process is a relatively simple operation where the rolls of paper are unwound, with the product being cut to proper size, decorated (if required), rewound on a core (if required) and packaged for shipment. The impacts of converting to 1,000 square feet, two-ply consumer towels are shown in Table C-13.

TABLE C-12

DATA FOR PAPERMAKING 1,000 POUNDS 2-PLY TOWEL STOCK

Impact Category	Quantities	Sources
Virgin Pulp (Dry Basis)		89
Dry	386 lb	
Slush	403 lb	
Subtotal - Pulp	789 lb	
Waste Paper (Dry Basis)		89
Pulp Substitute	51.6 lb	
Deinking	24.0 lb	
Broke (Mill Scrap)	130 lb	
Subtotal - Waste Paper	206 lb	
Total Fiber	995 lb	
Other Materials		89
Miscellaneous	2.9 lb	
Wet Strength	7.8 lb	
Total Other	10.7 lb	
Energy (Purchased)		89
Electricity	451 kw-hr	
Natural Gas	3,335 cu ft	
Fuel Oil	19.0 gal.	
Propane	0.12 gal.	
Energy (Self-Generated)		89
Recovery Boiler (Wood Wastes)	0.749 Btu (Million)	
Air Pollutants[a/] [1]		89
Particulates	0.23 lb (63%)	
Sulfur Oxides	3.62 lb (63%)	
Nitrogen Oxides	1.13 lb (30.9%)	
Water Volume	6,575 gal.	89
Water Pollutants		89
BOD	2.35 lb	
Suspended Solids	2.99 lb	
Solid Wastes		89
Landfill	9.8 lb	
Incineration	6.1 lb	
Sludge	14.7 lb	

a/ The pollutants listed represent projected industry totals based on a fraction of mills which report pollutants. The percent of production reported by reporting mills is in parentheses.

1/ See comment No. 9 Appendix J, page 39.

TABLE C-13

DATA FOR CONVERTING L,000 SQUARE FEET 2-PLY CONSUMER TOWELS

Impact Category	Quantities	Sources
Raw Materials		89
Paper[a/]	10.43 lb	
Core Stock	0.366 lb	
Poly Wrappers	0.179 lb	
Corrugated	0.984 lb	
Inks and Adhesives	0.169 lb	
Energy		89
Electricity	0.329 kw-hr	
Natural Gas	1.37 cu ft	
Scrap	1.095 lb	89

a/ Includes approximately 5 percent moisture.

II. Paper Napkins

A. Home

The major processes in producing home paper napkins are: (1) pulp wood harvesting; (2) bleached kraft and sulfite pulp production; (3) salt mining; (4) chlorine manufacturing; (5) caustic manufacturing; (6) limestone mining; (7) lime manufacturing; (8) sulfur mining; (9) sulfuric acid manufacturing; (10) tissue papermaking; and (11) converting to home paper napkins.

Processes 1 through 9 are discussed in the paper towel section (Appendix C-I). A discussion of the remaining processes will follow.

1. Tissue Papermaking: After wood pulp has been produced (and bleached to achieve a specified brightness) it is either dried, or sent to a papermaking machine in slush form. If it is dried, it is baled and transported to a papermaking site, where it is defibered and beaten into a slush pulp by mixing with water in a large pulping device. In any event, the input material for a paper machine is a slush pulp.

Papermaking equipment consists of a paper machine which utilizes an endless wire or plastic mesh screen, sets of water removal devices, and dryers. The slush pulp is placed on the rapidly moving screen where water drains out of the pulp and leaves a fiber mat on the screen. The fiber mat is picked up on rolls, and in subsequent operations additional water is removed. The paper is then dried on steam heated rolls until it is dry enough to wind into large rolls. These rolls of finished paper are the final product of the papermaking operation.

Table C-14 presents the impact data for manufacturing the paper to be used in napkins. These data were obtained from a survey of paper mills (Reference 89), which represents 62 percent of napkin production. The data are complete except for values of air pollutants, which were not available for all mills. The values given in the tables are based on the percent of total production given in parentheses. However, these values for air pollution were proportionately increased so as to represent all mills by assuming that air pollutants from mills not reporting is the same as from those reporting air pollution.

2. Conversion of Paper to Consumer Napkins: Rolls of paper are transported to converting sites for manufacture into final products. In many cases the converting site is located quite close to the papermaking site, but sometimes the rolls are transported for a long distance. In any event, at the converting site, materials are assembled for the converting operation.

The converting process is a relatively simple operation where the rolls of paper are unwound, with the product being cut to proper size, decorated (if required), rewound on a core (if required) and packaged for shipment. The impacts of converting to 1,000 single-ply consumer napkins are shown in Table C-15.

B. Commercial

The intermediate steps involved in manufacturing commercial napkins are identical to those listed in the home napkin discussions (refer to Appendix C-II), with the exception of the conversion process. A discussion of this process shall follow.

Conversion of Paper to Commercial Napkins: Rolls of paper are transported to converting sites for manufacture into final products. In many cases the converting site is located quite close to the papermaking site, but sometimes the rolls are transported for a long distance. In any event, at the converting site, materials are assembled for the converting operation.

DATA FOR PAPERMAKING - 1,000 NAPKINS (POUNDS)

Impact Category	Quantities	Sources
Virgin Pulp (dry basis)		89
Dry (lb)	266 lb	
Slush (lb)	405 lb	
Subtotal - Pulp	671 lb	
Waste Paper (dry basis)		89
Deinking	214 lb	
Pulp Sub	43 lb	
Broke (mill scrap)	108 lb	
Subtotal - Waste Paper	365 lb	
Total Fiber	1,036 lb	
Miscellaneous Materials	4.2 lb	89
Wet Strength	3.2 lb	
Energy (purchased)		89
Electricity	386 kw-hr	
Natural Gas	2,768 cu ft	
Fuel Oil	19.3 gal.	
Propane	0.33 gal.	
Energy (self-generated)		89
Recovery Boiler (wood wastes)	1,057 million Btu	
Air Pollutants[a/] [1]		89
Particulates	0.25 lb	
Sulfur Oxides	1.81 lb	
Nitrogen Oxides	1.52 lb	
Water	8,688 gal.	89
Water Pollutants		89
BOD	3.57 lb	
Suspended Solids	4.49 lb	
Solid Wastes		89
Landfill	50.3 lb	
Incinerator	19.8 lb	
Sludge	7.48 lb	

a/ Air pollutants were reported by mills accounting for 46.8 percent of the total production. The values listed were ratioed up so as to represent total industry pollutants.

1/ See comment No. 10 Appendix J, page 39.

TABLE C-15

DATA FOR CONVERTING - 1,000 SINGLE-PLY CONSUMER NAPKINS

Impact Category	Quantities	Sources
Materials		89
Paper[a]	5.590 lb	
Cartons	0.0539 lb	
Poly Wrappers	0.154 lb	
Corrugated	0.975 lb	
Inks, etc.	0.099 lb	
Energy		89
Electricity	0.18 kw-hr	
Natural Gas	1.53 cu ft	
Oil	0.0009 gal.	
Scrap	0.40 lb	89

a/ Includes approximately 5 percent moisture.

The converting process is a relatively simple operation where the rolls of paper are unwound, with the product being cut to proper size, decorated (if required), rewound on a core (if required) and packaged for shipment. The impacts of converting to 1,000 two-ply industrial napkins are shown in Table C-16.

TABLE C-16

DATA FOR CONVERTING - 1,000 TWO-PLY INDUSTRIAL NAPKINS

Impact Category	Quantities	Sources
Materials		89
Paper[a]	14.46 lb	
Cartons	0.179 lb	
Poly Wrappers	0.0734 lb	
Paper Wrappers	0.0332 lb	
Corrugated	1.18 lb	
Energy		89
Electricity	0.649 kw-hr	
Natural Gas	6.46 cu ft	
Scrap	0.753 lb	89

a/ Includes approximately 5 percent moisture.

II. Diapers

The processes needed for the manufacture of disposable diapers are: (1) wood pulp harvest; (2) pulp manufacturing; (3) salt mining; (4) chlorine manufacturing; (5) caustic manufacturing; (6) limestone mining; (7) lime manufacturing; (8) sulfur mining; (9) sulfuric acid manufacturing; (10) paper manufacturing; (11) ethylene manufacturing, including production of crude oil, natural gas production, natural gas processing, and ethylene production; (12) LDPE resin manufacturing; (13) LDPE film manufacturing; (14) acrylic resin including the same processes as ethylene production, ammonia production, acrylonitrile manufacturing, and acrylic resin manufacturing; (15) rayon manufacturing including wood pulp harvesting, pulp manufacturing, salt mining, caustic manufacturing, natural gas production and processing, sulfur mining, carbondisulfide manufacturing, sulfuric acid manufacturing, and rayon production; (16) PET resin manufacturing including ethylene oxide manufacturing, methanol manufacturing, oxygen manufacturing, acetaldehyde manufacturing, naphtha reforming, p-xylene extraction, terephthalate manufacturing and PET resin production; and (17) the production of diapers.

Processes 1 through 9 are discussed in Appendix C-I (Paper Towels). The remaining processes are discussed on the following pages.

A. Tissue Papermaking

After wood pulp has been produced (and bleached to achieve a specified brightness) it is either dried, or sent to a papermaking machine in slush form. If it is dried, it is baled and transported to a papermaking site, where it is defibered and beaten into a slush pulp by mixing with water in a large pulping device. In any event, the input material for a paper machine is a slush pulp.

Papermaking equipment consists of a paper machine which utilizes an endless wire or plastic mesh screen, sets of water removal devices, and dryers. The slush pulp is placed on the rapidly moving screen where water drains out of the pulp and leaves a fiber mat on the screen. The fiber mat is picked up on rolls, and in subsequent operations additional water is removed. The paper is then dried on steam heated rolls until it is dry enough to wind into large rolls. These rolls of finished paper are the final product of the papermaking operation.

Table C-17 present the impact data for manufacturing the paper to be used in towels, napkins and diapers. These data were obtained from a survey of paper mills (Reference 89), which represent more than 90 percent of disposable diaper production. The data are complete except for values of air pollutants, which were not available for all mills. The values given in the table are based on the percent of total production given in parentheses.

However, these values for air pollution were proportionately increased so as to represent all mills by assuming that air pollutants from mills not reporting is the same as from those reporting air pollution. Table C-17T contains transportation factors for tissue products.

TABLE C-17

DATA FOR PAPERMAKING - 1,000 DIAPER TISSUE (POUNDS)

Impact Category	Quantities	Sources
Materials		89
Virgin Pulp (dry basis)		
Purchased	675 lb	
Slush	178 lb	
Subtotal - Pulp	853 lb	
Waste Paper - Deinking (dry basis)	30 lb	89
Broke (mill scrap)	125 lb	
Subtotal - Waste Paper	155 lb	
Total Fiber	1,008 lb	
Other Materials	16 lb	89
Energy		89
Electricity	463 kw-hr	
Natural Gas	5,327 cu ft	
Residual Oil	4.99 gal.	
Propane	0.27 gal.	
Water Volume	4,621 gal.	89
Water Pollutants		89
BOD	1.48 lb	
Suspended Solids	1.24 lb	
Solid Wastes		89
Landfill	17.4 lb	
Sludge	22.4 lb	

TABLE C-17T

TRANSPORTATION FACTORS FOR DISPOSABLE TISSUE PRODUCTS

Material - locations	Unit	Rail (ton-miles)	Truck (ton-miles)	Water (ton-mil
Wood to pulp mill	Thou pounds pulp	91	22	-
Pulp to towel papermaking	Thou pounds paper	324	56	-
Waste paper to towel papermaking	Thou pounds paper	8	-	-
Consumer towels to market	Thou square feet	2.44	0.198	-
Pulp to napkin papermaking	Thou pounds paper	152	-	14
Waste paper to napkin papermaking	Thou pounds paper	33	11	-
Paper to napkin converting	Thou pounds paper	32	-	-
Single-ply consumer napkins to market	Thou napkins	1.37	0.078	-
2-ply industrial napkins to market	Thou napkins	3.71	0.18	-
Pulp to diaper tissue papermaking	Thou pounds paper	408	-	-
Waste paper to diaper tissue papermaking	Thou pounds paper	4	-	-
Diaper tissue to converting	Thou pounds paper	40	35	-
Polyethylene fiber to diaper converting	Hundred diapers	0.012	0.066	-
Non-woven fiber to diaper converting	Hundred diapers	0.152	0.018	-
Fluffing pulp to diaper converting	Hundred diapers	3.79	-	-
Diapers to market	Hundred diapers	2.00	0.49	-

B. Ethylene Manufacturing

1. Production of Crude Oil and Natural Gas: A production well is classified as a gas or oil well, based on the ratio of oil production to gas production. The definition of an oil well will typically cover those wells which produce at least one barrel of oil to each 100,000 cubic feet of natural gas. The gas well would be defined as a well having a lower crude to gas ratio.

Figure C-3 shows a flow diagram for the production of oil and natural gas.

Field processing is required to separate the oil, gas, and water. The natural gas generally follows three routes: (1) the gas can be flared; (2) some gas is returned to the underground formation to assist in future production; and (3) the gas is transferred to a natural gas processing plant.

The crude oil is treated in water separators, and oil-gas separators. The resulting crude is pumped to storage tanks and eventually to a refinery.

With respect to drilling for oil and gas, information is limited concerning the ways in which drilling fluids, drilling muds, well cuttings, and well treatment chemicals may contribute to pollution. Studies have been made of well blowout and mixing of fresh water aquifers and oil bearing sands. Several publications are available discussing oil field brine disposal by subsurface injection.

Materials added to the crude oil to assist in extraction represent less than 2 percent of the oil produced.

Acids represent the major chemicals used in oil and gas well treatment. The amount consumed yearly is shown in Table C-18 (Reference 35).

TABLE C-18

ACIDS USED FOR WELL TREATMENT

Acid	Gallons Per Year	Gallons/Barrel Crude Produced
Hydrochloric	8.7×10^{7}	26.9×10^{-2}
Formic	2.0×10^{6}	6.2×10^{-4}
Acetic	1.0×10^{6}	3.1×10^{-4}

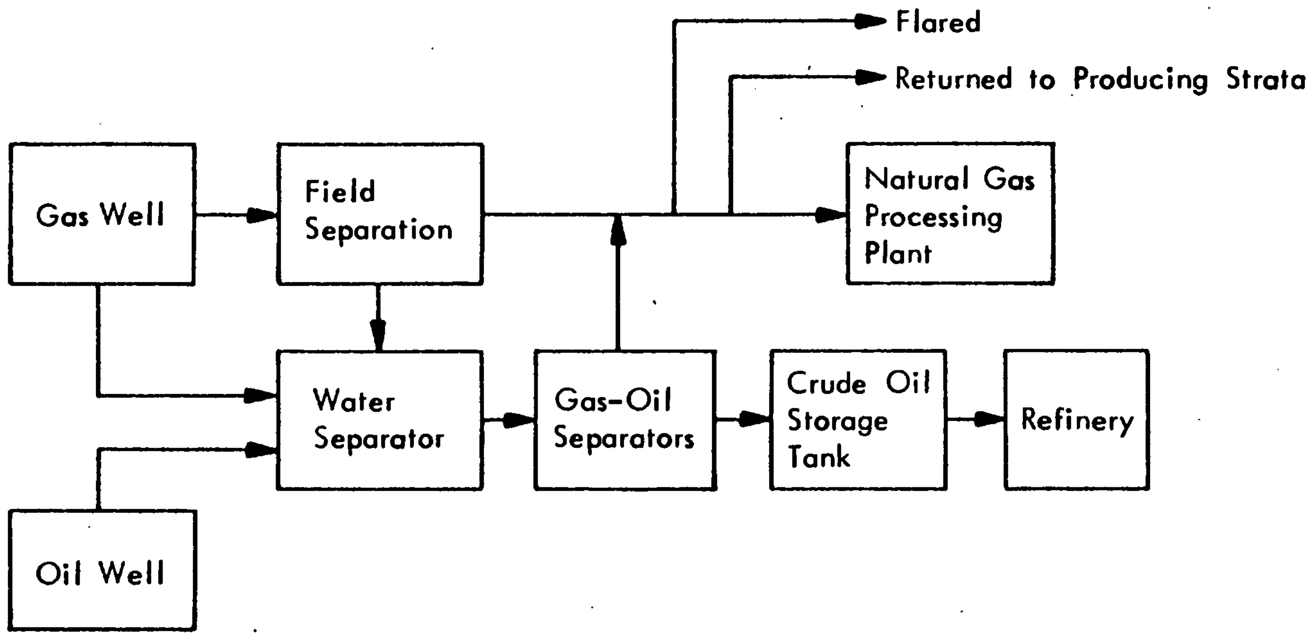


Figure C-3 - Flow diagram for crude oil and natural gas production.

Approximately 30 x 10^5 pounds of inhibitors and 37 x 10^5 pounds of additives are also used per year in well treatment. The total domestic crude production in 1972 was 3,234,600,000 barrels, resulting in a use of 9.3 x 10^{-4} pounds of inhibitors and 11.4 x 10^{-4} pounds of additives per barrel of oil. Since these products are injected into the subsurface reservoir, the amount of pollution to fresh water aquifers is probably very small (Reference 111). The drilling muds used prior to production are usually expensive and, therefore, merit special handling to prevent excessive losses. However, most spent muds are left in open slush pits to permit evaporation of liquids. Most pits are earth filled when evaporation is complete. Some remain in limited service to contain the effluents from well servicing.

Several sources of pollution resulting from oil field operations are:

a. Well blowout - resulting in surface and subsurface contamination.

b. Dumping of oil-based drilling muds, oil soaked cuttings and treatment chemicals.

c. Crude oil escape from pipeline leaks, overflow of storage vessels and rupture of storage and transport vessels.

d. Discharge of bottom sediment from storage vessels.

e. Subsurface disposal of brine into a formation which would permit migration of the brine into an area which could result in pollution of fresh water or contribute toward other natural disasters.

f. Escape of natural gas containing hydrogen sulfide could pollute fresh water supplies and local atmosphere.

Crude losses from production are estimated to be 0.13 percent based on information in the <u>1971 Minerals Yearbook</u>. This loss has been accounted for by allocation to the energy of material resource and to environmental pollutants. The energy content of the crude oil was 19,500 Btu per pound. This assumes an average API gravity of 35 which is equivalent to a weight of 297 pounds per barrel of crude oil (Reference 50). Therefore, the total energy of material resource assigned to the production of 1,000 pounds of crude oil is 19,525,350 Btu (19,500,000 Btu + 25,350 Btu for crude losses in production). The process energy requirements were taken from the <u>1972 Census of Mineral Industries</u>.

Natural gas losses were derived from 1971 and 1972 census data. The losses are estimated to be 3.81 percent as follows: (1) 0.36 percent from vents; (2) 0.36 percent from flares; (3) 1.69 percent in lease operations; and (4) 1.4 percent in transmission to the consumer. In the production of 1,000 pounds of natural gas, this loss has been charged as 853,109 Btu (38.1 pounds x 0.046 cubic feet x 1,030 Btu per cubic feet) of material resource energy, producing 25.88 pounds of atmospheric emissions (crude production was charged with 8.62 pounds of atmospheric emissions since about 25 percent of the natural gas produced comes from oil wells). The 0.36 percent burned in flares was not included in the atmospheric emissions. The total energy of materials resource assigned to natural gas production is 23,244,109 Btu (22,391,000 Btu for 1,000 pounds of natural gas + 853,109 Btu for the 38.1 pounds of natural gas lost in production).

The principal waterborne wastes in oil and gas production are dissolved solids and oils. Approximately 2.5 barrels of brine are produced for each barrel of crude extracted. The brine contains about 32 pounds of dissolved solids (mostly chlorides) per barrel, and 0.59 pounds of oils per barrel. Industry sources have estimated that approximately 10 percent of the brine enters streams, rivers, etc., while 90 percent is disposed of by methods which do not pollute water resources. Brine disposal methods include evaporation ponds, subsurface injection, and brine water treatment systems.

The 0.25 barrels of brine (containing 8 pounds of dissolved solids and 0.147 pound of oils) which enter waterways include 6.0 pounds of dissolved solids and 0.11 pounds of oils charged to the production of 1,000 pounds of crude oil (3.367 barrels), and 2 pounds of dissolved solids and 0.037 pound of oil charged to the production of 1,000 pounds of natural gas (75 percent allocated to crude oil production and 25 percent to natural gas production).

Table C-19 contains the raw impact data for the production of 1,000 pounds of crude oil. Table C-20 contains the primary (raw) data for natural gas production. The energy content of these hydrocarbon products appear in the table. Crude oil and natural gas inputs are counted as their energy equivalents rather than pounds of raw materials. Table C-21 shows the raw impact data for the production of 1,000 pounds of distilled and hydrotreated crude.

2. Natural Gas Liquids Processing: Light straight chain hydrocarbons are normal products of a gas processing plant. Compression, refrigeration and oil absorption are used to extract these products. Heavy hydrocarbons are removed first. The remaining components are extracted and kept under controlled conditions until transported in high pressure pipelines, insulated railcars, ships and barges. The primary nonsalable residues from the natural gas stream are volatile hydrocarbons leaking into the atmosphere. Figure C-4 shows a diagram of a natural gas processing plant.

TABLE C-19

DATA FOR PRODUCTION OF 1,000 POUNDS OF CRUDE OIL

Impact Category	Quantities	Sources
Energy of Material Resource	19.525 million Btu	19
Raw Materials		19,35
Material Process Additions (chemicals 0.29, cement 1.0, muds 0.59)	1.88 lb	
Energy		
Electric	6.18 kwhr	17,18,19
Residual Oil	0.47 gal.	
Gasoline	0.02 gal.	
Natural Gas Internal Combustion	287.2 cu ft	
Water Volume	72.0 gal.	19
Solid Wastes	0.60 lb	19
Process Atmospheric Emissions		19
Hydrocarbons	8.62 lb	
Waterborne Wastes		19,28,29
Dissolved Solids	6.05 lb	
Oil and Grease	0.11 lb	
Transportation		19
Barge	28.0 ton-miles	
Truck	10.0 ton-miles	
Pipeline	110.0 ton-miles	

a/ 1,001.3 lb oil x 19,500 Btu/lb = 19.525 million Btu (includes 1.3 lb for losses

TABLE C-20

DATA FOR PRODUCTION OF 1,000 POUNDS OF NATURAL GAS[1]

Impact Category	Quantities	Sources
Energy of Material Resource	23.244 million Btu[a/]	19,36
Energy		17,18
Electric	6.18 kw-hr	
Fuel Oil	0.1 gal.	
Gasoline	0.02 gal.	
Natural Gas Internal Combustion	541.2 cu ft	
Water Volume	29.0 gal.	19
Process Atmospheric Emissions		
Hydrocarbons	25.88 lb	17,18,19
Waterborne Wastes		27,28,29
Dissolved Solids	2.0 lb	
Oil and Grease	0.037 lb	

a/ 1,038.1 lb NG ÷ 0.046 $\frac{\text{lb}}{\text{cu ft}}$ x 1,030 $\frac{\text{Btu}}{\text{cu ft}}$ = 23.244 million Btu (includes 38.1 lb losses.

TABLE C-21

DATA FOR PRODUCTION OF 1,000 POUNDS OF DISTILLED AND HYDROTREATED CRUDE

Impact Category	Quantities	Sources
Raw Materials		19
Additives	1.0 lb	
Energy		17,18
Electric	40 kw-hr	
Natural Gas	340 scf	
Water Volume	29 gal.	19

1/ See comment No. 7 Appendix B, page 7.

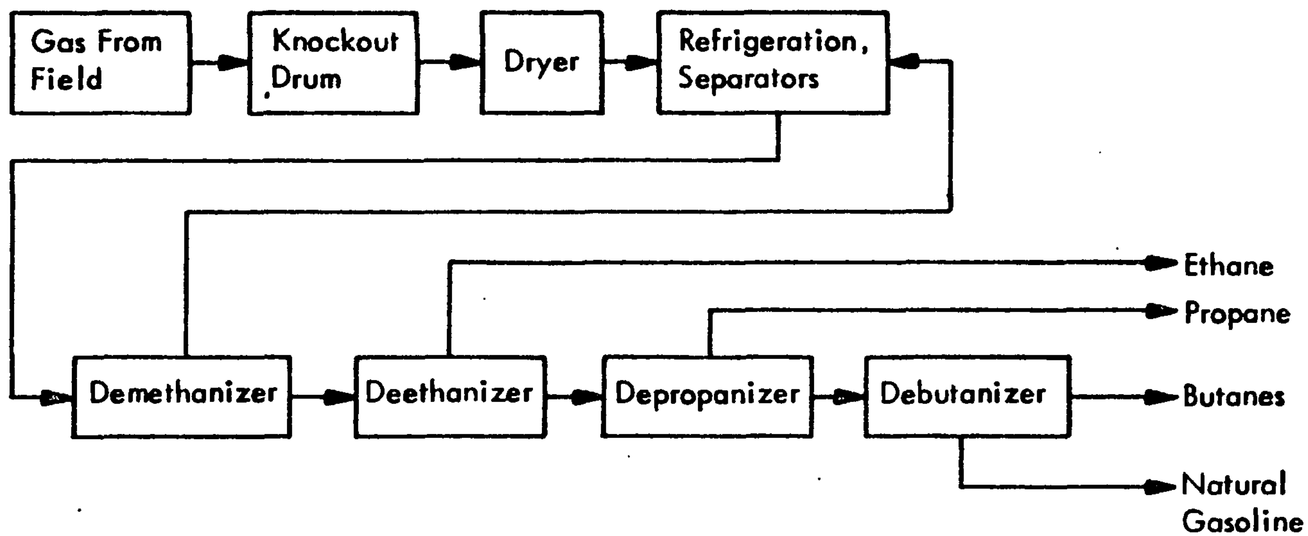


Figure C-4 - Flow diagram for a natural gas processing plant.

Table C-22 contains a summary of production impacts. The process energy values were obtained from the 1972 Census of Minerals Industries. The amount of natural gas processed in 1972 was 18,530.8 x 10^9 cubic feet. The total gas used as fuel was 632.1 x 10^9 cubic feet or 3.41 percent of throughput.

TABLE C-22

DATA FOR PRODUCTION PROCESSING 1,000 POUNDS OF NATURAL GAS LIQUIDS

Impact Category	Quantities	Sources
Energy		17,18,19
Electric	1.64 kwhr	
Natural Gas	753.0 scf	
Water Volume	280.0 gal.	19
Process Atmospheric Emissions		7,17,18,19
Hydrocarbons	10.0 lb	
SOX	2.62 lb	
Transportation		19
Rail	42.0 ton-miles	
Truck	14.0 ton-miles	
Barge	14.0 ton-miles	
Pipeline	70.0 ton-miles	

This represents 742 cubic feet per 1,000 pounds of natural gas processed or 753 cubic feet per 1,000 pounds of natural gas liquids (allowing for 1.5 percent loss and by-product credit for the residue gas). The 1971 Minerals Yearbook shows a loss of 0.36 percent (0.15 in flaring or venting + 0.21 percent unaccounted for) in NGL production. Industry sources report that losses in gas processing plants range between 1 and 2 percent. For this report, the total losses (processing, storage, and transportation) are estimated to be 1.5 percent.

With reference to atmospheric emissions, the sulfur oxides emitted from natural gas processing plants in 1971 were 1,036,000 metric tons or 2.62 pounds per 1,000 pounds of NGL produced (with by-product credit). Hydrocarbon emissions are estimated to be 10.0 pounds per 1,000 pounds of NGL.

3. Pollution Factors-Petroleum Refining: The solid waste resulting from petroleum refining (Table C-23) was assumed to consist of the solids resulting from air and water pollution-control techniques. According to Reference 30, the total residues from air and water pollution control in 1975 is estimated to be 990 million kilograms (2.182 x 10^{12} pounds). The United States petroleum refining capacity in 1975 was approximately 15 million barrels per calendar day, or 1.64 x 10^{12} pounds for the year 1975. The quantity of solid wastes per 1,000 pounds of refinery products is calculated to be 1.38 pounds (with 4 percent loss of throughput).

TABLE C-23

POLLUTION FACTORS FOR 1,000 POUNDS OF PETROCHEMICAL REFINING

Impact Category	Quantities	Sources
Energy		27
Electric	6.8 kw-hr	
Industrial Solid Waste	1.38 lb	19,30
Atmospheric Emissions		
Particles	0.22 lb	7
Sulfur Oxides	0.42 lb	7
Carbon Monoxide	11.80 lb	7
Hydrocarbons	3.77 lb	5,7
Nitrogen Oxides	0.06 lb	7
Waterborne Wastes		1
BOD	0.029 lb	
TSS	0.018 lb	
COD	0.169 lb	
Oil	0.009 lb	
Phenolic	0.0001 lb	
Ammonia (N)	0.017 lb	
Sulfide	0.0001 lb	
Chromium	0.0005 lb	

The atmospheric emissions present after pollution control treatment are shown in Table C-23. The process emissions from petroleum refining were assumed to result from three sources.

The sources and emissions breakdown are shown below:

Source	Pounds of Emissions Per 1,000 Pounds of Products				
	Particles	SOX	CO	H-C	NOx
1 - Catalyst Regeneration	0.22	0.42	11.8	0.18	0.06
2 - Storage Tanks	--	--	--	1.26	--
3 - Miscellaneous	--	--	--	2.33	--
Total	0.22	0.42	11.8	3.77	0.06

These emissions do not include fuel combustion pollutants. Process fuel emissions are secondary impacts and are added to the impact categories during the computer calculations.

The waterborne waste values for petroleum refining were obtained from Reference 1. The size factor used in the calculations was 1.04 (100 to 149.9 thousand barrels of feedstock per stream day). The process factor used was 1.27 (process configuration of 6.75 to 8.74). A value of 300 pounds per barrel was used for the weight of the incoming crude oil.

Table C-23 presents the solid wastes, atmospheric emissions and waterborne waste for refining 1,000 pounds of products in a petrochemical refinery. These values will be combined with the resource requirements (virgin raw materials, energy, and water) for the various petrochemical products in order to obtain the total resource and environmental impacts associated with various petrochemicals.

4. Ethylene Manufacture and Profile Analysis[1]: The primary processes used for manufacturing ethylene are ethane/propane pyrolysis, naphtha cracking, and gas oil cracking. Presently, the pyrolysis of light gases accounts for 75 percent of the ethylene produced.

Figure C-5 shows a flow diagram for the manufacture of ethylene. The hydrocarbon feedstock enters the cracking unit where decomposition occurs under the influence of heat and pressure. In the transition reaction that follows, ethylene and by-products are formed. When ethane is the principal feedstock, the final product distribution shows 80 percent ethylene and 20 percent by-products. For propane and naphtha feeds, ethylene represents 44 percent and 34 percent of the total reaction products (Hydrocarbon Processing, February 1974). Therefore, with the present feedstock mix (75 percent ethane/propane, 25 percent heavier feeds), ethylene represents about 60 percent of the total reaction products (assuming the light gas feed represents 62 percent ethane and 38 percent propane).

After cracking the feedstock, the products are sent through heat exchangers for the recovery of furnace heat. The Btu recovery for ethane, propane, and naphtha feeds can approximate 2,100, 3,300 and 4,000 Btu, respectively, per pound of ethylene produced. After heat exchange, the reaction products are purified and fractionated into methane, ethylene, propylene, etc.

1/ See comment No. 7 Appendix B, page 7.

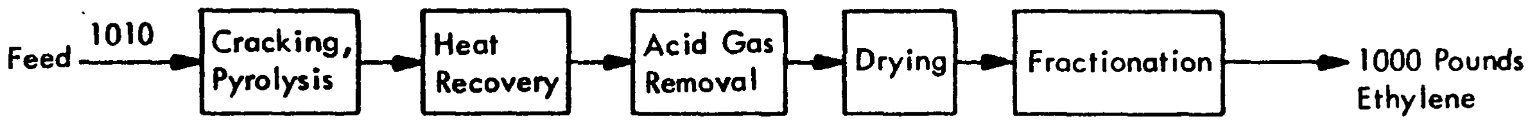


Figure C-5 - Flow diagram for manufacture of ethylene (in pounds).[1]

1/ See comment No. 1 Appendix F, page 1.

The energy requirements for ethylene manufacture will depend upon the type of fuel used and the amount of heat recovery experienced. Based on Reference 21, the total process energy for manufacturing ethylene and coproducts in 1973 was 382.3×10^9 Btu. With an ethylene production in 1973 of 23×10^9 pounds, and assuming 60 percent of the total energy for ethylene and coproducts manufacture was used in the ethylene manufacture, the energy used to manufacture 1 pound of ethylene is 9.973 Btu (as an ethylene manufacturing process). This agrees closely with the value stated in the article for ethylene manufacture corrected for by-products. Based on Reference 20, the energy requirement for manufacturing ehtylene from naphtha is about 8,700 Btu per pound. Reference 24 indicates that ehtylene can be manufactured from ethane with an energy requirement of approximately 3,000 Btu per pound. Confidential sources report that energy values of 5,000 to 7,500 Btu per pound of ethylene are representative of many ethylene plants. Reference 34 gives an excellent account of ethylene manufacture. This report shows that the fuel requirements for ethylene manufacture vary from 7,410 (from ethane) to 11,400 Btu per pound (from gas oil). For this report, the manufacture of ethylene has been charged with the following energy sources per 1,000 pounds of ethylene in 1975: Electric = 100 kilowatt-hours and natural gas = 6,800 cubic feet. These values represent 11,200 Btu per pound of ethylene manufactured from naphtha and 7,200 Btu per pound for ethylene manufactured from ethane or propane, resulting in a national average of 8,200 Btu per pound of ethylene (75 percent ethane/propane pyrolysis and 25 percent naphtha cracking).

The raw impacts for producing 1,000 pounds of ethylene are shown in Table C-24. The hydrocarbon feed requirements in the production process are approximately 1,071 pounds of feed per 1,000 pounds of ethylene.[1]

The primary use of water in the cracking process is for dilution steam requirements and for quench waters required in the cooling and primary separation of the cracked gases. The major wastewater sources are the quench tower effluents and acid gas scrubber effluents. A common practice is to send the wastewater through a steam condensate stripper to remove hydrocarbons. The effluent water from the stripper can be reused. Wastewater volume is 355 gallons per 1,000 pounds of ethylene. The EPA 1977 effluent limitations are 0.058 pound BOD and 0.088 pound TSS per 1,000 pounds of ethylene. Atmospheric emissions are reported to be 0.79 pound per 1,000 pounds of product.

The energy requirement for pollution control is 5.23 kilowatt-hours per 1,000 pounds of ethylene, or about 0.7 percent of the total energy requirements.

1/ See comment No. 1 Appendix F, page 1.

TABLE C-24

DATA FOR THE PRODUCTION OF 1,000 POUNDS OF ETHYLENE [1]

Impact Category	Quantities	Sources
Raw Materials		
Process additions	5.0 lb	19,24
(1,071 lb hydrocarbon fuel)		
Energy		
Electric	77.23 kwhr 9200	19,20,21,24,34
Natural Gas	6,800 cubic feet 7600	
Wastewater volume	335 gal.	4
Solid Waste	18.0 lb	30
Atmospheric Emission		8
Particulates	0.01 lb	
Sulfur Oxides	0.09 lb	
Carbon Monoxide	0.01 lb	
Hydrocarbons	0.67 lb	
Nitrogen Oxides	0.01 lb	
Waterborne Wastes		4
BOD	0.058 lb	
Suspended Solids	0.088 lb	

C. Low Density Polyethylene (LDPE) Resin Manufacture [2]

LDPE manufacture generally requires high pressures (1,500 atmospheres) and temperatures around 380°F. Catalysts (oxygen, organic peroxides, metal oxides, etc.) and ethylene are introduced into a reactor for polymerization. After reacting, the monomer and polymer are separated, with the unconverted ehtylene being recycled. The polymer is extruded, chilled and chopped into a granular product. Some catalysts can be used to produce the full range of densities between 0.925 and 0.965 gram per cubic centimeter.

The raw data used to calculate the environmental impacts of LDPE manufacture are shown in Table C-25. The values were taken from the actual operating data of two plants producing LDPE.

TABLE C-25

DATA FOR MANUFACTURE OF 1,000 POUNDS OF LOW DENSITY POLYETHYLENE

Impact Category	Quantities	Sources
Raw Materials		11
(ethylene - 1,050 lb)		
Additives	20.0 lb	
Energy		11
Electricity	605.0 kw-hr	
Natural Gas	1,090.0 cu ft	
Water Volume	1,000.0 gal.	19
Process Solid Wastes	4.5 lb	19
Process Atmospheric Emissions		19
Particulates	0.87 lb	
Hydrocarbons	5.0 lb	
Waterborne Wastes		80
BOD	0.2 lb	
COD	2.00 lb	
Suspended Solids	0.55 lb	

D. Low Density Polyethylene Film Manufacture[1]

A common method for fabrication of polyethylene film is an extrusion system using either a tubular air blow or water bath process. Typical rates for an air blown process are 125 pounds of plastic per hour. The water bath process has been demonstrated to produce in excess of 600 pounds per hour. For this report, a process was simulated, using 245 kilowatt-hour per 1,000 pounds of film produced. Processes are described in the literature using from 180 to 350 kilowatt-hour per 1,000 pounds of products. Water usage is estimated to be around 1,780 gallons per 1,000 pounds of LDPE film. Waste plastic scrap is estimated to be 5 pounds per 1,000 pounds of product.

Environmental impacts for 1,000 pounds of LDPE film are shown in Table C-26.

1/ See comment No. 3 Appendix F, page 1.

TABLE C-26

DATA FOR MANUFACTURING 1,000 POUNDS OF LDPE FILM

Impact Category	Quantities	Sources
Raw Materials		19
LDPE Resin	1,005 lb	
Energy		
Electricity	245 kw-hr	19
Water Volume	1,780 gal.	19
Process Solid Wastes	5 lb	19

E. Acrylic Resin Manufacturing

1. Ammonia: Ammonia is produced primarily by steam reforming natural gas. Natural gas is fed with steam into a tubular furnace where the reaction over a nickel reforming catalyst produces hydrogen and carbon oxides. The primary reformer products are then mixed with preheated air and reacted in a secondary reformer to produce the nitrogen needed in ammonia synthesis. The gas is then cooled to a lower temperature and subjected to the water shift reaction in which carbon monoxide and steam are reacted to form carbon dioxide and hydrogen. The carbon dioxide is removed from the shifted gas in an absorbent solution. Hydrogen and nitrogen are reacted in a synthesis converter to form ammonia.

In the ammonia manufacturing process, 7 pounds of natural gas will theoretically produce 17 pounds of ammonia and 19 pounds of carbon dioxide. The actual natural gas usage as process feed is 318 pounds per 1,000 pounds of products from an ammonia (products being defined as 45 percent ammonia and 55 percent carbon dioxide). The process data for ammonia manufacture are presented in Table C-27.

2. Acrylonitrile Manufacture: The most widely used process for the manufacture of acrylonitrile involves the reaction of propylene, ammonia and air in a fluidized bed reactor. The basic chemical equation for the process is:

$$2CH_2{=}CH{-}CH_3 + 2NH_3 + 3O_2 \longrightarrow 2CH_2{=}CH{-}CN + 6H_2O$$

The reaction is exothermic with recovered heat being used to generate steam for use in the process. The effluent from the reactor is first sent to a water quench tower where the excess ammonia is neutralized by sulfuric acid. After rejection on inert gases, the mixture is fractionated to remove HCN, and then acetonitrile is removed by extractive distillation. The acrylonitrile product is dried and then distilled to produce a product which is 99 percent pure.

TABLE C-27

DATA FOR MANUFACTURE OF 1,000 POUNDS OF AMMONIA

Impact Category	Quantities	Sources
Raw Materials		39
Process Additions (natural gas 318 lb)	4.55 lb	
Energy		
Electric	18.5 kw-hr	19
Natural Gas	2,363 cu ft	19,38
Water Volume	5,000 gal.	19,41
Solid Waste	0.2 lb	19
Atmospheric Emissions		
Ammonia	1.0 lb	19,40,44
Hydrocarbons	1.0 lb	19,40,44
Waterborne Wastes		
Ammonia (as N)	0.062	44

The REPA process data are shown in Table C-28. The atmospheric emission values are significant but represent typical emission in 1975 for plants without incineration. The emission per 1,000 pounds of acrylonitrile from new plants will be 0.5 pound of hydrocarbons and 9.8 pounds of NO_x. The waterborne waste values represent Bert Practicable Control Technology currently available as defined by EPA. The solid wastes associated with the process is reported to vary from 0.3 to 8.0 pounds per 1,000 pounds of acrylonitrile.

TABLE C-28

DATA FOR MANUFACTURING 1,000 POUNDS OF ACRYLONITRILE

Impact Category	Quantities	Sources
Raw Materials		
Process Additions (Ammonia 510 lb, propylene 1,260 lb)	5.0 lb	19,10
Energy		
Electric	70.0 kw-hr	19
Water Volume	505.0 gal.	27
Solid Waste, Process	0.8 lb	53
Atmospheric Emissions		53
Hydrocarbons	107.0 lb	
Nitrogen Oxides	6.7 lb	
Carbon Monoxide	122.0 lb	
Waterborne Wastes		27
BOD	0.88 lb	
TSS	1.32 lb	
Acrylonitrile	0.0005 lb	
Phenol	0.02 lb	

3. Acrylic Resin: Acrylic resins are generally copolymers of acrylonitrile. Acrylics contain more than 85 percent acrylonitrile. The comonomers are added to improve dyeability and dissolving characteristics in commercial solvents. Common names for acrylic fibers are Creslan, Acrilan, Zefran, Orlong, Verel and Dynel.

Acrylonitrile is appreciably soluble in water and is usually polymerized in aqueous solution, using water-soluble, free-radial initiators. The utility requirements are estimates based on the requirements for the production of an acrylonitrile-butadiene-styrene resin.

Table C-29 presents the manufacturing data for production of 1,000 pounds of an acrylic resin. The polymer was assumed to be 100 percent acrylonitrile.

TABLE C-29

DATA FOR PRODUCTION OF 1,000 POUNDS OF AN ACRYLIC RESIN

Impact Category	Quantities	Sources
Raw Materials		11
(Acrylonitrile 1,020 lb)		
Catalysts and Chemicals	5.2 lb	
Energy		11
Electricity	74.0 kw-hr	
Natural Gas		
Water Volume	4,800.0 gal.	19
Solid Wastes	5.2 lb	19
Atmospheric Emissions		19
Hydrocarbons	1.2 lb	
Waterborne Wastes		80
BOD	2.75 lb	
COD	13.8 lb	
Suspended Solids	1.1 lb	
Phenol	0.0083 lb	

F. Rayon Manufacturing

1. Carbon Disulfide Manufacture: Most of the carbon disulfide manufactured in the world, and all that is manufactured in the U.S., is produced by reacting methane or natural gas with vaporized sulfur at elevated temperature (1200°F to 1300°F).

Molten sulfur is vaporized in a furnace and mixed with methane (natural gas). The gases are transferred to a reactor containing activated alumina or clay catalyst where carbon disulfide and hydrogen sulfide are formed.

The reacted gases are transferred to a scrubber where unreacted sulfur is removed and recycled. The carbon disulfide gas is then dissolved in mineral oil in an absorption column while the hydrogen sulfide is separated and sent to a sulfur recovery unit.

The carbon disulfide is purified (up to 99+ percent) by a series of distillations and stored under water to prevent fire.

The environmental impacts generated by carbon disulfide manufacture are not great and do not contribute greatly to the Rayon system. The most important impact associated with CS_2 manufacture is the energy consumption.

Data for manufacture of 1,000 pounds of carbon disulfide are contained in Table C-30.

TABLE C-30

DATA FOR MANUFACTURE OF 1,000 POUNDS OF CARBON DISULFIDE

Impact Category	Quantities	Sources
Raw Materials		109
(Natural Gas - 5,500 cu ft)		
(Sulfur - 925 lb)		
Energy		109
Electricity	322.0 kw-hr	
Natural Gas	3,880.0 cu ft	
Material Resource	9.396 million Btu	
Water Volume	1,000.0 gal.	19
Solid Wastes	5.0 lb	19
Atmospheric Emissions		19
Hydrogen Sulfide	0.01 lb	
Particulates	1.0 lb	
Waterborne Solids		19
Sulfides	0.01 lb	
Transportation		
Rail	100.0 ton-miles	
Barge	50.0 ton-miles	
Truck	25.0 ton-miles	
Pipeline	148.0 ton-miles	

2. Rayon Manufacture: Rayon is manufactured from woodpulp or cotton linters raw materials. The fibers are first steeped in a solution of caustic soda form alkali cellulose. The sheets of cellulose are crumbled and mixed with carbon disulfide to form the xantrate crumb. The resulting mixture is dissolved in a dilute caustic solution to form a thick, honey-colored liquid known as viscose. The viscose is extruded through fine holes in a spinnoid (into a sulfuric acid bath) to form rayon fibers. The fibers can now be spun as continuous filament or cut into staple of desired length.

The raw impacts for rayon manufacture are shown in Table C-31. The process requires a relatively high quantity of energy when compared to other manufacturing steps.

TABLE C-31

DATA FOR MANUFACTURING 1,000 POUNDS OF RAYON

Impact Category	Quantities	Sources
Raw Materials		
Dry pulp	1,075.0 lb	
Caustic	650.0 lb	
Sulfuric acid	1,000.0 lb	
Carbon disulfide	340.0 lb	
Additive	17.0 lb	
Energy		
Coal	2,220.0 lb	
Electricity	300.0 kw-hr	
Natural Gas	5,180.0 set	
Distillate	1.1 gal.	
Residual	74.0 gal.	
Water Volume	1,600.0 gal.	19
Process Solid Waste	41.0 lb	19
Atmospheric Emissions		
Odorous sulfur	6.1 lb	19
Waterborne Wastes		
BOD	4.8 lb	80
COD	72.0 lb	
TSS	8.8 lb	
Zinc	0.534 lb	

G. Poly (Ehtylene Terephthalate) Regin Manufacture

1. Ethylene Oxide and Glycol: Ethylene oxide is manufactured by reacting ethylene feedstock with oxygen in the presence of a silver-base catalyst. The reaction is highly exothermic, producing high pressure steam as a by-product. The reactor effluent is mixed with water to effect removal of unreacted gases. The water rich stream of ethylene oxide is fed to a stripper where EO is recovered. For the production of ethylene glycol, the ethylene oxide is conveyed directly to the glycol reactor where the EO reacts with the required amount of water to form ethylene glycol.

Table C-32 contains the process data for manufacturing ethylene glycol including the manufacture of ethylene oxide as an intermediate step.

TABLE C-32

DATA FOR MANUFACTURE OF 1,000 POUNDS OF ETHYLENE GLYCOL

Impact Category	Quantities	Sources
Raw Materials		
Process Additions (Ethylene 910 lb, oxygen 1,200 lb)	1.0 lb	19,12
Energy		
Electric	325 kw-hr	12
Water	602 gal.	4
Process Solid Waste	8.2	14,19
Atmospheric Emissions		
Hydrocarbons	28.0 lb	4,53,54
Waterborne Wastes[a/]		
BOD	0.12	4
TSS	0.19	4

a/ The waste water from the ethyleue oxide plant contains about 2 percent glycols and is generally routed to the glycol plant for product recovery. Therefore, the wastewater output from the ethylene oxide plant is assumed to be zero.

2. Methanol: Methanol can be manufactured from gaseous and liquid hydrocarbons by a steam reforming route. The hydrocarbons are first desulfurized and then mixed with steam and carbon dioxide and reformed at about 840°C in the presence of a catalyst. The reforming reaction converts the hydrocarbons into carbon monoxide and hydrogen. The resulting gaseous mixture is adjusted to obtain a ratio of about two volumes of hydrogen to one volume of carbon monoxide. The mixture is reacted under pressure (50 to 80 atmospheres) at a temperature of 250 to 260°C in the presence of a catalyst to form methanol. The reaction is exothermic, producing 24,620 calories per gram mole of methanol. The reactor gases are cooled in a heat exchanger, resulting in the condensation of methanol. The unreacted gases are either recycled to the compressor or used as fuel.

The impacts from manufacturing 1,000 pounds of methanol are shown in Table C-33.

TABLE C-33

DATA FOR MANUFACTURE OF 1,000 POUNDS OF METHANOL

Impact Category	Quantities	Sources
Raw Materials		
Catalyst (natural gas 829 lb)	1.0	19
Energy		
Electric	36.6 kw-hr	47
Natural Gas	1,395 cu ft	19,43,47
Water	50 gal.	4
Solid Wastes	0.5 lb	19
Atmospheric Emissions		
Hydrocarbons	5.0 lb	19
Waterborne Wastes		27
BOD	0.058	
TSS	0.088	

3. Oxygen: Oxygen is extracted from air by cryogenic separation. The process is essentially one of liquifying the air and then collecting the oxygen by fractionation. The oxygen is produced in the form of a liquid which boils at 300°F below zero at normal atmospheric pressure. Most oxygen plants are located close to their point of use to minimize transportation difficulties. Table C-34 contains the process information relevant to the manufacture of oxygen.

TABLE C-34

DATA FOR MANUFACTURE OF 1,000 POUNDS OF OXYGEN

Impact Category	Quantities	Sources
Energy		
Electric	208 kw-hr	19
Natural Gas	764 cu ft	
Residual Oil	0.3 gal.	
Distillate Oil	0.1 gal.	
Gasoline	0.25 gal.	
Water	2,800 gal.	19

4. Acetaldehyde: Acetaldehyde can be manufactured by the oxidation of ethylene by palladium chloride in the presence of water.

$$C_2H_4 + 1/2\ O_2 \xrightarrow{\text{catalyst}} CH_3CHO$$

The reaction proceeds almost quantitatively and is very selective with respect to product ouput. The catalyst solution is recycled after purification and has a long life. In the process, ethylene and oxygen are fed to the bottom of a reaction tower filled with the catalyst solution. The vaporized reaction products are separated from the catalyst solution by a demister. Acetaldehyde is removed from unreacted gases by cooling and scrubbing with water. The crude product is separated in an extractive distillation process. The direct oxidation process produces a dilute waste stream ready for wastewater treatment. In 1970, the ethylene oxidation process accounted for 56 percent of the U.S. acetaldehyde capacity.

Table C-35 presents the impacts for acetaldehyde manufacture. The process additions consist of catalyst and hydrochloric acid. The process solid waste value is an estimate based on the amount of sewage sludges formed during waste wastewater treatment.

TABLE C-35

DATA FOR MANUFACTURE OF 1,000 POUNDS OF ACETALDEHYDE

Impact Category	Quantities	Sources
Raw Materials		
Process Additions (ethylene 670 lb, oxygen 397 lb)	12.0 lb	10,55 19,55
Energy		
Electric	22.7 kw-hr	55
Natural Gas	1,631 cu ft	19,55
Water	793 gal.	55
Process Solid Wastes	1.8 lb	19,27
Atmospheric Emissions		
Hydrocarbons	0.5 lb	53
Waterborne Wastes		
BOD	0.42	4
TSS	0.64	4

5. Naptha Reforming: The reforming processes are used to convert parafinic hydrocarbon streams into aromatic compounds such as benzine, toluene, and xylene.

The impact data for 1,000 pounds of naphtha reforming are shown in Table C-36.

TABLE C-36

DATA FOR 1,000 POUNDS OF NAPHTHA REFORMING

Impact Category	Quantities	Sources
Energy		
Electric	14.8 kw-hr	19
Natural Gas	502.0 scf	

6. Paraxylene Manufacture: Reformate feedstock rich in xylenes is fractionated to obtain a stream rich in the paraisomer. Further purification is accomplished by heat exchange and refrigeration. The solid paraxylene crystals are separated from the feedstock by centrifugation.

Table C-37 contains the raw impacts for separating paraxylene from a reformate feedstock.

TABLE C-37

DATA FOR MANUFACTURING 1,000 POUNDS OF PARAXYLENE

Impact Category	Quantities	Sources
Raw Materials		11
Crude Oil	1,035.0 lb	
Additives	1.0 lb	
Energy		11
Electric	2.6.8 kw-hr	
Natural Gas	2,651.0 scf	
Residual Oil	39.0 gal.	
Process Solid Waste	1.38 lb	19
Atmospheric Emissions		
Particulates	0.22 lb	
Sulfur Oxides	0.42 lb	
Carbon Monoxide	11.8 lb	
Hydrocarbon	3.77 lb	
Nitrogen Oxides	0.06 lb	
Waterborne Wastes		19
BOD	0.029 lb	
COD	0.169 lb	
TSS	0.018 lb	
Oil	0.006 lb	
Phenol	0.0001 lb	
Ammonia	0.017 lb	
Sulfides	0.0001 lb	
Chromium	0.0005 lb	

7. Terephthalic Acid: Terephthalic acid (TPA) is manufactured primarily by oxidation of p-sylene in the liquid phase.

$$(CH_3)_2\ C_6H_4 + 3O_2 \longrightarrow C_6H_4(COOH)_2 + 2H_2O$$

The oxidation is carried out in an acetic acid medium in the presence of manganese and cobalt bromides. Typical reaction conditions are 200°C and 400 psi. The reactor effluents are continuously removed from the reactor and routed to a crystallizer, where they are cooled by flashing the reactant liquids. The acetic acid used in the reaction is recovered by distillation and then recycled. TPA of greater than 99 percent can be recovered in the process.

The REPA data for the process are shown in Table C-38. Process solid wastes were estimated from raw waste loads to the wastewater treatment plant. The stoichemetry of the reaction indicates that 3.4 percent of the incoming p-xylene is unreacted during the process and is either recycled or emitted as waste. By-product credit was not given for the acetic acid which can be produced at 0.55 to 1.1 pounds per pound of TPA. The source data for the utilities required in the TPA process did not include the purification requirements to refine the acetic acid.

8. Dimethyl Terephthalate (DMT): DMT is produced by esterfication of TPA. TPA and methanol are fed to a reactor at moderate pressure and temperature. The reaction is:

$$C_6H_4(COOH)_2 + 2CH_3OH \longrightarrow C_6H_4(COOCH_3)_2 + 2H_2O$$

The ester is formed by replacing the hydrogen of the carboxyl group with the methyl group of the alcohol. The crude DMT is purified in a distillation and recycled back to the reactor.

Table C-39 presents the process data for manufacture of DMT. About 1.6 percent of the TPA and 3 percent of the methanol are lost in the process. The solid waste value represents primarily sewage sludges estimated from the DMT process raw waste load.

9. Poly (Ethylene Terephthalate) (PET) Resin Manufacture: PET resin is manufactured from dimethyl terephthalate (DMT) or terephthalic acid (TPA) by an esterification reaction with ethylene glycol. The reaction produces by product methanol which can be reused in the manufacture of DMT. The polyester melt can be cooled and granulated or fed directly to a fiber spinning machine.

TABLE C-38

DATA FOR MANUFACTURE OF 1,000 POUNDS OF TEREPHTHALIC ACID (TPA)

Impact Category	Quantities	Sources
Raw Materials		11
Process Additions (p-xylene 660 lb, acetic acid 890 lb)	1.0	
Energy		11
Electric	36.4 kw-hr	
Residual Oil	15.0 gal.	
Water	186 gal.	
Process Solid Waste	1.5	19,27
Atmospheric Emissions		
Hydrocarbons	13.3	19,53
Particles	0.18	19,53
Sulfur Oxides	0.16	19,53
Carbon Monoxide	7.7	19,53
Waterborne Wastes		
BOD	0.12	27
TSS	0.19	27

TABLE C-39

DATA FOR MANUFACTURE OF 1,000 POUNDS OF DIMETHYL TEREPHTHALATE (DMT)

Impact Category	Quantities	Sources
Raw Materials		
Process addition (TPA 870 lb, methanol 340 lb)	1.0	19
Energy		
Electric	40.8 kw-hr	
Residual Oil	29.4 gal.	
Water	270 gal.	27
Process Solid Waste	12.2 lb	19,27
Atmospheric Emissions		
Hydrocarbons	15.7	19,53
Particles	0.22	19,53
Sulfur Oxides	0.16	19,53
Carbon Monoxide	9.0	19,53
Waterborne Wastes		
BOD	0.51	27
TSS	0.07	27

The raw impacts for PET manufacture are presented in Table C-40.

TABLE C-40

DATA FOR MANUFACTURING 1,000 POUNDS OF PET RESIN

Impact Category	Quantities	Sources
Raw Materials		11
DMT	1,020 lb	
Terephthalic Acid	888 lb	
Acetaldehyde	230 lb	
Oxygen	87.7 lb	
Methanol	12.2 lb	
Ethylene Oxide-Glycol	332 lb	
P-xylene	372 lb	
Energy		11
Electric	85 kw-hr	
Natural Gas	819 scf	
Residual Oil	19 gal.	
Water Volume	950 gal	19
Process Solid Waste	5.5 lb	19
Atmospheric Emissions		
Hydrocarbons	1 lb	19
Waterborne Wastes		
BOD	0.78 lb	80
COD	11.7 lb	
TSS	0.52 lb	

H. Conversion of Paper to Diaper

Rolls of paper are transported to converting sites for manufacture into final products. In many cases the converting site is located quite close to the papermaking site, but sometimes the rolls are transported for a long distance. In any event, at the converting site, materials are assembled for the converting operation.

The converting process is a relatively simple operation where the rolls of paper are unwound, with the product being cut to proper size, decorated (if required), rewound on a core (if required) and packaged for shipment. The impacts of converting to 100 diapers are shown in Table C-41.

TABLE C-41

DATA FOR CONVERTING - 100 DIAPERS

Impact Category	Quantities	Sources
Materials		
Fluffing Pulp[a/]		89
Sulphate	7.92 lb	
Sulphite	0.020 lb	
Tissue[a/]		89
Virgin	1.28 lb	
Deinked	0.22 lb	
PE Film	0.98 lb	
Non-woven Fiber		89
Rayon	0.45 lb	
Resin	0.19 lb	
Polyester	0.008 lb	
Crepe Wadding	0.110 lb	
Other	0.137 lb	
Other Materials	0.015 lb	89
Total Materials	11.31 lb	89
Packaging		
Corrugated Containers	1.22 lb	89
Cartons	1.57 lb	
Poly Wrappers	0.015 lb	
Energy	1.31 kw-hr	89
Solid Wastes	0.020 lb	89
Scrap	0.781 lb	89

a/ Includes approximately 5 percent moisture.

IV. Nonwoven Bedding

The disposable bedding is made of paper tissue and LDPE film. The paper tissue manufacturing is identical to the tissue discussed in the diaper section (Appendix C-III). Also, the steps for LDPE film are discussed in the diaper section.

Information regarding the manufacturing step for the disposable sheets was not submitted by industry for this study. Therefore, we have used the disposable diaper manufacturing impacts to represent the impacts for manufacturing the disposable sheets. The impacts are shown in Table C-42.

TABLE C-42

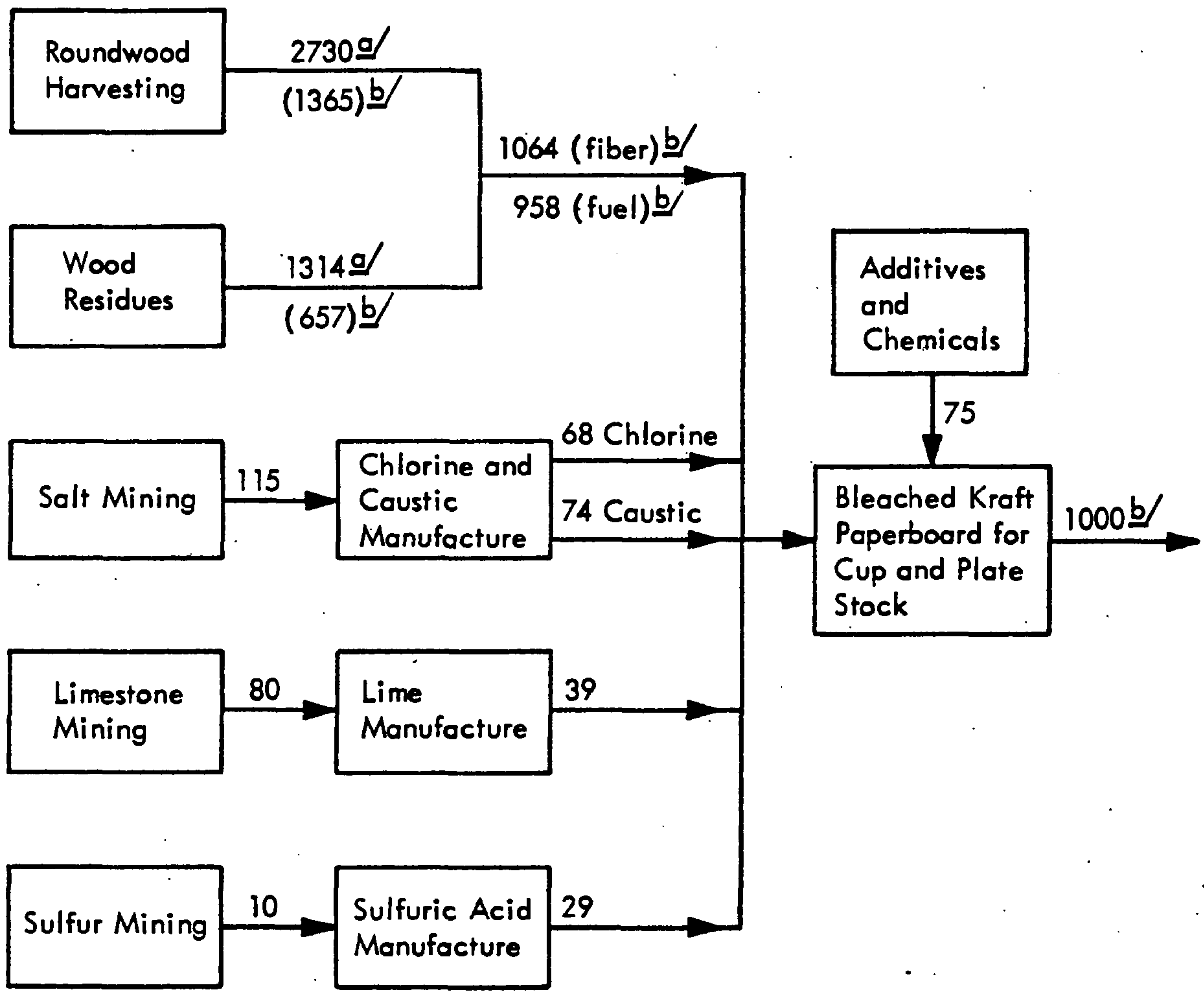
DATA FOR MANUFACTURING 1,000 DISPOSABLE SHEETS

Impact Category	Quantities	Sources
Virgin Materials		19
Tissue Paper	107.4 lb	
LDPE Film	143.2 lb	
Energy		
Electricity	13.1 lw-hr	19
Process Solid Waste	0.002 lb	19
Packaging		
Corrugated Containers	4.1 lb	19
Transportation		19
Rail	30 Ton-miles	
Truck	30 Ton-miles	

V. Containers

A. Cold Drink

1. Wax Coated Paper Cups: The major processes for producing wax coated paper cups are: (1) pulpwood harvesting; (2) bleached kraft paperboard; (3) salt mining; (4) chlorine manufacturing; (5) caustic manufacturing; (6) limestone mining; (7) lime manufacturing; (8) sulfur mining; (9) sulfuric acid manufacturing; (10) crude oil production; (11) distillation and hydrotreating; (12) dewaxing heavy oils; (13) wax purification; and (14) cup manufacturing.



a/ As received, includes moisture.
b/ Dry fiber base.

Source: Based on data in (5).

Figure C-6 - Materials Flow for Bleached Paperboard Manufacture for Cup and Plate Stock (in Pounds)

TABLE C-43

DATA FOR MANUFACTURE OF 1,000 POUNDS (DRY BASIS) BLEACHED PAPERBOARD FOR CUP AND PLATE STOCK

Impact Category	Quantities	Sources
Materials		90,93
Roundwood (trees)	2,730 lb (1,365 lb dry weight)	
Wood Residues (sawdust, etc)	1,314 lb (657 lb dry weight)	
Chlorine	68 lb	
Caustic	74 lb	
Lime	39 lb	
Sulfuric Acid	29 lb	
Others	75 lb	
Energy (purchased)[a/]		94
Electricity	143 kw-hr	
Residual Oil	14.2 gal.	
Coal	304 lb	
Distillate Oil	0.078 gal.	
LPG	0.046 gal.	
Natural Gas	5,532 cu ft	
Energy (self-generated)		
Wood Wastes	9.29 million Btu	
Water - gal.	10,700	90
Industrial Solid Wastes (lb)	142	96
Process Air Pollutants[b/] - lb		90,93
Particulates	0.32[1]	
Sulfur Oxides	0.89	
Nitrogen Oxides	0.46	
TRS	0.72	
Water Pollutants - lb		93
Suspended Solids	4.49	
BOD	3.61	

a/ Includes 1,031 lb of steam (calculated at 1,400 Btu/lb) which is distributed among the fossil fuels.

b/ See Table C-45 for more detail on sources of air pollution.

1/ See comment No. 11 Appendix J, page 39.

TABLE C-44

EMISSIONS TO THE ATMOSPHERE FROM MILLS FOR MANUFACTURE OF 1,000 POUNDS BLEACHED PAPERBOARD FOR CUP AND PLATE STOCK

	Power Source	Kraft Process	Total
Particulates - lb	1.67	2.32	3.99
Sulfur Oxides - lb	13.92	0.89	14.81
Nitrogen Oxides - lb	4.15	0.46	4.61
TRS[a/] - lb	--	0.72	0.72

Source: 93, except as noted.
a/ Estimated from 90.

TABLE C-45

ENERGY AND SECONDARY IMPACT FACTORS FOR FUEL PURCHASED AND CONSUMED ON-SITE FOR MANUFACTURE OF 1,000 POUNDS BLEACHED PAPERBOARD FOR CUP AND PLATE STOCK[a/]

Energy (total) - mil Btu	
Fuel Oils (14.24 gal.)	2.418
Natural Gas and LPG (5.536 cu ft)	6.012
Coal (304 lb)	4.043
Total	12.473
Solid Wastes (secondary) - lb	58.8
Air Pollutants (secondary) - lb	
Particulates	0.68
Nitrogen Oxides	2.62
Hydrocarbons	6.59
Sulfur Oxides	0.97
Carbon Monoxide	1.50
Water Pollutants (secondary)	
Dissolved Solids - lb	2.20

Source: 90.
a/ Energy is total energy from Table C-44. Pollutants are from secondary sources which occur off-site such as refining the fuel oil. Primary factors which occur on-site are in Tables C-44 and C-45.

Processes 1 through 9 are discussed in Appendix C-I (Paper Towel Step 10 and 11 are covered in Appendix C-III (Diapers). Discussions of the remaining processes will follow.

a. Bleached Kraft Paperboard for Cups and Plate Stock: Paper cups and plates are manufactured primarily from bleached kraft paperboard. A discussion of the kraft process can be found in Section B and C, to which the reader is referred. Figure C-6 illustrates the materials flow for this process as applied to cup and plate manufacture, while Tables C-43, C-44, and C-45 show the data used to calculate the impact profiles for paperboard manufacture.

Paperboard used in the manufacture of plastic coated paper hot drink cups is shipped to the converting plant as a plastic coated paperboard. In order to estimate the effects of the coating, impacts for manufacture of 51 pounds of low density polyethylene resin were added per 1,000 pounds of paperboard required (Reference 95).

Impacts of manufacture of the chemicals shown in Figure C-6 are discussed elsewhere in this report.

b. Dewaxing Heavy Oils: Distillate or residual oils are used as a stock material for dewaxing systems. The stock material is diluted, chilled and filtered. The resulting products are dewaxed oils and a waxy solution.

The raw impacts involved with 1,000 pounds of dewaxed oils are shown in Table C-46.

TABLE C-46

DATA FOR 1,000 POUNDS OF DEWAXING OILS

Impact Category	Quantities	Sources
Virgin Material		11
Additives	0.07 lb	
Energy		11
Electric	39.6 kw-hr	
Natural Gas	179.0 scf	
Residual Oil	5.6 gal.	
Water Volume	760.0 gal.	11

c. Wax Purification: High oil wax materials are placed in solution, cooled, filtered, then cooled and filtered again. The resulting waxes are either parrafin waxes or microcrystalline waxes.

The impacts associated with deoiling 1,000 pounds of wax are shown in Table C-47.

TABLE C-47

DATA FOR MANUFACTURING 1,000 POUNDS OF DEOILED WAX

Impacts	Quantities	Sources
Virgin Materials		11
Additives	0.07 lb	
Energy		11
Electric	29.7 kw-hr	
Natural Gas	269 scf	
Residual Oil	5.8 gal.	
Water Volume	825 gal.	11

d. Conversion of Paperboard to Wax Coated Paper Cups: The process of conversion of paperboard consists essentially of unwinding rolls of paperboard, decorating, coating with wax (where required), forming mechanically into the proper shape and packaging for shipment. The primary impacts result from energy use.

These data were based on a survey of cup and plate manufacturers by the Single Service Institute (SSI). The survey sample included manufacturers of more than 50 percent of paper cups and paper plates manufactured in the U.S. (Reference 95). Environmental impact data are found in Table C-48.

2. Thermoformed Polystyrene Cup: The processes necessary for manufacturing thermoformed polystyrene cups are: (1) ethylene manufacturing (discussed in Appendix C-III, Diapers); (2) reforming; (3) benzene extraction; (4) toluene dealkylation; (5) styrene manufacturing; and (6) cup manufacturing.

a. Reforming, Benzene Extraction, and Toluene Dealkylation: Reforming processes are used in converting parafinic hydrocarbon streams into aromatic compounds such as benzene and toluene. The environmental impacts associated with this procedure are shown in Table C-49.

TABLE C-48

DATA FOR CONVERTING ONE MILLION 9-OUNCE WAX COATED PAPER COLD DRINK CUPS

Impact Category	Quantities	Sources
Materials		95
Bleached Paperboard[a/]	12,490 lb	
Wax	5,380 lb	
LD Poly Bags	160 lb	
Cartons	350 lb	
Corrugated	1,270 lb	
Inserts and Protectors	100 lb	
Energy		95
Electricity	4,390 kw-hr	
Natural Gas	8,160 cu ft	
Residual Oil	75 gal.	
Solid Waste	170 lb	95

a/ Includes approximately 6 percent moisture by weight.

TABLE C-49

DATA FOR 1,000 POUNDS OF REFORMED FUEL

Impact Category	Quantities	Sources
Energy		10
Electric	14.8 kw-hr	
Natural Gas	902.0 scf	

The toluene produced in the reformer is treated in the toluene dealkylation process to remove the methyl group and benzene. The benzene is extracted. The resource inputs associated with these processes are shown in Tables C-50 and C-51.

TABLE C-50

DATA FOR 1,000 POUNDS OF TOLUENE DEALKYLATION

Impact Category	Quantities	Sources
Energy		10
Electric	40 kw-hr	
Natural Gas	773 scf	
Residual	5.3 gal.	

TABLE C-51

DATA FOR 1,000 POUNDS EXTRACTED BENZENE

Impacts Category	Quantities	Sources
Virgin Materials		10
Additives	2 lb	
Energy		10
Electric	5.9 kw-hr	
Natural Gas	1,126.0 scf	
Distillate	7.8 gal.	

The environmental outputs associated with benzene manufacture are expressed in Table C-52. The impacts represent the pollutants resulting from the total refining process from crude oil distillation to benzene purification. The energy value represents the energy used in treating the water-borne wastes.

TABLE C-52

BENZENE SYSTEM ENVIRONMENTAL OUTPUT[a] FOR 1,000 POUNDS OF BENZENE

Impact Category	Quantities	Sources
Energy		
Electric[b]	3.22 kw-hr	19
Water Volume	100 gal.	19
Solid Waste	4.64 bl	19
Atmospheric Emissions		7
Particles	0.24 lb	
Sulfur Oxides	0.55 lb	
Carbon Monoxide	14.60 lb	
Hydrocarbons	1.78 lb	
Nitrogen Oxides	0.06 lb	
Waterborne Waste		1
BOD	0.029 lb	
COD	0.169 lb	
Oil	0.009 lb	
Suspended Solids	0.018 lb	
Phenol	0.0001 lb	
Ammonia	0.017 lb	
Sulfides	0.0001 lb	
Chromium	0.0005 lb	

a/ Raw impacts resulting from the refining processes (crude oil distillation, hydrotreating, reforming, benzene extraction, and purification) used in the manufacture of benzene.

b/ Energy for processing wastes.

b. Styrene Manufacture: Figure C-7 shows a flow diagram for the manufacture of styrene. Dry benzene enters the alkylation reactor where ethylene and benzene react in the presence of an aluminum chloride catalyst to form ethylbenzene. Fractionation towers separate ethylbenzene from other reaction products and unreacted feed components. The purified ethylbenzene is then catalytically dehydrogenated to form styrene. Additional fractionation towers separate the high purity styrene from unconverted ethylbenzene and reaction by-products. Ethylbenzene is recycled to the dehydrogenation reactor and benzene to the alkylation reactor. Toluene (52 pounds per 1,000 pounds of styrene) and aluminum chloride (2 pounds per 1,000 pounds of styrene) are produced as by-products. The aluminum chloride is used for water treatment applications.

The raw impacts for producing 1,000 pounds of styrene are presented in Table C-53. Chemicals for pollution control have been included in process additions and the ethylene and benzene raw materials requirements have been adjusted for a 6.1 percent by-product credit. Electricity use of 43.8 kilowatt-hours includes 15.5 kilowatt-hours for pollution control. The vent gases are treated for recovery of aromatics and removal of hydrochloric acid. Process condensate from the dehydrogenation step is stripped to remove dissolved aromatics and then is used as boiler feed water.

c. Cup Manufacture: The 9 fluid ounce polystyrene cup is manufactured by thermoforming a plastic sheet. Basically, the process consists of heating the polystyrene sheet to a formable plastic state and then applying air and/or mechanical assists to shape it to the contours of a mold.

The raw impacts for manufacturing the cup are shown in Table C-54.

B. Hot Drink

1. LDPE Coated Paper Cups: The paper manufacturing steps are identical to those discussed in Appendix C-I (Paper Towels) with the exception of the paperboard manufacturing which was covered in the paper cold drink section. The LDPE manufacturing processes are covered in Appendix C-III (Diapers).

A discussion of the manufacture of LDPE lined cups follows.

Conversion of Paperboard to Cups and Plates: The process of conversion of paperboard consists essentially of unwinding rolls of paperboard, decorating, coating with wax (where required), forming mechanically into the proper shape and packaging for shipment. The primary impacts result from energy use.

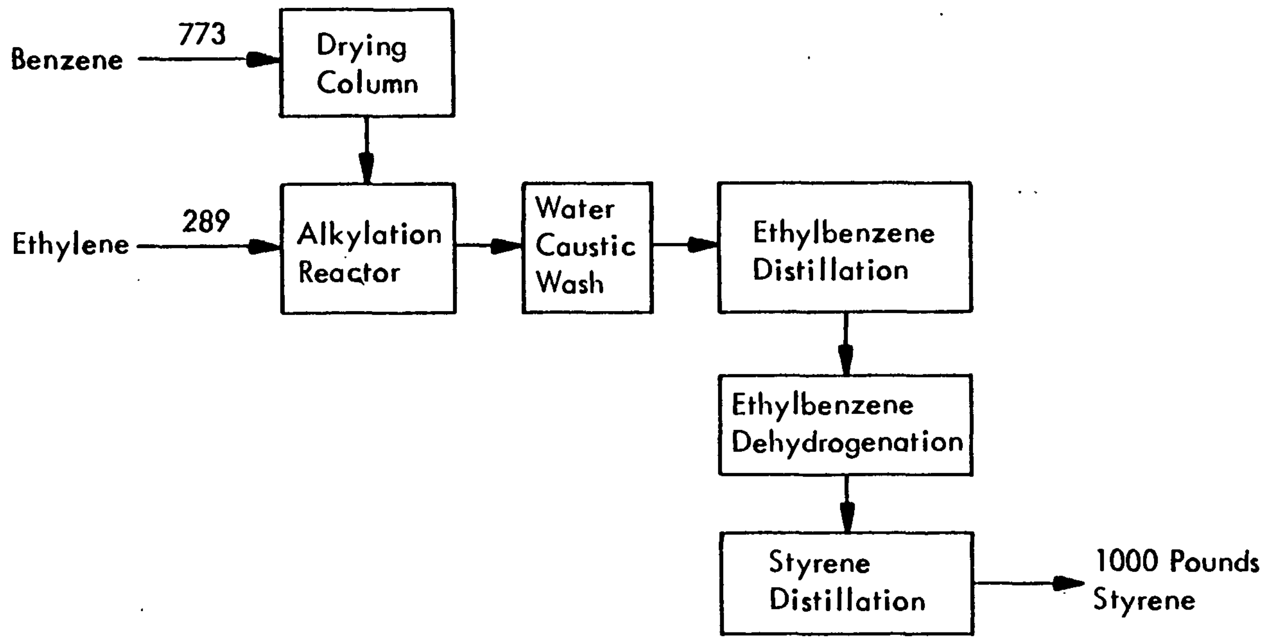


Figure C-7 - Flow Diagram for Styrene Manufacture (pounds)

TABLE C-53

DATA FOR THE PRODUCTION OF 1,000 POUNDS OF STYRENE

Impact Category	Quantities	Sources
Raw Materials		10
Process Additions	13.0 lb	
Pollution Control Chemicals	7.0 lb	
(289 lb of ethylene and 773 lb of benzene are allocated to the production of 1,000 lb styrene)		
Energy		
Electric	43.8 kw-hr	10,27
Natural Gas	2,489 cu ft	10
Residual Oil	15.3 gal.	10
Wastewater Volume	1,733 gal.	
Solid Wastes, Process	27 lb	31
Atmospheric Emissions, Process		8
Particulates	0.01 lb	
Hydrocarbons	0.072 lb	
Nitrogen Oxides	0.02 lb	
Waterborne Wastes		4
BOD	0.42 lb	
Suspended Solids	0.64 lb	

TABLE C-54

DATA FOR MANUFACTURING ONE MILLION 9-OUNCE THERMOFORMED CUPS

Impact Category	Quantities	Sources
Virgin Material		
PS Resin	14,120 lb	123
Energy		
Electric	8,350 kw-hr	123
Process Solid Waste	190 lb	19
Packaging		
LDPE Bags	120 lb	19
Corrugated Containers	1,020 lb	

These data were based on a survey of cup and plate manufacturers by the Single Service Institute (SSI). The survey sample included manufacturers of more than 50 percent of paper cups and paper plates manufactured in the U.S. (Reference 95). Environmental impact data are found in Table C-55. Air and water pollutants are negligible, and no process water is used.

TABLE C-55

DATA FOR CONVERTING ONE MILLION 7-OUNCE PAPER HOT DRINK CUPS (LDPE LINED)

Impact Category	Quantities	Sources
Materials - lb		95
Bleached Paperboard (LDPE Coated)[a/]	19,280[a/]	
Paper Bags	390	
Cartons	1,550	
Other	60	
Energy		95
Electricity	2,420 kw-hr	
Natural Gas	10,940 cu ft	
Solid Waste	380 lb	95

a/ Paperboard includes approximately 6 percent moisture by weight. The coated paperboard is 5.1 percent coating (by weight), and 94.9 percent paperboard.

2. Foam Polystyrene Cups: The manufacturing processes for the 7 fluid ounce foam polystyrene cup are the same as those for the 9 fluid ounce thermoformed polystyrene cup with the addition of: (1) polystyrene resin manufacturing; (2) isopentane manufacturing; and (3) cup manufacturing.

A discussion of these three processes follows.

a. Polystyrene Resin Manufacture: Styrene is normally polymerized by either suspension or bulk methods. Suspension polymerization refers to an aqueous system with the monomer as a dispersed phase, resulting in polymer as a dispersed solid phase. The dispersion is maintained by a combination of agitation and the use of water soluble stabilizers. In bulk polymerization, inhibitor-free styrene is prepolymerized in a stirred vessel until the reaction mixture is approximately 30 percent polymer. The solution is then transferred to a second reactor where the temperature is controlled during final polymerization. The pure molten polymer is discharged through spinnerets or into an extruder, producing small diameter rods which are chopped into polystyrene pellets. Figure C-8 shows flow diagrams for both suspension and bulk polymerization.

Table C-56 contains the raw impact data for manufacturing polystyrene resin. The process additives include solvents, plasticizers, etc. The energy category includes 3.67 kilowatt-hours for pollution control. Wastewater volume and pollutants are 1977 EPA guideline values. Atmospheric emissions represent the current estimate for the national average emissions from polystyrene manufacturing plants.

TABLE C-56

DATA FOR THE MANUFACTURE OF 1,000 POUNDS OF POLYSTYRENE RESIN

Impact Category	Quantities	Sources
Raw Materials		
Process Additions	24.0 lb	25
(1,010 lb styrene monomer required)		
Energy		19,25,27
Electric	53.67 kw-hr	
Natural Gas	1,710 cu ft	
Wastewater Volume	650 gal.	
Solid Waste, Process	9.0 lb	19,33
Atmospheric Emissions, Process		8
Particulates	0.08 lb	
Sulfur Oxides	0.24 lb	
Hydrocarbons	4.00 lb	
Waterborne Wastes		3
BOD	0.13 lb	
COD	1.30 lb	
Suspended Solids	0.36 lb	
Chromium	0.001 lb	

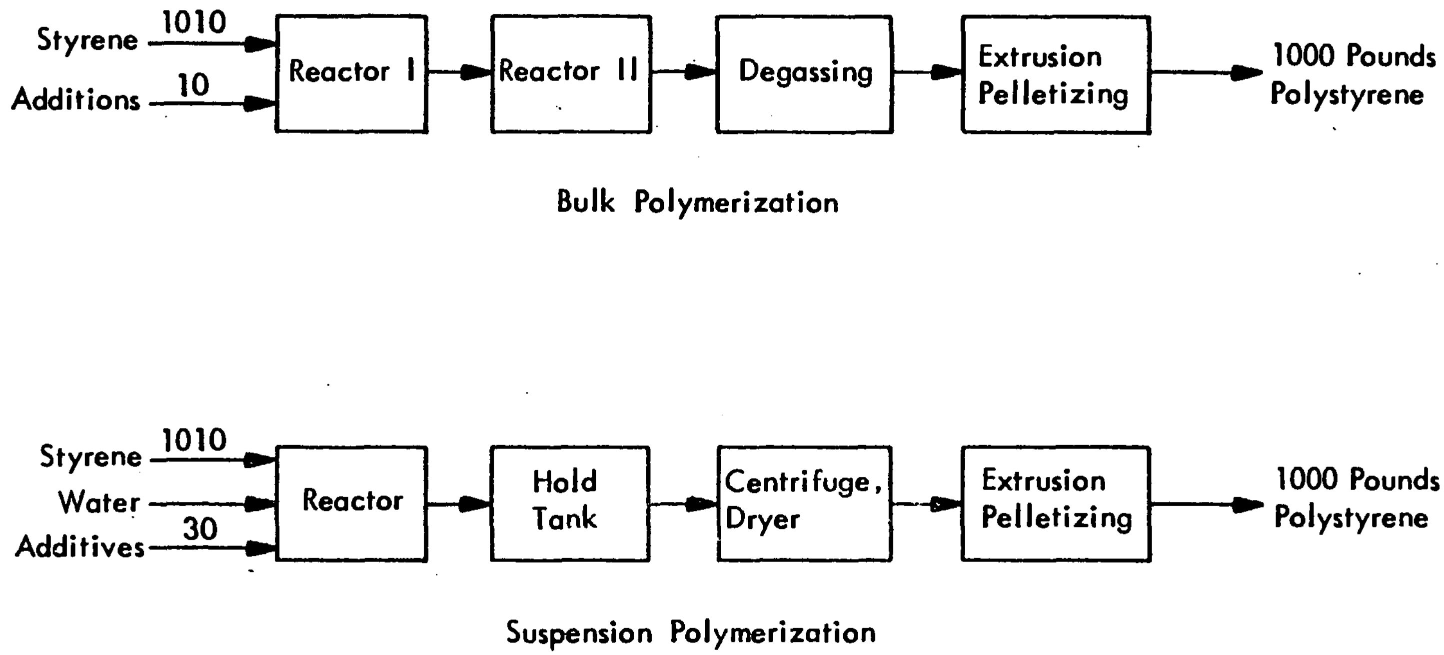


Figure C-8 - Flow Diagram For the Manufacture of Polystyrene Resin (Pounds)

b. Isopentane Production (Blowing Agents): The hydrocarbon blowing agents (isopentane, pentane, etc.) were assumed to be produced in a natural gas liquids plant. In 1971, the total quantity of isopentane produced in NGL plants was approximately 5.6 million barrels (0.9 percent of production). This can be compared with an ethane production of 80.5 million barrels. The raw impacts for the production of 1,000 pounds of isopentane are presented in Table C-57 and are identical to the impacts assigned to NGL production.

TABLE C-57

DATA FOR THE PRODUCTION OF 1,000 POUNDS OF ISOPENTANE

Impact Category	Quantities	Sources
Energy		17,18,19
Electricity	1.64 kw-hr	
Natural Gas	753 cu ft	
Waterborne Wastes	280 gal.	19
Atmospheric Emissions		7,17,18,19
Hydrocarbons	10.0	
SOX	2.62	

c. Foam Cup Manufacture: Table C-58 contains the data submitted by the Single Service Institute for the polystyrene foam cup manufacturing steps.

TABLE C-58

DATA FOR MANUFACTURING ONE MILLION 9-OUNCE FOAM CUPS[1]

Impact Category	Quantities	Sources
Virgin Materials		123
PS Resin	4,650 lb	
Isopentane	220 lb	
Energy		
Electric	3,960 kw-hr	123
Natural Gas	116,950 scf	
Residual	50 gal.	
Distillate	800 gal.	
Solid Waste Process	90 lb	19
Atmospheric Emissions		19
Hydrocarbons	150 lb	
Packaging		
LDPE Bags	225 lb	19
Corrugated Containers	1,850 lb	

VI. Plates

A. Paper

The processes necessary for the manufacture of paper plates are: (1) pulpwood harvesting; (2) paperboard manufacturing; (3) salt mining; (4) chlorine manufacturing; (5) caustic manufacturing; (6) limestone mining; (7) lime manufacturing; (8) sulfur mining; (9) sulfuric acid; and (10) plate manufacturing.

Processes 1 through 9 are covered in Appendix C-I (Paper Towels). A discussion of process 10 follows.

1. Conversion of Paperboard to Cups and Plates: The process of conversion of paperboard consists essentially of unwinding rolls of paperboard, decorating, coating with wax (where required), forming mechanically into the proper shape and packaging for shipment. The primary impacts result from energy use. For plates, this is electricity used to mold and transport the product inside the plant.

1/ Heading should be for 7-ounce cups.

These data were based on a survey of cup and plate manufacturers by the Single Service Institute (SSI). The survey sample included manufacturers of more than 50 percent of paper cups and paper plates manufactured in the U.S. (Reference 95). Environmental impact data are found in Table C-59. Air and water pollutants are negligible, and no process water is used.

TABLE C-59

DATA FOR CONVERTING ONE MILLION 9-INCH ROUND PRESSED PAPER PLATES

Impact Category	Quantities	Sources
Materials	28,165 lb	95
Bleached Paperboard[a]	120 lb	
Poly Bags	120 lb	
Currugated	945 lb	
Energy		95
Electricity	1,800 kw-hr	
Solid Waste	20 lb	95

a/ Includes approximately 6 percent moisture by weight.

2. Transportation for Disposable Paper Plates and Cups: Table C-60 shows the significant transportation steps for the manufacture of disposable paper plates and cups.

B. Foam Polystyrene

The production steps for foam polystyrene plates are identical to those for foam polystyrene cups.

The manufacturing impacts for polystyrene foam plate production represent industry averages submitted for the study by the Single Service Institute. The data are shown in Table C-61.

TABLE C-60

TRANSPORTATION FACTORS FOR DISPOSABLE PAPER PLATES AND CUPS

Material - locations	Unit	Rail (ton-miles)	Truck (ton-miles)
Paperboard to 9-oz wax coated cup conversion	Million cups	4,930	--
Wax to 9-oz wax coated cup conversion	Million cups	1,860	330
Shipping containers to 9-oz wax coated cup conversion	Million cups	--	82.5
9-oz wax coated cups to market	Million cups	980	2,920
Paperboard to plate conversion	Million plates	10,000	1,410
Shipping containers to plate conversion	Million plates	--	57
Plates to market	Million plates	520	3,240
Paperboard to 7-oz LDPE coated cup conversion	Million cups	4,150	--
Shipping containers to 7-oz LDPE coated cup conversion	Million cups	--	110
7-oz LDPE coated cups to market	Million cups	454	2,220

Source: (7)

TABLE C-61

DATA FOR MANUFACTURING ONE MILLION FOAM PLATES

Impact Category	Quantities	Sources
Virgin Materials		123
PS Resin	26,610 lb	
Isopentane	1,040 lb	
Energy		
Electric	20,200 kw-hr	123
Process Solid Waste	460 lb	19
Atmospheric Emissions		
Hydrocarbons	270 lb	19
Packaging		
LDPE Bags	350 lb	19
Corrugated Containers	3,600 lb	

APPENDIX D

REUSABLES

I. Towels

A. Cloth

The processes necessary for manufacturing cloth towels are: (1) cotton growing (fertilizer); (2) cotton ginning; and (3) cotton cloth production.

A brief discussion of the steps in each process will be given, along with environmental impact data.

1. Cotton Growing:[1,2] The main impacts generated by growing cotton are due to the use of chemicals (pesticides and fertilizers) and the burning of petroleum derived fuels in farm machinery.

The amount of pesticides that is used in cotton is large. Cotton receives approximately 50 percent of all insecticides used annually in the U.S. To control insects, farmers must dust or spray the growing cotton many times a season; the number and concentration is dependent upon the weather conditions and degree of infestation. The pollution resulting from pesticide use is extremely hard to measure due to the different methods of application, types of chemicals used, and geographical nature of the farmland.

Fertilizer use also varies with the type of cotton grown, conditions of the soil, and region of the country, etc. Although data on the pollution attributable to fertilizer use are more readily available than that associated with pesticide use, the amount of pollution depends upon a wide number of variables, making an extremely accurate estimate of the impacts difficult.

The frequent application of pesticides, fertilizers, and other activities necessary in cultivating cotton, require a relatively large amount of fuel for the machinery involved. This not only adds to the air pollution of cotton growing, but also increases the energy requirement. Table D-1 lists the major impacts attributable to the growing of 1,000 pounds of finished cotton.

1/ See comment No. 3 Appendix B, page 5.
2/ See comment No. 4 Appendix B, pages 5-6.

TABLE D-1

DATA FOR GROWING 1,000 POUNDS OF COTTON

Impact Category	Quantities	Sources
Raw Materials		19
Fertilizer	152.5 lb	
Pesticides	8.6 lb	
Energy		59
Diesel	23.34 gal.	
Gasoline	5.38 gal.	
Atmospheric Emissions		19
Pesticides	2.2 lb	
Hydrocarbons	4.2 lb	
Waterborne Wastes		19
Pesticides	0.46 lb	
Hydrocarbons	0.08 lb	
Transportation		
Diesel	1.2 gal.	59

2. NP Fertilizer Manufacturing: NP fertilizers are manufactured from phosphate rock, nitric acid, ammonia, and carbon dioxide. The phosphate rock reacts with nitric acid resulting in calcium nitrate and phosphoric acid; the calcium nitrate is removed and ammonia and carbon dioxide are added to control the ratio of $N:P_2O_5$.

The environmental impacts for 1,000 pounds of NP fertilizer production are shown in Table D-2.

a. Phosphate Rock Mining: Phosphate rock is obtained chiefly from deposits in Florida, Tennessee, and the western states. The deposits are generally classified as residual, replacement and sedimentary. Residual phosphate is derived from phosphatic limestone. Replacement phosphate is phosphatized limestone formed by the reaction of phosphoric acid of organic origin and limestone. Sedimentary phosphates, believed to be derived from marine organisms, occur in irregular pockets of many sizes embedded in clay or sand.

TABLE D-2

DATA FOR 1,000 POUNDS NP FERTILIZER MANUFACTURE

Impact Category	Quantities	Sources
Raw Materials		10
Phosphate	430.0 lb	
Nitric Acid	690.0 lb	
Ammonia	230.0 lb	
Carbon Dioxide	160.0 lb	
Energy		10
Electricity	43.5 kw-hr	
Natural Gas	1,064.0 scf	
Atmospheric Emissions		10
Particulates	9.0 lb	
Nitrogen Oxide	0.4 lb	
Ammonia	0.5 lb	
Hydrogen Flouride	0.02 lb	
Waterborne Wastes		80
Ammonia	0.0375 lb	
Nitrogen	0.05 lb	

The Florida and Tennessee phosphates are usually formed in surface deposits and are worked by open-cut mining methods. Western phosphates are mined by underground methods.

Most commercial deposits of phosphate rock are amorphous, impure varieties of the mineral fluorapatite, $Ca_{10}(PO_4)_6F_2$. The deposits contain 18 to 90 percent available tricalcium phosphate, $Ca_3(PO_4)_2$, known as BPL (bone phosphate of lime). About three-fourths of the phosphate rock marketed contains between 70 and 76 percent BPL.

The general practice in open-pit methods is to strip the overburden with electric powered draglines and then remove the phosphate rock. The rock is placed in a sluice pit where hydraulic monitors break up the rock with 200 psi pressure. The slurry (40 percent solids) is pumped through movable steel pipelines to the benefication plant.

At the benefication plant, the first step is to separate the coarse phosphate rock from clay, sand, and fine phosphate. The coarse phosphate is removed and stocked as a marketable product. The fine material is delimed to remove clays and sent to a flotation process to remove fine phosphate. The sand tails and slimes, which contain 4 to 6 percent solids, are pumped to slime ponds for settling. The slimes account for about one-third of the total tonnage mined, and present a disposal problem. The solids can be concentrated by settling, thickening with slow stirring, freezing, and electrophoresis methods. The economics of rapid concentration are excessive at the present time.

The chief impurities in domestic phosphate rock are iron, aluminum, and silicon oxides. Most of the impurities are removed during the washing and sintering operations prior to phosphoric acid manufacture.

Elements that might be recovered as by-products from phosphate rock processing are fluorine, vanadium, uranium, scandium, and the rare earths. Phosphorites contain about 3 percent fluorine. The fluorine, released in part as a gas in the chemical processing, is a potential air pollutant.

The total marketed production of phosphate rock products in the United States was 38,739,000 long tons in 1970. The total amount of mineral which must be mined to market this amount is about 454,408,470 long tons.

Table D-3 presents the raw data for mining 1,000 pounds of phosphate rock.

b. <u>Nitric Acid Production</u>: The necessary raw materials for the modern production of nitric acid are ammonia, air, water and platinum-rhodium (a catalyst). The series of reactions are:

$$4NH_3 + 5D_2 \longrightarrow HNO + 6H_2O$$

$$2NO + O_2 \longrightarrow 2NO_2$$

$$3NO_2 + H_2O \longrightarrow 2HNO_3 + NO$$

The environmental impacts of manufacturing 1,000 pounds of nitric acid are shown in Table D-4.

TABLE D-3

DATA FOR MINING 1,000 POUNDS OF PHOSPHATE ROCK

Impact Category	Quantities	Sources
Raw Materials		108,114
Raw Ore	2,920.0 lb	
Flotation Chemicals	5.0 lb	
Energy		103,108, 115
Electric	7.30 kw-hr	
Natural Gas	25.9 cu ft	
Residual Fuel Oil	0.04 gal.	
Distillate Fuel Oil	0.8 gal.	
Water Volume	902.0 gal.	104
Solid Wastes, Mining	1,523.0 lb	
Atmospheric Emissions		108,114
Particulate	21.0 lb	19,114,115
Waterborne Wastes		19,114
Suspended Solids	376.0 lb	
Transportation		86,88
Barge	15.3 ton-miles	
Rail	10.2 ton-miles	
Truck	9.0 ton-miles	

TABLE D-4

DATA FOR 1,000 POUNDS OF NITRIC ACID PRODUCED

Impact Category	Quantities	Sources
Raw Materials		39
(Ammonia 292 pounds)[a/]	--	
Energy		39
Electric	5.0 kw-hr	
Water Volume	3,125.0 gal.	39
Atmospheric Emissions		39
Nitrogen Oxide	1.5 lb	

a/ Ammonia is discussed in the disposable diaper section in Appendix C-III (Acrylic Resin).

c. Carbon Dioxide Manufacture: More than 60 percent of the carbon dioxide manufactured in the United States is produced by steam reforming of natural gas and is actually a by-product from ammonia manufacture. The gas is desulfurized, preheated, and reacted in a tubular furnace. The hydrocarbon gases are converted to hydrogen and carbon oxides. The primary reformer gas is reacted with air to produce a synthesis gas having a hydrogen to nitrogen rating of about 3.0. The exit gas from the secondary reformer is reduced in temperature (generating steam through the use of heat exchanges) and reacted with steam to produce more hydrogen and also carbon dioxide. The mixture of hydrogen and nitrogen is compressed in a synthesis loop to produce ammonia.

The carbon dioxide produced in the carbon monoxide shift reaction is removed by absorption with activated carbonate solution or other absorbent.

The theoretical reaction for ammonia production from methane shows that 7 pounds of methane (when reacted with steam and air) will produce approximately 17 pounds of ammonia and 19 pounds of carbon dioxide. Therefore, carbon dioxide represents 55 percent of the ammonia plant production of useful products. The environmental pollutants are assumed to be identical to these associated with ammonia plants.

The environmental impacts are shown in Table D-5.

TABLE D-5

DATA FOR MANUFACTURE OF 1,000 POUNDS OF CARBON DIOXIDE

Impact Category	Quantities	Sources
Raw Materials		39
Chemicals (Natural Gas 494 lb)	455 lb	
Energy		19,38
Electric	18.5 kw-hr	
Natural Gas	2,363 cu ft	
Water Volume	5,000 gal.	14,41
Solid Waste	0.2 lb	19
Atmospheric Emissions		14,40,44
Ammonia	1.0 lb	
Hydrocarbons	1.0 lb	
Waterborne Wastes		44
Ammonia (as N)	0.062 lb	

3. Cotton Ginning: The primary job of a cotton gin is to take raw seed cotton and separate the seed from the fibers. The amount of trash (hulls, leaves, dirt, etc.) removed from the raw cotton to produce one 500-pound bale of cotton fiber has increased from about 80 to 1,500 pounds due to the increased use of mechanical harvesters.

The basic machinery components for a cotton gin processing mechanically harvested cotton in the order of use are:

a. Suction unloading telescope.
b. Green boll trap.
c. Air line cleaner.
d. Bulk feed control unit.
e. Dryer, 3 million Btu, moisture sensitive control.
f. Inclined cleaner.
g. Burr machine.
h. Green leaf and stick machine.
i. Dryer, 3 million Btu.
j. Inclined cleaner.
k. Extractor feeders.

l. Gin stands.
m. Tandem saw-type cleaning.
n. Press.

The current disposal practice for gin wastes is to incinerate 37 percent, return 58 percent to land, and 5 percent is unaccounted for. The trash is used on land for its fertilizer and humus value. The waste trash will consist of about 36 percent hulls, 54 percent leaf trash and dirt, and 10 percent sticks and stems. The seeds are reclaimed for use as fuel or processing for valuable oils.

Table D-6 contains the raw data pertaining to the production of 1,000 pounds of cotton from a cotton gin. Raw material inputs and water pollution are assumed to be small and therefore were not researched.

TABLE D-6

DATA FOR PRODUCING 1,000 POUNDS OF COTTON FROM GINNING

Impact Category	Quantities	Sources
Energy		59
Electric	23.5 kw-hr	
Natural Gas	154.0 scf	
Solid Wastes	138 lb	61
Atmospheric Emissions		57
Particulates	1.63 lb	
Transportation		62
Rail	250 ton-miles	
Truck	150 ton-miles	

In computing the impacts of growing and ginning cotton, credit has been given for the cottonseed produced as a by-product of the cotton lint. For every pound of cotton lint harvested, 1.65 pounds of cottonseed is also harvested.

The total fertilizer, pesticide, fuel and waste quantities have been allocated between cotton lint and cottonseed on the basis of weight. For example, a total of 404.3 pounds of fertilizer, used to produce 1,000 pounds of cotton lint and 1,650 pounds of cottonseed, was multiplied by a factor of 0.3773 (1.00/2.65) to obtain the amount of fertilizer which should be applied to the impacts of cotton lint (152.5 pounds). The quantities in Tables D-1 and D-6 reflect the amounts allocated to cotton lint only.

4. Cotton Cloth Manufacture:[1] The conversion of raw cotton fiber into the finished cloth involves a series of steps that can be classified as either "dry" or "wet." The "dry" processes are involved with converting the raw cotton into cloth (spinning, weaving, etc.), while the "wet" processes include chemical treatments such as bleaching, scouring, desizing, and mercerizing.

The dry processes contribute impacts to the cloth system through the use of electrical energy that is required to operate the various weaving and spinning machines. Approximately 2,706 kilowatt hours of electricity are required to perform the dry processing of 1,000 pounds of finished cloth. Also, there is a significant amount of natural gas (5,708 square cubic feet) and coal (343 pounds) consumed per 1,000 pounds of cotton processed.

The major impact of the wet processing steps is on the water quality. The wastes characteristically have a high BOD, COD, phenols, sulfides, chromium, and inorganic salts. See Table D-7 for raw impact data.

MRI has determined that 132 pounds of cotton cloth are used to manufacture 1,000 cloth towels (16 x 27 inches at 81 grams).[2]

B. Sponges

The required processes for producing sponges are: (1) natural gas production; (2) natural gas processing; (3) sulfur mining; (4) carbon disulfide; (5) wood harvest; (6) bleached kraft pulp paper manufacturing; (7) sodium sulfate production; (8) salt mining; (9) caustic manufacturing; and (10) sponge manufacturing.

Processes 1, 2, and 4 are discussed in Appendix C-I (Disposable Diapers); processes 3, 5, 6, 8 and 9 are discussed in Appendix C-I (Paper Towels). A discussion of processes 7 and 10 follows.

1. Sodium Sulfate Manufacture: Sodium sulfate (Na_2SO_4) can be produced by several processes. It is a by-product of hydrochloric acid, rayon, phenol, dichromate and other manufacturing procedures. Glauber's salt ($Na_2SO_4 \cdot 10H_20$) and natural brines are other important sources for the compound.

In this report we have used natural brines as the raw material for sodium sulfate production. The Ozark-Mahoning plant, located close to Monahans, Texas, was used as the source of raw production data.

1/ See comment No. 5 Appendix B, page 6.
2/ The correct weight is 60.0 grams, see Table 1.

TABLE D-7

DATA FOR PRODUCTION OF 1,000 POUNDS OF COTTON CLOTH

Impact Category	Quantities	Sources
Raw Materials		
Material Cotton (1109.0 lb)		
Caustic	510.0 lb	63
Sulfuric Acid	30.0 lb	
Additives	42.0 lb	
Energy		
Electric	2,706.0 kw-hr	56,65
Natural Gas	5,708.0 cu ft	
Coal	343.0 lb	
Distillate Oil	3.7 gal.	
Residual Fuel Oil	6.6 gal.	
Water Volume	19,600.0 gal.	19
Solid Wastes	474.0 lb	19
Atmospheric Emissions		
Particulates	20.6 lb	46,65
Waterborne Wastes		
BOD	4.0 lb	63,65
COD	46.4 lb	
Suspended Solids	9.6 lb	
Chromium	0.05 lb	
Phenol	0.05 lb	
Sulfide	0.10 lb	
Transportation		
Rail	80.0 ton-miles	19
Truck	370.0 ton-miles	

The brine is removed from wells varying from 60 to 90 feet in depth. It is transferred to a holding lake and then through a halite (NaCl mineral) formation before entering the plant. The sulphate brine is saturated with sodium chloride to reduce the solubility of the sodium sulfate when the brine is chilled. The production steps are settling, chilling, thickening, filtering, submerged combustion evaporation, and drying in a rotary kiln (Figure D-1).

The Glauber's salt precipitates during the chilling stage. The remaining solids are discharged with the spent liquor. About 1.5 pounds of sodium chloride are required per pound of sodium sulfate produced. Most of this is in the natural brine, with approximately one-third added during the passage through the halite well. About 500 tons of refrigeration are required for the chilling step, of which 200 are produced from waste heat.

The submerged combustion unit evaporates about 70 percent of the total water load. Natural gas usage is 340 cubic feet per minute. A 200-horsepower compressor supplies air for the combustion. The final treatment is drying in a gas fired rotary kiln. The energy requirements were calculated from thermodynamic data.

Table D-8 contains the raw data for manufacture of 1,000 pounds of sodium sulfate, 99+ percent.

2. Sponge (Cellulose) Manufacture: The primary ingredients used in manufacturing the cellulose sponge are wood pulp, sodium sulfate, sodium hydroxide, and carbon disulfide. The wood pulp is used in the form of paper sheeting.

In the sponge manufacturing process, the first step involves converting the cellulose sheet into viscose. The cellulose is mixed in a solution of water, treated with carbon disulfide and sodium hydroxide until the cellulose becomes the jelly-like substance called viscose. The second step involves adding sodium sulfate crystals, vegetable or hemp reinforcing fibers, and dyes to the viscose. Next, the mixture is poured in rectangular block-shaped molds for cooking. After the cooking process (cellulose regeneration), the sponge blocks are washed, processed, and cut into the desirable size. The sponges are then packaged in plastic or cellophane wrapping and shipped in corrugated containers.

The raw impact data for the manufacture of 1,000 pounds of sponges is presented in Table D-9. The data are representative of the manufacturing operations of a major supplier of cellulose sponges. The 1,000 pounds of sponges represents approximately 16,925 sponges (6-3/16 x 3-11/16 x 1-1/8 inches per sponge).

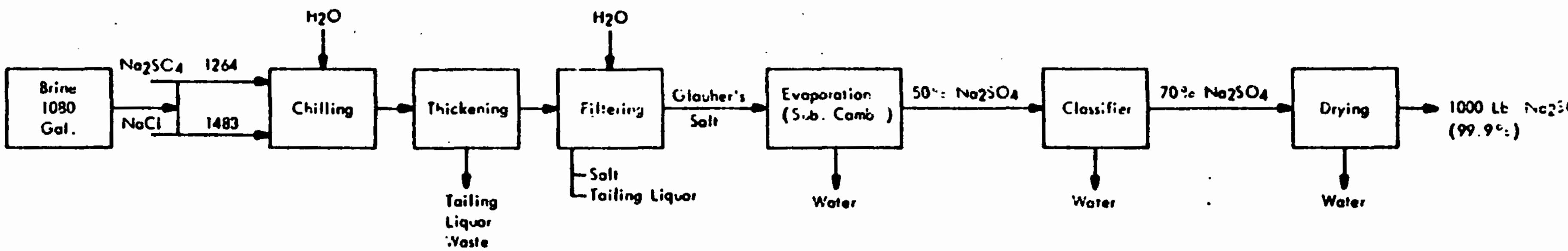


Figure D-1 - Flow Diagram for Manufacture of Sodium Sulfate

TABLE D-8

DATA FOR PRODUCTION OF 1,000 POUNDS OF SODIUM SULFATE (99.9+%)

Impact Category	Quantities	Sources
Raw Materials		
Brine (1,080 gallons) =	1,264 lb	117
Sodium Sulfate	1,483 lb	
Sodium Chloride		
Energy	10.0 kw-hr	19,117
Electric	3,631.0 cu ft	
Natural Gas		
	1,000.0 gal.	19,117
Water Volume		
	100.0 lb	19,117
Solid Wastes Mining		
Waterborne Wastes	75.0 lb	19,117
Dissolved Solids		
Transportation	450.0 ton-miles	
Rail	50.0 ton-miles	
Truck		

TABLE D-9

DATA FOR MANUFACTURING 1,000 POUNDS OF CELLULOSE SPONGES

Impact Category	Quantities	Sources
Raw Materials		
Dry Pulp	830.0 lb	19
Caustic	291.0 lb	
Carbon Disulfide	278.0 lb	
Sodium Sulfate	330.0 lb	
Energy		
Electricity	3,130.0 kw-hr	19
Natural Gas	28,261.0 scf	
Residual Oil	17.0 gal.	
Water Volume	121,738.0 gal.	19
Process Solid Waste	174.0 lb	19
Atmospheric Emissions		
Sulfur Oxides	0.4 lb	19
Odorous Sulfur	221.7 lb	
Waterborne Waste		
BOD	21.7 lb	19
COD	52.2 lb	
TSS	8.7 lb	
Packaging		
LDPE Bags	85.0 lb	19
Corrugated Containers	217.0 lb	

The 1,000 pounds of sponges require 365 pounds of packaging (78 pounds of plastic wrap, 70 pounds of cellophane wrap, and 217 pounds of corrugated shipping containers).

The sponges are transported an average of 600 miles, 40 percent by truck and 60 percent by rail.

II. Napkins

A. Cloth-Home [1,2]

The processes needed for fabricating cloth napkins (50 percent rayon, 50 percent polyester) for the home are: (1) ethylene manufacturing; (2) PET resin manufacturing; (3) rayon manufacturing; and (4) napkin manufacturing.

Processes 1 through 3 are discussed in Appendix C-III (Disposable Diapers). The impacts for cloth napkin manufacturing are shown in Table D-10.

B. Cloth--Commercial

The prinicpal processes for the production of commercial cotton napkins are: (1) cotton growing (fertilizer); (2) cotton ginning; (3) cotton cloth napkin manufacturing; and (4) napkin working.

Process 1 through 3 are discussed in the cloth towel section (Appendix D-I).

MRI determined that 100 pounds of cotton cloth would produce 1,000, 18 x 18 inch napkins. Therefore, only 10 percent of the impacts discussed in the cloth manufacturing section of the cloth towel discussion are applicable to the production of 1,000 napkins.

III. Diapers

The major processes for the manufacture of cloth diapers are: (1) cotton growing (fertilizer); (2) cotton ginning; and (3) diaper cloth manufacturing.

Processes 1, 2, and 3 are covered in the discussion of cloth towels (Appendix D-I).

MRI has determined that 13.67 pounds of cotton cloth are needed to produce 100, 21 x 40 inch diapers. Therefore, only 1.367 percent of the impacts discussed in the cloth manufacturing section of the cloth towel discussion are applicable to the production of 100 diapers.

1/ See comment No. 6 Appendix B, page 6.
2/ See comment No. 7 Appendix B, page 7.

TABLE D-10

DATA FOR MANUFACTURING 1,000 HOME CLOTH NAPKINS

Impact Category	Quantities	Sources
Virgin Materials		19
Rayon	54.7 lb	
PET Resin	54.7 lb	
Caustic	49.7 lb	
Sulfuric Acid	2.9 lb	
Additive	4.09 lb	
Energy		19
Electricity	263.67 kw-hr	
Natural Gas	555.19 scf	
Coal	33.4 lb	
Distillate Oil	0.36 gal.	
Residual Oil	0.64 gal.	
Water Volume	1,909.8 gal.	19
Process Solid Waste	46.2 lb	19
Atmospheric Emissions		19
Particulates	2.01 lb	
Waterborne Effluents		80
BOD	0.39 lb	
COD	4.52 lb	
Suspended Solids	0.94 lb	
Chromium	0.005 lb	
Phenol	0.005 lb	
Sulfides	0.01 lb	
Packaging		19
LDPE Bag	2.0 lb	
Corrugated Container	2.0 lb	

IV. Bedding

The processes necessary for manufacturing bedding made of 35 percent cotton and 65 percent polyester are: (1) ethylene manufacturing; (2) PET resin manufacturing; (3) cotton growing (fertilizer); (4) cotton ginning; and (5) sheet manufacturing.

Processes 1 and 2 are discussed in Appendix C-III (Disposable Diapers); processes 3 and 4 are covered in the discussion of cloth towels (Appendix D-I). The impacts for sheet manufacture are shown in Table D-11.

V. Containers

A. Cold Drink

1. Glass: The processes needed for the fabrication of glass tumblers are: (1) limestone mining; (2) lime manufacturing; (3) soda ash mining; (4) glass sand mining; (5) feldspar mining; and (6) tumbler manufacturing.

Processes 1 and 2 are discussed in Appendix C-I (Paper Towels). A discussion of the remaining processes follows.

a. Natural Soda Ash Mining: Soda ash, which is the common name for sodium carbonate, is used in glass manufacture as a fluxing agent. Under the temperature conditions of a glass furnace, the carbonate is converted to sodium oxide which lowers the melting and working temperature and decreases the viscosity of the melt. Sodium oxide is the second most abundant material in finished glass, constituting about 15 percent of the finished glass weight.

Soda ash is obtainable in either its natural form or in a manufactured form. The glass industry has utilized manufactured soda ash in the United States for most of this century. However, in the late 1950's, large beds of natural soda ash (trona) were discovered in Wyoming. It is also mined in California. Since the 1950's, trona has achieved considerable market penetration; until 1973, trona accounted for 38 percent of the soda ash used by the glass industry.

Since 1973, a combination of market, energy, and environmental pollution factors have acted together to force the closing of numerous synthetic ash plants, thus increasing the penetration of trona in the market. There is general agreement that in the near future, the manufacture of synthetic soda ash will practically cease in this country, and the glass industry will be using only trona as a source of soda ash. We estimate that by 1977, all of the soda ash used to manufacture glass will be trona.

TABLE D-11

DATA FOR MANUFACTURING 1,000 CLOTH SHEETS

Impact Category	Quantities	Sources
Virgin Materials		19
PET Resin	818.0 lb	
Cotton	440.0 lb	
Caustic	571.2 lb	
Sulfuric Acid	33.6 lb	
Additives	47.04 lb	
Energy		19
Electricity	3,031.0 kw-hr	
Natural Gas	6,393.0 scf	
Coal	384.2 lb	
Distillate Oil	4.14 gal.	
Residual Oil	7.39 gal.	
Water Volume	21,952.0 gal.	19
Process Solid Waste	530.9 lb	19
Atmospheric Emissions		19
Particulates	34.1 lb	
Waterborne Wastes		80
BOD	4.48 lb	
COD	52.0 lb	
Suspended Solids	10.75 lb	
Chromium	0.056 lb	
Phenol	0.056 lb	
Sulfides	0.112 lb	
Packaging		19
LDPE Bags	23.4 lb	
Corrugated Containers	23.4 lb	

Table D-12 shows that natural soda ash mining produces relatively low environmental impacts compared to the other operations in glass manufacture. However, the substantially greater use of energy as compared to the other mined minerals leads to higher atmospheric emissions than experienced by other mineral mining operations.

TABLE D-12

DATA FOR MINING OF 1,000 POUNDS NATURAL SODA ASH (TRONA)

Impact Category	Quantities	Sources
Energy		
Natural Gas	2,900 cu ft	119
Water Volume	600 gal.	104
Mining Wastes	60 lb	118
Process Atmospheric Emission		119
Particulates	5 lb	

b. Glass Sand Mining: Glass sand is the predominant raw material for glass manufacture. It comprises 53 percent by weight of the raw materials used in the production of glass and is the source of almost all of the silicon dioxide present in finished container glass. Silicon dioxide is the major chemical constituent of glass and amounts to approximately 70 percent by weight of the finished container glass.

Glass sand is a high purity quartz sand which usually contains less than 1 percent other minerals or foreign materials. These stringent purity restrictions prevent the use of most of the sand available in this country. However, sizable deposits of glass sand do exist in New Jersey in the form of unconsolidated sand banks, and as sandstones found in the Alleghenies and the Mississippi River Valley. In addition, there are smaller deposits of glass sand located in various other sections of the country.

The mining operations chosen depend on the nature of the deposit at each location. The mining operations range from simply scooping sand from a pit or bank and loading it into a truck, to quarrying hard sandstone in a fashion similar to the procedures used to extract limestone. In the latter event, extensive crushing, washing and screening may be necessary.

Data pertaining to the mining of 1,000 pounds of glass sand are shown in Table D-13 along with the sources of each number.

TABLE D-13

DATA FOR MINING OF 1,000 POUNDS GLASS SAND

Impact Category	Quantities	Sources
Energy		103
Coal	5.8 lb	
Distillate	0.15 gal.	
Residual	0.05 gal.	
Gas	216 cu ft	
Gasoline	0.041 gal.	
Electricity	2.0 kw-hr	
Water Volume	900 gal.	104
Waterborne Wastes		119
Suspended Solids	0.5 lb	

c. Feldspar Mining: Feldspar is an aluminum, silicate mineral which is used in glass manufacture to obtain aluminum oxide. This oxide acts as a stabilizer and improves the stability and durability of the glass microstructure. It is added in small quantitites and generally makes up less than 3 percent of the total glass weight.

Feldspar is mined in 13 states but North Carolina and California produce 65 percent of the nation's total. Hence, transportation expenses to bring feldspar to glass plants may be quite high. Feldspar is mined primarily by open pit quarry techniques. Usually drilling and blasting are required although this is not always so.

The data pertaining to the raw impacts associated with feldspar mining are listed in Table D-14. The dominant impact is the considerable mining waste associated with feldspar mining. More solid waste is associated with this operation per ton of material than any other operation for glass manufacture. Also, there is a significant amount of air pollution which is primarily dust produced by mining and crude ore processing.

TABLE D-14

DATA FOR MINING OF 1,000 POUNDS FELDSPAR

Impact Category	Quantities	Sources
Virgin Raw Materials	1,025 lb	103
Energy		
Distillate	30.0 gal.	
Gasoline	0.12 gal.	
Electricity	28.0 kw-hr	
Water Volume	2,250 gal.	104
Mining Wastes	2,300 lb	84
Atmospheric Emissions	7.5 lb	19
Transportation		19
Rail	765 ton-miles	

d. Glass Tumbler Manufacture: The glass tumbler manufacturing process consists of three primary steps: (1) melting the raw materials; (2) pressing or forming the product; and (3) annealing.

Around 8 to 9 million Btu are required to melt 1 ton of glass. The reject rate of molten material is about 10 percent. The press plant has a total connected power of around 300 horsepower per line, producing 15 to 20 tons per day. The furnace requires some electrical energy. Fuel oil is used as a stand by energy source. The total energy requirement per ton of glass tumblers is 10 to 12 million Btu. The manufacture of glass beverage containers is less energy intensive, generally requiring 8 to 9 million Btu per ton.

The impacts for manufacturing 1,000 pounds of glass tumblers are shown in Table D-15. Data for 1 million glass tumblers are presented in Table D-16.

2. Polypropylene Tumbler: The processes required for the production of polypropylene tumblers are: (1) propylene manufacturing; (2) propylene resin manufacturing; and (3) tumbler manufacturing.

TABLE D-15

DATA FOR MANUFACTURING 1,000 POUNDS OF GLASS TUMBLERS

Impact Category	Quantities	Sources
Raw Materials		124,19
Glass Sand	660.0 lb	
Limestone	263.0 lb	
Lime	46.0 lb	
Feldspar	75.0 lb	
Soda Ash	216.0 lb	
Additive	10.0 lb	
Energy		124,19
Electricity	125.0 kw-hr	
Natural Gas	4,680.0 scf	
Residual Oil	1.8 gal.	
Water Volume	125.0 gal.	19
Process Solid Waste	13.0 lb	19
Atmospheric Emissions		19
Sulfur Oxides	0.8 lb	
Particulates	1.0 lb	
Waterborne Wastes		19
Suspended Solids	0.07 lb	

TABLE D-16

DATA FOR MANUFACTURING 1 MILLION GLASS TUMBLERS

Impact Category	Quantities	Sources
Raw Materials		124,19
Glass Sand	192,063.0 lb	
Limestone	76,534.0 lb	
Lime	13,386.0 lb	
Feldspar	21,825.0 lb	
Soda Ash	62,857.0 lb	
Additives	2,910.0 lb	
Energy		124,19
Electricity	36,375.6 kw-hr	
Natural Gas	1,361,903.4 scf	
Residual Oil	523.8 gal.	
Water Volume	72,751.3 gal.	19
Process Solid Waste	3,783.0 lb	19
Atmospheric Emissions		19
Sulfur Oxide	232.8 lb	
Particulates	291.0 lb	
Waterborne Wastes		19
Suspended Solids	20.4 lb	
Packaging		19
Corrugated Containers	117,000.0 lb	

We have assumed that all the environmental impacts associated with propylene manufacturing are identical to those associated with ethylene manufacturing (refer to Disposable Diapers, Appendix C-III). A discussion of processes 2 and 3 will follow.

a. Polypropylene Resin Manufacture: The propylene monomer is fed into a polymerization reactor containing catalyst and alkyl aluminum activator suspended in a hydrocarbon solvent. The reaction occurs at 10 atmospheres pressure and 60°C. The polymer slurry is extracted with alcohol to deactivate and remove catalyst residues. The solvent is recovered for reuse. The polypropylene product is dewatered and then dried with hot air. The polymer is obtained in the form of a powder which can be used for molding purposes.

The process data for manufacturing polypropylene are shown in Table D-17.

TABLE D-17

DATA FOR MANUFACTURE OF 1,000 POUNDS OF POLYPROPYLENE POWDER

Impact Category	Quantities	Sources
Raw Materials		10
Solvents (Propylene 1,060 lb)	41.0 lb	
Energy		10
Electric	200.0 kw-hr	
Natural Gas	4,540.0 cu ft	
Water Volume	2,520 gal.	3
Process Solid Wastes	7.0 lb	19
Atmospheric Emissions		53,54
Hydrocarbons	19.7 lb	
Waterborne Wastes		3
BOD	0.42 lb	
COD	2.10 lb	
SS	1.16 lb	

b. Polypropylene Tumbler Manufacture: Polypropylene tumblers can be manufactured by injection molding, blow molding, etc. The injection mold temperature would run 400°F to 475°F. A typical machine would use 650 to 750 tons of clamp force, requiring a motor with 110 horsepower.

The impacts associated with the manufacture of 1,000 pounds of polypropylene tumblers are presented in Table D-18.

TABLE D-18

DATA FOR MANUFACTURING 1 MILLION 9-OUNCE POLYPROPYLENE TUMBLERS

Impact Category	Quantities	Sources
Virgin Materials		19
Polypropylene Resin	88,626 lb	
Energy		19
Electricity	21,600 kw-hr	
Water Volume	157,000 gal.	19
Process Solid Waste	441 lb	19
Packaging		19
LDPE Bags	833 lb	
Corrugated Containers	8,333 lb	

B. Hot Drink

1. Ceramics:[1] The necessary processes for manufacturing ceramic cups are: (1) clay mining; (2) plaster (gypsum mining); (3) silica (flint and glaze) mining; (4) feldspar mining; (5) nepheline syenite mining; (6) bauxite mining; (7) alumina manufacturing; and (8) cup manufacturing.

A brief description of the processes and their respective environmental impacts will be discussed.

a. Clay Mining: There are several types of clay: kaolin, bentanite, fire clay, Fuller's earth, and ball clay. The primary clays used in the production of china are kaolin and ball clays; the respective percentages are 40 percent and 60 percent.

1/ See comments Appendix J, pages 3, 19, 21.

Kaolin clay is mined using conventional surface-mining techniques and is processed via an air-floating or a water-washing procedure. Air-floating involves primary crushing, drying, grinding, classifying, bleaching, filtration, dewatering, drying and packaging (Reference 83).

The energy use breakdowns for these two processes are shown in Table D-19.

TABLE D-19

KAOLIN: AIR--FLOATED (per 1,000 pounds)

Mining	Diesel Fuel Oil	1.2 gal.
Primary Crushing	Electricity	1.69 kw-hr
Drying	Electricity	7.89 kw-hr
	Natural Gas	890.0 scf
Grinding and Classifying	Electricity	14.26 kw-hr
Packaging	Electricity	3.06 kw-hr

KAOLIN: WATER--WASHED (per 1,000 pounds)

Mining	Diesel Fuel Oil	1.2 gal.
Degritting	Electricity	14.45 kw-hr
Centrifying and	Electricity	15.7 kw-hr
Blending	Natural Gas	315.0 scf
Filtration and Dewatering	Electricity	12.86 kw-hr
Drying	Electricity	9.06 kw-hr
	Natural Gas	951.0 scf
Packaging	Electricity	3.06 kw-hr

Source: Reference 83.

Of the kaolin used in the U.S. in 1973, 29 percent was processed using air-floating, with the remaining 71 percent processed by water-washing (Reference 83). The combination of these valves and the energy use figures in Table D-19 were used to help calculate the energy impacts shown in Table D-20.

Also used in these calculations were the energies involved in processing ball clay. We know that the average energy consumed per ton of ball clay processed is 0.95 x 10 6 Btu (Reference 82). We assumed that the processing and energy types consumed are the same as the air-floated kaolin; further, the quantities of each type of energy is the same ratio.

TABLE D-20

DATA FOR PROCESSING 1,000 POUNDS OF KAOLIN CLAY

Impact Category	Quantities	Sources
Virgin Raw Materials		19
Clay	1,089 lb	
Energy		83
Diesel Fuel Oil	0.74 gal.	
Electricity	23.64 kw-hr	
Natural Gas	656.88 scf	
Atmospheric Emissions		
Particulates	68.2 lb	46
Transportation	450 ton-miles	19

Table D-19 also shows the amount of emissions associated with the drying, grinding and storage of ceramic clay (Reference: Marshall Sittig, 1975). It was assumed that 70 percent of the processing facilities use cyclones only, 10 percent use cyclones and scrubbers and 20 percent have no controls. The air emissions are primarily particulates.

To estimate the transportation involved in shipping the processed kaolin the following information was used: (1) 89 percent of the kaolin processed in 1973 came from Georgia and South Carolina (Reference 82); and (2) most of the china produced in the U.S. is made in the Northern Atlantic states.

The significant impacts are the large amount of natural gas consumed, the large quantity of particulate air emissions, and the long transportation distance.

b. Gypsum (Plaster) Mining: Plaster is used to make the molds for chinaware. Plaster is dehydrated gypsum. Of the gypsum used in 1973, 13.9 percent was mined from Michigan, 12.5 percent from Texas, 12.4 percent from California, 11.2 percent from Iowa, and 9.7 percent from Oklahoma. The major states where gypsum is calcined are Texas (10.7 percent), California (10.4 percent), New York (9.8 percent), Iowa (7.7 percent) and Georgia (5.5 percent).

The major processes involved in obtaining gypsum are: mining, crushing, grinding, drying and calcining. Underground mining or quarrying techniques are generally used; then, the gypsum is ground and dried into a fine powder. The calcining process removes approximately 75 percent of the water of hydration.

The types and quantities of energy used to accomplish the above process are shown in Table D-21. The major portions of all the energy categories are used in the calcining step.

TABLE D-21

DATA FOR PROCESSING OF 1,000 POUNDS OF GYPSUM

Impact Category	Quantities	Sources
Raw Material		19
Gypsum	1,077 lb	
Energy		82
Natural Gas	1,282.0 scf	
Heavy Fuel Oil	1.87 gal.	
Electricity	36.5 kw-hr	
Diesel Oil	0.68 gal.	
LPG	0.29 gal.	
Gasoline	0.05 gal.	
Atmospheric Emissions		46
Particulate	26.6 lb	
Transportation	683 ton-miles	19

Also, Table D-21 shows the amount of emissions associated with the drying, grinding, and calcining of the gypsum. It was assumed that 70 percent of the processing facilities use fabric filters, 10 percent use cyclones and electostatic precipitator, and 20 percent have no controls. All of the air emissions are particulates.

The processing of gypsum is very energy intense; therefore, all the energy impacts of natural gas are of significant quantity. Also, the particulate air emissions and impacts associated with transportation are important considerations.

c. Silica Mining: Silica is a quartz (SiO_2). It is known that flint is merely a hard quartz and that glaze is made primarily of silica. Therefore, we are using the impacts associated with silica for the processing of flint and glaze. The flint is used as a bonding/hardening agent in the manufacture of chinaware.

Silica is extracted using surface mining techniques or quarrying from limestone. In the latter case, crushing, washing and screening may be necessary. The types of energy used and their respective quantities per thousand pounds of silica are shown in Table D-22.

TABLE D-22

DATA FOR MINING 1,000 POUNDS OF SILICA

Impact Category	Quantities	Sources
Virgin Raw Material		19
Silica	1,005 lb	
Energy		68
Coal	5.8 lb	
Distillate	0.15 gal.	
Residual	0.05 gal.	
Gas	216.0 cu ft	
Gasoline	0.04 gal.	
Electricity	6.9 kw-hr	
Water Volume	900.0 gal.	68
Waterborne Wastes		46
Suspended Solids	0.5 lb	
Transporation		
Rail	45 ton-miles	14
Barge	2 ton-miles	13
Truck	14 ton-miles	52-1

There are significant amounts of natural gas and water used in the mining and processing of silica.

d. Feldspar Mining: Feldspar is an aluminum silicate mineral which is used in ceramic manufacture to act as a fluxing agent.

Feldspar is mined in 13 states but North Carolina and California produce 65 percent of the nation's total. Hence, transportation expenses to bring feldspar to ceramic plants may be quite high. Feldspar is mined primarily by open pit quarry techniques. Usually drilling and blasting are required, although this is not always so.

The data pertaining to the raw impacts associated with feldspar mining are listed in Table D-23. The dominant impact is the considerable mining waste associated with feldspar mining. More solid waste is associated with this operation per ton of material than any other operation for glass manufacture. Also, there is a significant amount of air pollution which is primarily dust produced by mining and crude ore processing.

TABLE D-23

DATA FOR MINING OF 1,000 POUNDS FELDSPAR

Impact Category	Quantities	Sources
Raw Materials	1,025 lb	MRI
Energy		103
Distillate	30.0 gal.	
Gasoline	0.12 gal.	
Electricity	28.0 kw-hr	
Water Volume	2,250 gal.	104
Mining Wastes	2,300 lb	120
Atmsopheric Emissions	7.5 lb	19
Transportation		19
Rail	765 ton-miles	

Nepheline syenite, a refractory ingredient, is a type of feldspar. Therefore, the impact data from feldspar will be used.

e. Bauxite Mining: Aluminum is the most widely distributed metal in the earth's crust, with only the nonmetallic elements oxygen and silicon surpassing it in abundance. However, bauxite ore is at the present time the only commercially expolited source of aluminum. Although other types of earth, including ordinary clay, contain aluminum, industry economics favor bauxite as the preferred ore.

Bauxite is formed by the action of rain and erosion on materials containing aluminum oxide (alumina). The heavy rainfall and warm temperatures of the tropics provide the most nearly ideal conditions for this process, and most of the world's bauxite is mined in these regions. Although the United States is the world's largest consumer of bauxite, nearly 90 percent of the bauxite used here is imported.

Most bauxite is mined by open-pit methods. In Jamaica, the leading producer of bauxite, the ore lies close to the surface, and only the vegetation and topsoil need to be stripped. In Arkansas, the top domestic producing region, open-pit mining is also used, with stripping ratios of 10 feet of overburden to 1 foot of ore considered minable. Underground mining is employed at one location in Arkansas, and this method is the most common in Europe.

TABLE D-24

DATA FOR THE MINING OF 1,000 POUNDS OF BAUXITE ORE

Impact Category	Quantities	Sources
Energy		103
Distillate	0.061 gal.	
Residual	0.0378 gal.	
Gasoline	0.082 gal.	
Natural Gas	199 cu ft	
Electric	3.52 kw-hr	
Water Volume	7.85 gal.	103
Atmospheric Emissions		121
Particulates	3.35 gal.	
Transportation		19
Truck	5 ton-miles	
Barge[a/]	975 ton-miles	

a/ Domestic transportation of imported ore.

Table D-24 presents the data relating to the mining of 1,000 pounds of bauxite ore, based on domestic data.

Mining solid wastes which are often associated with ore mining are not included here, but are instead counted in the refining operation, where they show up either as suspended solids in wastewater effluents or as solid wastes.

f. Refining of Alumina: Before it can be used in the manufacture of ceramics as a refractor ingredient, bauxite ore must be refined to nearly pure aluminum oxide, Al_2O_3, usually called alumina. The method used to accomplish this is called the Bayer process, which is used almost exclusively. The bauxite is crushed and dissolved in digesters, using strong caustic soda and lime solutions. The undissolved residue, known as red mud, is filtered out and constitutes a major disposal problem for alumina refiners. Sodium aluminate remains in solution, where it is hydrolyzed and precipitated as aluminum hydroxide, which is then calcined to alumina, generally in a rotary kiln.

Waterborne wastes and solid wastes constitute the largest parts of the environmental profile. Both of these categories consist largely of mining wastes, the roughly 45 percent of bauxite that is discarded after the sodium aluminate is removed in solution. The manner in which wastes are handled determines whether they show up as waterborne wastes or as solid wastes. If these red muds are simply discharged into a river, they are of course a major water pollutant. In some cases, however, they are impounded in settling ponds, where they end up as solid wastes on land. The figures used in the present study are based on data reflecting current practice. It should be noted, however, that there is an increasing tendency, in some cases required by legislation, to impound the red muds as solids. Current industry projections call for reductions of as much as 97 percent in the waterborne wastes of alumina plants by mid-1975 (U.S. EPA).

The virgin raw materials category reflects only that portion of the bauxite ore which is mined domestically. The most recent data put this amount at about 10.4 percent of domestic consumption. Impact data for alumina refining are presented in Table D-25.

g. China Cup Manufacture: During the manufacturing process the raw materials are first blended in mixing tanks and then prepared for use in the dinnerware manufacturing line. The cups are molded and baked in a kiln for the required amount of time. The final manufacturing steps include decorating and firing to the final finish.

At the current time, manufacturing wastes are being landfilled. According to tests conducted at the Buffalo Testing Labs, Buffalo, New York, in March 1972, the ceramic wastes from the china industry can be used in many applications involving: (1) decorative cement panels for architectural work; (2) swimming pool construction, construction type concrete; and (3) commercial and home garden shops and hobbies.

TABLE D-25

DATA FOR THE PRODUCTION OF 1,000 POUNDS OF REFINED ALUMINA

Impact Category	Quantities	Sources
Raw Materials		19
Bauxite	1,523 lb	
Other	70 lb	
Energy		107
Coal	140.0 lb	
Distillate	3.28 gal.	
Residual	6.1 gal.	
Natural Gas	2,700 scf	
Electric	350.0 kw-hr	
Water Volume	240 gal.	19
Atmospheric Emissions		121
Particulates	12.2 lb	
Solid Waste Mining	3,722.0 lb	
Waterborne Wastes		122
BOD	0.82 lb	
COD	19.9 lb	
Suspended Solids	198.5 lb	
Chemicals	5.8 lb	
Metal Ions	76.5 lb	
Fluorides	0.245 lb	
Oil and Grease	0.0349 lb	
Penols	0.0178 lb	
Transportation		19
Rail	378 ton-miles	
Barge	378 ton-miles	
Truck	43 ton-miles	

The data for manufacture of 1,000 pounds of china cups are shown in Table D-26, and for 1 million cups in Table D-27.

2. Melamine Cup: The principal processes for the production of melamine (plastic) cups are: (1) natural gas production; (2) natural gas processing; (3) ammonia manufacturing; (4) carbon dioxide manufacturing; (5) urea manufacturing; (6) methanol manufacturing; (7) formaldehyde manufacturing; (8) melamine resin manufacturing; (9) wood harvesting; (10) bleached pulp manufacturing; (11) melamine molding composite manufacturing; and (12) cup manufacturing.

Processes 1, 2, 3, and 6 are discussed in the Disposable Diapers section (Appendix C-III). Process 4 is covered in the cotton growing section of Cloth Towels (Appendix D-I). Processes 9 and 10 are covered in the Paper Towel section (Appendix C-I). The remaining processes will follow.

a. Urea Manufacture: Urea is colorless crystalline compound which is very soluable in water and has a melting point of 132.7°C. Urea is used in the manufacture of fertilizers, varnishes, dyes, flameproofing materials, resins, and other products.

Commercially, urea is manufactured by reacting ammonia and carbon dioxide at high temperature and pressure to form ammonium carbamate, which is then dehydrated to form urea and water. The reactor effluent is stripped with carbon dioxide. In the stripper, the nonconverted carbamate is decomposed into ammonia and carbon dioxide and recycled back to the high pressure condenser where partial conversion into ammonium carbamate occurs. This carbamate and the noncondensed gases are fed to the reactor to begin another cycle.

Urea plants normally have these areas of pollution: urea dust, gaseous ammonia, and wastewater containing urea and ammonia. The particulate contamination from pulling dust is estimated to be 0.24 pound per 1,000 pounds of urea. These particles will probably fall from the air in the vicinity of the urea plant and add to the waterborne waste load. Solid wastes are estimated to be 0.05 percent of production. The atmospheric ammonia emissions come from the urea concentrator and represent estimates based on open literature sources. The waterborne wastes represent EPA effluent guidelines for 1977.

The environmental impacts for 1,000 pounds of urea are shown in Table D-28.

TABLE D-26

DATA FOR MANUFACTURING 1,000 POUNDS OF CHINA CUPS

Impact Category	Quantities	Sources
Raw Materials		19
Clay	437.5 lb	
Nepheline Syenite	156.2 lb	
Alumina	156.2 lb	
Flint	328.1 lb	
Glaze	62.5 lb	
Plaster	46.9 lb	
Bauxite	260.0 lb	
Feldspar	93.8 lb	
Energy		19
Electricity	375.0 kw-hr	
Natural Gas	13,438.0 scf	
Water Volume	4,000.0 gal.	19
Process Solid Waste	281.25 lb	19
Atmospheric Emissions		19
Particulates	3.5 lb	
Waterborne Wastes		19
BOD	1.21 lb	
COD	2.4 lb	
Suspended Solids	2.26 lb	

TABLE D-27

DATA FOR MANUFACTURING 1 MILLION CHINA CUPS

Impact Category	Quantities	Sources
Raw Materials		19
Clay	280,000 lb	
Nepheline Syenite	99,968 lb	
Alumina	99,968 lb	
Flint	209,984 lb	
Feldspar	60,032 lb	
Glaze	40,000 lb	
Plaster	30,016 lb	
Bauxite	166,400 lb	
Energy		19
Electricity	240,000 kw-hr	
Natural Gas	8,600,320 scf	
Water Volume	2,560,000 gal.	19
Process Solid Waste	180,000 lb	19
Atmospheric Emissions		19
Particulates	2,240 lb	
Waterborne Wastes		19
BOD	774.4 lb	
DOC	1,536 lb	
Suspended Solids	1,446 lb	
Packaging		19
Corrugated Containers	54,000 lb	

TABLE D-28

DATA FOR MANUFACTURE OF 1,000 POUNDS OF UREA

Impact Category	Quantities	Sources
Raw Materials		45
Ammonia	575 lb	
Carbon Dioxide	763 lb	
Process Addition	2.0 lb	19
Energy		10,44,45
Electric	71.0 kw-hr	
Natural Gas	1,359 cu ft	
Water Volume	1,720 gal.	10,46
Solid Wates	0.5 lb	19
Atmospheric Emissions		
Ammonia	2.0 lb	46
Particulates	0.24 lb	19,44
Waterborne Wastes		44
Ammonia (as N)	0.05 lb	
Organic Nitrogen (as N)	0.50 lb	

b. Formaldehyde Manufacture: About 90 percent of the formaldehyde manufactured in the United States comes from the oxidation of methanol. The oxidation process will use either a silver catalyst or iron-molybdenum oxide catalyst.

With the silver catalyst, methanol, air, and water are superheated and sent to the reaction vessel. The reaction proceeds upon contact with the catalyst. At the catalytic bed outlet, the reaction gases are cooled in a boiler which produces steam. Gases from the boiler are sent to an absorption tower. Absorption tower bottoms go to the distillation tower where the formaldehyde is purified.

In the iron-molybdenum oxide catalyst process, methanol is mixed with air and preheated before entering the reactor. As the reaction proceeds the heat of reaction is removed by heat transfer fluids and used to prevent the incoming feed, and produce superheated steam. The reactor effluent is sent to an absorption tower where the proper formaldehyde-water concentration is obtained.

The total direct costs are generally higher for the silver process; however, the iron-molybdenum process becomes less competitive in the 20,000 to 25,000 metric tons per year capacity range.

The impacts for formaldehyde manufacture shown in Table D-29 are a combination of the silver and iron-molybdenum processes. The iron-molybdenum process is a net producer of 4.9 x 10^6 Btu of steam per metric ton of 100 percent formaldehyde, while the silver process uses 6.78 x 10^6 Btu. The net steam requirement when averaging the values for the two processes are 0.43 x 10^6 Btu per thousand pounds of formaldehyde.

TABLE D-29

DATA FOR MANUFACTURE OF 1,000 POUNDS OF FORMALDEHYDE (100% BASIS)

Impact Category	Quantities	Sources
Raw Materials		19
Chemicals (Methanol - 1,168 lb)	1.0 lb	
Energy		10,42
Electric	74 kw-hr	
Natural Gas	417 cu ft	
Water Volume	262 gal.	4
Solid Wastes	1.0 lb	19
Atmospheric Emissions		8
Hydrocarbons	10.8 lb	
Carbon Monoxide	40.0 lb	
Waterborne Wastes		4
BOD	0.058 lb	
TSS	0.088 lb	

The wastewater volume is estimated to be 131 gallons per 1,000 pounds of 50 percent formaldehyde. The process wastewater streams are intermittent and generally occur during washing of the absorber, regeneration of the nonexchange units and effluents from an aqueous slip stream exiting the bottom of the feed vaporizer. The waterborne wastes represent EPA 1977 guidelines.

The atmospheric emissions represent present-day quantities being released. The new formaldehyde plants coming on stream will have almost zero atmospheric emissions.

The solid waste value is an estimate based on the quantities of chemicals used and sludges produced during water pollution control.

c. Melamine Manufacture: Melamine is formed from reacting urea in a fluidized bed reactor with an aluminia catalyst. The first step in the process involves heat exchange between the reactor gases and urea. The molten urea enters the reactor and vaporizes spontaneously. The gaseous urea reacts to form melamine, ammonia and carbon dioxide. The conversion rate is approximately 95 percent. The reaction products contain around 35 percent melamine, 37 percent carbon dioxide, and 28 percent ammonia.

The product gases are cooled in stages to remove cyclic polymeric by-products (melem and melon) and to condense the melamine gas which is ultimately recovered as finely divided crystals.

Part of the off-gas products remain in the urea cycle and serve to heat the incoming urea and then cool the hot reaction gases. The rest of the off-gases are returned to the urea plant and used as raw materials. By-product credit was not given for the off-gases.

The environmental impacts for 1,000 pounds of melamine are shown in Table D-30.

d. Melamine Molding Compound: The melamine molding compound used in the manufacture of melamine dinnerware is generally produced at other locations. The materials profile diagram in Chapter 5 shows that urea is manufactured from ammonia and carbon dioxide raw materials. The urea is then reacted in a catalyst bed to form melamine.

In manufacturing the melamine molding compound, chemical melamine is mixed with alpha cellulose (wood pulp), formaldehyde, and a catalyst. The mixture is reacted, requiring around 500 Btu per pound of melamine molding compound. The reaction product is dryed, chopped, and sent through a ball mill to produce the molding compound used in the manufacture of melamine dinnerware.

The raw impacts associated with manufacturing 1,000 pounds of the molding compound are shown in Table D-31.

e. Melamine Cup Manufacture: Melamine cups are typically manufactured at the rate of 480 cups per hour. The molding powder is first preheated with microwave heaters and then subjected to pressure in the compression molding machines. Preheating requires approximately 10 percent

TABLE D-30

DATA FOR MANUFACTURE OF 1,000 POUNDS OF MELAMINE

Impact Category	Quantities	Sources
Raw Materials		37
Catalyst	1.8 lb	
Energy		19,37
Electric	603 kw-hr	
Natural Gas	2,913 cu ft	
Residual Oil	45 gal.	
Water Volume	160 gal.	3
Solid Waste (Process)	1.0 lb	19
Atmospheric Emissions		
Hydrocarbons	5.0 lb	
Waterborne Wastes		
BOD	0.06 lb	
COD	0.30 lb	
Suspended Solids	0.04 lb	

TABLE D-31

DATA FOR MANUFACTURING 1,000 POUNDS OF MELAMINE MOLD COMPOUND

Impact Category	Quantities	Sources
Raw Materials		19
Natural Gas	890 lb	
Carbon Dioxide	1,170 lb	
Ammonia	881 lb	
Urea	1,533 lb	
Methanol	272 lb	
Formaldehyde	233 lb	
Dry Pulp	273 lb	
Additive	0.9 lb	
Energy		19
Electricity	303 kw-hr	
Natural Gas	1,956 scf	
Residual Oil	22.7 gal.	
Water Volume	80.8 gal.	19
Process Solid Waste	5.5 lb	19
Atmospheric Emissions		19
Hydrocarbons	2.53 lb	
Waterborne Wastes		19
BOD	0.031 lb	
COD	0.152 lb	
Suspended Solids	0.02 lb	

of the total energy; while the molding step accounts for around 60 percent. Preforming, conveyors, and mold heaters account for the rest of the energy.

Table D-32 contains the data for manufacturing 1 million melamine cups.

TABLE D-32

DATA FOR MANUFACTURING 1 MILLION MELAMINE CUPS

Impact Category	Quantities	Sources
Raw Materials		19
Melamine Mold Comp	266,953 lb	
Energy		
Electricity	100,000 kw-hr	19
Water Volume	1,435,000 gal.	19
Process Solid Waste	531 lb	19
Packaging		
Corrugated Containers	26,043 lb	19

VI. Plates

A. Ceramic

The processes needed for manufacturing ceramic plates are identical to those discussed in the ceramic hot cup section (Appendix D-V). The plate manufacturing process is similar to the cup manufacturing process. Table D-33 and D-34 contain the impact data for the manufacture of china plates.

B. Melamine Plates

The processes required for the production of melamine (plastic) plates are identical to those discussed in the melamine hot cup section (Appendix D-V). The plate manufacturing process is similar to the cup manufacturing process. The molding powder is preheated and subjected to pressure in the compression molding mcahine. Approximately 240 plates per hour are produced by the machine. The manufacturing impacts for 1 million melamine plates are shown in Table D-35.

TABLE D-33

DATA FOR MANUFACTURING 1,000 POUNDS OF CHINA PLATES

Impact Category	Quantities	Sources
Raw Materials		19
Clay	457.0 lb	
Nephetine Syenite	139.1 lb	
Alumina	15.23 lb	
Flint	317.9 lb	
Feldspar	106.0 lb	
Glaze	59.6 lb	
Plaster	53.0 lb	
Bauxite	260.0 lb	
Energy		19
Electricity	364.2 kw-hr	
Natural Gas	12,980.0 scf	
Water Volume	3,947.0 gal.	19
Process Solid Waste	291.39 lb	19
Atmospheric Emissions		19
Particulates	3.5 lb	
Waterborne Wastes		19
BOD	1.28 lb	
COD	2.17 lb	
Suspended Solids	2.3 lb	

TABLE D-34

DATA FOR MANUFACTURING 1 MILLION CHINA PLATES

Impact Category	Quantities	Sources
Raw Materials		19
Clay	690,070.0 lb	
Nepheline Syenite	210,041.0 lb	
Alumina	229,973.0 lb	
Flint	480,029.0 lb	
Feldspar	160,060.0 lb	
Glaze	89,996.0 lb	
Plaster	80,030.0 lb	
Bauxite	392,600.0 lb	
Energy		19
Electricity	549,942.0 kw-hr	
Natural Gas	19,599,800.0 scf	
Water Volume	5,959,970.0 gal.	19
Process Solid Waste	439,999.0 lb	19
Atmospheric Emissions		19
Particulates	5,285.0 lb	
Waterborne Wastes		19
BOD	1,932.8 lb	
COD	3,276.7 lb	
Suspended Solids	2,473.0 lb	
Packaging		19
Corrugated Containers	75,000.0 lb	

TABLE D-35

DATA FOR MANUFACTURING 1 MILLION MELAMINE PLATES

Impact Category	Quantities	Sources
Raw Materials		19
Melamine Mold Comp	455,391 lb	
Energy		19
Electricity	198,208 kw-hr	
Water Volume	2,440,000 gal.	19
Process Solid Waste	873 lb	19
Packaging		19
Corrugated Containers	26,042 lb	

APPENDIX E E

DISHWASHING AND CLOTH LAUNDERING PROCESSES

1. Diswashing: In this report, only commercial dishwashers were considered in deriving the impact associated with washing dishes, cups, glasses, etc.

The capacity of commercial dishwashing machines can vary widely. The small capacity machines will wash around 800 dishes per hour while the larger widetrack conveyor units will process up to 14,250 dishes per hour. In this study, the operations parameters for a single tank-rack conveyor dishwasher, having a capacity of 150 racks per hour (2,700 plates, 5,400 tumblers, or 2,400 cups per hour) are used in calculating energy, water, and detergent requirements for washing reusable dinnerware.

The dishwasher requires approximately 20 gallons of water for filling the wash tank (140°F) and 426 gallons per hour (continuous operation) for the final rinse water. The wash tank water is heated to and maintained at 160°F by electric immersion heaters. The final rinse water is heated from 140°F to 180°F by booster heaters. In commercial foodservice establishments, 94 percent of operations use natural gas to heat water to the 140°F temperature. Regarding booster heaters, 36 percent are gas and 64 percent are electric. The detergent concentration in the wash tank is maintained at 0.3 percent. Some of the final rinse water is routed to the wash tank to help maintain the 160°F temperature, and to purge or skim the wash water in the tank of food particles and grease which may accumulate on the surface of the water.

In preparation for the washing process, the plates and cups are scraped, rinsed, and placed on the conveyor racks. Each rack will hold around 18 plates or 16 cups. At 150 racks per hour, the machine will wash 2,700 plates, 2,400 cups, or 5,400 tumblers per hour. Energy requirements for washing 2,700 plates are presented below in Table E-1.

Regarding water pollution, EPA guidelines have not been established for the waterborne wastes associated with commercial dishwashing. In this study, the waterborne wastes were assumed to be comprised entirely of the detergent components present in the wastewater. Municipal treatment was assumed to reduce the quantity of detergent (expressed as dissolved solids) by 80 percent.

The impacts assigned to dishwashing are presented in Table E-2. The energy and water requirements come from excellent data sources. The waterborne waste values are rough estimates only. Both the National Restaurant Association and the National Sanitation Foundation were contacted for

TABLE E-1

ENERGY DATA FOR WASHING 2,700 CHINA PLATES--COMMERCIAL DISHWASHER
(one hour of operation)

	Heat Wash Water 20 gal. 55-140°F	Heat Wash Water 20 gal. 140-160°F Emersion Heaters	Heat Rinse Water 426 gal. 55-140°F	Heat Rinse Water 426 gal. 140-180°F Booster Heater	Power For Dishwasher Motor	Totals
Natural Gas, Cubic Feet	17.25	0	367.5	66.3		451.0
Killowatt-hour	0.26	1.0	5.4	27.1	1.14	34.9

Note: The above energy values represent one hour of continuous operation. The same energy is assigned to washing melamine plates (2,700 per hour), china and melamine cups (2,400 per hour), and glass and polypropylene tumblers (5,400 per hour). The energy lost in heating the dinnerware is assumed to come from the rinse water. The final effluent rinse water is generally routed through the dishwasher to accomplish some heat recovery. This heat recovery is assumed to offset the energy required to heat the dinnerware. For example: to heat 2,700 china plates from 75°F to 160°F requires approximately 70,000 Btu (specific heat of china plate = 0.2 cal per °C per gram). The rinse water contains about 467,000 Btu. Therefore, using the rinse water to heat the china plate represents an energy recovery factor of 15 percent. The above figures are based on 75 percent efficiency for gas water heaters and 98 percent for electric water heaters.

information regarding water pollution resulting from commercial dishwashing; however, no data were available for submission to the study. Also, the food residues removed from the plates during the washing cycle were not considered. (The food residues remaining on the disposable plates were not considered when calculating the postconsumer solid waste attributable to disposable dinnerware.)

TABLE E-2

DATA FOR WASHING ONE MILLION OF EACH REUSABLE DINNERWARE PRODUCT

	Dinnerware Product		
Impacts	Glass Polypropylene Tumblers	China Melamine Cups	China Melamine Plates
Raw Materials			
Detergent, Thousand Pounds	1.44	3.4	3.02
Energy			
Electric, Thousand kilowatt hour	6.472	14.562	12.944
Natural Gas, Thousand Cubic Feet	83.517	187.912	167.030
Water Volume, Thousand Gallon	79.0	178.0	158.0
Waterborne Dissolved Solids, Pounds	288.0	860.0	604.0

Source: MRI calculations based on data submitted by industry sources.

Energy reduction through use of chemical sanitation rather than $180^\circ F$ water, would reduce the total energy to requirements of the dishwashing system by around 42 percent. This would reduce the energy per tumbler from 160 to 93 Btu, per cup 360 to 210 Btu and per plate 321 to 186 Btu (Table E-3).

TABLE E-3

ENERGY DATA COMPARISONS FOR HOT WATER AND CHEMICAL SANITIZATION

Dinnerware Item	Hot Water Sanitization	Chemical Sanitization
Tumblers	160	93
Cups	360	210
Plates	321	186

Source: MRI.

2. Commercial Laundering:[1] The primary trade association for the textile maintenance companies in this country is the Linen Supply Association of America (LSAA). The LSAA has a membership of around 855 companies. Most of the textile laundering information contained in this report was furnished by the LSAA or member companies.

The typical commercial laundering facilities utilize washers having 800 pounds of textile capacity (dry weight) per load, and dryers which process 400 pounds per load. The smaller on-premise laundry would use washers with approximately 60 pounds of capacity, and dryers with 50 pounds of capacity per load. The resource and environmental data in this report are based on the larger commercial laundering companies.

Table E-4 presents a typical laundering schedule for kitchen towels. The flushing operation is an initial rinse to remove readily loosened soil. The suds operation emulsifies the oils and greases and loosens most or all of the remaining soil.

1/ See comment No. 2 Appendix B, page 10.

TABLE E-4

LAUNDERING SCHEDULE FOR KITCHEN TOWELS, 100 PERCENT COTTON

Operation	Water Level	Water Temperature	Time, Minutes	Supplies/1,000 Pounds Towels
1. Flush	High	Hot	2	
2. Flush	High	Hot	2	
3. Break/ Suds	Low	190°F	15	40 pounds detergent
4. Carry-over	Low	160°F	5	
5. Carry-over	Low	160°F	5	
6. Bleach	Low	160°F	10	5 pounds, 20 percent bleach
7. Rinse	High	Hot	2	
8. Rinse	High	Hot	2	
9. Rinse	High	Split	2	
10. Rinse	High	Split	2	
11. Sour	Few	100°F	5	1.3 pounds sour

The carryover is an extension of the suds operation since much of the detergent still remains in the material. Carryover is followed by bleaching, rinsing and sour treatment. A sour is an acid chemical added to neutralize any remaining alkalinity.

The laundering schedules for napkins, sheets and diapers will differ slightly from the schedule in Table E-4. The many different laundering formulations, coupled with the many different types of soil contained on the textiles, will cause the raw wastewater to be highly variable with respect to type and concentration of waterborne wastes.

Table E-5 presents the detailed calculations used in deriving the energy requirements for heating the wash water for laundering napkins, sheets, and diapers in a commercial laundry. We used the assumption that 100 percent of thė waste water is heated by natural gas with an efficiency of 76 percent.[1] The energy assigned to heating water for the various products is heavily dependent upon the gallons of water used in the washing process. The energy varies from 3,168 Btu per pound for napkins to 4,726 Btu per pound for diapers. In some commercial laundry establishments, the water use will be much different than shown, and therefore will require more or less Btu per pound of laundry.

1/ Waste should be wash.

TABLE E-5

ENERGY REQUIREMENTS FOR HEATING WATER-COMMERCIAL LAUNDRY

Temperatures of Wash Steps T. (°F)	% of Water at T.	Gallons of Water at T.	Temperature Difference Wash Temperature-Incoming Temperature = AT			Btu to Heat Water (At 100% Efficiency)	Btu to Heat Water 76% Efficiency
			CLOTH NAPKINS (3,650 Gallons Water Per 1,000 Pounds Napkins)				
160	26.0	949	160	55	105	831,039	1,093,472
145	9.1	332	145	55	90	291,199	383,156
140	18.6	679	140	55	85	481,343	633,346
120	18.6	679	120	55	65	368,085	484,322
110	18.6	679	110	55	55	311,457	409,812
100 100	9.1	332	100	55	45	124,600	163,947
	100.0	3,650				2,407,723	3,168,055
					Total Btu		
			CLOTH SHEETS (3,140 Gallons Water Per 1,000 Pounds Sheets)				
160	26.0	816	160	55	105	714,571	940,225
145	9.1	286	145	55	90	214,672	282,463
140	18.6	584	140	55	85	413,998	544,734
120	18.6	584	120	55	65	316,586	416,560
110	18.6	584	110	55	555	267,880	352,474
100	9.1	286	100	55	445	107,336	141,232
	100.0	3,140				2,035,043	2,677,688
					Total Btu		
			CLOTH DIAPERS (5,500 Gallons of Water Per 1,000 Pounds Diapers)				
160	26.0	1,431	160	55	105	1,253,127	1,648,851
145	9.1	500	145	55	90	375,300	493,816
140	18.6	1,023	140	55	85	752,204	989,742
120	18.6	1,023	120	55	65	554,568	729,694
110	18.6	1,023	110	55	55	469,250	617,434
100	9.1	500	100	55	45	187,650	241,908
	100.0	5,500				3,592,099	4,726,445

Source: MRI calculations from industry data.

Table E-6 contains a summary of the primary energy consuming steps in a commercial laundry. The data are broken down into the various steps to permit the reader to substitute alternative values and test the effect of the new value on the total energy required per pound of laundry. The scope and funding of the study did not permit an indepth analysis of the commercial laundry industry to pinpoint the low energy requirements of the more efficient laundries, or the high energy requirements of the inefficient laundries. The values in this report represent averages found in the open literature.

The energy requirement of the gas dryer amounts to about 1,200 Btu per pound of laundry. The energy for drying primarily depends upon the amount and temperature of the water left in the linen after the extractor step.

Regarding waterborne wastes, EPA has not set 1977 guidelines for the commercial laundry industry. At the present time, EPA is planning to study 21 industries concerning 65 classes of compounds (124 organic chemicals and 15-20 inorganic chemicals). Laundries are among the 21 industries. The studies are projected to begin in late 1977. The results will be included in the 1983 guidelines.

For this study we have used proposed EPA guidelines as follows; BOD-30 milligrams per liter, suspended solids-30 milligrams per liter, oil and grease-10 milligrams per liter, and metals-2.2 milligrams per liter. These concentrations were used to calculate the waterborne wastes for the various product categories, based on the volume of water discharged.

The REPA impacts for 1,000 pounds of napkin, sheet and diaper laundering are shown in Tables E-7, E-8 and E-9.

3. Home Laundering[1,2]

a. Cloth Diapers: Industry data submitted for this study indicate that 4.264 pounds of cloth diapers are washed in the average load, requiring 0.185 pounds of detergent and 0.064 pounds of bleach and softener. During the washing process, the washing machine uses 0.35 killowatts per hour of electricity and requires 25 gallons of hot water and 23 gallons of cold water.[3] The drying process requires 1.91 killowatts per hour and 3.12 cubic feet of natural gas (at the 67 percent electric and 33 percent gas national average).

The impacts for washing diapers are calculated for 100 changes or diaperings. Industry data show 8.56 diapers used per day for 5.82 changes per day, resulting in 1.47 diapers per change. Due to double and triple diaperings, the 100 changes will result in 147 diapers being washed (20.09 pounds or 4.71 washer loads). Table E-10 contains the impact data for laundering 100 changes (147 diapers).

1/ See comment No. 8 Appendix B, page 7.
2/ See comment Appendix H.
3/ See comment No. 9 Appendix B, pages 7-8.

TABLE E-6

ENERGY USE FOR 1,000 POUNDS OF COMMERCIAL LAUNDRY[a/] [1]

Cloth Product	Heat Water, 10^6 Btu[b/]	Operate Washer kwhr	Operate Extractor kwhr	Operate Dryer Motor kwhr	Gas Dryer 10^6 Btu	Iron Linens 10^6 Btu	Total Energy 10^6 Btu	Total, Energy CF NG	Total, Type kwhr
Napkins	3.168	14.0	2.8	7.0	1.2	0.12	4.48	4,350	23.8
Sheets	2.678	14.0	2.8	7.0	1.2	0.12	4.00	3,880	23.8
Diapers	4.726	14.0	2.8	7.0	1.2	0.12	6.05	5,870	23.8

Source: MRI calculation using basic data supplied by the Linen Supply Association of America.

a/ Using an 800 pound capacity washer and 400 pound capacity dryer.

b/ 76 percent efficient water heater.

1/ See comment No. 15 Appendix B, page 9.

TABLE E-7

DATA FOR LAUNDERING 1,000 POUNDS OF NAPKINS-COMMERCIAL LAUNDRY[1]

Impact Category	Quantities	Source
Raw Materials		
Soap	5.6	75
Detergent	6.9	75
Bleach	1.2	75
Sour	1.0	75
Softener	1.2	75
Starch	3.8	75
Energy		
Electric	23.8 kwhr	
Natural Gas	4,350 ft^3	
Water	3,650 gal.	72
Solid Waste	52.0 lb	72
Waterborne Wastes		73
BOD	0.9	
COD		
Suspended Solids	0.9	
Dissolved Solids		
Oil and Grease	0.3	
Metal Ion	0.07	

1/ See comment No. 15 Appendix B, page 9.

TABLE E-8

DATA FOR LAUNDERING 1,000 POUNDS OF SHEETS-COMMERCIAL LAUNDRY[1]

Impact Category	Quantities	Sources
Raw Materials		
Soap	5.07	73
Detergent	6.18	73
Bleach	1.20	
Sour	1.00	
Energy		
Electric	23.8 kwhr	
Natural Gas	3,880 ft^3	
Water	3,140 gal	73
Solid Wastes	48 lb	72
Waterborne Wastes		73
BOD	0.8	
COD		
Suspended Solids	0.8	
Dissolved Solids		
Oil and Grease	0.26	
Metal Ion	0.06	

1/ See comment No. 15 Appendix B, page 9.

TABLE E-9

DATA FOR LAUNDERING 1,000 POUNDS OF CLOTH DIAPERS (COMMERCIAL LAUNDRY)[1]

Impact Category	Quantities	Sources
Raw Materials		
Soap	9.0 lb	72, 75
Detergent	11.0 lb	72, 75
Bleach	2.5 lb	72, 75
Sour	0.9 lb	72, 75
Softener/Sanitizer	1.2 lb	72, 75
Energy		
Electric	23.8 KWHR	
Natural Gas	5,870 ft^3	
Water	5,500 gal	72
Solid Wastes	78.0 lb	72
BOD	1.4 lb	
COD		
Suspended Solids	1.4 lb	
Dissolved Solids		
Oil and Grease	0.46 lb	
Metal Ion	0.10 lb	

1/ See comment No. 15 Appendix B, page 9.

TABLE E-10

DATA FOR HOME LAUNDRY OF DIAPERS (100 CHANGES)

Impact Category	Quantities	Sources
Raw Materials		19, 75
Detergent	0.87 lbs	
Bleach	18.3 fl oz	
Softeners	4.58 fl oz	
Energy		19, 75, 79
Electric	23.93 kwhr	
Natural Gas	97.64 ft^3	
Residual Oil	0.15 gal	
Water	220 gal	79
Solid Waste	1.5 lb	19, 72
Waterborne Wastes		19, 78
BOD	0.12	
SS	0.085	
Oil and Grease	0.01	
Metal Ion	0.002	

The energy requirements in Table E-10 are expanded into more detail in Table E-11. The latter table presents the energy requirement for one washer load and for 100 changes (4.71 washer loads) according to the energy source. The energy required per diapering change is 4,020 Btu.

TABLE E-11

ENERGY ANALYSIS FOR HOME LAUNDRY OF DIAPERS

Energy Source	Heat Water (58% Nat. Gas 27% Electric 15% Fuel Oil)	Washer Motor	Dryer Motor	Dryer Heat (33% Nat. Gas 67% Electric)	Total Energy
Per Washer Load (31.2 Diapers)					
Electric, kwhr	18.2[1]	0.35	1.0	1.91	5.08
Nat. Gas, Cu Ft	17.61			3.12	20.73
Fuel Oil, gal	0.031				0.031
Total Btu					85,350
Per 100 Changes (147 Diapers)					
Electric, kwhr	8.57	1.65	4.71	9.0	23.93
Nat. Gas, Cu ft	82.94			14.7	97.64
Fuel Oil, gal	0.146				0.146
Total Btu					402,000

The water requirements (hot and cold) for home laundry represent average usage for washing machines currently on the market as reported by Consumer Reports.

Solid waste from the home laundering of diapers is primarily sewage sludge formed during municipal waste treatment.

Typical BOD and suspended solids values from home laundry waste are 184 and 233 milligrams per liter respectively. For this report, we assumed that 65 percent of the BOD and 80 percent of the suspended solids are removed in sewage treatment plants. Oil and metal ion quantities are estimates based on open literature values. Each water pollutant calculation is based on 220 gallons of waste water.

Table E-12 contains the impacts, based on 100 diaperings, which pertain to diaper treatment prior to laundering. Industry data show that 55 percent of the changes result in a rinse in, and flush of, the

1/ The number should be 1.82.

toilet. At 5 gallons per flush, 275 gallons of water are used to rinse the 55 changes of diapers. Also, in each rinse approximately 2.96 grams of feces are flushed to the sewer. At 65 percent removal efficiency and assigning one pound of BOD to each pound of feces flushed, 100 changes will result in 0.126 pounds of BOD entering receiving waters. The suspended solid load was assumed to be 80 percent of the BOD load or 0.1 pounds per 100 changes. The solid wastes value is calculated from the BOD level by assigning 20 percent of the BOD removed to sewage sludges or 0.07 pounds per 100 diaper changes (2.96 x 55 x 0.2)/454 = 0.07 pounds sewage sludge). The "use" impacts in Table E-12 are part of the home diaper REPA profile and are added to the total system impacts during the computer calculations.

TABLE E-12

IMPACTS FOR CLOTH DIAPER USE (100 CHANGES)

Impact Category	Values	Sources
Water Volume	275 gal	
Solid Waste	0.07 lb	
Waterborne Waste		
BOD	0.126 lb	
Suspended Solids	0.10 lb	

Table E-13 contains the impact data for home laundry of cloth towels, cloth napkins, and sponges. The washer load for linen used in this report is 12 pounds. The energy values are based on the energy to wash diapers in the home laundry with the heavier load of linen taken into account. The water volume, solid waste, and waterborne wastes are also based on industry data used in calculating the diaper washing impacts.

TABLE E-13

DATA FOR HOME LAUNDRY OF 1,000 POUNDS OF LINENS
(Towels, Sponges, Napkins)

Impact Category	Quantities	Sources
Raw Materials		75
Detergent	15.42 lb	
Bleach	333 fl oz	
Softener	83 fl oz	
Energy		19, 75, 78
Electric	423 kwhr	
Natural Gas	1,727 ft^3	
Fuel Oil	2.55 gal	
Water	4,003 gal	78
Solid Wastes	27.3 lb	19, 72
Waterborne Wastes		19, 78
BOD	2.15 lb	
SS	1.56 lb	
Oil	0.3 lb	
Metal Ion	0.07 lb	

Table E-14 compares the total REPA summary data for Cloth Towels (U100, L5) and Cloth Napkins Home Use (U100) with the laundering component of the profile represented by data from 8 pound loads and 12 pound loads. The older washing machines (home) would encourage the use of 8 pound loads while the newer 18 to 20 pound capacity machines would probably result in wash loads of 12 pounds and heavier. The values in Table E-14 represent the total profile summary and not just the laundering component.

The values in Table E-14 show a total system energy increase of 25 percent for the cloth towel system, and 29 percent for the home cloth napkin system when decreasing the wash load from 8 pounds to 12 pounds. A similar decrease in energy would be expected for those households using 16 pound loads rather than 12 pounds per load.

TABLE E-14

IMPACT SUMMARIES FOR THE CLOTH AND PAPER TOWEL AND CLOTH AND PAPER NAPKIN SYSTEMS USING 8 AND 12 POUND WASH LOADS FOR THE REUSABLE
(Basis; Towels 1,000 Spills, Napkins 1,000 Meals)

Impact Category	Cloth Towel System (U100, L5)		Paper Towel	Home Cloth Napkin System (U100)		Paper Napkin
	8 Pound	12 Pound	2-Ply	8 Pound	12 Pound	1-Ply
Raw Materials (lb)	3.23	2.91	14.22	5.25	4.03	4.66
Energy (million Btu)	0.36	0.27	0.50	1.16	0.82	0.17
Water (thousand gallons)	0.20	0.14	0.28	0.65	0.45	0.10
Industrial Solid Waste (cu ft)	0.06	0.05	0.05	0.18	0.13	0.01
Atmospheric Emission (lb)	1.49	1.13	1.79	4.57	3.23	0.65
Waterborne Wastes (lb)	0.40	0.31	0.48	1.11	0.80	0.18
Postconsumer Solid Waste (cu ft)	0.03	0.03	0.26	0.20	0.20	0.09

Note: The effect on other scenarios can be estimated by refering to Volume I-A, Tables 2 and 3.

APPENDIX F

DETAILED COMPUTER TABLES FOR PROCESS AND PRODUCT SYSTEMS

This appendix section contains the computer data for the master systems, comparing the scenarios in each product category, and computer tables showing the resource and environmental impacts for 1,000 pounds of selected primary processes.

TABLE F-1

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE THOU SPILLS EACH SYSTEM

		CLOTH TOWEL U 32 L 1 M SPILLS	CLOTH TOWEL U 32 L 5 M SPILLS	CLOTH TOWEL U100 L 1 M SPILLS	CLOTH TOWEL U100 L 5 M SPILLS	CLTH TWL COLD WSH U100 L 1 M SPILLS	CELLULO SPONGE U100 L 1 M SPILLS	CELLULO SPONGE U100 L 5 M SPILLS	PAPER TOWEL 1830 TWL M SPILLS
INPUTS TO SYSTEMS									
NAME	UNITS								
MATERIAL COTTON	POUND	4.913	4.913	1.571	1.571	1.571	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	.900	.180	.900	.180	.900	.649	.327	0.000
MATERIAL WOOD FIBER	POUND	.063	.063	.020	.020	.020	.485	.485	10.754
MATERIAL LIMESTONE	POUND	0.000	0.000	0.000	0.000	0.000	.039	.039	.962
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	2.852	1.939	1.689	.776	1.689	.697	.288	1.133
MATERIAL GLASS SAND	POUND	.394	.079	.394	.079	.394	.176	.035	0.000
MATERIAL NAT SODA ASH	POUND	.348	.070	.348	.070	.348	.156	.031	0.000
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	.145	.062	.116	.034	.116	.051	.014	.121
ENERGY SOURCE PETROLEUM	MILL BTU	.250	.107	.211	.060	.110	.095	.027	.157
ENERGY SOURCE NAT GAS	MILL BTU	.457	.147	.410	.100	.157	.204	.065	.137
ENERGY SOURCE COAL	MILL BTU	.389	.151	.327	.089	.222	.146	.039	.067
ENERGY SOURCE MISC	MILL BTU	.083	.029	.072	.018	.048	.033	.009	.014
ENERGY SOURCE WOOD FIBER	MILL BTU	.001	.001	.000	.000	.000	.005	.005	.122
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	.001	.001	.000	.000	.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	.695	.380	.490	.175	.490	.231	.090	1.250
ENERGY PROCESS	MIL BTU	1.169	.421	1.010	.262	.527	.477	.142	.450
ENERGY TRANSPORT	MIL BTU	.007	.007	.003	.002	.003	.001	.001	.032
ENERGY OF MATL RESOURCE	MIL BTU	.011	.006	.008	.003	.008	.004	.002	.014
WATER VOLUME	THOU GAL	.645	.201	.584	.140	.574	.329	.130	.270
OUTPUTS FROM SYSTEMS									
NAME	UNITS								
SOLID WASTES PROCESS	POUND	7.190	4.103	4.925	1.838	4.925	1.945	.562	1.055
SOLID WASTES FUEL COMB	POUND	2.231	.823	1.911	.503	1.281	.865	.234	.459
SOLID WASTES MINING	POUND	6.282	2.397	5.312	1.428	3.632	2.392	.652	1.058
SOLID WASTE POST-CONSUM	CUBIC FT	.001	.001	.026	.026	.026	.009	.009	.266
ATMOSPHERIC PESTICIDE	POUND	.011	.011	.003	.003	.003	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	.631	.318	.467	.155	.323	.200	.060	.221
ATMOS NITROGEN OXIDES	POUND	1.080	.424	.903	.247	.530	.414	.121	.396
ATMOS HYDROCARBONS	POUND	.671	.251	.572	.152	.266	.273	.084	.240
ATMOS SULFUR OXIDES	POUND	2.230	.837	1.898	.505	1.224	.861	.237	.658
ATMOS CARBON MONOXIDE	POUND	.234	.135	.159	.060	.101	.066	.021	.230
ATMOS ALDEHYDES	POUND	.004	.002	.003	.001	.001	.001	.000	.003
ATMOS OTHER ORGANICS	POUND	.008	.005	.004	.002	.003	.003	.002	.025
ATMOS ODOROUS SULFUR	POUND	.002	.000	.002	.000	.002	.132	.131	.009
ATMOS AMMONIA	POUND	.002	.001	.002	.001	.001	.001	.000	.000
ATMOS HYDROGEN FLOURIDE	POUND	.000	.000	.000	.000	.000	0.000	0.000	0.000
ATMOS LEAD	POUND	.000	.000	.000	.000	.000	.000	.000	.000
ATMOS MERCURY	POUND	.000	.000	.000	.000	.000	.000	.000	.000
ATMOSPHERIC CHLORINE	POUND	.019	.011	.013	.005	.013	.006	.002	.006
WATERBORNE DIS SOLIDS	POUND	.007	.001	.007	.001	.007	.003	.001	0.000
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	.205	.069	.181	.045	.106	.099	.038	.093
WATERBORNE BOD	POUND	.308	.076	.296	.064	.294	.149	.045	.159
WATERBORNE PHENOL	POUND	.000	.000	.000	.000	.000	.000	.000	.000
WATERBORNE SULFIDES	POUND	.001	.000	.000	.000	.000	.000	.000	.000
WATERBORNE OIL	POUND	.040	.000	.040	.000	.040	.018	.004	.000
WATERBORNE COD	POUND	.201	.193	.071	.063	.071	.035	.032	.002
WATERBORNE SUSP SOLIDS	POUND	.380	.206	.270	.096	.269	.109	.031	.197
WATERBORNE ACID	POUND	.119	.044	.101	.027	.069	.046	.012	.022
WATERBORNE METAL ION	POUND	.038	.013	.034	.008	.026	.015	.004	.005
WATERBORNE CHEMICALS	POUND	.000	.000	.000	.000	.000	.000	.000	.001
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	.001	.000	.001	.000	.001	.000	.000	0.000
WATERBORNE CHROMIUM	POUND	.000	.000	.000	.000	.000	.000	.000	0.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	.000	.000	.000	.000	.000	.000	.000	.000
WATERBORNE LEAD	POUND	.000	.000	.000	.000	.000	.000	.000	.000
WATERBORNE PHOSPHATES	POUND	.000	.000	.000	.000	.000	.000	.000	0.000
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	.000	.000	.000	.000	.000	.000	.000	0.000
WATERBORNE NITROGEN	POUND	.002	.000	.002	.000	.002	.001	.000	0.000
WATERBORNE PESTICIDE	POUND	.002	.002	.001	.001	.001	.000	.000	0.000
SUMMARY OF ENVIRONMENTAL IMPACTS									
NAME	UNITS								
RAW MATERIALS	POUNDS	10.310	7.687	5.529	2.906	5.529	2.485	1.310	14.219
ENERGY	MIL BTU	1.188	.435	1.020	.267	.538	.482	.144	.496
WATER	THOU GAL	.646	.201	.584	.140	.574	.329	.130	.270
INDUSTRIAL SOLID WASTES	CUBIC FT	.212	.099	.164	.051	.133	.070	.020	.046
ATM EMMISSIONS	POUNDS	4.891	1.996	4.027	1.131	2.469	1.956	.659	1.767
WATERBORNE WASTES	POUNDS	1.305	.615	1.004	.314	.887	.475	.167	.478
POST-CONSUMER SOL WASTE	CUBIC FT	.001	.001	.026	.026	.026	.009	.009	.266
ENERGY SOURCE PETROLEUM	MIL BTU	.250	.107	.211	.060	.110	.095	.027	.157
ENERGY SOURCE NAT GAS	MIL BTU	.457	.147	.410	.100	.157	.204	.065	.137
ENERGY SOURCE COAL	MIL BTU	.389	.151	.327	.089	.222	.146	.039	.067
ENERGY SOURCE NUCL HYPWR	MIL BTU	.083	.029	.072	.018	.048	.033	.009	.014
ENERGY SOURCE WOOD WASTE	MIL BTU	.001	.001	.000	.000	.000	.005	.005	.122

TABLE F-2

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE THOU NAPKINS HOME USE

NAME	UNITS	CLOTH NAPKIN HOME USE1 L1	CLOTH NAPKIN HOME USE27 L1	CLOTH NAPKIN HOME USE54 L1	CLOTH NAPKIN HOME USE100L1	CLOTH NAP HOME CLD WASH USE 54L1	CLOTH NAP HOME CLD WASH USE100L1	PAPER NAPKIN HOME USE1
INPUTS TO SYSTEMS								
MATERIAL COTTON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	.665	.665	.665	.665	.665	.665	0.000
MATERIAL WOOD FIBER	POUND	48.848	1.787	.893	.488	.893	.488	3.523
MATERIAL LIMESTONE	POUND	4.704	.172	.086	.047	.086	.047	.269
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	75.805	3.601	2.222	1.592	2.222	1.592	.349
MATERIAL GLASS SAND	POUND	.291	.291	.291	.291	.291	.291	0.000
MATERIAL NAT SODA ASH	POUND	.257	.257	.257	.257	.257	.257	0.000
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	20.144	.810	.443	.277	.443	.277	.036
ENERGY SOURCE PETROLEUM	MILL BTU	3.568	.265	.202	.173	.128	.098	.055
ENERGY SOURCE NAT GAS	MILL BTU	3.383	.400	.343	.317	.156	.130	.045
ENERGY SOURCE COAL	MILL BTU	4.503	.377	.298	.262	.221	.185	.022
ENERGY SOURCE MISC	MILL BTU	.521	.067	.058	.054	.041	.037	.004
ENERGY SOURCE WOOD FIBER	MILL BTU	.505	.019	.009	.005	.009	.005	.042
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	13.611	.780	.535	.423	.535	.423	.401
ENERGY PROCESS	MIL BTU	11.366	1.082	.886	.797	.530	.439	.149
ENERGY TRANSPORT	MIL BTU	.299	.011	.006	.003	.006	.003	.013
ENERGY OF MATL RESOURCE	MIL BTU	.816	.034	.019	.013	.019	.013	.007
WATER VOLUME	THOU GAL	4.317	.553	.432	.449	.474	.441	.098
OUTPUTS FROM SYSTEMS								
SOLID WASTES PROCESS	POUND	76.238	5.554	4.201	3.582	4.201	3.582	.781
SOLID WASTES FUEL COMB	POUND	19.221	1.959	1.629	1.478	1.166	1.014	.164
SOLID WASTES MINING	POUND	68.378	5.968	4.776	4.232	3.539	2.995	.336
SOLID WASTE POST-CONSUM	CUBIC FT	1.913	.071	.035	.019	.035	.019	.089
ATMOSPHERIC PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	9.911	.642	.465	.384	.359	.278	.088
ATMOS NITROGEN OXIDES	POUND	9.759	.942	.774	.697	.498	.421	.135
ATMOS HYDROCARBONS	POUND	7.842	.662	.525	.463	.299	.236	.086
ATMOS SULFUR OXIDES	POUND	24.388	2.135	1.710	1.517	1.214	1.018	.225
ATMOS CARBON MONOXIDE	POUND	4.163	.241	.166	.132	.124	.089	.099
ATMOS ALDEHYDES	POUND	.045	.003	.002	.002	.001	.001	.001
ATMOS OTHER ORGANICS	POUND	.123	.007	.004	.003	.003	.002	.013
ATMOS ODOROUS SULFUR	POUND	.377	.015	.008	.005	.008	.005	.003
ATMOS AMMONIA	POUND	.085	.001	.001	.001	.001	.001	.000
ATMOS HYDROGEN FLOURIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS LEAD	POUND	.003	.000	.000	.000	.000	.000	.000
ATMOS MERCURY	POUND	.000	.000	.000	.000	.000	.000	.000
ATMOSPHERIC CHLORINE	POUND	.384	.022	.015	.011	.015	.011	.002
WATERBORNE DIS SOLIDS	POUND	.005	.005	.005	.005	.005	.005	0.000
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	1.860	.189	.157	.142	.101	.086	.034
WATERBORNE BOD	POUND	1.377	.257	.235	.225	.235	.225	.064
WATERBORNE PHENOL	POUND	.006	.000	.000	.000	.000	.000	.000
WATERBORNE SULFIDES	POUND	.011	.000	.000	.000	.000	.000	.000
WATERBORNE OIL	POUND	.034	.030	.029	.029	.029	.029	.000
WATERBORNE COD	POUND	8.486	.319	.163	.092	.163	.092	.001
WATERBORNE SUSP SOLIDS	POUND	2.323	.240	.200	.182	.200	.182	.071
WATERBORNE ACID	POUND	1.456	.120	.094	.083	.071	.059	.007
WATERBORNE METAL ION	POUND	.267	.033	.028	.026	.022	.020	.002
WATERBORNE CHEMICALS	POUND	.002	.000	.000	.000	.000	.000	.001
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	.000	.000	.000	.000	.000	.000	0.000
WATERBORNE CHROMIUM	POUND	.005	.000	.000	.000	.000	.000	0.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	.000	.000	.000	.000	.000	.000	.000
WATERBORNE LEAD	POUND	.000	.000	.000	.000	.000	.000	.000
WATERBORNE PHOSPHATES	POUND	.000	.000	.000	.000	.000	.000	0.000
WATERBORNE ZINC	POUND	.029	.001	.001	.000	.001	.000	0.000
WATERBORNE AMMONIA	POUND	.000	.000	.000	.000	.000	.000	0.000
WATERBORNE NITROGEN	POUND	.001	.001	.001	.001	.001	.001	0.000
WATERBORNE PESTICIDE	POUND	.000	.000	.000	.000	.000	.000	0.000
SUMMARY OF ENVIRONMENTAL IMPACTS								
RAW MATERIALS	POUNDS	164.324	8.362	5.391	4.039	5.391	4.039	4.659
ENERGY	MIL BTU	12.484	1.128	.911	.812	.555	.455	.168
WATER	THOU GAL	4.317	.553	.482	.449	.474	.441	.098
INDUSTRIAL SOLID WASTES	CUBIC FT	2.212	.182	.143	.125	.120	.102	.017
ATM EMMISSIONS	POUNDS	57.001	4.670	3.671	3.215	2.521	2.063	.651
WATERBORNE WASTES	POUNDS	15.863	1.194	.916	.788	.830	.702	.179
POST-CONSUMER SOL WASTE	CUBIC FT	1.913	.071	.035	.019	.035	.019	.089
ENERGY SOURCE PETROLEUM	MIL BTU	3.568	.265	.202	.173	.128	.098	.055
ENERGY SOURCE NAT GAS	MIL BTU	3.383	.400	.343	.317	.156	.130	.045
ENERGY SOURCE COAL	MIL BTU	4.503	.377	.298	.262	.221	.185	.022
ENERGY SOURCE NUCL HYPWR	MIL BTU	.521	.067	.058	.054	.041	.037	.004
ENERGY SOURCE WOOD WASTE	MIL BTU	.505	.019	.009	.005	.009	.005	.042

TABLE F-3

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE THOU NAPKINS COMMERCIAL USE

INPUTS TO SYSTEMS NAME	UNITS	CLOTH NAPKIN COMMER USE1 L1	CLOTH NAPKIN COMMER USE27 L1	CLOTH NAPKIN COMMER USE84 L1	CLOTH NAP COMM CLD WASH USE 27L1	PAPER 2P NAPKIN COMMER USE1
MATERIAL COTTON	POUND	119.034	4.411	2.206	4.411	0.000
MATERIAL SULFATE BRINE	POUND	.305	.305	.305	.305	0.000
MATERIAL WOOD FIBER	POUND	1.394	.052	.026	.052	8.380
MATERIAL LIMESTONE	POUND	0.000	0.000	0.000	0.000	.752
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	42.542	2.550	1.782	2.550	.912
MATERIAL GLASS SAND	POUND	.162	.162	.162	.162	0.000
MATERIAL NAT SODA ASH	POUND	.143	.143	.143	.143	0.000
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	1.050	.073	.054	.073	.095
ENERGY SOURCE PETROLEUM	MILL BTU	1.821	.080	.047	.080	.114
ENERGY SOURCE NAT GAS	MILL BTU	2.194	.553	.521	.218	.098
ENERGY SOURCE COAL	MILL BTU	2.241	.100	.059	.180	.051
ENERGY SOURCE MISC	MILL BTU	.384	.018	.011	.018	.010
ENERGY SOURCE WOOD FIBER	MILL BTU	.012	.000	.000	.000	.101
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	.023	.001	.000	.001	0.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	7.623	.573	.438	.573	.933
ENERGY PROCESS	MIL BTU	6.219	.732	.627	.398	.359
ENERGY TRANSPORT	MIL BTU	.288	.013	.007	.013	.013
ENERGY OF MATL RESOURCE	MIL BTU	.144	.007	.005	.007	.002
WATER VOLUME	THOU GAL	2.584	.463	.422	.457	.251

OUTPUTS FROM SYSTEMS NAME	UNITS	CLOTH NAPKIN COMMER USE1 L1	CLOTH NAPKIN COMMER USE27 L1	CLOTH NAPKIN COMMER USE84 L1	CLOTH NAP COMM CLD WASH USE 27L1	PAPER 2P NAPKIN COMMER USE1
SOLID WASTES PROCESS	POUND	86.386	8.552	7.056	8.552	1.925
SOLID WASTES FUEL COMB	POUND	11.585	.528	.316	.528	.354
SOLID WASTES MINING	POUND	34.981	1.603	.962	1.603	.794
SOLID WASTE POST-CONSUM	CUBIC FT	1.962	.073	.036	.073	.221
ATMOSPHERIC PESTICIDE	POUND	.262	.010	.005	.010	0.000
ATMOS PARTICULATES	POUND	5.871	.251	.143	.244	.171
ATMOS NITROGEN OXIDES	POUND	6.723	.533	.414	.357	.297
ATMOS HYDROCARBONS	POUND	4.179	.612	.544	.296	.162
ATMOS SULFUR OXIDES	POUND	12.001	.549	.329	.545	.492
ATMOS CARBON MONOXIDE	POUND	3.699	.210	.143	.172	.116
ATMOS ALDEHYDES	POUND	.047	.003	.002	.002	.002
ATMOS OTHER ORGANICS	POUND	.157	.009	.006	.007	.017
ATMOS ODOROUS SULFUR	POUND	.008	.008	.008	.008	.007
ATMOS AMMONIA	POUND	.026	.007	.006	.007	.008
ATMOS HYDROGEN FLOURIDE	POUND	.000	.000	.000	.000	0.000
ATMOS LEAD	POUND	.006	.000	.000	.000	.000
ATMOS MERCURY	POUND	.000	.000	.000	.000	.000
ATMOSPHERIC CHLORINE	POUND	.218	.017	.013	.017	.004
WATERBORNE DIS SOLIDS	POUND	.006	.006	.006	.006	0.000
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	1.024	.143	.127	.085	.067
WATERBORNE BOD	POUND	.550	.123	.115	.123	.139
WATERBORNE PHENOL	POUND	.006	.000	.000	.000	.000
WATERBORNE SULFIDES	POUND	.011	.000	.000	.000	.000
WATERBORNE OIL	POUND	.031	.030	.030	.030	.000
WATERBORNE COD	POUND	4.695	.216	.130	.216	.001
WATERBORNE SUSP SOLIDS	POUND	4.045	.253	.180	.253	.171
WATERBORNE ACID	POUND	.625	.029	.018	.029	.017
WATERBORNE METAL ION	POUND	.158	.014	.011	.014	.004
WATERBORNE CHEMICALS	POUND	.011	.000	.000	.000	.001
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	.000	.000	.000	.000	0.000
WATERBORNE CHROMIUM	POUND	.005	.000	.000	.000	0.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	.000	.000	.000	.000	.008
WATERBORNE LEAD	POUND	.000	.000	.000	.000	.000
WATERBORNE PHOSPHATES	POUND	.001	.001	.001	.001	0.000
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	.001	.000	.000	.000	0.000
WATERBORNE NITROGEN	POUND	.011	.010	.010	.010	0.000
WATERBORNE PESTICIDE	POUND	.085	.002	.001	.002	0.000

SUMMARY OF ENVIRONMENTAL IMPACTS NAME	UNITS	CLOTH NAPKIN COMMER USE1 L1	CLOTH NAPKIN COMMER USE27 L1	CLOTH NAPKIN COMMER USE84 L1	CLOTH NAP COMM CLD WASH USE 27L1	PAPER 2P NAPKIN COMMER USE1
RAW MATERIALS	POUNDS	172.277	8.270	5.116	8.270	11.072
ENERGY	MIL BTU	6.652	.752	.638	.417	.374
WATER	THOU GAL	2.584	.463	.422	.457	.251
INDUSTRIAL SOLID WASTES	CUBIC FT	1.795	.144	.113	.144	.041
ATM EMMISSIONS	POUNDS	33.201	2.208	1.612	1.665	1.269
WATERBORNE WASTES	POUNDS	11.237	.829	.628	.770	.400
POST-CONSUMER SOL WASTE	CUBIC FT	1.962	.073	.036	.073	.221
ENERGY SOURCE PETROLEUM	MIL BTU	1.821	.080	.047	.080	.114
ENERGY SOURCE NAT GAS	MIL BTU	2.194	.553	.521	.218	.098
ENERGY SOURCE COAL	MIL BTU	2.241	.100	.059	.100	.051
ENERGY SOURCE NUCL HYPWR	MIL BTU	.384	.018	.011	.018	.010
ENERGY SOURCE WOOD WASTE	MIL BTU	.012	.000	.000	.000	.101

TABLE F-4

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE THOU SHEETS EACH SYSTEM

NAME	UNITS	CLOTH SHEETS INST USE 1 L1	CLOTH SHEETS INST USE50 L1	CLOTH SHEETS INST USE100L1	CLOTH SHEETS INST USE300L1	DISPOSBL SHEETS INST USE1
INPUTS TO SYSTEMS						
MATERIAL COTTON	POUND	577.668	11.542	5.777	1.926	0.000
MATERIAL SULFATE BRINE	POUND	3.073	3.073	3.073	3.073	.000
MATERIAL WOOD FIBER	POUND	16.310	.326	.163	.054	76.799
MATERIAL LIMESTONE	POUND	0.000	0.000	0.000	0.000	7.329
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	469.765	13.942	9.291	6.188	0.637
MATERIAL GLASS SAND	POUND	1.635	1.635	1.635	1.635	0.000
MATERIAL NAT SODA ASH	POUND	1.445	1.445	1.445	1.445	0.000
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	11.708	.579	.465	.389	.921
ENERGY SOURCE PETROLEUM	MILL BTU	34.634	.820	.475	.245	2.025
ENERGY SOURCE NAT GAS	MILL BTU	32.343	5.451	5.177	4.994	5.768
ENERGY SOURCE COAL	MILL BTU	26.338	.699	.438	.263	1.207
ENERGY SOURCE MISC	MILL BTU	4.582	.128	.083	.052	.267
ENERGY SOURCE WOOD FIBER	MILL BTU	.138	.003	.002	.001	.793
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	.111	.002	.001	.000	0.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	84.766	4.363	3.543	2.996	13.004
ENERGY PROCESS	MIL BTU	80.638	6.714	5.960	5.457	5.907
ENERGY TRANSPORT	MIL BTU	3.575	.091	.055	.032	.492
ENERGY OF MATL RESOURCE	MIL BTU	13.822	.297	.159	.067	3.659
WATER VOLUME	THOU GAL	29.329	4.190	3.933	3.762	2.325
OUTPUTS FROM SYSTEMS						
SOLID WASTES PROCESS	POUND	808.258	72.013	64.503	59.493	18.803
SOLID WASTES FUEL COMB	POUND	138.223	3.753	2.381	1.466	7.335
SOLID WASTES MINING	POUND	411.644	11.299	7.214	4.489	19.275
SOLID WASTE POST-CONSUM	CUBIC FT	21.990	.440	.220	.073	3.737
ATMOSPHERIC PESTICIDE	POUND	1.271	.025	.013	.004	0.000
ATMOS PARTICULATES	POUND	65.650	1.647	.994	.558	2.375
ATMOS NITROGEN OXIDES	POUND	79.439	4.473	3.708	3.198	6.325
ATMOS HYDROCARBONS	POUND	94.473	6.550	5.653	5.054	9.415
ATMOS SULFUR OXIDES	POUND	156.092	4.158	2.607	1.573	8.071
ATMOS CARBON MONOXIDE	POUND	53.879	1.820	1.289	.934	2.168
ATMOS ALDEHYDES	POUND	.505	.021	.016	.013	.022
ATMOS OTHER ORGANICS	POUND	1.581	.060	.045	.035	.150
ATMOS ODOROUS SULFUR	POUND	.084	.084	.084	.084	.066
ATMOS AMMONIA	POUND	.198	.061	.059	.058	.001
ATMOS HYDROGEN FLOURIDE	POUND	.002	.000	.000	.000	0.000
ATMOS LEAD	POUND	.050	.001	.001	.001	.002
ATMOS MERCURY	POUND	.003	.000	.000	.000	.000
ATMOSPHERIC CHLORINE	POUND	2.382	.087	.063	.048	.042
WATERBORNE DIS SOLIDS	POUND	.026	.026	.026	.026	0.000
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	17.434	1.423	1.260	1.151	1.425
WATERBORNE BOD	POUND	6.792	1.180	1.123	1.085	.923
WATERBORNE PHENOL	POUND	.066	.001	.001	.000	.000
WATERBORNE SULFIDES	POUND	.125	.003	.001	.000	.000
WATERBORNE OIL	POUND	.367	.296	.295	.294	.009
WATERBORNE COD	POUND	52.630	1.488	.966	.618	.291
WATERBORNE SUSP SOLIDS	POUND	27.018	1.589	1.330	1.157	1.224
WATERBORNE ACID	POUND	7.389	.206	.133	.084	.386
WATERBORNE METAL ION	POUND	1.854	.116	.098	.086	.092
WATERBORNE CHEMICALS	POUND	.064	.001	.001	.000	.003
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	.002	.002	.002	.002	0.000
WATERBORNE CHROMIUM	POUND	.056	.001	.001	.000	0.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	.000	.000	.000	.000	.000
WATERBORNE LEAD	POUND	.001	.000	.000	.000	.000
WATERBORNE PHOSPHATES	POUND	.005	.005	.005	.005	0.000
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	.012	.000	.000	.000	0.000
WATERBORNE NITROGEN	POUND	.105	.101	.101	.101	0.000
WATERBORNE PESTICIDE	POUND	.264	.006	.003	.001	0.000
SUMMARY OF ENVIRONMENTAL IMPACTS						
RAW MATERIALS	POUNDS	1166.479	36.908	25.394	17.708	106.680
ENERGY	MIL BTU	98.034	7.102	6.174	5.555	10.059
WATER	THOU GAL	29.329	4.190	3.933	3.762	2.325
INDUSTRIAL SOLID WASTES	CUBIC FT	18.335	1.175	1.000	.884	.613
ATM EMMISSIONS	POUNDS	485.609	18.988	14.532	11.560	28.637
WATERBORNE WASTES	POUNDS	114.214	6.445	5.346	4.613	4.354
POST-CONSUMER SOL WASTE	CUBIC FT	21.990	.440	.220	.073	3.737
ENERGY SOURCE PETROLEUM	MIL BTU	34.634	.820	.475	.245	2.025
ENERGY SOURCE NAT GAS	MIL BTU	32.343	5.451	5.177	4.994	5.768
ENERGY SOURCE COAL	MIL BTU	26.338	.699	.438	.263	1.207
ENERGY SOURCE NUCL HYPWR	MIL BTU	4.582	.128	.083	.052	.267
ENERGY SOURCE WOOD WASTE	MIL BTU	.138	.003	.002	.001	.793

TABLE F-5

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

100 CHANGES EACH DIAPERING SYS

		CLOTH DIAP SY H LAUN USE 100	CLOTH DIAP SY H LAUN USE 50	CLOTH DIAP SY H LAUN USE 25	CLOTH DIAP SY C LAUN USE 100	CLOTH DIAP SY C LAUN USE 50	CLOTH DIAP SY C LAUN USE 1	DISPOS DIAPER SYSTEM
INPUTS TO SYSTEMS								
NAME	UNITS							
MATERIAL COTTON	POUND	.238	.473	.957	.233	.478	24.880	0.000
MATERIAL SULFATE BRINE	POUND	.385	.385	.385	.098	.098	.098	0.000
MATERIAL WOOD FIBER	POUND	.006	.011	.023	.006	.011	.564	9.219
MATERIAL LIMESTONE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	.873
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	.288	.372	.539	.224	.307	8.484	1.498
MATERIAL GLASS SAND	POUND	.168	.168	.168	.052	.052	.052	0.000
MATERIAL NAT SODA ASH	POUND	.149	.149	.149	.046	.046	.046	0.000
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	.046	.048	.052	.013	.015	.215	.265
ENERGY SOURCE PETROLEUM	MILL BTU	.084	.088	.095	.007	.010	.347	.092
ENERGY SOURCE NAT GAS	MILL BTU	.169	.172	.179	.136	.139	.471	.109
ENERGY SOURCE COAL	MILL BTU	.131	.135	.144	.008	.013	.450	.061
ENERGY SOURCE MISC	MILL BTU	.029	.030	.032	.001	.002	.077	.008
ENERGY SOURCE WOOD FIBER	MILL BTU	.000	.000	.000	.000	.000	.005	.100
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	.000	.000	.000	.000	.000	.005	0.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	.166	.181	.211	.101	.116	1.589	1.033
ENERGY PROCESS	MIL BTU	.410	.422	.445	.150	.162	1.291	.322
ENERGY TRANSPORT	MIL BTU	.001	.001	.002	.001	.001	.034	.013
ENERGY OF MATL RESOURCE	MIL BTU	.003	.003	.004	.001	.001	.024	.035
WATER VOLUME	THOU GAL	.510	.514	.523	.125	.129	.562	.166
OUTPUTS FROM SYSTEMS								
NAME	UNITS							
SOLID WASTES PROCESS	POUND	1.810	1.973	2.299	1.825	1.980	18.147	1.581
SOLID WASTES FUEL COMB	POUND	.771	.795	.841	.044	.067	2.335	.394
SOLID WASTES MINING	POUND	2.133	2.203	2.342	.137	.207	7.033	.854
SOLID WASTE POST-CONSUM	CUBIC FT	.004	.008	.016	.004	.008	.388	.190
ATMOSPHERIC PESTICIDE	POUND	.001	.001	.002	.001	.001	.055	0.000
ATMOS PARTICULATES	POUND	.178	.190	.213	.020	.032	1.197	.191
ATMOS NITROGEN OXIDES	POUND	.362	.375	.401	.090	.103	1.361	.261
ATMOS HYDROCARBONS	POUND	.231	.238	.253	.135	.142	.846	.184
ATMOS SULFUR OXIDES	POUND	.766	.790	.838	.046	.070	2.425	.437
ATMOS CARBON MONOXIDE	POUND	.058	.063	.074	.026	.032	.572	.090
ATMOS ALDEHYDES	POUND	.001	.001	.001	.000	.000	.008	.001
ATMOS OTHER ORGANICS	POUND	.002	.002	.002	.001	.001	.027	.015
ATMOS ODOROUS SULFUR	POUND	.001	.001	.001	.003	.003	.003	.010
ATMOS AMMONIA	POUND	.001	.001	.001	.002	.002	.006	.000
ATMOS HYDROGEN FLOURIDE	POUND	.000	.000	.000	.000	.000	.000	0.000
ATMOS LEAD	POUND	.000	.000	.000	.000	.000	.001	.000
ATMOS MERCURY	POUND	.000	.000	.000	.000	.000	.000	.000
ATMOSPHERIC CHLORINE	POUND	.002	.003	.003	.002	.002	.043	.006
WATERBORNE DIS SOLIDS	POUND	.001	.001	.001	.001	.001	.001	0.000
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	.074	.076	.080	.032	.034	.205	.058
WATERBORNE BOD	POUND	.249	.250	.252	.037	.038	.133	.103
WATERBORNE PHENOL	POUND	.000	.000	.000	.000	.000	.001	.000
WATERBORNE SULFIDES	POUND	.000	.000	.000	.000	.000	.002	.000
WATERBORNE OIL	POUND	.010	.010	.010	.009	.009	.010	.000
WATERBORNE COD	POUND	.013	.023	.041	.023	.033	.948	.040
WATERBORNE SUSP SOLIDS	POUND	.190	.206	.222	.043	.051	.854	.129
WATERBORNE ACID	POUND	.041	.042	.048	.003	.004	.126	.020
WATERBORNE METAL ION	POUND	.012	.012	.013	.003	.003	.032	.004
WATERBORNE CHEMICALS	POUND	.000	.000	.000	.000	.000	.003	.001
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	.000	.000	.000	.000	.000	.000	0.000
WATERBORNE CHROMIUM	POUND	.000	.000	.000	.000	.000	.001	.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	.000	.000	.000	.000	.000	.000	.000
WATERBORNE LEAD	POUND	.000	.000	.000	.000	.000	.000	.000
WATERBORNE PHOSPHATES	POUND	.000	.000	.000	.000	.000	.000	0.000
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	.000
WATERBORNE AMMONIA	POUND	.000	.000	.000	.000	.000	.000	.000
WATERBORNE NITROGEN	POUND	.001	.001	.001	.003	.003	.003	0.000
WATERBORNE PESTICIDE	POUND	.000	.000	.000	.000	.000	.011	0.000
SUMMARY OF ENVIRONMENTAL IMPACTS								
NAME	UNITS							
RAW MATERIALS	POUNDS	1.445	1.792	2.483	.773	1.124	35.932	12.889
ENERGY	MIL BTU	.413	.426	.450	.152	.164	1.350	.371
WATER	THOU GAL	.510	.514	.523	.125	.129	.562	.166
INDUSTRIAL SOLID WASTES	CUBIC FT	.064	.067	.074	.027	.031	.371	.038
ATM EMMISSIONS	POUNDS	1.602	1.664	1.789	.326	.388	6.543	1.196
WATERBORNE WASTES	POUNDS	.601	.623	.666	.155	.177	2.331	.356
POST-CONSUMER SOL WASTE	CUBIC FT	.004	.008	.016	.004	.008	.388	.190
ENERGY SOURCE PETROLEUM	MIL BTU	.084	.088	.095	.007	.010	.347	.092
ENERGY SOURCE NAT GAS	MIL BTU	.169	.172	.179	.136	.139	.471	.109
ENERGY SOURCE COAL	MIL BTU	.131	.135	.144	.008	.013	.450	.061
ENERGY SOURCE NUCL HYPWR	MIL BTU	.029	.030	.032	.001	.002	.077	.008
ENERGY SOURCE WOOD WASTE	MIL BTU	.000	.000	.000	.000	.000	.005	.100

TABLE F-6

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE MILLION 9FLOZ COLD DRINK SYS

NAME	UNITS	GLASS TUMBLER 9FLOZ USE 100	GLASS TUMBLER 9FLOZ USE 1000	POLYPROP TUMBLER 9FLOZ USE 100	POLYPROP TUMBLER 9FLOZ USE 1000	PAPER WAX COAT 9FLOZ USE 1	PLASTIC THERM PS USE 1
INPUTS TO SYSTEMS							
MATERIAL COTTON	POUND	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	637.056	637.056	637.056	637.056	0.000	0.000
MATERIAL WOOD FIBER	POUND	815.490	81.549	58.031	5.808	9500.010	[illegible]
MATERIAL LIMESTONE	POUND	267.720	26.772	0.000	0.000	943.720	0.000
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	64.246	64.246	64.246	64.246	1442.168	0.000
MATERIAL GLASS SAND	POUND	278.488	278.488	278.488	278.488	0.000	0.000
MATERIAL NAT SODA ASH	POUND	246.150	246.150	246.150	246.150	0.000	0.000
MATERIAL FELDSPAR	POUND	223.706	22.371	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	71.937	71.937	71.937	71.937	121.901	0.000
ENERGY SOURCE PETROLEUM	MILL BTU	19.879	11.245	60.757	15.333	218.085	375.810
ENERGY SOURCE NAT GAS	MILL BTU	126.872	107.405	141.830	108.900	118.586	243.114
ENERGY SOURCE COAL	MILL BTU	16.964	11.917	14.098	11.630	97.619	59.160
ENERGY SOURCE MISC	MILL BTU	2.930	2.519	3.042	2.531	9.789	12.735
ENERGY SOURCE WOOD FIBER	MILL BTU	6.962	.798	.601	.162	119.345	5.970
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	344.548	244.648	280.624	238.255	1181.983	773.275
ENERGY PROCESS	MIL BTU	167.489	129.097	142.705	126.619	420.288	309.462
ENERGY TRANSPORT	MIL BTU	1.828	.497	50.750	5.389	31.290	43.401
ENERGY OF MATL RESOURCE	MIL BTU	4.291	4.291	26.872	6.549	112.347	343.926
WATER VOLUME	THOU GAL	89.601	85.722	93.112	86.073	145.481	50.908
OUTPUTS FROM SYSTEMS							
SOLID WASTES PROCESS	POUND	239.565	113.041	132.291	102.314	2280.102	920.298
SOLID WASTES FUEL COMB	POUND	132.935	73.061	97.194	69.487	1031.031	396.239
SOLID WASTES MINING	POUND	869.617	308.656	289.844	250.679	775.091	942.584
SOLID WASTE POST-CONSUM	CUBIC FT	18.333	1.833	14.127	1.413	241.357	186.750
ATMOSPHERIC PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	84.145	26.182	31.517	20.920	191.414	129.110
ATMOS NITROGEN OXIDES	POUND	115.399	82.074	152.089	85.743	293.470	365.459
ATMOS HYDROCARBONS	POUND	139.930	111.649	230.392	120.696	260.464	573.246
ATMOS SULFUR OXIDES	POUND	152.035	77.338	103.044	72.439	568.344	480.240
ATMOS CARBON MONOXIDE	POUND	33.255	21.449	376.499	55.774	261.969	394.869
ATMOS ALDEHYDES	POUND	.482	.282	4.471	.681	2.231	2.557
ATMOS OTHER ORGANICS	POUND	10.310	1.579	16.564	2.204	20.364	17.466
ATMOS ODOROUS SULFUR	POUND	1.184	1.184	1.184	1.184	8.593	0.000
ATMOS AMMONIA	POUND	.843	.824	.957	.835	.152	.218
ATMOS HYDROGEN FLOURIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS LEAD	POUND	.015	.007	1.013	.106	.314	.228
ATMOS MERCURY	POUND	.002	.001	.001	.001	.006	.006
ATMOSPHERIC CHLORINE	POUND	.323	.323	.323	.323	7.042	0.000
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	73.887	63.683	93.618	65.657	103.746	164.863
WATERBORNE BOD	POUND	28.061	6.464	6.270	4.285	70.317	29.539
WATERBORNE PHENOL	POUND	.006	.002	.026	.004	.032	.046
WATERBORNE SULFIDES	POUND	.008	.003	.033	.005	.041	.059
WATERBORNE OIL	POUND	.079	.074	.144	.080	.713	1.807
WATERBORNE COD	POUND	6.404	6.362	8.510	6.573	1.593	21.492
WATERBORNE SUSP SOLIDS	POUND	20.254	9.169	10.017	8.146	68.699	24.906
WATERBORNE ACID	POUND	6.077	5.027	5.767	4.996	16.901	17.789
WATERBORNE METAL ION	POUND	1.147	.884	1.069	.877	3.592	4.447
WATERBORNE CHEMICALS	POUND	.898	.098	.072	.015	.965	.775
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	1510.380	1510.380	1510.380	1510.380	0.000	0.000
WATERBORNE CHROMIUM	POUND	.000	.000	.000	.000	.003	.023
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	.000	.000	.000	.000	.000	0.000
WATERBORNE LEAD	POUND	.000	.000	.000	.000	.003	0.000
WATERBORNE PHOSPHATES	POUND	.074	.074	.074	.074	0.000	0.000
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	.005	.005	.005	.005	.091	.240
WATERBORNE NITROGEN	POUND	1.427	1.427	1.427	1.427	0.000	0.000
WATERBORNE PESTICIDE	POUND	.008	.008	.008	.008	0.000	0.000
SUMMARY OF ENVIRONMENTAL IMPACTS							
RAW MATERIALS	POUNDS	2949.341	1673.216	1636.582	1541.940	13229.863	1484.215
ENERGY	MIL BTU	173.607	133.884	220.327	138.556	563.925	696.789
WATER	THOU GAL	89.601	85.722	93.112	86.073	145.481	50.908
INDUSTRIAL SOLID WASTES	CUBIC FT	16.769	6.679	7.011	5.703	55.164	30.498
ATM EMMISSIONS	POUNDS	537.922	322.893	918.056	360.907	1614.363	1963.398
WATERBORNE WASTES	POUNDS	1648.714	1603.660	1537.421	1602.530	266.696	265.984
POST-CONSUMER SOL WASTE	CUBIC FT	18.333	1.833	14.127	1.413	241.357	186.750
ENERGY SOURCE PETROLEUM	MIL BTU	19.879	11.245	60.757	15.333	218.085	375.810
ENERGY SOURCE NAT GAS	MIL BTU	126.872	107.405	141.830	108.900	118.586	243.114
ENERGY SOURCE COAL	MIL BTU	16.964	11.917	14.098	11.630	97.619	59.160
ENERGY SOURCE NUCL HYPWR	MIL BTU	2.930	2.519	3.042	2.531	9.789	12.735
ENERGY SOURCE WOOD WASTE	MIL BTU	6.962	.798	.601	.162	119.845	5.970

TABLE F-7

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE MILLION 7FLOZ HOT DRINK SYS

		CHINA CUP 7FLOZ USE 100	CHINA CUP 7FLOZ USE 1000	MELAMINE CUP 7FLOZ USE 100	MELAMINE CUP 7FLOZ USE 1000	PAPER LDPE CTD 7FLOZ USE 1	PLASTIC FOAM PS 7FLOZ USE 1
INPUTS TO SYSTEMS							
NAME	UNITS						
MATERIAL COTTON	POUND	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	1504.160	1504.160	1504.160	1504.160	0.000	0.000
MATERIAL WOOD FIBER	POUND	752.760	75.276	769.640	76.964	13P16.085	1289.450
MATERIAL LIMESTONE	POUND	0.000	0.000	58.303	5.830	1357.720	0.000
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	151.691	151.691	220.398	158.562	2091.272	0.000
MATERIAL GLASS SAND	POUND	657.541	657.541	657.541	657.541	0.000	0.000
MATERIAL NAT SODA ASH	POUND	581.187	581.187	581.187	581.187	0.000	0.000
MATERIAL FELDSPAR	POUND	1640.000	164.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	3194.833	319.483	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	169.852	169.852	177.180	170.585	175.583	0.000
ENERGY SOURCE PETROLEUM	MILL BTU	158.637	37.361	49.770	26.474	93.999	297.713
ENERGY SOURCE NAT GAS	MILL BTU	346.922	249.054	331.649	247.526	172.393	225.706
ENERGY SOURCE COAL	MILL BTU	45.965	27.854	39.870	27.244	119.306	30.917
ENERGY SOURCE MISC	MILL BTU	9.030	5.962	8.604	5.920	9.115	5.832
ENERGY SOURCE WOOD FIBER	MILL BTU	6.589	.900	7.907	1.032	173.696	10.828
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	3049.200	304.920	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	323.272	32.327	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	2512.339	251.234	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	697.009	565.989	664.186	562.707	1616.460	365.573
ENERGY PROCESS	MIL BTU	441.306	298.688	362.872	290.845	526.131	405.391
ENERGY TRANSPORT	MIL BTU	115.707	12.312	10.380	1.779	18.804	42.343
ENERGY OF MATL RESOURCE	MIL BTU	10.131	10.131	64.549	15.572	23.575	123.263
WATER VOLUME	THOU GAL	247.467	198.140	254.280	198.821	191.687	29.639
OUTPUTS FROM SYSTEMS							
NAME	UNITS						
SOLID WASTES PROCESS	POUND	2106.069	420.945	355.982	245.936	3432.039	436.591
SOLID WASTES FUEL COMB	POUND	323.991	168.374	245.069	160.482	1354.949	279.156
SOLID WASTES MINING	POUND	8280.411	1337.483	789.212	588.363	770.655	486.300
SOLID WASTE POST-CONSUM	CUBIC FT	32.640	3.264	35.169	3.517	236.913	761.200
ATMOSPHERIC PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	376.145	78.305	79.920	48.683	244.466	133.002
ATMOS NITROGEN OXIDES	POUND	425.955	202.556	270.881	187.048	304.650	366.499
ATMOS HYDROCARBONS	POUND	487.243	270.136	409.325	262.344	246.962	571.082
ATMOS SULFUR OXIDES	POUND	351.000	176.902	276.303	169.432	632.648	446.026
ATMOS CARBON MONOXIDE	POUND	835.786	125.119	114.693	53.010	142.323	306.660
ATMOS ALDEHYDES	POUND	10.291	1.563	1.066	.640	1.276	4.922
ATMOS OTHER ORGANICS	POUND	43.167	5.565	5.191	1.767	23.919	24.559
ATMOS ODOROUS SULFUR	POUND	2.796	2.796	3.320	2.848	12.482	0.000
ATMOS AMMONIA	POUND	2.288	1.974	15.643	3.310	.076	.502
ATMOS HYDROGEN FLOURIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS LEAD	POUND	2.188	.231	.052	.017	.139	.435
ATMOS MERCURY	POUND	.004	.003	.004	.003	.006	.003
ATMOSPHERIC CHLORINE	POUND	.763	.763	1.097	.796	10.133	0.000
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE FLUORIDES	POUND	.245	.024	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	235.930	154.848	168.354	148.090	72.387	166.982
WATERBORNE BOD	POUND	40.479	12.684	20.225	10.659	103.109	41.033
WATERBORNE PHENOL	POUND	.085	.012	.013	.005	.018	.091
WATERBORNE SULFIDES	POUND	.086	.013	.017	.007	.023	.117
WATERBORNE OIL	POUND	.297	.185	.272	.182	.083	.724
WATERBORNE COD	POUND	50.979	18.606	15.517	15.060	2.055	8.326
WATERBORNE SUSP SOLIDS	POUND	243.599	41.226	29.070	19.774	101.034	23.251
WATERBORNE ACID	POUND	16.812	11.847	15.636	11.729	17.42A	8.874
WATERBORNE METAL ION	POUND	79.800	9.730	2.992	2.049	3.446	2.219
WATERBORNE CHEMICALS	POUND	6.639	.682	.218	.040	1.521	1.406
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	3400.898	3400.898	3400.898	3400.898	0.000	0.000
WATERBORNE CHROMIUM	POUND	.000	.000	.003	.000	0.000	.007
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	.000	.000	.000	.000	.000	0.000
WATERBORNE LEAD	POUND	.000	.000	.001	.000	.005	0.000
WATERBORNE PHOSPHATES	POUND	.174	.174	.174	.174	0.000	0.000
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	.012	.812	2.602	.271	0.000	.079
WATERBORNE NITROGEN	POUND	3.368	3.368	3.368	3.368	0.000	0.000
WATERBORNE PESTICIDE	POUND	.018	.018	.018	.018	0.000	0.000
SUMMARY OF ENVIRONMENTAL IMPACTS							
NAME	UNITS						
RAW MATERIALS	POUNDS	15233.845	4777.661	4632.594	3717.536	19057.119	1655.023
ENERGY	MIL BTU	567.144	321.130	437.801	308.196	568.510	570.997
WATER	THOU GAL	247.467	198.140	254.280	198.821	191.687	29.639
INDUSTRIAL SOLID WASTES	CUBIC FT	144.591	26.012	18.769	13.430	75.028	16.228
ATM EMMISSIONS	POUNDS	2537.624	865.911	1177.494	729.898	1619.080	1853.689
WATERBORNE WASTES	POUNDS	4079.421	3654.330	3659.375	3612.326	301.104	253.111
POST-CONSUMER SOL WASTE	CUBIC FT	32.640	3.264	35.169	3.517	236.913	761.200
ENERGY SOURCE PETROLEUM	MIL BTU	158.637	37.361	49.770	26.474	93.999	297.713
ENERGY SOURCE NAT GAS	MIL BTU	346.922	249.054	331.649	247.526	172.393	225.706
ENERGY SOURCE COAL	MIL BTU	45.965	27.854	39.870	27.244	119.306	30.917
ENERGY SOURCE NUCL HYPWR	MIL BTU	9.030	5.962	8.604	5.920	9.115	5.832
ENERGY SOURCE WOOD WASTE	MIL BTU	6.589	.900	7.907	1.032	173.696	10.828

TABLE F-8

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ONE MILLION 9INCH PLATE SYS

NAME	UNITS	CHINA PLATES 9 INCH USE 100	CHINA PLATES 9 INCH USE 1000	CHINA PLATES 9 INCH USE 6903	MELAMINE PLATES 9 INCH USE 100	MELAMINE PLATES 9 INCH USE 1000	PAPER WHT PRES 9 INCH USE 1	PLASTIC FOAM PS 9 INCH USE 1
INPUTS TO SYSTEMS								
MATERIAL COTTON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	1336.048	1336.048	1336.048	1336.048	1336.048	0.000	0.000
MATERIAL WOOD FIBER	POUND	522.750	52.275	7.580	1184.709	118.479	1[illegible]567.715	2500.200
MATERIAL LIMESTONE	POUND	0.000	0.000	0.090	99.457	9.946	2065.050	0.000
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	134.738	134.738	134.738	251.943	146.458	3[illegible]54.231	0.000
MATERIAL GLASS SAND	POUND	584.051	584.051	584.051	584.051	584.051	0.000	0.000
MATERIAL NAT SODA ASH	POUND	516.231	516.231	516.231	516.231	516.231	0.000	0.000
MATERIAL FELDSPAR	POUND	3793.535	379.354	55.019	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	7448.119	744.812	108.022	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	150.868	150.863	150.868	163.370	152.116	267.114	0.000
ENERGY SOURCE PETROLEUM	MILL BTU	329.993	52.056	25.653	57.707	24.827	131.026	785.784
ENERGY SOURCE NAT GAS	MILL BTU	485.311	236.091	215.266	371.100	227.670	193.632	502.870
ENERGY SOURCE COAL	MILL BTU	64.308	26.998	23.453	47.717	25.339	161.351	140.091
ENERGY SOURCE MISC	MILL BTU	12.805	5.754	5.084	10.385	5.512	10.602	29.417
ENERGY SOURCE WOOD FIBER	MILL BTU	4.628	.677	.302	12.193	1.434	251.510	21.071
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	7514.862	751.486	108.990	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	861.923	86.192	12.501	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	5728.751	572.875	83.086	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	703.282	511.149	492.897	669.278	507.749	2192.474	1578.018
ENERGY PROCESS	MIL BTU	586.533	284.767	256.101	387.776	264.892	706.688	660.427
ENERGY TRANSPORT	MIL BTU	271.513	27.809	4.658	9.495	1.608	38.322	142.908
ENERGY OF MATL RESOURCE	MIL BTU	8.998	8.998	8.998	101.830	18.281	3.112	675.898
WATER VOLUME	THOU GAL	298.423	183.761	172.869	275.618	181.481	288.655	101.547
OUTPUTS FROM SYSTEMS								
SOLID WASTES PROCESS	POUND	4657.828	852.613	272.132	403.527	227.182	4502.651	1951.801
SOLID WASTES FUEL COMB	POUND	454.172	165.659	138.251	292.350	149.477	1883.405	977.773
SOLID WASTES MINING	POUND	18225.246	2273.569	758.218	897.679	540.812	857.020	2226.373
SOLID WASTE POST-CONSUM	CUBIC FT	77.010	7.701	1.117	59.994	5.999	367.730	4582.520
ATMOSPHERIC PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	770.331	113.066	50.628	92.951	45.328	272.221	345.244
ATMOS NITROGEN OXIDES	POUND	707.680	212.755	165.739	300.012	171.988	391.424	893.661
ATMOS HYDROCARBONS	POUND	762.263	272.999	226.521	490.630	245.836	273.740	1480.313
ATMOS SULFUR OXIDES	POUND	489.939	174.448	144.477	336.835	159.137	782.303	1152.517
ATMOS CARBON MONOXIDE	POUND	1892.341	226.129	67.845	136.161	50.511	253.422	987.784
ATMOS ALDEHYDES	POUND	23.230	2.797	.856	1.017	.576	2.418	7.886
ATMOS OTHER ORGANICS	POUND	85.210	9.630	2.450	5.496	1.659	20.984	54.933
ATMOS ODOROUS SULFUR	POUND	2.483	2.483	2.483	3.378	2.573	19.062	0.000
ATMOS AMMONIA	POUND	2.524	1.803	1.734	25.078	4.058	.122	.585
ATMOS HYDROGEN FLOURIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS LEAD	POUND	5.138	.525	.086	.038	.015	.360	.930
ATMOS MERCURY	POUND	.006	.003	.002	.005	.003	.008	.014
ATMOSPHERIC CHLORINE	POUND	.677	.677	.677	1.248	.735	15.414	0.000
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE FLUORIDES	POUND	.563	.056	.008	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	330.628	149.671	132.481	163.434	132.952	92.537	355.741
WATERBORNE BOD	POUND	45.523	12.223	9.060	22.877	9.939	115.213	90.189
WATERBORNE PHENOL	POUND	.189	.022	.006	.016	.005	.026	.119
WATERBORNE SULFIDES	POUND	.190	.023	.007	.020	.006	.034	.152
WATERBORNE OIL	POUND	.439	.182	.157	.315	.169	.045	3.499
WATERBORNE COD	POUND	93.508	21.349	14.494	14.156	13.414	.546	41.133
WATERBORNE SUSP SOLIDS	POUND	518.875	46.869	23.930	32.495	18.231	129.794	63.194
WATERBORNE ACID	POUND	21.960	11.198	10.175	17.764	10.778	21.080	41.637
WATERBORNE METAL ION	POUND	180.639	19.611	4.314	3.595	1.907	3.887	10.410
WATERBORNE CHEMICALS	POUND	13.927	1.409	.220	.216	.038	.718	2.736
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	3020.798	3020.798	3020.798	3020.798	3020.798	0.000	0.000
WATERBORNE CHROMIUM	POUND	.080	.000	.000	.000	.000	0.000	.043
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	.000	.000	.000	.000	.000	.000	0.000
WATERBORNE LEAD	POUND	.000	.000	.000	.001	.000	.007	0.000
WATERBORNE PHOSPHATES	POUND	.154	.154	.154	.154	.154	0.000	0.000
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	.010	.010	.010	4.429	.452	0.000	.452
WATERBORNE NITROGEN	POUND	2.992	2.992	2.992	2.992	2.992	0.000	0.000
WATERBORNE PESTICIDE	POUND	.016	.016	.016	.016	.016	0.000	0.000
SUMMARY OF ENVIRONMENTAL IMPACTS								
RAW MATERIALS	POUNDS	29295.159	5820.079	3590.031	4805.168	3371.080	27346.585	4087.218
ENERGY	MIL BTU	867.044	321.575	269.757	499.102	284.781	748.122	1479.233
WATER	THOU GAL	298.423	183.761	172.869	275.618	181.481	288.655	101.547
INDUSTRIAL SOLID WASTES	CUBIC FT	315.053	41.740	15.776	21.513	12.386	97.782	69.605
ATM ENMISSIONS	POUNDS	4741.822	1017.315	663.499	1392.850	682.418	2031.477	4923.869
WATERBORNE WASTES	POUNDS	4230.412	3306.586	3218.825	3283.282	3211.873	363.887	609.305
POST-CONSUMER SOL WASTE	CUBIC FT	77.010	7.701	1.117	59.994	5.999	367.730	4582.520
ENERGY SOURCE PETROLEUM	MIL BTU	329.993	52.056	25.653	57.707	24.827	131.026	785.784
ENERGY SOURCE NAT GAS	MIL BTU	455.311	236.091	215.266	371.100	227.670	193.632	502.870
ENERGY SOURCE COAL	MIL BTU	64.308	26.998	23.453	47.717	25.339	161.351	140.091
ENERGY SOURCE NUCL HYPWR	MIL BTU	12.805	5.754	5.084	10.385	5.512	10.602	29.417
ENERGY SOURCE WOOD WASTE	MIL BTU	4.628	.677	.302	12.193	1.434	251.510	21.071

TABLE F-9

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

DISP PAP PROD THOU LB EA W/EX P1

NAME	UNITS	PULPWOOD HARVEST	TRANSPOR WOOD	S/S DRY PULP MANUF	S/S DRY PULP SYSM	S/S SLSH PULP SYSM	S/S DRY PULP SYSM TRANSPOR	DIAPER TISSUE PAPER-MAKING	DIAPER CONVERT (HUNDRED DIAPERS)
INPUTS TO SYSTEMS									
MATERIAL COTTON	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFATE BRINE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL WOOD FIBER	POUND	0.00000	0.00000	807.00000	807.00000	807.00000	0.00000	688.37100	0.00000
MATERIAL LIMESTONE	POUND	0.00000	0.00000	0.00000	80.00000	80.00000	0.00000	68.24000	0.00000
MATERIAL IRON ORE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SALT	POUND	0.00000	0.00000	0.00000	94.27600	94.27600	0.00000	80.41743	0.00000
MATERIAL GLASS SAND	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL NAT SODA ASH	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL FELDSPAR	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL BAUXITE ORE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFUR	POUND	0.00000	0.00000	0.00000	10.05550	10.05550	0.00000	8.57734	0.00000
ENERGY SOURCE PETROLEUM	MILL BTU	.12896	.03097	.47515	4.72530	3.58515	.19397	5.67099	.00282
ENERGY SOURCE NAT GAS	MILL BTU	0.00000	0.00000	.47957	3.79462	2.89492	0.00000	9.89368	.00284
ENERGY SOURCE COAL	MILL BTU	0.00000	0.00000	1.15362	1.81753	1.50252	0.00000	3.91114	.00684
ENERGY SOURCE MISC	MILL BTU	0.00000	0.00000	.26078	.37612	.30532	0.00000	.85457	.00155
ENERGY SOURCE WOOD FIBER	MILL BTU	0.00000	0.00000	8.39000	8.39000	8.39000	0.00000	7.15667	0.00000
ENERGY SOURCE HYDROPOWER	MILL BTU	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL POTASH	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL PHOSPHATE ROCK	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL CLAY	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL GYPSUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SILICA	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL PROCESS ADD	POUNDS	0.00000	0.00000	75.00000	79.10844	79.10844	0.00000	83.47950	.00001
ENERGY PROCESS	MIL BTU	0.00000	0.00000	10.75912	18.93370	16.50805	0.00000	27.34215	.01404
ENERGY TRANSPORT	MIL BTU	.12896	.03097	0.00000	.16987	.16987	.19397	.14490	0.00000
ENERGY OF MATL RESOURCE	MIL BTU	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATER VOLUME	THOU GAL	.00801	.00178	13.43757	13.49327	13.48307	.01110	16.34890	.00022
OUTPUTS FROM SYSTEMS									
SOLID WASTES PROCESS	POUND	0.00000	0.00000	89.00000	110.72209	110.72209	0.00000	134.24594	.02000
SOLID WASTES FUEL COMB	POUND	.03222	.00715	6.78470	11.10721	9.01951	.04464	23.49758	.04022
SOLID WASTES MINING	POUND	0.00000	0.00000	18.47560	28.74680	23.73080	0.00000	62.33497	.10952
SOLID WASTE POST-CONSUM	CUBIC FT	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
ATMOSPHERIC PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
ATMOS PARTICULATES	POUND	.15353	.00467	3.50650	7.85578	7.20218	.02792	9.84226	.00851
ATMOS NITROGEN OXIDES	POUND	.13768	.07238	2.49730	13.18995	11.09225	.42267	19.69798	.01480
ATMOS HYDROCARBONS	POUND	.14000	.02638	.97240	5.76945	4.45515	.15345	12.50706	.00576
ATMOS SULFUR OXIDES	POUND	.03355	.01430	7.20270	17.06733	14.49769	.10788	28.85904	.03750
ATMOS CARBON MONOXIDE	POUND	.92676	.06050	.30940	2.26883	2.04362	.40423	3.28342	.00183
ATMOS ALDEHYDES	POUND	.01104	.00122	.00420	.02227	.02113	.00802	.04528	.00002
ATMOS OTHER ORGANICS	POUND	.03960	.00238	.00553	.06189	.06039	.01483	.09336	.00003
ATMOS ODOROUS SULFUR	POUND	0.00000	0.00000	.72000	.72000	.72000	0.00000	.61416	0.00000
ATMOS AMMONIA	POUND	.00036	.00008	0.00000	.00076	.00076	.00049	.00265	0.00000
ATMOS HYDROGEN FLOURIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
ATMOS LEAD	POUND	.00267	.00009	0.00000	.00352	.00352	.00064	.00302	0.00000
ATMOS MERCURY	POUND	0.00000	0.00000	.00011	.00025	.00022	0.00000	.00045	.00000
ATMOSPHERIC CHLORINE	POUND	0.00000	0.00000	0.00000	.45920	.45920	0.00000	.39170	0.00000
WATERBORNE DIS SOLIDS	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE FLUORIDES	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE DISS SOLIDS	POUND	.06880	.01527	.13667	2.67908	2.02367	.09533	3.85752	.00081
WATERBORNE BOD	POUND	.00018	.00004	7.00035	7.00684	7.00675	.00025	7.45856	.00000
WATERBORNE PHENOL	POUND	.00006	.00001	.00012	.00031	.00028	.00009	.00087	.00000
WATERBORNE SULFIDES	POUND	.00008	.00002	.00016	.00040	.00036	.00011	.00112	.00000
WATERBORNE OIL	POUND	.00009	.00002	.00018	.00045	.00040	.00012	.00124	.00000
WATERBORNE COD	POUND	.00071	.00016	.00141	.00357	.00318	.00099	.00993	.00001
WATERBORNE SUSP SOLIDS	POUND	.00044	.00010	10.40088	10.45592	10.45568	.00062	10.16320	.00001
WATERBORNE ACID	POUND	.00014	.00003	.35387	.74102	.64495	.00019	1.35711	.00210
WATERBORNE METAL ION	POUND	.00003	.00001	.08847	.13320	.10918	.00005	.29487	.00052
WATERBORNE CHEMICALS	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE CYANIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALKALINITY	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE CHROMIUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE IRON	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALUMINUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE NICKEL	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE MERCURY	POUND	0.00000	0.00000	0.00000	.00000	.00000	0.00000	.00000	0.00000
WATERBORNE LEAD	POUND	0.00000	0.00000	0.00000	.00021	.00021	0.00000	.00018	0.00000
WATERBORNE PHOSPHATES	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ZINC	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE AMMONIA	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE NITROGEN	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
SUMMARY OF ENVIRONMENTAL IMPACTS									
RAW MATERIALS	POUNDS	0.00000	0.00000	882.00000	1070.43994	1070.43994	0.00000	929.08527	.00001
ENERGY	MIL BTU	.12896	.03097	10.75912	19.10357	16.67791	.19397	27.48704	.01404
WATER	THOU GAL	.00801	.00178	13.43757	13.49327	13.48307	.01110	16.34890	.00022
INDUSTRIAL SOLID WASTES	CUBIC FT	.00043	.00010	1.54251	2.03278	1.93688	.00060	2.97106	.00229
ATM EMMISSIONS	POUNDS	1.44518	.18201	15.21813	47.41924	40.55612	1.14013	75.34038	.06857
WATERBORNE WASTES	POUNDS	.07053	.01566	17.98211	21.02100	20.24466	.09774	23.14461	.00345
POST-CONSUMER SOL WASTE	CUBIC FT	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
ENERGY SOURCE PETROLEUM	MIL BTU	.12896	.03097	.47515	4.72530	3.58515	.19397	5.67099	.00282
ENERGY SOURCE NAT GAS	MIL BTU	0.00000	0.00000	.47957	3.79462	2.89492	0.00000	9.89368	.00284
ENERGY SOURCE COAL	MIL BTU	0.00000	0.00000	1.15362	1.81753	1.50252	0.00000	3.91114	.00684
ENERGY SOURCE NUCL HYPWR	MIL BTU	0.00000	0.00000	.26078	.37612	.30532	0.00000	.85457	.00155
ENERGY SOURCE WOOD WASTE	MIL BTU	0.00000	0.00000	8.39000	8.39000	8.39000	0.00000	7.15667	0.00000

TABLE F-10

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

DISP PAP PROD THOU LB EA W/EX P2

	UNITS	PAPER PROD DISPOSAL	2 PLY TOWEL PAPERMAK	2 PLY TOWEL CONVERT (THOUSF)	NAPKIN PAPERMKG	NAPKIN CONVERT (THOU SQ PLY)	NAPKIN CONVERT (THOU 2 PLY)	PAPBD FOR CUPS AND PLAT MANUF	PAPBD FOR CUPS AND PLAT SYSTEM
INPUTS TO SYSTEMS									
NAME	UNITS								
MATERIAL COTTON	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFATE BRINE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL WOOD FIBER	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	718.00000	713.00000
MATERIAL LIMESTONE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.00000	79.00000
MATERIAL IRON ORE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SALT	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	119.14000
MATERIAL GLASS SAND	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL NAT SODA ASH	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL FELDSPAR	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL BAUXITE ORE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFUR	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	10.08930
ENERGY SOURCE PETROLEUM	MILL BTU	.05361	4.19775	.00190	4.10897	.00124	.00140	2.72545	3.34219
ENERGY SOURCE NAT GAS	MILL BTU	0.00000	4.61256	.00757	3.87689	.00520	.00842	6.32231	6.91343
ENERGY SOURCE COAL	MILL BTU	0.00000	2.35422	.00233	2.01492	.00130	.00339	4.78946	5.61835
ENERGY SOURCE MISC	MILL BTU	0.00000	.53218	.00053	.45548	.00029	.00077	.16874	.31516
ENERGY SOURCE WOOD FIBER	MILL BTU	0.00000	.74900	0.00000	1.05700	0.00000	0.00000	9.29100	9.29100
ENERGY SOURCE HYDROPOWER	MILL BTU	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL POTASH	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL PHOSPHATE ROCK	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL CLAY	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL GYPSUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL SILICA	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
MATERIAL PROCESS ADD	POUNDS	0.00000	10.70000	.00440	7.40000	.00258	0.00000	75.00000	80.19392
ENERGY PROCESS	MIL BTU	0.00000	12.44571	.00782	11.51326	.00539	.01397	23.29696	25.30392
ENERGY TRANSPORT	MIL BTU	.05361	0.00000	.00022	0.00000	.00013	0.00000	0.00000	.17631
ENERGY OF MATL RESOURCE	MIL BTU	0.00000	0.00000	.00430	0.00000	.00252	0.00000	0.00000	0.00000
WATER VOLUME	THOU GAL	.00333	6.88290	.00042	8.97769	.00026	.00023	10.72431	10.78851
OUTPUTS FROM SYSTEMS									
NAME	UNITS								
SOLID WASTES PROCESS	POUND	0.00000	24.50000	.00398	57.80000	.00233	0.00000	142.00000	166.81137
SOLID WASTES FUEL COMB	POUND	.01339	14.53350	.01372	12.54886	.00768	.01992	62.69010	67.00282
SOLID WASTES MINING	POUND	0.00000	37.70360	.03736	32.26960	.02082	.05426	11.95480	24.91637
SOLID WASTE POST-CONSUM	CUBIC FT	15.70000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
ATMOSPHERIC PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
ATMOS PARTICULATES	POUND	.00562	3.76992	.00311	3.41203	.00178	.00435	5.59950	8.24741
ATMOS NITROGEN OXIDES	POUND	.05724	10.17339	.00791	9.56881	.00500	.01102	8.84590	10.84417
ATMOS HYDROCARBONS	POUND	.05820	6.51872	.01174	5.70814	.00762	.00949	7.21920	8.33324
ATMOS SULFUR OXIDES	POUND	.01395	21.96378	.01326	18.38334	.00767	.01870	19.88410	24.96942
ATMOS CARBON MONOXIDE	POUND	2.28528	1.36752	.00132	1.28172	.00086	.00171	1.70020	3.24103
ATMOS ALDEHYDES	POUND	.00459	.04186	.00001	.03995	.00001	.00003	.00272	.02240
ATMOS OTHER ORGANICS	POUND	.31646	.03751	.00003	.03329	.00002	.00005	.00357	.06309
ATMOS ODOROUS SULFUR	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.72000	.72000
ATMOS AMMONIA	POUND	.00015	.00760	.00000	.00772	.00000	0.00000	0.00000	.00090
ATMOS HYDROGEN FLOURIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
ATMOS LEAD	POUND	.00111	.00006	.00000	.00006	.00000	0.00000	0.00000	.00345
ATMOS MERCURY	POUND	0.00000	.00026	.00000	.00023	.00000	.00000	.00007	.00025
ATMOSPHERIC CHLORINE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.58220
WATERBORNE DIS SOLIDS	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE FLUORIDES	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE DISS SOLIDS	POUND	.02860	2.38336	.00143	2.26232	.00104	.00163	2.28843	2.59469
WATERBORNE BOD	POUND	.00007	2.35452	.00004	3.57448	.00003	.00000	3.61023	3.61685
WATERBORNE PHENOL	POUND	.00003	.00158	.00000	.00157	.00000	.00000	.00008	.00031
WATERBORNE SULFIDES	POUND	.00003	.00203	.00000	.00201	.00000	.00000	.00010	.00039
WATERBORNE OIL	POUND	.00004	.00226	.00001	.00224	.00001	.00000	.00011	.00044
WATERBORNE COD	POUND	.00030	.01809	.00034	.01791	.00020	.00000	.00092	.00350
WATERBORNE SUSP SOLIDS	POUND	.00019	3.00130	.00011	4.50119	.00007	.00000	4.49057	4.55554
WATERBORNE ACID	POUND	.00006	.72504	.00072	.62100	.00040	.00104	.22897	.64419
WATERBORNE METAL ION	POUND	.00001	.18127	.00018	.15526	.00010	.00026	.05724	.11381
WATERBORNE CHEMICALS	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE CYANIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALKALINITY	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE CHROMIUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE IRON	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALUMINUM	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE NICKEL	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE MERCURY	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.00000
WATERBORNE LEAD	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	.00027
WATERBORNE PHOSPHATES	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE ZINC	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE AMMONIA	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE NITROGEN	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
WATERBORNE PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
SUMMARY OF ENVIRONMENTAL IMPACTS									
NAME	UNITS								
RAW MATERIALS	POUNDS	0.00000	10.70000	.00440	7.40000	.00258	0.00000	793.00000	1005.42322
ENERGY	MIL BTU	.05361	12.44571	.01234	11.51326	.00803	.01397	23.29696	25.48013
WATER	THOU GAL	.00333	6.88290	.00042	8.97769	.00026	.00023	10.72431	10.78851
INDUSTRIAL SOLID WASTES	CUBIC FT	.00018	1.03595	.00074	1.38535	.00042	.00100	2.92471	3.49296
ATM EMMISSIONS	POUNDS	2.74260	43.38061	.03739	38.43529	.02296	.04535	43.97526	57.02774
WATERBORNE WASTES	POUNDS	.02932	8.66945	.00283	11.13799	.00183	.00294	10.67666	11.55000
POST-CONSUMER SOL WASTE	CUBIC FT	15.70000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
ENERGY SOURCE PETROLEUM	MIL BTU	.05361	4.19775	.00190	4.10897	.00124	.00140	2.72545	3.34219
ENERGY SOURCE NAT GAS	MIL BTU	0.00000	4.61256	.00757	3.87689	.00520	.00842	6.32231	6.91343
ENERGY SOURCE COAL	MIL BTU	0.00000	2.35422	.00233	2.01492	.00130	.00339	4.78946	5.61835
ENERGY SOURCE NUCL HYPWR	MIL BTU	0.00000	.53218	.00053	.45548	.00029	.00077	.16874	.31516
ENERGY SOURCE WOOD WASTE	MIL BTU	0.00000	.74900	0.00000	1.05700	0.00000	0.00000	9.29100	9.29100

TABLE F-11

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

DISP PAP PRCU THCU LB EA W/EX P3

		9OZ PAP-WAX CD CONV (ML CUPS)	9IN PAP-BD PLATE CONV (MIL PL)	LDPE COATED PAPBD HAN SYS	7OZ PAP-PE CUP CONV (ML CUP)
INPUTS TO SYSTEMS					
NAME	UNITS				
MATERIAL COTTON	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFATE BRINE	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL WOOD FIBER	POUND	0.00000	0.00000	681.38200	0.00000
MATERIAL LIMESTONE	POUND	0.00000	0.00000	74.02200	0.00000
MATERIAL IRON ORE	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL SALT	POUND	0.00000	0.00000	113.06386	0.00000
MATERIAL GLASS SAND	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL NAT SODA ASH	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL FELDSPAR	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL BAUXITE ORE	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL SULFUR	POUND	0.00000	0.00000	9.57475	0.00000
ENERGY SOURCE PETROLEUM	MILL BTU	22.18100	3.87000	3.53257	5.20300
ENERGY SOURCE NAT GAS	MILL BTU	18.38806	3.90600	8.18208	17.13224
ENERGY SOURCE COAL	MILL BTU	22.91580	9.39600	5.51746	12.63240
ENERGY SOURCE MISC	MILL BTU	5.18020	2.12400	.34105	2.85560
ENERGY SOURCE WOOD FIBER	MILL BTU	0.00000	0.00000	8.81716	0.00000
ENERGY SOURCE HYDROPOWER	MILL BTU	0.00000	0.00000	0.00000	0.00000
MATERIAL POTASH	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL PHOSPHATE ROCK	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL CLAY	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL GYPSUM	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL SILICA	POUND	0.00000	0.00000	0.00000	0.00000
MATERIAL PROCESS ADD	POUNDS	100.00000	0.00000	77.43331	60.00000
ENERGY PROCESS	MIL BTU	68.66506	19.29600	24.85976	37.82324
ENERGY TRANSPORT	MIL BTU	0.00000	0.00000	.23380	0.00000
ENERGY OF MATL RESOURCE	MIL BTU	0.00000	0.00000	1.29676	0.00000
WATER VOLUME	THOU GAL	1.56818	.30600	10.34046	.60832
OUTPUTS FROM SYSTEMS					
NAME	UNITS				
SOLID WASTES PROCESS	POUND	170.00000	20.00000	159.50607	380.00000
SOLID WASTES FUEL COMB	POUND	137.48800	55.26000	64.67793	74.29400
SOLID WASTES MINING	POUND	367.00400	150.48000	26.61876	202.31200
SOLID WASTE POST-CONSUM	CUBIC FT	0.00000	0.00000	0.00000	0.00000
ATMOSPHERIC PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000
ATMOS PARTICULATES	POUND	30.74636	11.70000	8.11234	15.95974
ATMOS NITROGEN OXIDES	POUND	62.26886	20.34000	11.32158	33.59274
ATMOS HYDROCARBONS	POUND	31.99382	7.92000	10.58934	21.88338
ATMOS SULFUR OXIDES	POUND	147.21842	51.66000	24.84348	69.58528
ATMOS CARBON MONOXIDE	POUND	8.30534	2.52000	3.28368	4.74456
ATMOS ALDEHYDES	POUND	.20473	.03420	.02287	.06786
ATMOS OTHER ORGANICS	POUND	.18805	.04500	.06296	.11520
ATMOS ODOROUS SULFUR	POUND	0.00000	0.00000	.68328	0.00000
ATMOS AMMONIA	POUND	.03000	0.00000	.00086	0.00000
ATMOS HYDROGEN FLOURIDE	POUND	0.00000	0.00000	0.00000	0.00000
ATMOS LEAD	POUND	.00023	0.00000	.00347	0.00000
ATMOS MERCURY	POUND	.00234	.00090	.00025	.00121
ATMOSPHERIC CHLORINE	POUND	0.00000	0.00000	.55251	0.00000
WATERBORNE DIS SOLIDS	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE FLUORIDES	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE DISS SOLIDS	POUND	10.06268	1.11312	2.75273	3.57513
WATERBORNE BOD	POUND	.02202	.00288	3.44575	.00387
WATERBORNE PHENOL	POUND	.00771	.00101	.00031	.00136
WATERBORNE SULFIDES	POUND	.00991	.00130	.00040	.00174
WATERBORNE OIL	POUND	.01101	.00144	.00365	.00194
WATERBORNE COD	POUND	.08810	.01152	.10556	.01549
WATERBORNE SUSP SOLIDS	POUND	.05506	.00720	4.35612	.00968
WATERBORNE ACID	POUND	7.04074	2.88219	.68726	3.87494
WATERBORNE METAL ION	POUND	1.76024	.72055	.12224	.96875
WATERBORNE CHEMICALS	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE CYANIDE	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALKALINITY	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE CHROMIUM	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE IRON	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE ALUMINUM	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE NICKEL	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE MERCURY	POUND	0.00000	0.00000	.00000	0.00000
WATERBORNE LEAD	POUND	0.00000	0.00000	.00026	0.00000
WATERBORNE PHOSPHATES	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE ZINC	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE AMMONIA	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE NITROGEN	POUND	0.00000	0.00000	0.00000	0.00000
WATERBORNE PESTICIDE	POUND	0.00000	0.00000	0.00000	0.00000
SUMMARY OF ENVIRONMENTAL IMPACTS					
NAME	UNITS				
RAW MATERIALS	POUNDS	100.00000	0.00000	955.47592	60.00000
ENERGY	MIL BTU	68.66506	19.29600	26.39032	37.82324
WATER	THOU GAL	1.56818	.30600	10.34046	.60832
INDUSTRIAL SOLID WASTES	CUBIC FT	9.10564	3.04749	3.38584	8.86418
ATM EMMISSIONS	POUNDS	280.95815	94.22010	59.47662	145.94997
WATERBORNE WASTES	POUNDS	19.05747	4.74121	11.47429	8.45289
POST-CONSUMER SOL WASTE	CUBIC FT	0.00000	0.00000	0.00000	0.00000
ENERGY SOURCE PETROLEUM	MIL BTU	22.18100	3.87000	3.53257	5.20300
ENERGY SOURCE NAT GAS	MIL BTU	18.38806	3.90600	8.18208	17.13224
ENERGY SOURCE COAL	MIL BTU	22.91580	9.39600	5.51746	12.63240
ENERGY SOURCE NUCL HYPWR	MIL BTU	5.18020	2.12400	.34105	2.85560
ENERGY SOURCE WOOD WASTE	MIL BTU	0.00000	0.00000	8.81716	0.00000

TABLE F-12

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

ANCILLARY SYSTEMS THOU LB EACH

INPUTS TO SYSTEMS NAME	UNITS	UNBLEACH KRAFT PROD SYSTEM	BLEACHED KRAFT CARTON SYSTEM	CORRUGAT CONTAIN SYSTEM	RECYCLE PAPBD SYSTEM
MATERIAL COTTON	POUND	0.000	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	0.000	0.000	0.000	0.000
MATERIAL WOOD FIBER	POUND	689.000	530.000	697.000	0.000
MATERIAL LIMESTONE	POUND	0.000	80.000	0.000	0.000
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	0.000	238.471	0.000	0.000
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	0.000	10.094	0.000	0.000
ENERGY SOURCE PETROLEUM	MILL BTU	5.333	6.982	4.587	2.829
ENERGY SOURCE NAT GAS	MILL BTU	3.629	4.006	2.900	2.944
ENERGY SOURCE COAL	MILL BTU	3.325	5.210	2.766	3.528
ENERGY SOURCE MISC	MILL BTU	0.000	.397	0.000	.432
ENERGY SOURCE WOOD FIBER	MILL BTU	7.432	9.530	5.853	.827
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	0.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	70.000	85.150	70.000	28.120
ENERGY PROCESS	MIL BTU	19.631	25.846	16.016	10.560
ENERGY TRANSPORT	MIL BTU	.089	.278	.090	0.000
ENERGY OF MATL RESOURCE	MIL BTU	0.000	0.000	0.000	0.000
WATER VOLUME	THOU GAL	.374	10.808	.317	11.891

OUTPUTS FROM SYSTEMS NAME	UNITS	UNBLEACH KRAFT PROD SYSTEM	BLEACHED KRAFT CARTON SYSTEM	CORRUGAT CONTAIN SYSTEM	RECYCLE PAPBD SYSTEM
SOLID WASTES PROCESS	POUND	67.000	148.260	67.000	65.380
SOLID WASTES FUEL COMB	POUND	57.357	58.685	45.355	20.956
SOLID WASTES MINING	POUND	47.500	30.889	39.520	53.702
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	0.000	0.000
ATMOSPHERIC PESTICIDE	POUND	0.000	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	43.912	9.562	39.038	6.280
ATMOS NITROGEN OXIDES	POUND	18.799	11.597	16.226	7.704
ATMOS HYDROCARBONS	POUND	11.750	6.918	9.749	4.454
ATMOS SULFUR OXIDES	POUND	40.483	21.912	55.481	19.387
ATMOS CARBON MONOXIDE	POUND	6.273	3.848	5.618	1.367
ATMOS ALDEHYDES	POUND	.097	.033	.084	.029
ATMOS OTHER ORGANICS	POUND	10.665	.096	8.089	.027
ATMOS ODOROUS SULFUR	POUND	0.000	.400	0.000	0.000
ATMOS AMMONIA	POUND	.013	.001	.012	.005
ATMOS HYDROGEN FLOURIDE	POUND	0.000	0.000	0.000	0.000
ATMOS LEAD	POUND	.002	.006	.002	.000
ATMOS MERCURY	POUND	.000	.000	.000	.000
ATMOSPHERIC CHLORINE	POUND	0.000	.590	0.000	0.000
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	6.453	4.164	5.493	1.532
WATERBORNE BOD	POUND	20.507	4.407	20.506	12.973
WATERBORNE PHENOL	POUND	.002	.000	.002	.001
WATERBORNE SULFIDES	POUND	.003	.001	.003	.001
WATERBORNE OIL	POUND	.003	.001	.003	.001
WATERBORNE COD	POUND	.027	.005	.023	.012
WATERBORNE SUSP SOLIDS	POUND	15.017	7.867	9.514	19.117
WATERBORNE ACID	POUND	.505	1.277	.420	.831
WATERBORNE METAL ION	POUND	.126	.262	.105	.208
WATERBORNE CHEMICALS	POUND	.880	0.000	.760	0.000
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000
WATERBORNE CHROMIUM	POUND	0.000	0.000	0.000	0.000
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	0.000	.000	0.000	0.000
WATERBORNE LEAD	POUND	0.000	.000	0.000	0.000
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	0.000	0.000	0.000	0.000
WATERBORNE NITROGEN	POUND	0.000	0.000	0.000	0.000
WATERBORNE PESTICIDE	POUND	0.000	0.000	0.000	0.000

SUMMARY OF ENVIRONMENTAL IMPACTS NAME	UNITS	UNBLEACH KRAFT PROD SYSTEM	BLEACHED KRAFT CARTON SYSTEM	CORRUGAT CONTAIN SYSTEM	RECYCLE PAPBD SYSTEM
RAW MATERIALS	POUNDS	759.000	944.714	767.000	28.120
ENERGY	MIL BTU	19.719	26.124	16.106	10.560
WATER	THOU GAL	.374	10.808	.317	11.891
INDUSTRIAL SOLID WASTES	CUBIC FT	2.320	3.211	2.050	1.891
ATM EMMISSIONS	POUNDS	131.994	54.964	134.300	39.254
WATERBORNE WASTES	POUNDS	43.524	17.983	36.819	34.677
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	0.000	0.000
ENERGY SOURCE PETROLEUM	MIL BTU	5.333	6.982	4.587	2.829
ENERGY SOURCE NAT GAS	MIL BTU	3.629	4.006	2.900	2.944
ENERGY SOURCE COAL	MIL BTU	3.325	5.210	2.766	3.528
ENERGY SOURCE NUCL HYPWR	MIL BTU	0.000	.397	0.000	.432
ENERGY SOURCE WOOD WASTE	MIL BTU	7.432	9.530	5.853	.827

TABLE F-13

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

THOU LB EACH PROCESS

INPUTS TO SYSTEMS NAME	UNITS	CRUDE OIL PROD 1000 LB	NATURAL GAS PROD 1000 LB	BENZENE SYS 1000 LB	ETHYLENE SYS 1000 LB	AMMONIA MFG 1000 LB	ACRYLON MFG 1000 LB	STYRENE MFG 1000 LB	POLL FAC PETRO CHEM REF 1000 LB
MATERIAL COTTON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFATE BRINE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL WOOD FIBER	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL LIMESTONE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL IRON ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SALT	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GLASS SAND	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL NAT SODA ASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL FELDSPAR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL BAUXITE ORE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SULFUR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ENERGY SOURCE PETROLEUM	MILL BTU	19.621	.033	21.732	5.499	.040	.150	2.694	.015
ENERGY SOURCE NAT GAS	MILL BTU	.325	23.845	3.510	27.897	2.606	.152	2.798	.015
ENERGY SOURCE COAL	MILL BTU	.032	.032	.294	.459	.097	.365	.229	.035
ENERGY SOURCE MISC	MILL BTU	.007	.007	.066	.104	.022	.083	.052	.008
ENERGY SOURCE WOOD FIBER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ENERGY SOURCE HYDROPOWER	MILL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL POTASH	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PHOSPHATE ROCK	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL CLAY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL GYPSUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL SILICA	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MATERIAL PROCESS ADD	POUNDS	1.880	0.000	5.047	5.776	4.550	5.000	20.000	.100
ENERGY PROCESS	MIL BTU	.129	.066	5.248	8.502	2.765	.750	5.772	.073
ENERGY TRANSPORT	MIL BTU	.332	.608	.340	1.241	0.000	0.000	0.000	0.000
ENERGY OF MATL RESOURCE	MIL BTU	19.525	23.244	20.013	24.216	0.000	0.000	0.000	0.000
WATER VOLUME	THOU GAL	.083	.041	.433	.839	5.046	.517	1.923	.001

OUTPUTS FROM SYSTEMS NAME	UNITS	CRUDE OIL PROD 1000 LB	NATURAL GAS PROD 1000 LB	BENZENE SYS 1000 LB	ETHYLENE SYS 1000 LB	AMMONIA MFG 1000 LB	ACRYLON MFG 1000 LB	STYRENE MFG 1000 LB	POLL FAC PETRO CHEM REF 1000 LB
SOLID WASTES PROCESS	POUND	.600	0.000	1.795	18.162	.200	.800	27.000	1.380
SOLID WASTES FUEL COMB	POUND	.207	.194	2.087	2.708	.568	2.149	1.899	.209
SOLID WASTES MINING	POUND	.517	.517	4.707	7.351	1.547	5.852	3.662	.568
SOLID WASTE POST-CONSUM	CUBIC FT	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOSPHERIC PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS PARTICULATES	POUND	.054	.045	.853	.737	.170	.455	.763	.264
ATMOS NITROGEN OXIDES	POUND	1.952	3.527	5.242	12.139	1.558	7.491	3.569	.137
ATMOS HYDROCARBONS	POUND	9.201	26.903	16.862	41.704	3.508	107.308	4.346	3.800
ATMOS SULFUR OXIDES	POUND	.319	.218	4.022	4.880	.559	2.009	5.597	.615
ATMOS CARBON MONOXIDE	POUND	.539	.966	12.916	2.948	.319	122.098	.604	11.810
ATMOS ALDEHYDES	POUND	.002	.001	.030	.017	.005	.001	.027	.000
ATMOS OTHER ORGANICS	POUND	.001	.001	.021	.038	.012	.002	.021	.000
ATMOS ODOROUS SULFUR	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS AMMONIA	POUND	.000	.000	.004	.000	1.000	0.000	.006	0.000
ATMOS HYDROGEN FLOURIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ATMOS LEAD	POUND	.000	.000	.000	.000	0.000	0.000	.000	0.000
ATMOS MERCURY	POUND	.000	.000	.000	.000	.000	.000	.000	.000
ATMOSPHERIC CHLORINE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DIS SOLIDS	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE FLUORIDES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE DISS SOLIDS	POUND	6.146	2.116	7.595	4.869	.460	.043	1.683	.004
WATERBORNE BOD	POUND	.000	.000	.031	.058	.000	.880	.423	.029
WATERBORNE PHENOL	POUND	.000	.000	.001	.000	.000	.020	.001	.000
WATERBORNE SULFIDES	POUND	.000	.000	.001	.000	.000	.000	.001	.000
WATERBORNE OIL	POUND	.110	.037	.123	.060	.000	.000	.002	.009
WATERBORNE COD	POUND	.000	.000	.177	.001	.000	.000	.013	.169
WATERBORNE SUSP SOLIDS	POUND	.000	.000	.023	.088	.000	1.320	.648	.018
WATERBORNE ACID	POUND	.010	.010	.092	.141	.030	.112	.072	.011
WATERBORNE METAL ION	POUND	.002	.002	.023	.035	.007	.028	.018	.003
WATERBORNE CHEMICALS	POUND	0.000	0.000	0.000	0.000	0.000	.001	0.000	0.000
WATERBORNE CYANIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALKALINITY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE CHROMIUM	POUND	0.000	0.000	.001	0.000	0.000	0.000	0.000	.001
WATERBORNE IRON	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ALUMINUM	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE NICKEL	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE MERCURY	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE LEAD	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE PHOSPHATES	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE ZINC	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE AMMONIA	POUND	0.000	0.000	.017	0.000	.062	0.000	0.000	.017
WATERBORNE NITROGEN	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WATERBORNE PESTICIDE	POUND	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

SUMMARY OF ENVIRONMENTAL IMPACTS NAME	UNITS	CRUDE OIL PROD 1000 LB	NATURAL GAS PROD 1000 LB	BENZENE SYS 1000 LB	ETHYLENE SYS 1000 LB	AMMONIA MFG 1000 LB	ACRYLON MFG 1000 LB	STYRENE MFG 1000 LB	POLL FAC PETRO CHEM REF 1000 LB
RAW MATERIALS	POUNDS	1.880	0.000	5.047	5.776	4.550	5.000	20.000	.100
ENERGY	MIL BTU	19.986	23.918	25.602	33.960	2.765	.750	5.772	.073
WATER	THOU GAL	.083	.041	.433	.839	5.046	.517	1.923	.001
INDUSTRIAL SOLID WASTES	CUBIC FT	.018	.010	.119	.381	.031	.119	.440	.029
ATM EMMISSIONS	POUNDS	12.069	31.662	39.951	62.463	7.132	239.364	14.933	16.626
WATERBORNE WASTES	POUNDS	6.270	2.166	8.083	5.252	.560	2.405	2.861	.261
POST-CONSUMER SOL WASTE	CUBIC FT	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ENERGY SOURCE PETROLEUM	MIL BTU	19.621	.033	21.732	5.499	.040	.150	2.694	.015
ENERGY SOURCE NAT GAS	MIL BTU	.325	23.845	3.510	27.897	2.606	.152	2.798	.015
ENERGY SOURCE COAL	MIL BTU	.032	.032	.294	.459	.097	.365	.229	.035
ENERGY SOURCE NUCL HYPWR	MIL BTU	.007	.007	.066	.104	.022	.083	.052	.008
ENERGY SOURCE WOOD WASTE	MIL BTU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

TABLE F-14

RESOURCE AND ENVIRONMENTAL PROFILE ANALYSIS

1000 LB EACH PROCESS OR SYSTEM

NAME	UNITS	POLYSTY RESIN SYS	POLYPROP RESIN SYS	MELAMINE MOLDING COMPOUND SYS	PET RESIN SYS	HDPE RESIN SYS	LDPE RESIN SYS	LAS SYS	ACRYLIC RESIN SYS
INPUTS TO SYSTEMS									
MATERIAL COTTON	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL SULFATE BRINE	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL WOOD FIBER	POUND	0.00	0.00	220.31	0.00	0.00	0.00	0.00	0.00
MATERIAL LIMESTONE	POUND	0.00	0.00	21.84	0.00	0.00	0.00	0.00	0.00
MATERIAL IRON ORE	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL SALT	POUND	0.00	0.00	25.74	0.00	0.00	0.00	191.66	0.00
MATERIAL GLASS SAND	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL NAT SODA ASH	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL FELDSPAR	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL BAUXITE ORE	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL SULFUR	POUND	0.00	0.00	2.75	0.00	0.00	0.00	249.78	0.00
ENERGY SOURCE PETROLEUM	MILL BTU	22.63	.65	6.21	23.01	6.74	7.08	18.13	5.84
ENERGY SOURCE NAT GAS	MILL BTU	15.35	40.14	33.89	15.09	31.11	31.79	8.60	35.75
ENERGY SOURCE COAL	MILL BTU	.86	1.52	3.03	2.54	2.82	3.64	1.94	.91
ENERGY SOURCE MISC	MILL BTU	.19	.34	.68	.57	.64	.82	.38	.20
ENERGY SOURCE WOOD FIBER	MILL BTU	0.00	0.00	2.29	0.00	0.00	0.00	0.00	0.00
ENERGY SOURCE HYDROPOWER	MILL BTU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL POTASH	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL PHOSPHATE ROCK	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL CLAY	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL GYPSUM	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL SILICA	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MATERIAL PROCESS ADD	POUNDS	49.48	46.30	35.41	7.62	56.06	26.06	16.76	13.03
ENERGY PROCESS	MIL BTU	14.25	15.87	24.40	23.35	14.56	16.60	13.91	11.62
ENERGY TRANSPORT	MIL BTU	.65	1.53	1.31	.54	1.30	1.30	.25	1.40
ENERGY OF MATL RESOURCE	MIL BTU	24.14	25.24	20.39	17.32	25.43	25.43	14.90	29.68
WATER VOLUME	THOU GAL	3.31	3.51	17.48	3.17	1.85	2.00	4.21	7.80
OUTPUTS FROM SYSTEMS									
SOLID WASTES PROCESS	POUND	46.67	26.08	37.28	27.78	23.57	23.57	82.13	23.96
SOLID WASTES FUEL COMB	POUND	5.84	8.92	18.76	17.74	16.57	21.42	11.10	5.33
SOLID WASTES MINING	POUND	13.79	24.27	48.43	40.70	45.09	58.30	30.64	14.49
SOLID WASTE POST-CONSUM	CUBIC FT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ATMOSPHERIC PESTICIDE	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ATMOS PARTICULATES	POUND	2.13	2.15	6.49	5.83	3.94	5.60	7.05	1.34
ATMOS NITROGEN OXIDES	POUND	12.59	18.88	24.15	19.47	18.24	20.21	10.94	15.18
ATMOS HYDROCARBONS	POUND	34.77	75.11	56.77	67.46	51.55	52.57	21.30	52.27
ATMOS SULFUR OXIDES	POUND	11.84	11.43	27.48	36.78	17.96	22.50	29.46	7.43
ATMOS CARBON MONOXIDE	POUND	17.20	4.29	15.97	23.72	3.82	4.08	13.82	3.5[illegible]
ATMOS ALDEHYDES	POUND	.06	.03	.07	.13	.03	.03	.04	.0[illegible]
ATMOS OTHER ORGANICS	POUND	.06	.07	.09	.08	.05	.06	.05	.05
ATMOS ODOROUS SULFUR	POUND	0.00	0.00	.20	0.00	0.00	0.00	0.00	0.00
ATMOS AMMONIA	POUND	.01	.00	5.13	.03	.00	.00	.01	.42
ATMOS HYDROGEN FLOURIDE	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ATMOS LEAD	POUND	.00	.00	.00	.00	.00	.00	.00	.00
ATMOS MERCURY	POUND	.00	.00	.00	.00	.00	.00	.00	.00
ATMOSPHERIC CHLORINE	POUND	0.00	0.00	.13	0.00	0.00	0.00	.96	0.00
WATERBORNE DIS SOLIDS	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE FLUORIDES	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE DISS SOLIDS	POUND	9.69	4.86	6.55	10.71	5.54	5.69	7.36	5.84
WATERBORNE BOD	POUND	.60	.48	1.98	1.59	.24	.26	.20	2.81
WATERBORNE PHENOL	POUND	.00	.00	.00	.01	.00	.00	.00	.01
WATERBORNE SULFIDES	POUND	.00	.00	.00	.01	.00	.00	.00	.00
WATERBORNE OIL	POUND	.13	.04	.04	.07	.06	.06	.16	.07
WATERBORNE COD	POUND	1.49	2.10	.17	11.83	1.76	2.00	.27	13.80
WATERBORNE SUSP SOLIDS	POUND	1.06	1.25	2.93	1.04	.57	.65	.58	1.19
WATERBORNE ACID	POUND	.27	.46	.98	.79	.86	1.12	5.73	.28
WATERBORNE METAL ION	POUND	.07	.12	.23	.20	.22	.28	.14	.07
WATERBORNE CHEMICALS	POUND	0.00	0.00	0.00	0.00	0.00	0.00	.03	0.00
WATERBORNE CYANIDE	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE ALKALINITY	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE CHROMIUM	POUND	.00	0.00	0.00	.00	0.00	0.00	.00	0.00
WATERBORNE IRON	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE ALUMINUM	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE NICKEL	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE MERCURY	POUND	0.00	0.00	.00	0.00	0.00	0.00	.00	0.00
WATERBORNE LEAD	POUND	0.00	0.00	.00	0.00	0.00	0.00	.00	0.00
WATERBORNE PHOSPHATES	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE ZINC	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE AMMONIA	POUND	.02	0.00	.97	.01	0.00	0.00	.02	.03
WATERBORNE NITROGEN	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WATERBORNE PESTICIDE	POUND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUMMARY OF ENVIRONMENTAL IMPACTS									
RAW MATERIALS	POUNDS	49.48	46.30	306.04	7.62	56.06	26.06	458.21	13.03
ENERGY	MIL BTU	39.04	42.65	46.09	41.21	41.29	43.33	29.06	42.70
WATER	THOU GAL	3.31	3.51	17.48	3.17	1.85	2.00	4.21	7.80
INDUSTRIAL SOLID WASTES	CUBIC FT	.89	.80	1.41	1.16	1.15	1.39	1.67	.59
ATM EMMISSIONS	POUNDS	78.65	111.95	136.47	153.49	95.59	105.04	83.63	80.27
WATERBORNE WASTES	POUNDS	13.32	9.32	13.86	26.25	9.26	10.07	14.50	24.09
POST-CONSUMER SOL WASTE	CUBIC FT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENERGY SOURCE PETROLEUM	MIL BTU	22.63	.65	6.21	23.01	6.74	7.08	18.13	5.84
ENERGY SOURCE NAT GAS	MIL BTU	15.35	40.14	33.89	15.09	31.11	31.79	8.60	35.75
ENERGY SOURCE COAL	MIL BTU	.86	1.52	3.03	2.54	2.82	3.64	1.94	.91
ENERGY SOURCE NUCL HYPWR	MIL BTU	.19	.34	.68	.57	.64	.82	.38	.2[illegible]
ENERGY SOURCE WOOD WASTE	MIL BTU	0.00	0.00	2.29	0.00	0.00	0.00	0.00	0.0[illegible]

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I. INTRODUCTION AND METHODOLOGY

The products included in this study--towels, napkins, sheets, diapers and foodservice ware--are vital components in the American way of life. The average individual uses or comes into contact with the majority of these types of products during the course of each day. Accordingly, the relative sanitation of the disposable and reusable variants within each product type is a significant concern of all involved in delivering these items to the consumer.

The "Public Health and Sanitation" component of this comprehensive study of selected disposable versus reusable products examines concerns that have been raised regarding the public health and sanitation aspects of these products. In accordance with the scope of work for this investigation, MRI conducted a literature review of relevant sanitation studies, as well as of the U.S. Food and Drug Administration Sanitation Code and selected state and local sanitation ordinances.[1,2] A total of 85 references were reviewed for this task. Additionally, MRI contacted 32 public health associations and industrial associations, 40 product manufacturers, national and regional FDA officials, and 5 state health agencies. A complete list of these contacts is provided in Appendix B of this report.

In accordance with the contract scope of work, no original research was to be conducted in the development of information for this study. Yet, MRI believes that the report presents a consensus of the available literature and of the opinions of industry and government officials regarding the public health impacts of these selected disposable and reusable products.[3]

1/ See comments, Appendix B , pages 11-12.
2/ See comments, Appendix J, pages 37-38.
3/ See comments, Appendix J, page 21.

II. GENERAL SANITATION CONCERNS RELATED TO CLOTH PRODUCTS

A. Contamination of Cloth by Microorganisms

One of the central health concerns related to the use of cloth products is their sanitation. Scientific studies have shown that fabrics can harbor microorganisms which can be transmitted from person to person. In light of this finding, it is especially significant to investigate the presence of microorganisms on cloth--their persistence, transmittal from fabric to humans, and their diminution or eradication via laundering.

1. Mechanisms of Contamination: There are four basic mechanisms by which microorganisms may be transmitted:

a. Contact: In this type of contamination, bacteria may be suspended in fluid or dispersed in a more dense medium. For example, a hospital sheet could be contaminated by urine, a fluid medium; or through skin lesions or feces, both of which are relatively dense.

b. Droplet: Droplets are large moisture-laden particles which can be spread by talking, coughing and sneezing. They remain airborne only a short time but can contaminate fabrics as they fall.

c. Droplet Nuclei: These are the residues resulting from evaporation of moisture from droplets. They may remain airborne for long periods of time but eventually fall, at which point contamination may occur. (Droplet nuclei contamination is also called aerosol contamination.)

d. Dust: In this type of contamination, microorganisms adhere to particles of dust which may be dislodged, by sweeping or other similar movements, from the fabric. These dust particles may then become airborne and subsequently lodge on a surface or directly on a person.

2. Persistence of Microorganisms: Once fabrics have become contaminated, the microorganisms may survive for a relatively long period of time under favorable conditions (e.g., rough-textured material and low humidity). A number of studies have been done on the persistence of microorganisms under normal conditions on certain types of fabrics. McNeil and Greenstein (38), demonstrated that viable Staphylococcus aureus persisted on cotton for 84 days, E. coli for 32 days and Mycobacterium butyricum for 70 days. The authors also tested the persistence of the same microorganisms on wool and acetate tricot, finding longer survival times on the wool and shorter times on the tricot. They explained this result in terms of the construction of the various materials, wool having a scaly, rough texture to which microorganisms adhere quite easily and tricot being relatively smooth and more resistant to such adherence. Survival times also varied with degree of humidity, with a fairly high humidity (70 percent) usually associated with less persistence than a low humidity (28 percent). McNeil and Greenstein concluded that "it is evident from the data...that the test bacteria survived on the fabrics for sufficient periods of time to be of epidemiological significance."[1/] (38, Page 137).

1/ Although the phrase "of epidemiological significance" is not precisely defined in this or in a subsequently cited study, the author's implication is that longer survival times provide a greater opportunity for exposure to a potential human host, thus presenting greater public health significance. No evidence of actual infectiousness is presented.

A series of studies performed by Sidwell, Dixon and McNeil (10, 67, 68 and 69) examined the persistence of vaccinia virus and poliomyelitis virus on cotton and wool fabrics. Two types of wool material and three types of cotton, including cotton sheeting, were exposed to the virus strains by direct contact, aerosol, and dust; and then held in two varying conditions of humidity--at 35 percent and 78 percent. Vaccinia was found to survive up to 14 weeks in the wool fabrics at low humidity. In cotton, the virus was recovered only up to 6 to 8 weeks at the low humidity, and for less than 6 weeks at the 78 percent humidity. Again, persistence of vaccinia virus on all fabrics was concluded to be of sufficient duration to be of epidemiological significance. The poliomyelitis virus persisted for 1 to 4 weeks on cotton fabrics at 35 percent humidity. In higher humidity, the period of viral persistence was shorter, although the decrease in virus titer was less rapid. The authors note that "since the major source of poliovirus in the human environment is feces of infected individuals (cases or carriers), the persistence of the virus on fabrics commonly used in clothing and bedding is of major importance in considering possible virus dissemination by fomites," (10, Page 183).

Two studies done by Wilkoff, Westbrook and Dixon (83 and 84), demonstrate that Staphylococcus aureus and Salmonella typhimurium also remain on fabrics for significant periods of time. Staph aureus was found to survive on all fabrics, including cotton sheeting and cotton wash-and-wear (exact composition not indicated) for sufficient periods to be of epidemiological significance. Salmonelia persisted on cotton sheeting for 24 weeks at 35 percent humidity and for 6 to 12 weeks under 78 percent humidity. Both Staph aureus and Salmonella survived for relatively brief periods on the cotton wash-and-wear.

3. Release of Microorganisms from Cloth and Potential for Disease Transmission: Obviously then, fabrics can harbor bacteria for a significant period of time. However, the next step in the transmission process involves the release of these resident bacteria into the environment or directly onto a surface where they may impact negatively on humans. Sidwell et al. (69) undertook a study to determine whether poliovirus and vaccinia could be released in sufficient amounts to be capable of dissemination to susceptible hosts. A number of fabrics, including cotton, wool, and synthetic blends, were exposed to these viruses by direct contact and by aerosolization, allowed to dry and then randomly tumbled with sterile swatches of the same fabrics for 30 minutes. Up to $10^{3.5}$ $CCID_{50}$[1/] of poliovirus per milliliter and $10^{4.4}$ $CCID_{50}$ of vaccinia virus per milliliter were recovered from the originally sterile fabrics as early as 1 to 10 minutes after contact. The authors note that the exposed fabrics were contaminated with an extremely large quantity of virus, greater than would be expected in domestic uses; however, they believe that the rapid transfer of poliovirus and vaccinia (considered to be sufficiently diverse to represent the most important human viruses) from contaminated to sterile fabric indicates that the virus particles adhere loosely to the fabric and would probably be disseminated rather easily under normal usage conditions. But, they conclude that, "it is yet to be

1/ Critical Concentration Intradermal, causing reaction in 50 percent of test animals receiving intradermal injection.

determined whether a... human being would become clinically infected by the quantity of virus that was transferred to the sterile fabrics," (69, Page 953).

In another study implicating fabrics as potential fomites, Duguid and Wallace (38), as reported in McNeil and Greenstein, compared the number of bacteria released from the clothing of nasal carriers of Staphylococcus aureus to the number transmitted via sneezing. Clothing is obviously subjected to significant agitation through the normal movements of the wearer; and such agitation is considered to be a factor in bacterial release. Duguid and Wallace found a significantly greater amount of Staph aureus air contamination from dust particles released from clothing than from droplet nuclei emitted during sneezing. Ten percent of the dust particles emanating from the clothing and containing Staph aureus remained airborne for at least 35 minutes, a sufficient period of time for contamination of persons or inanimate objects.

Other authors have reported cases of illness directly traced to contaminated fabrics. Oliphant, Gordon, Meis and Parker reported that laundry workers had contracted Q fever (a rickettsial disease) from handling contaminated clothing, presumably by inhaling infected lint. In 1951, several unvaccinated laundry workers in Great Britain contracted smallpox by handling the soiled linen used by persons suffering from subclinical cases of the disease. And, Gonzaga studied the effects of exposing newborn infants to linens which had been contaminated by known Staph aureus carriers. The infants contracted the infection when exposed to heavily contaminated articles.[1/]

1/ All of the studies described in this paragraph were reported in Reference Number 43.

These studies emphasize the potential for disease transmission presented by contaminated cloth products. Although several of the investigations focused on clothing rather than linens (Duguid and Oliphant), the basic mechanisms of contamination and dissemination are the same.

In our present study, the cloth products under investigation exhibit the potential for significant contamination. A cloth towel, used in the kitchen for wiping kitchen spills, can easily be contaminated by hand contact. The hands are major carriers of microorganisms because they touch such a variety of potentially contaminated surfaces (8). Additionally, spilled food or liquids can provide excellent media which can support the growth of bacteria. Napkins present a different potential for contamination because of their contact with the mouth, where a variety of microorganisms are harbored. Finally, the bed sheet used in institutions is subject to the most severe contamination. Hospital patients, who often carry some type of infection, can contaminate sheets in a variety of ways: any type of wound or lesion may emit blood or purulent discharge onto the sheet; the patient may excrete, through urination or defecation, potentially pathogenic material; or he may contaminate the linen merely through touching, sneezing, coughing or talking.

Despite the fact that fabrics can harbor microorganisms, that these microorganisms can persist for a significant period of time, and that cases of disease have been traced to contaminated fabrics, direct correlation between contaminated fabrics and disease is not always clear. The likelihood of particular microorganisms causing disease when transmitted from one person to another, via fabric, is dependent on a variety of factors: the numbers and types of organism involved, their degree of virulence, the mode of entry, and the degree of immunity of the person involved. While these factors are undeniably important in accurately assessing the overall health threat represented by exposure to various microorganisms, definitive data in these areas are sorely lacking. Most of the studies presented in the following section, therefore, deal solely with the numbers of various bacteria found in fabrics, before and after laundering. While this measure does not totally assess the associated health threat, the basic relationship between the degree of exposure to potential pathogens and health jeopardy is logically sound. In summarizing this topic, Davis mades the following comment:

"The phenomena of communicability and invasiveness are complex and controlled by many factors, but, other things being equal, the contact with large numbers of potential pathogens must obviously increase the chance of infection," (8, Page 89). Consistent with this focus, the following sections investigate the laundering process in general and the effectiveness of typical commercial, institutional and home laundering practices in eliminating microorganisms from fabric.

B. Sanitation Mechanisms in the Laundering Process

Despite the foregoing conclusions regarding cloth products as potential disease carriers, the inherent potential for disease transmission can be virtually eliminated by proper laundering techniques. Laundering represents the best single key to the achievement of sanitation in cloth products; and, for this reason, the practice of effective laundering methods in the home, commercial and institutional facilities becomes highly significant in producing products which meet acceptable public health standards.

The laundering process provides three basic mechanisms by which bacteria can be destroyed:

- The mechanical action of water and detergent solutions;
- The action of heat; and
- The bactericidal action of reagents used for cleansing.

1. Mechanical Action: The first step involves the physical removal of bacteria-harboring soil from the fabric. The agitation of the washer, coupled with detergent, lifts the soil out of the fabric and suspends it in the wash water. At this point, called the first "break," millions of bacteria may be suspended in each milliliter of water in the average load. As the contaminated water is flushed away and replaced by clean water, the bacterial count is decrementally reduced through the dilution process. With each flushing operation, the count further decreases. The effect of detergency and dilution is illustrated in Figure 1. Although the lower curve in the figure represents a higher temperature (125° to 140°), the percentage of bacteria removal at each step is approximately the same as that of the 100° temperature--a 50 percent reduction at each flush. However, as shown in the graph, it was necessary to add bleach to effect total bactericidal action.

2. Heat: The action of heat alone can be effective in destroying bacteria. Smith and Mack note that "water alone at 160° F causes almost complete destruction of representative pathogenic organisms...(however)

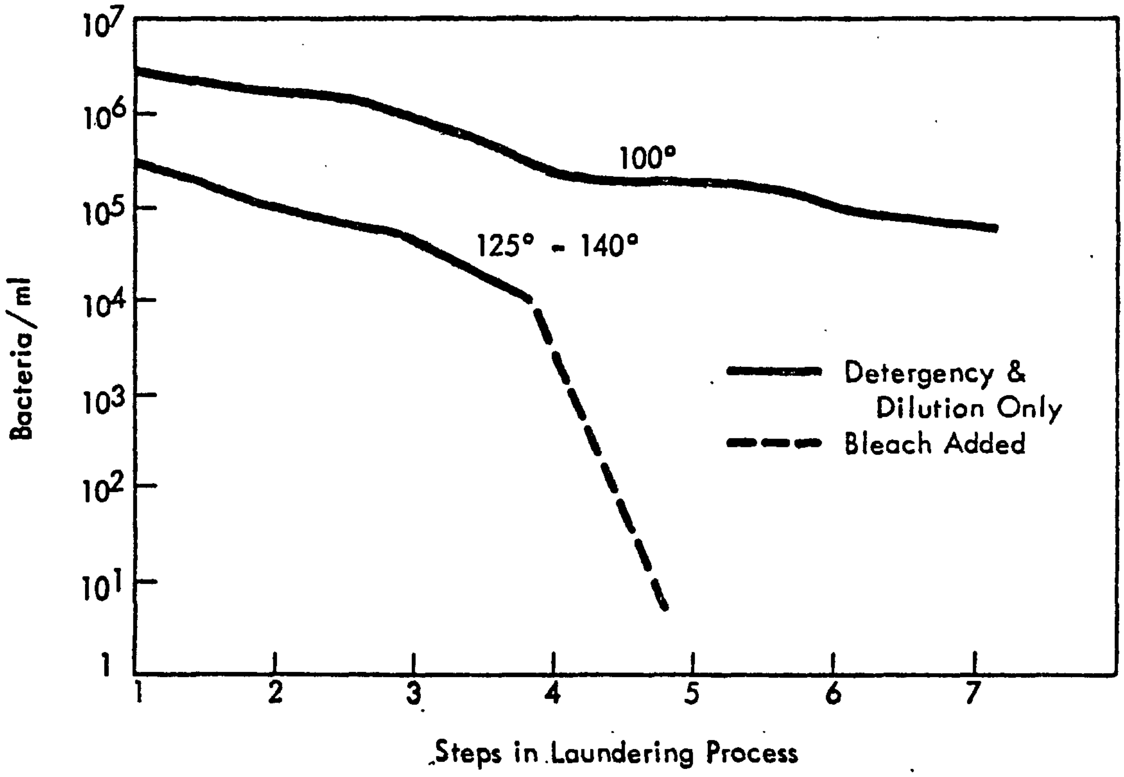


Figure 1 - The Role of Detergency and Dilution in the Sanitation Process

where low or moderate temperatures are used in laundering, it is difficult to attain complete sterilization," (71, Page 98). In addition to heat in the washing process, dryers and ironing can provide some bactericidal action, although the literature indicates that these latter heat sources should not be relied upon to achieve fabric sanitation.

A study done by Sidwell et al. (67) confirms the significance of heat in bacterial destruction. Swatches of fabric were contaminated, through direct and aerosol exposure, with poliovirus and then laundered at three different temperatures using two types of detergent and using no detergent. Table 1 shows the results of these tests on cotton sheeting.

As indicated in the table, detergent usage made little difference, but the hot wash water markedly reduced the amount of detectable virus. The authors note that "the heat supplied by the wash water was one of the most important factors in eliminating viable poliovirus from the contaminated fabrics, as shown by the fact that virus reductions were marked in the hot water experiments, with little detectable virus remaining on the fabrics," (67, Page 229). It is also interesting to note that drying had a significant effect on virus reduction.

Additionally, the study showed that no virus was recovered from the rinse water after hot water laundering; however, virus was recovered from rinse water after warm and cold water laundering. Sterile fabrics laundered with contaminated fabrics in hot water had a lower virus content than similar fabrics laundered in warm or cold water. These results indicate that warm and cold water physically remove the virus from the fabric, but that hot water not only removes the virus but also inactivates it.

TABLE 1

EFFECT OF LAUNDERING AT DIFFERENT TEMPERATURES ON CONTAMINATED COTTON SHEETING

Water Temperature	Detergent	Mean Virus Titers (CCID50/ml)					
		Direct Contact Exposure			Aerosol Exposure		
		Virus Control[a]	Test Wet[b]	Test Dry[c]	Virus Control	Test Wet	Test Dry
Hot (130-140° F)	Anionic	$10^{6.2}$	$10^{0.6}$	$10^{0.5}$	$10^{5.0}$	$10^{0.4}$	$<10^{0.4}$
	Nonionic	$10^{4.0}$	$10^{0.5}$	$<10^{0.4}$	$10^{4.0}$	$10^{0.4}$	$<10^{0.4}$
	None	$10^{5.8}$	$10^{0.4}$	$<10^{0.4}$			
Warm (100-108° F)	Anionic	$10^{5.9}$	$10^{2.3}$	$10^{0.5}$	$10^{4.5}$	$10^{0.7}$	$10^{0.4}$
	Nonionic	$10^{6.4}$	$10^{2.6}$	$<10^{0.4}$	$10^{4.5}$	$10^{1.0}$	$<10^{0.4}$
	None	$10^{5.9}$	$10^{2.9}$	$10^{0.4}$			
Cold (70-80° F)	Anionic	$10^{5.6}$	$10^{3.3}$	$<10^{0.4}$	$10^{3.9}$	$10^{1.1}$	$10^{0.4}$
	Nonionic	$10^{5.9}$	$10^{3.6}$	$10^{0.6}$	$10^{4.5}$	$10^{4.7}$	$<10^{0.6}$
	None	$10^{6.3}$	$10^{4.0}$	$10^{1.2}$			

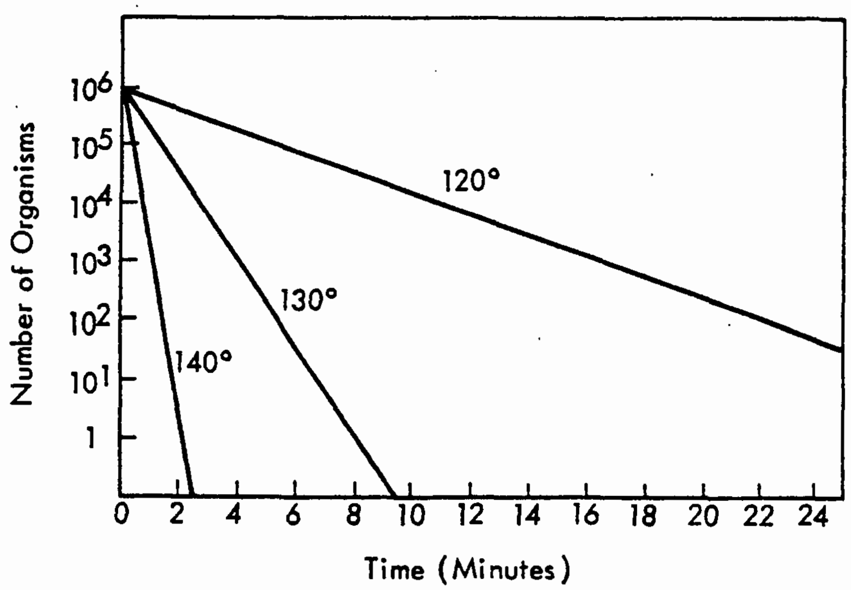
Source: Sidwell et al. "Quantitative Studies on Fabrics as Disseminators of Viruses: V. Effect of Laundering on Poliovirus - Contaminated Fabrics," (67).

a/ Swatches which were exposed to virus, held 16 hours at 97°F in 35 percent relative humidity and tested.

b/ Same as a/, plus swatches were laundered.

c/ Same as a/, plus swatches were laundered and allowed to dry for 20 hours.

Time is an inseparable component of temperature in effecting bacterial destruction. Davis (8) notes that the cumulative exposure time to high temperatures is the best indicator of bactericidal effectiveness. Stringent regulations on laundering, such as those established by the Joint Commission on the Accreditation of Hospitals for hospital laundries, dictate that fabrics be held at 160° for 25 minutes. There is little doubt, according to the literature, that fabrics would be effectively sanitized by such exposure. However, some studies (34,8) indicate that with a few minutes exposure to 140° temperature, fabrics become free of certain types of pathogens. Figure 2 depicts thermal destruction of one strain of Staph aureus at 140°, 130° and 120°; obviously, the 120° temperature was ineffective, leaving approximately 50 microorganisms after 25 minutes; whereas at 140°, all the Staph was destroyed after 2 minutes. Thus, a slight increase in temperature can markedly reduce kill time.



Source: Marmo, Anthony, "Bacteria Control in the Laundry," (34).

Figure 2 - Thermal Destruction of Staph Aureus

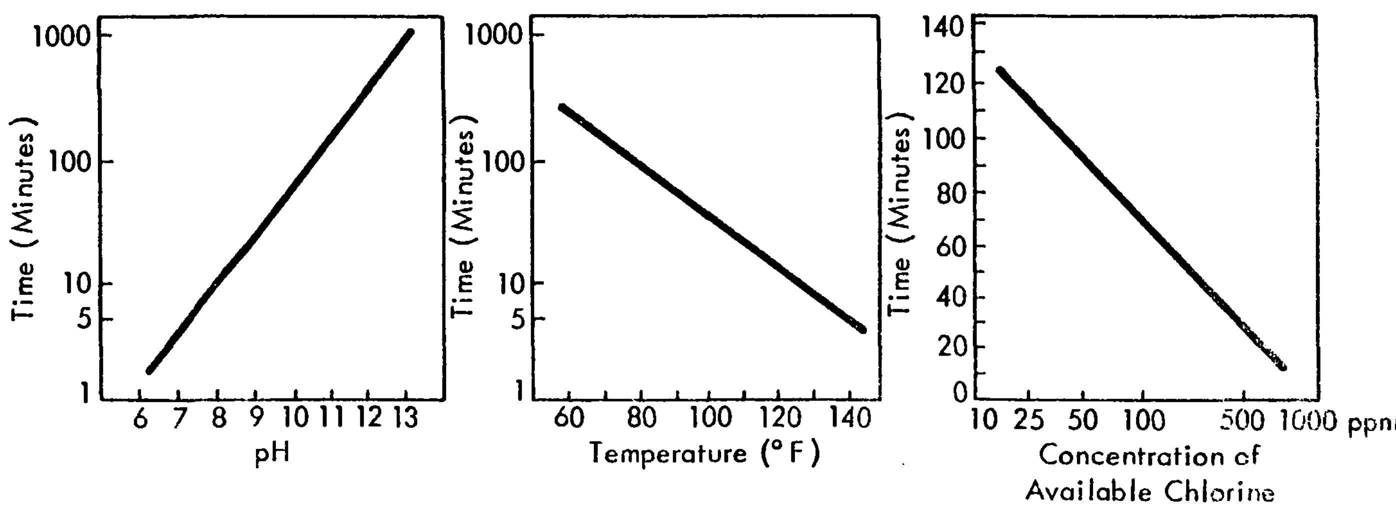
Two other significant factors in evaluating thermal destruction are the particular type of bacteria and the type of soil to which it adheres. For example, a strain of E. coli harbored in broth can be destroyed at a considerably lower temperature than the same strain adhering to cream. Also, whereas the strain of Staph aureus represented in Figure 2 could be destroyed by a 2-minute exposure to a 140° temperature, another strain of the same organism can survive up to 19 minutes of exposure to the same degree of heat.

3. Chemicals: Chemicals represent the third mechanism for bacterial destruction in the laundering process. There are four basic types of chemical bactericides (disinfectants):

a. Alkalies: Alkalies create a highly alkaline environment in which many bacteria cannot survive and also neutralize the acidity present in many soils, thereby enhancing the effect of detergents.

b. Detergents (soaps): Soaps have varying effects on microorganisms. Pneumococci, meningococci, gonococci, and numerous other organisms are easily destroyed by the chemical action of detergents. Others, such as certain strains of Staphylococci and tubercle bacilli, are more resistant and can be killed only by the combined action of heat and detergent.

c. Bleaches: Chlorine bleach is dependent on a number of factors for its effectiveness: a low pH value, high temperature, and relatively high bleach concentration. Figure 3 illustrates the significance of each of these factors in the destruction of Bacillus metiens.



Source: Marmo, Anthony, "Bacteria Control in the Laundry," (34).

Figure 3 - Time to Produce 99% Kill of Bacillus Metiens Spores Using Chlorine Bleach

d. Sours: A sour produces an acidic condition which neutralizes residual alkali from earlier processes and also completes bacterial destruction by creating a low pH condition deleterious to many bacteria. Sours are particularly useful as bactericides in colored loads where lower temperatures are used and no bleach is added.

Because the many organisms which can be found in fabrics respond so differently to laundry chemicals, there is no one substance which will kill all bacteria. Additionally, as illustrated in the case of chlorine bleach, there are several variables which can alter bactericidal action. However, proper combinations of agitation, heat, and chemicals should result in almost complete elimination of microorganisms. Smith and Mack note that "a good washing formula utilizing the successive actions of alkali, soap, bleach, and sour at temperatures in the range of 160° for the break and sudsing operations, with bleaching at 140° to 145°, can be expected to effectuate the complete destruction of bacteria ordinarily encountered in laundering" (71, Page 100).

C. Effectiveness of Commercial Laundering

The cloth products being investigated in this study (towels, napkins, diapers, and sheets) may be laundered by any one of the following methods:

- Commercial laundry (household towels and napkins, commercially-used napkins, diapers, some institutional sheets).
- Home laundry, including self-service laundromats (household

towels and napkins, diapers).

. Institutional laundry (sheets).

Because of special considerations inherent in the laundering of diapers and institutional (predominantly hospital) sheets, laundry procedures for these products will be discussed in the respective projects sections.

Towels and napkins, however, are generally treated by standard laundry procedures. If sent to a commercial laundry, towels and napkins would normally be handled by one of the following techniques recommended by the International Fabricare Institute, which is one of the major associations representing commercial laundries:

1. Standard White Work Washing Procedure:

Operation	Time (Min)	Level (Inch)	Temperature (°F)	pH
1. Suds	5-7	5-6-8	180	11.2-11.4
2. Suds	5-7	5-6-8	160	11.0
3. Suds	5-7	5-6-8	160	10.8
4. Bleach Suds	5-7	5-6-8	155	10.5-10.6
5. Rinse	2	10-12-15	160	
6. Rinse	2	10-12-15	140	
7. Rinse	2	10-12-15	120	
8. Rinse	2	10-12-15	100	
9. Sour	3-4	5-6-8	90	
10. Starch	10	2	90	5.0-5.5

2. Wash Procedure for Polyester/Cotton Linens:

Operation Number		Time (Min)	Level (Inch)	Temperature (°F)	Per 100 lb. load
1	Break	10	6	140	1.5 lb Sodium Orthosilicate 0.4 lb Tripolyphosphate 0.75 lb Nonionic detergent (1)(2)
2	Flush	3	8	140	
3	Suds	10	6	140	1/2 of supplies as listed in step No. 1
4	Rinse	3	12	140	
5	Bleach	10	6	140	2 qt 1% Av. chlorine bleach pH 10.4-10.5 (3) (4)
6	Extract[a/]	1			
7	Rinse	3	12	125	
8	Extract	1			
9	Rinse	3	12	110	
10	Sour	5	6	95	pH not lower than 5

a/ Spin.

3. Colored Loads (cotton): Same as standard white work except that the first suds is at 100°, subsequent suds are at 140°, and the rinses are done at 140°, 120°, 100°, and 100°, bleach is not used with the fourth suds.

4. Lightly Soiled White Loads: Same as standard white work except that first suds is at 100° and subsequent sudsings may be at slightly lower temperatures than for standard white work.

5. Commercial Flatwork (Such as napkins): Handled in the same manner as lightly soiled white loads.

These recommended procedures all involve a minimum of 17 minutes exposure to 140°F (colored loads) and a maximum of 30 minutes exposure to 155° or above (23 minutes to 160° or higher) for standard white work. Although these time and temperature recommendations do not match those presented in the literature (160° for 25 minutes), the addition of chemical bactericides (alkalies, detergents, bleaches and sours) supplement the antibacterial action of time and temperature.

In order to determine if such commercial laundering techniques produced reasonably sterile fabrics, Nicholes (43) performed bacteriological studies of commercially laundered items from all over the world. The products tested included continuous roll towels, napkins and dish towels. Nicholes' results were reported mainly on the continuous towels, which initially showed an average of 41,960 bacteria per square inch in one test and over 3 million in another. After the laundries were advised to make adjustments in time, temperature and chemicals, counts were reduced to <32 and to 160,000, respectively. Nicholes emphasizes, however, that even the initial high counts proved to be mostly gram-positive spore-forming (and thus heat-resistant) organisms which he feels do not present a great public health nuisance. Marmo concurs that these organisms tend not to be pathogenic but rather tend to be mold and mildew-producers (34). Nicholes also concluded, from an extensive literature review, that laundered fabrics <u>have never</u> been implicated in the transfer of disease.

It is significant to note that in Nicholes' study, bactericidal effectiveness was considerably improved by instructing the laundries in proper time, temperature, and chemical utilization. While standard practice in the commercial laundry industry involves bactericidal techniques, the human factor must be considered in evaluating the compliance of individual laundries to industry standards.

In another study conducted under the auspices of the American Institute of Laundering (AIL now IFI), bacterial counts were taken at each step of the white and colored laundry formulas, using temperatures considerably lower than are now recommended by IFI. Even at these lower temperatures, however, no bacteria were recovered at the end of the white washing procedure and only 158 bacteria per cubic centimeter at the conclusion of the colored method (again indicating the added effectiveness of bleach used in the white wash). Tables 2 and 3 summarize these test results.

The American Institute of Laundering study also compared commercially laundered loads with home washing. The average bacteria count in the last rinse for colored loads as found in 109 commercial laundries was 71 organisms per cubic centimeter compared to 318,792 per cubic centimeter as found in nine different randomly selected homes in a total of 180 tests. For white loads in the same laundries, the average count was only 31 per cubic centimeter.

D. Effectiveness of Home Laundering

The results of the AIL study are consistent with the majority of other literature on home laundering, which indicates that such poor results from home laundries are attributable to a number of factors:

1. Generally shorter wash times: an MRI survey of local service centers for three home washer manufacturers indicates that the washing (detergency and dilution) time in home laundry averages only 12 minutes for a normal full load. However, most washers can be set for shorter wash times,

TABLE 2

BACTERICIDAL EFFICIENCY OF A COMMERCIAL LAUNDRY WHITE FORMULA

Bath	Supplies Used	Temperature (°F)	Time (Min)	Average Bacterial Count Per cu cm
Flush	--	110	5	200,428
1st Suds	Soap and alkali	125	10	94,314
2d Suds	Soap and alkali	135	10	42,518
3d Suds	Soap and alkali	140	10	3,382
4th Suds	Soap and alkali plus Sodium hypochlorite	165-170		5
1st Rinse	--	165	3	1
2d Rinse	--	165	3	0.5
3d Rinse	--	165	3	0.4
4th Rinse	--	165	3	0.2
Sour and blue	Sodium acid fluoride[a/]	140 and 110		Sterile

Source: American Institute of Laundering.

TABLE 3

BACTERICIDAL EFFICIENCY OF A COMMERCIAL LAUNDRY COLORED FORMULA

Bath	Supplies Used	Temperature (°F)	Time (Min)	Average Bacterial Count Per cu cm
Flush	--	90-100	5	3,674,055
1st Suds	Soap and alkali	100	10	1,979,862
2d Suds	Soap and alkali	100	10	1,248,758
3d Suds	Soap and alkali	100	10	255,579
4th Suds	Soap and alkali	100	10	221,293
1st Rinse	--	100	3	88,966
2d Rinse	--	100	3	67,461
3d Rinse	--	100	3	43,809
4th Rinse	--	100	3	35,278
5th Rinse	--	100	3	24,441
Sour	Sodium acid fluoride	100	5	158

Source: American Institute of Laundering.

which are often recommended for synthetic fabrics. Coin-operated washers in laundromats average a 10-minute washing time.

2. Lower temperatures: McNeil (36) notes that average home laundry temperatures at the hot water setting range from 120° to 130°, while at the warm water setting, temperature averages about 100° (temperature being dependent in both cases on the setting of the hot water heater in the home or self-service laundry).

3. Use of less water.

4. Reuse of water.

5. Use of less effective chemical reagents.

According to the USDA, "Neither the water temperatures nor the detergents used under today's home laundering conditions can be relied on to reduce the number of bacteria in fabrics to a safe level," (66). Ethel McNeil, formerly of the USDA Agricultural Research Service, has performed several studies of home laundering. In one study, nine families brought soiled laundry to the lab each week for several months. The bactericidal effectiveness of three types of disinfectants (quaternary, phenolic and sodium hypochlorite, also called chlorine bleach) was tested at varying water temperatures and with varying types of detergents. The temperature of the wash water at the "hot water" setting varied from 122° to 140°F at the beginning of the wash cycle, and from 109° to 135°F at the end of the cycle. The temperature of the wash water at the "warm water" setting varied from 91°F to 118°F at the beginning of the wash cycle, and from 88°F to 108°F at the end of the wash cycle.

Bacterial counts were made of treated and untreated wash and rinse waters and of swatches of fabrics attached to an article of clothing. Detailed test results are presented in Tables I through V, in Appendix A to this report.

The conclusions of the report were as follows:

1. Large numbers of bacteria were recovered from many of the untreated wash and rinse waters, even at the "hot water" setting. Home laundering temperatures and detergents cannot, therefore, be relied on for the control of transmission of bacteria by textiles and clothing.

2. The quaternary disinfectant at a concentration of 200 ppm, added to either the wash or rinse water at the hot water setting, consistently reduced bacterial counts in the water and on the fabric swatches.

3. The phenolic disinfectants also reduced bacterial counts in the wash and rinse cycles when used at a concentration of 125 ppm or higher.

4. The sodium hypochlorite (chlorine bleach) was effective at 160 and 320 ppm of available chlorine.

5. Redeposition of bacteria did occur from soiled fabrics to the attached swatches.

As a corollary to the preceding study, McNeil investigated the types of bacteria which had been isolated from the home laundering procedures. Over 1,500 colonies of bacteria were described and gram stains were made. Four hundred of these were retained for further study; 30 species of 13 genera were identified, most of which were found in wash loads to which disinfectants were not added. These species are listed in Table 4. The most

TABLE 4

INCIDENCE OF 30 SPECIES OF BACTERIA IN THE LAUNDRY OF NINE FAMILIES

Species	Total Number of Strains Identified	Number of Families From Whose Laundry Species were Isolated (Total of 9)
Staphylococcus aureus	41	7
Staphylococcus epidermidis	58	8
Micrococcus aurantiacus	8	4
Micrococcus candidus	6	5
Micrococcus caseolyticus	5	3
Micrococcus conglomeratus	5	4
Micrococcus flavus	5	4
Micrococcus freudenreichii	1	1
Micrococcus luteus	5	2
Micrococcus varians	3	3
Sarcina sp	16	8
Pseudomonas aeruginosa	21	7
Escherichia coli	4	2
Escherichia intermedia	1	1
Paracolbactrum aerogenoides	20	8
Paracolbactrum intermedium	15	7
Paracolbactrum coliforme	7	7
Aerobacter aerogenes	3	2
Aerobacter cloacae	2	2
Proteus vulgaris	2	2
Flavobacterium sp	5	4
Achromobacter sp	1	1
Alcaligenes fecalis	55	9
Alcaligenes bookeri	5	3
Alcaligenes marshallii	1	1
Alcaligenes recti	6	2
Alcaligenes viscolactis	1	1
Brevibacterium sp	29	7
Bacillus subtilis group	27	8
Bacillus megatherium-cereus group	43	9

Source: McNeil, Ethel, "Studies of Bacteria Isolated From Home Laundering," (36).

significant bacteria from a household hygiene standpoint were Staphylococcus aureus, Pseudomonas aeruginosa and Paracolbactrum. In evaluating the health status of families whose laundered fabrics contained these bacteria, McNeil found that three of the seven families with Staph aureus reported skin lesions or upper respiratory infections during the period prior to laboratory laundry of their clothes; five of the eight with Paracolbactrum aerogenoides reported intestinal disorders; and three of the seven with Pseudomonas reported ear or genitourinary infections. In each case, the bacteria isolated represent a common causative agent for the type of infections reported. It is clear from McNeil's study that pathogenic bacteria can be transmitted from infected humans to fabrics, and that these bacteria can survive home laundering, especially when disinfectants are not added.

McNeil's work forms the basis for a USDA recommendation, contained in the bulletin, "Sanitation in Home Laundering," (66) that disinfectants be employed whenever:

1. There is illness in the family, or

2. Laundry facilities are shared.

Quaternary and liquid chlorine disinfectants are recommended by USDA for all temperatures; pine oil and phenolics, for hot and warm water.

Witt and Warden (85) also studied the effectiveness of home laundering by using varying water temperatures (hot = 140°, warm = 100°, cold = 60°), and detergent concentrations (none, 0.1 percent, 0.2 percent, 0.4 percent) on fabrics contaminated with Staph aureus. They found that none of the combinations of temperatures and detergent concentrations removed

100 percent of the organisms; however, as water temperatures and detergent concentrations increased, bacterial survival decreased on the contaminated fabrics, on the sterile fabrics following redeposition of bacteria from contaminated fabrics, and in the wash water. Figures 4 and 5 illustrate these results for the fabrics and wash waters.

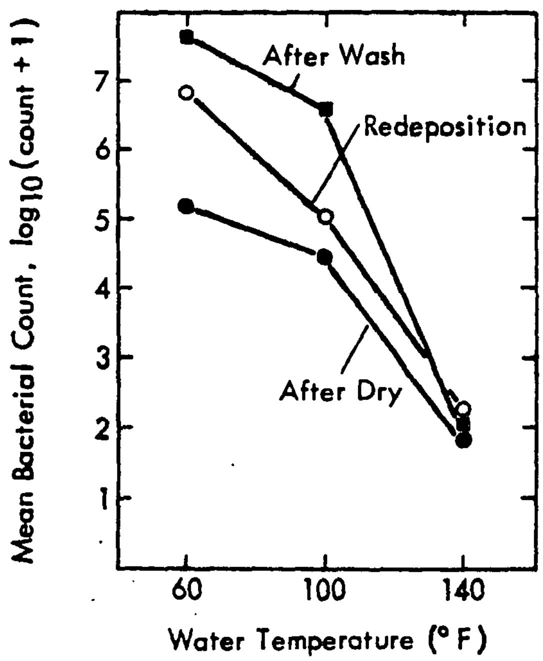


Figure 4 - Count After Washing with Various Water Temperatures

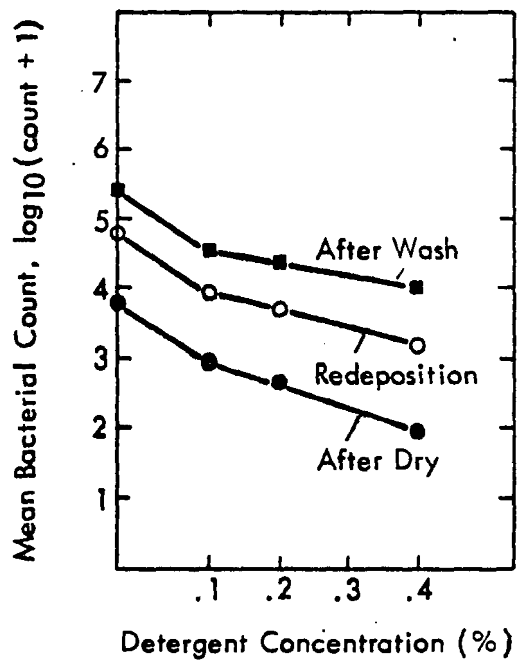


Figure 5 - Count After Washing with Various Detergent Concentrations

The study points out factors which can cause redeposition of soil from contaminated to uncontaminated fabrics:

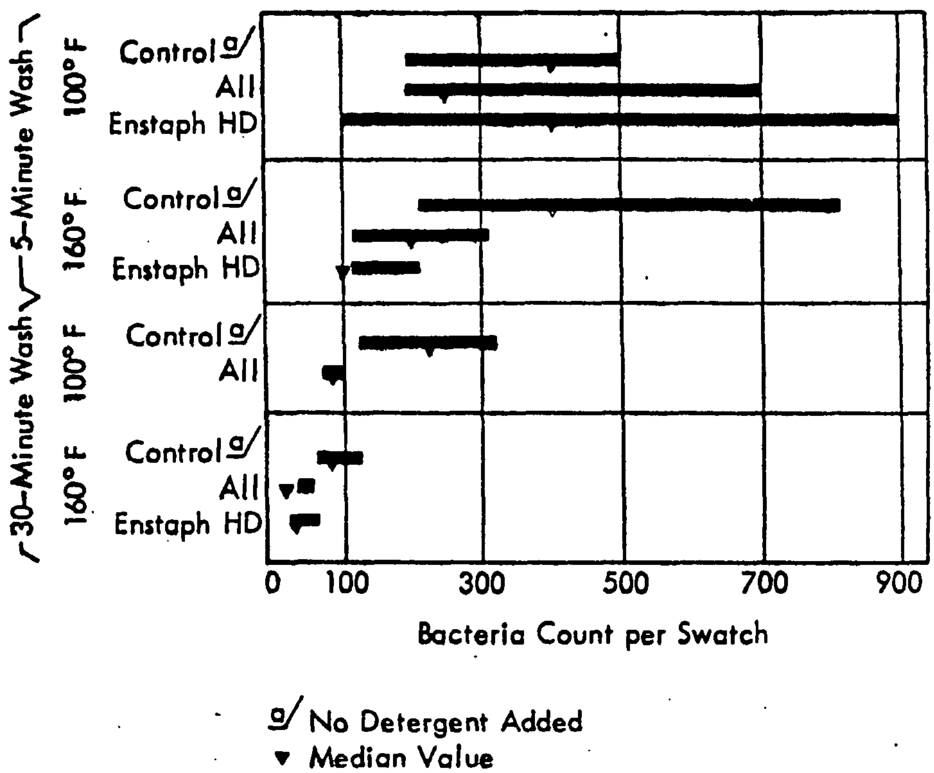
1. A high amount of soil;
2. Adverse temperature conditions;
3. A low volume of water; and
4. A low detergent concentration.

Home laundries often exhibit all of these factors, with lower water temperatures, overfilling of washers resulting in a low water-to-fabric ratio, and misuse of detergents. Another problem emphasized in this study is the removal of clothes from automatic dryers before they are completely dry. This practice, often followed for no-iron fabrics, provides a warm, moist environment which encourages bacterial growth.

Tables VI and VII in Appendix A to this report provide complete results of Witt and Warden's experiments on two types of fabric.

A fourth study which investigated noncommercial laundering was performed by the Applied Biological Science Lab, Inc., for the Linen Supply Association of America (LSAA). The purpose of the study was to determine the effectiveness of the washing procedure recommended by the American Hotel and Motel Association (AHMA) for no-iron linens. This procedure involves washing for 5 minutes at 100°F and adding a bacteriostat to achieve sanitation. Both cotton muslin and 50 percent cotton/50 percent polyester blend sheets were tested, using 100° and 160° temperatures, two types of detergents and no detergent. The sheets had been innoculated with a 1×10^6 dosage of Pseudomonas aeruginosa. The summary of the tests is presented in Figure 6.

As indicated in the figure, the most effective results were obtained from the 30-minute, 160° wash. The 5-minute washes (as recommended by AHMA) at both temperatures left a significant bacterial residue, although at 160°, with detergents, results were more favorable than at the lower temperature. There was no measureable difference in results between the cotton muslin and the cotton/polyester blend in terms of bacterial retention.



Source: Linen Supply Association of America.

Figure 6 - Effect of Time and Temperature on Bacteria Kill

In contrast to the preceding study, a University of Iowa Hospital comparison (2) of the same materials at the same temperatures and times indicated that 5-minute, 100° washes were quite effective in producing sanitary linen. Table 5 shows the results of their microbiological testing. As indicated, the no-iron sheets contained fewer bacteria prior to washing than the conventional cotton sheets. (No explanation of this phenomenon was offered.) Also, the 5-minute, 100° wash produced a level of sanitation comparable to that resulting from the commercial method for the 100 percent cotton sheets. It should be noted, however, that this was the only study encountered in the literature which indicated favorable results for short-time, low-temperature laundry procedures and which showed lower initial bacteria counts on no-iron fabrics.

The overwhelming evidence gathered during the course of this study indicates that standard commercial laundering methods, using at least 140° temperatures, 15- to 30-minute cycle periods, with the addititION of chemicals, produce far more sanitary fabrics than do typical home (short-time, low-temperature) laundering procedures.

A final consideration in cloth product sanitation and laundering is recontamination of fabrics after washing. Even though cloth may be totally sanitized and free of microorganisms at the conclusion of the washing process, it may be recontaminated during subsequent stages of laundering, drying, ironing and folding. Church and Loosli (6) studied this recontamination problem in one hospital and one commercial laundry. (For the purposes of this section, only the results of the commercial laundry testing will be discussed.) They

TABLE 5

MICROBIOLOGICAL TEST RESULTS IN NUMBER OF COLONIES PER SQUARE INCH

Group	Type Sheets and Washing Method	Contact Plates: Before Washing	Contact Plates: After Washing	Homogenization: Before Washing		Homogenization: After Washing	Direct Plate Count: Before Washing	Direct Plate Count: After Washing
Run 1	50% cotton	19	0.47	1/100	479	46	98	1.42
	50% polyester			1/1000	667	42		
	sheets washed at 100°F							
Run 2	with one 5-min suds	2	0.08	1/100	133	71	60	0.125
No iron	and two 3-min rinses.			1/1000	500	83		
sheets	Dried at 160°-165°F							
No sani-	using no bleach, no							
tizer	sour or sanitizer							
Run 1		71	1.34	1/100	6,150	6.0	276	1
				1/1000	15,500	0		
	Same as A, except 1 pt							
Run 2	of 1% sodium hypochlorite	3.0	0.11	1/100	846	12.5	28	0.08
No iron sheets	bleach per 100 lb added			1/1000	917	0		
Sodium Hypo-	for wash cycle							
chlorite								
Run 1		148	0.24	1/100	2,888	13	1,826	80
Ironed				1/1000	16,500	42		
Run 2	100% cotton sheets							
	washed by the usual	5.0	0.03	1/100	4,800	4.0	270	2.0
Not ironed	commercial method at			1/1000	5,750	Con-		
cotton	160°F, using bleach,					taminated		
sheets	sour and ironed on an							
Sodium Hypo-	eight-roll ironer							
chlorite								

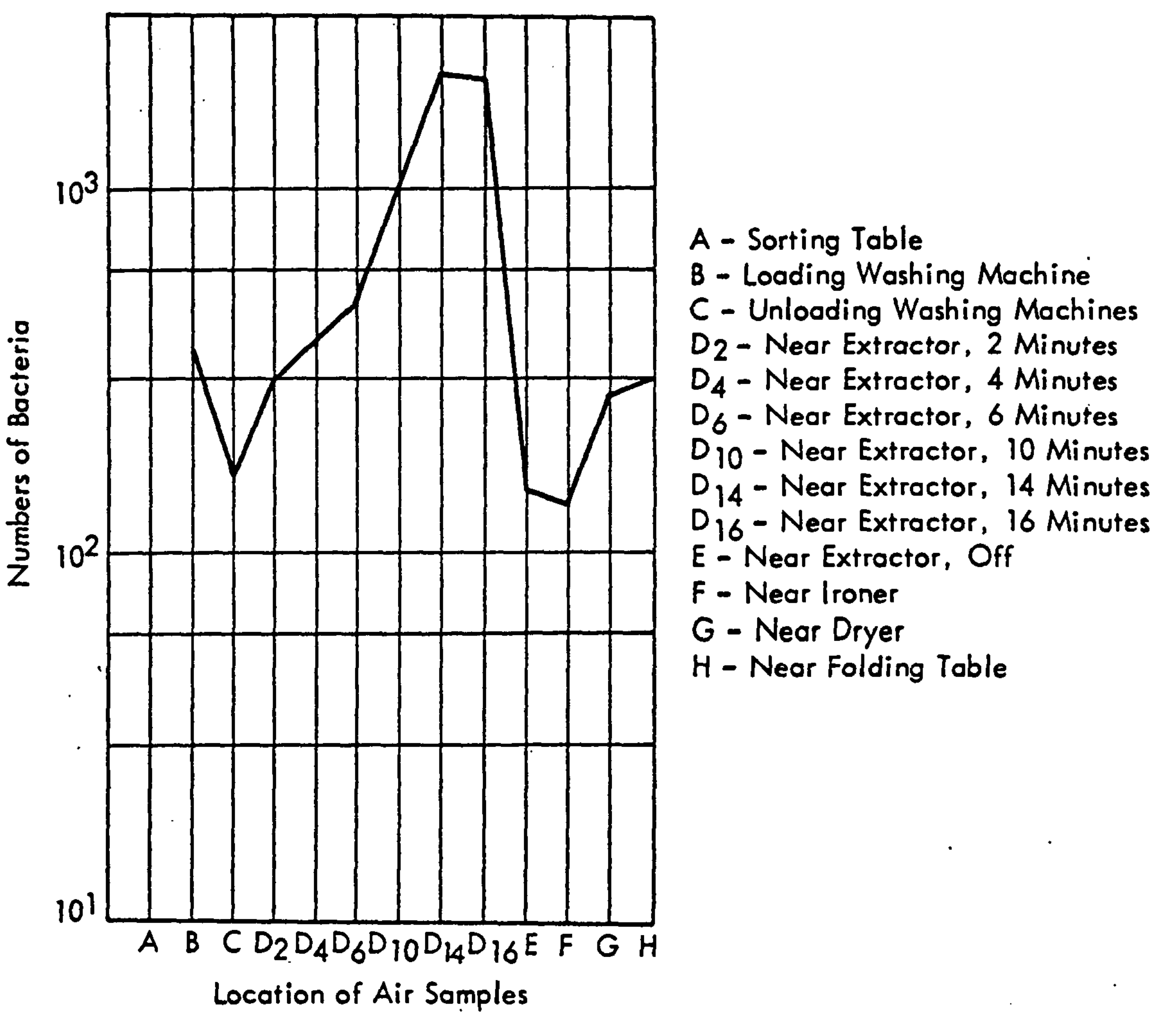
Source: Bradley, L. A., The No-Iron Laundry Manual, (2).

NOTE: Variation in bacteria counts on soiled sheets before washing, probably reflects the physical condition of different patients.

found that the laundry process was efficient in removing bacteria from the fabrics during washing, but that the materials became recontaminated during water extraction in the spin dryer or while they were being folded. Figure 7 graphically depicts the results of air samples taken at various sites in the laundry. As indicated, the highest counts were found near the sorting table, near the extractor at the end of the extraction process, and near the dryer and folding table.

The authors found that the open-lid extractors were drawing in large numbers of airborne bacteria which were subsequently harbored in the textiles being spun-dry. Table 6 shows the relationship among the increase in airborne bacteria, waterborne bacteria and linen contamination from the beginning of the laundering cycle through the end of the extraction process. Samples were taken at the time of maximum sorting activity, when movement of the soiled clothes contributes heavily to airborne bioload. Samples taken in the hospital laundry when no sorting was in process showed considerably lower bacterial counts. The study also concluded that the heat of the ironing process was insufficient to eliminate all the organisms built up during extraction.

The extent to which the recontamination problems outlined above occur in individual laundries related to the layout and operation of the facility. Solutions to identified problems are dependent on an understanding of potential trouble areas, so that precautions (e.g., ventilation, screening, etc.) may be taken to minimize bacterial redeposition.



Source: Church and Loosli, "The Role of the Laundry in the Recontamination of Washed Bedding," (6).

Figure 7 - Total Number of Bacteria per Cubic Foot of Air Sampled at Specific Sites During Routine Activities

TABLE 6

THE NUMBER OF ORGANISMS ISOLATED FROM DIFFERENT SOUCES IN LAUNDRY B DURING MAXIMUM SORTING ACTIVITY, 2:30 P.M. THE FOLIN-BUBBLER WAS EMPLOYED FOR SAMPLING THE AIR AND LINEN

Air		Water		Linen	
Location	Organisms/ ft^2	Source	Organisms/ ml	Step	Organisms/ ml
Sorting Table	350	Before Washing	200	Before washing	38,000
Near Washer	135	Final rinse	250	After rinse	350
Near Extractor, 2 in.	300	Extractor, 2 in.	12,200		
Near Extractor, 6 in.	500	Extractor, 6 in.	45,400		
Near Extractor, 10 in.	1040	Extractor, 10 in.	601,000		
Near Extractor, 14 in.	2150	Extractor, 14 in.	1,080,000		
Near Extractor (off)	150	End of extraction, 16 in.	1,940,000	After Extraction	165,000
Near Ironer	140			After Ironing	250
Folding Table	300			After Folding	1,140

Source: Church and Loosli, "The Role of the Laundry in the Recontamination of Washed Bedding," (6).

In summary, sanitation concerns related to cloth products in general involve a wide range of variables, and no definitive conclusions can be reached regarding absolute degrees of contamination or sanitation of a given product. However, the following points are overwhelmingly supported by the literature:

1. Cloth products are potential disseminators of microorganisms;

2. Laundering at 160° for 25 minutes can reasonably ensure destruction of pathogenic bacteria (lesser time and temperature being effective for some bacteria);

3. Commercial laundering methods are generally superior to home laundering methods in sanitizing cloth products; and

4. The impacts of inadequate sanitation on the public health cannot be definitively determined, since variables such as degree of contamination and susceptibility of the exposed populace significantly affect the relationship between contaminated fabrics and the development of disease.

III. TOWELS AND NAPKINS[1]

Despite an extensive literature search and comprehensive contacts with organizations, manufacturers and public health officials, very little data could be gathered regarding towels and napkins in the applications prescribed by this study (i.e., home use and laundry of cloth and paper towels and sponges; home and commercial use and laundry of cloth and paper napkins). Health and sanitation concerns related to toweling have focused primarily on hand drying applications in commercial and institutional environments. In particular, the communal cloth towel has been the subject of the

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1 See comments Appendix B, pages 17-18.

closest scrutiny. However, regarding the use of toweling or sponges for cleaning up kitchen spills, there is neither a clearly defined basis for public health concern nor any previous study which focuses on such application. Data on napkins are even more sparse. In the absence of definitive information, attention will be directed in this section to specific concerns raised regarding the prescribed product applications, and, where possible, to the interpolation of other relevant data to these concerns.

The chief concern in the use of towels or sponges for wiping up kitchen spills is the possible transmission of microorganisms, which may originate from food spills or hands and multiply in the favorable environment provided by the nutrient-enriched damp towel or sponge. Thus, if a cloth towel or sponge is used to wipe up a spill containing bacteria (e.g., juices from raw meat), and allowed to retain the food residues within a warm, damp environment, that towel or sponge could transmit a heavy bioload onto kitchen surfaces or onto human hands. The offensive odor often emitted by damp kitchen cloths or sponges, especially during warm weather, is indicative of the bacterial content of these products when used in this manner.

A major sponge manufacturer does not share this concern but indicates that, based on its test data,[1/] "There is little concern with spread of microorganisms since the product (is) usually well-rinsed or washed out in use." None of the cloth towel manufacturers provided any data regarding kitchen applications of their product. It would seem obvious from the foregoing discussion that the public health threat posed by reuse of cloth towels

1/ Stated to have been destroyed in a fire and hence not available to MRI.

or sponges would depend on the habits of the individual user; i.e., a sponge or towel which is indeed rinsed thoroughly between uses, periodically washed with some type of soap product, and allowed to dry sufficiently between uses, would be less likely to transmit bacteria than a product not treated so hygienically. But, the paper towel, used only once and then discarded, would virtually eliminate this potential for cross-infection.

Despite these observations and assumptions, the absence of laboratory data precludes a substantive or quantitative evaluation of the three products in kitchen applications.

Of primary concern in the use of napkins, both in the home and in commercial establishments, is the potential for transmission of bacteria from the hands and mouth of one user to those of the subsequent users. Again, no laboratory data are available from which to make quantitative assessments, but certain observations can be made. In the home setting, cloth napkins are often used for several days before they are laundered, creating increased potential for bacterial transmission. And, as discussed in the previous section, if they are processed by normal home laundry techniques, they are unlikely to be thoroughly sanitized prior to a new use cycle. If sent to a commercial laundry, however, the napkins should have significantly lower bacterial counts.

Cloth napkins used in a commercial setting must be changed after each usage, as prescribed in almost every local food sanitation ordinance. Generally, these napkins are commercially laundered, and again may be assumed to exhibit sanitation standards such as were described in the preceding section.

In terms of the sanitary qualities of paper towels and napkins, the literature does provide one piece of data on unused paper towels which can be presumed to relate to paper napkins as well. Test data supplied by the American Paper Institute (47) indicates that typical total bacterial counts of paper toweling from one manufacturer average 180 organisms per square foot. This may be compared to the FDA Sanitation Code (14) standard of 100 organisms per foodservice product contact surface. Depending on the size of the towel or napkin being considered, the API count could be either slightly inferior or slightly superior to the FDA standard. However, it should also be pointed out here that the FDA standard itself may not be based on any real evidence linking degree of microbial contamination to attendant public health threat.

The literature has also compared typical paper towel counts to bacterial counts on commercially-laundered cloth products in hand-drying applications (40, 47, 8); in each comparison, paper toweling has been shown to harbor significantly fewer bacteria than cloth toweling. While this type of data cannot be related directly to conditions likely to prevail in the home kitchen or commercial restaurant facility, it is still reasonable to assume that paper would show fewer bacteria than would cloth towels or napkins.

However, in view of the lack of substantive evidence establishing cloth towels, cloth napkins and sponges as sources of pathogenic organisms, to which normal exposure would likely cause infection, MRI can formulate no definitive conclusion as to the relative health and sanitation status of paper versus cloth towels versus sponges, or paper versus cloth napkins.[1]

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[1] See comment Appendix B, pages 13-15.

IV. DIAPERS[1,2,3,4]

The disposable diaper has become an increasingly popular product for infant care in the home. More than 2,800 hospitals have adopted the disposable diaper for use in their newborn nurseries. Seventy-five percent of all babies born in hospitals are first diapered in disposable diapers (9), and many parents continue this method of diapering in the home situation. Unquestionably, the disposable diaper provides an element of convenience not offered by the conventional cloth diaper. The disposable is merely removed and discarded, whereas the cloth diaper must be soaked, laundered, dried, folded, and returned to storage. In the hospital situation, utilization of cloth diapers adds a significant burden to the laundry facility; in the home, parents either assume the extra work themselves or employ a commercial diaper service.

Aside from convenience considerations, both disposable and reusable diapers present certain health and sanitation concerns which have been raised in the course of this study:

1. The possibility of increased skin irritation or rash associated with the use of disposable diapers.

2. The ineffectiveness of home laundering of cloth diapers compared to commercial laundering.

3. The health implications of disposing of single-use diapers contaminated with urine and feces.

In order to understand the significance of diapering in the overall health of the baby, it is important to understand the role of the diaper

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[1] See comments Appendix B, pages 11-13 and pages 15-16.

[2] See comments Appendix B, page 18.

[3] See comments Appendix D.

[4] See comments Appendix G.

in inhibiting or encouraging skin rashes. Grant, Street and Fearnow (19) list two of the most common causes of diaper rash as: (1) Monilial or bacterial infection; and (2) Ammonial contact dermatitis. The diaper provides a moist, warm environment conducive to the growth of bacteria, which may originate from an improperly laundered diaper, from the infant's skin (especially if the skin is not cleansed following defecation), and from the excreted stools and urine. Other factors in rash development are laundry chemical residuals in the diaper, maceration (softening of the skin by wetness causing increased permeability), marked changes in skin pH, and metabolic wastes in stools.

Brown and Tyson (3), in studying diaper dermatitis, found that a 2-stage process exists in the development of dermatitis.[1] In the first stage, bacteria act on the urea present in urine, decomposing it into ammonia, which is in itself irritating to the skin. The infant who is not cleaned after defecation, not changed frequently, or who wears plastic pants over diapers (thereby enhancing the moist, warm environment of the diaper region) is much more susceptible to ammonial dermatitis.

The second stage of the process involves the secondary invasion of already-irritated skin by pathogenic bacteria. Brown isolated _Staphylococcus aureus_ and _Beta hemolytic streptococci_ (both known pathogens) in babies with rash, but only one incident of _Staph aureus_ and two incidents of Streptococci were found in the babies without rash.[2]

Thus, bacteria in the diaper region contribute to dermatitis by producing ammonia and also by invading the site of primary infections caused

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[1] See comment Appendix D, page 39.

[2] See comment Appendix D, page 39.

by the ammonia. Both the disposable and cloth diaper can produce conditions favorable to bacterial growth; however, actual hygienic practices of changing the baby frequently and cleaning him adequately are still of major importance.

1. The Possibility of Increased Skin Rash Associated with the Use of Disposable Diapers: A 1968 study performed by Silverburg and Glaser (70) at the Long Island Jewish Hospital showed that the incidence of diaper rash was significantly greater with disposable diapers than with cloth diapers. Two plastic-backed disposable diapers and one paper-backed disposable were compared with cloth diapers in the newborn and premature nurseries. Results are presented in Table 7.

The results indicate that in all cases except one, cloth showed a statistically significant improvement in protecting against diaper rash over either plastic-backed or paper-backed disposables. Additionally, only 9.4 cloth diapers were used per baby per day in the newborn unit, compared to 10.4 per day for the disposables; in the premature unit, 7.8 cloth diapers were used per baby per day, compared to 10.0 disposables. However, the authors did not attempt to explain the results of their study nor did they postulate any reason for the difference.

2. The Ineffectiveness of Home Diaper Laundering Compared to Commercial Laundering:[1] The effectiveness of the cloth diaper in retarding bacterial growth and diaper rash is based on how the diaper is laundered. Within the home setting prescribed in this study, diapers would be laundered either in the home (or in a self-service laundry comparable to home facilities) or by a commercial establishment, in many cases a diaper service.

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[1] See comment Appendix D, corner letter.

TABLE 7

DIAPER RASH INCIDENCE IN DISPOSABLES COMPARED TO CLOTH

Type of Diaper	Number of Babies	Number of Diaper Changes	Percent of Babies Developing Rash
		Newborn Nursery	
Plastic-backed disposable #1	225	2,752 (3 weeks)[a/]	4.5%
Plastic-backed disposable #2	225	3,364 (4 weeks)	1.0%[b/]
Paper-backed disposable	225	1,668 (7 weeks)	2.5%
Cloth	173	2,092 (4 weeks)	0.3%
		Premature Nursery	
Plastic-backed disposable #1	67	2,648 (3 weeks)	10.2%
Plastic-backed disposable #2	67	4,135 (4 weeks)	5.8%
Paper-backed disposable	67	3,864 (7 weeks)	2.6%
Cloth	64	3,711 (4 weeks)	0.9%

Source: Silverberg, Alvin and David Glaser, "Disposable Versus Reusable Linen in the Nursery--Results of a Comparative Study," (70).

a/ Inconsistencies in number of changes compared to number of babies and test time can be attributed to fluctuations in the length of stay for each baby.

b/ Not statistically significant in comparison to cloth.

The diaper service industry has been in existence since 1932. Through its association, the National Institute of Infant Services (NIIS), this industry has monitored its operations through an independent medical laboratory--Philadelphia Medical Laboratory (formerly Usona Bio-Chem Laboratory). The laboratory established the "Diaseptic Process," a specific method for laundering diapers so they will meet certain standards of sanitation, aesthetic quality, pH balance, softness, and absorbency.[1] This process has been considered standard in the industry, and its effectiveness is checked by taking regular samples of commercially laundered diapers and submitting them to the laboratory for testing.

The 100 members (representing the most active diaper services throughout the U.S.) of NIIS must maintain the following standards:

1. The service must submit one random sample per month, taken from a finished package of diapers, to a specified medical laboratory. The sample must be free of all pathogenic bacteria or fungi and may contain no more than 20 colonies of nondisease-producing bacteria per 8 square inches of fabric. (This compares to a standard of less than two colonies per square inch for disposable diapers.[1/])

2. The sample diaper must read within the range of 4.5 to 6.5 pH by the colorimetric procedure (compared to pH of 7.0 in disposables prior to use[1/]).

3. The sample will be tested for zone of inhibition (bacteriostatic effectiveness) against <u>Staph</u> <u>aureus</u>.

1/ Results from individual disposable diaper manufacturers' continuous quality control testing programs, as reported by the American Paper Institute.

1 See comment Appendix D, page 42.

4. Diapers served to customers must be soft to the touch and free from stiffness.

5. Diapers served to customers must be so absorbent that water added drop by drop enters the fabric immediately.

6. Diapers served to customers must be free from stains, tears, and excessive wear. (A package selected at random should show no greater than 3 percent substandard diapers.)

Additionally, in 1970, NIIS established a Diaper Service Accreditation Council which is now composed of two pediatricians, a public health director, a bacteriologist, and three industry representatives. The Council formulated an accreditation program which requires site inspection, self-analysis procedures, and rigorous in-plant standards in order for a service to merit accreditation. Although less than half of the NIIS member services are currently accredited, the Institute plans to require accreditation for all of its members within the next 3 years. In addition to administering the accreditation program, the Council advises the industry on new laundry detergents, new bacteriostats and other additives to ensure their safety and effectiveness. This monitoring is especially important in light of several laundry components found during the 1960's to cause adverse effects on infants. Trichloro carbanibide (TCC), a bacteriostat used in laundry softeners, was found to produce free aniline, a known toxin, when exposed to high heat. In premature nurseries where diapers are autoclaved, this reaction led to the development of cyanosis and methemoglobulinemia in some infants. Another substance, sodium pentachlorophenate, an antimildew agent, caused two deaths and a number of cases of illness in two separate hospitals. Both of these cases emphasize the need for careful evaluation and usage of chemicals in laundering diapers.

Diapers can, of course, be laundered commercially outside of a diaper service, or by a service which is not a NIIS member. In either case, the diaper would be processed according to the standards described in the section on general laundering. In most instances, as discussed in this section, the commercially laundered diaper would be washed at higher temperatures for longer periods of time and would be more effectively rinsed than a home-laundered diaper.

This conclusion is borne out by the Grant, Street and Fearnow study in which the authors compared the incidence of significant diaper rash reported by 1,197 mothers attending a well-baby clinic as it related to the method of laundering (disposables, commercial diaper service, or home washing) used more than 50 percent of the time. Diapers washed by a diaper service were associated with the lowest incidence of diaper rash--24.4 percent. Disposables showed about the same incidence as the commercially laundered cloth diapers. However, the home-laundered diaper was associated with the significantly greatest incidence of diaper rash, at 35.6 percent. These results are shown in Table 8.

The authors attribute their findings to the fact that commercially laundered diapers are virtually sterile and are thoroughly rinsed of all chemical contaminants.[1] Additionally, bacteriostatic agents such as bleach and quaternary ammonium compounds used in commercial diaper services are

[1] See comment Appendix D, page 44.

TABLE 8

INCIDENCE OF DIAPER RASH ACCORDING TO METHOD OF DIAPER LAUNDRY

	Diaper Service		Disposable Diaper		Home Washed	
	Number	%	Number	%	Number	%
Total	74	--	236	--	887	--
Diaper Rash (2 Days or Less)	11	14.9	37	15.7	201	22.6
Diaper Rash (Over 2 Days)	7	9.5	24	10.0	114	12.9
Diaper Rash Total	18	24.4	61	25.0	315	35.6

Source: Grant et al. "Diaper Rashes in Infancy: Studies on the Effects of Various Methods of Laundering," (19).

cited as inhibitors of rash. Even with multiple rinses, the home-laundered diaper failed to meet the standards of the commercially washed product, as shown in Table 9. These results confirm the fact that home laundry does not render as sterile a product; i.e., adequate rinsing alone does not solve the problem.[1]

TABLE 9

EFFECT OF NUMBER OF RINSES OF HOME-LAUNDERED DIAPERS ON INCIDENCE OF DIAPER RASH

	1 to 3 Rinses		Over 3 Rinses	
	No.	%	No.	%
Total	692	--	195	--
Diaper Rash 2 Days or Less	162	23.5	35	20.0
Diaper Rash Over 2 Days	86	12.4	28	14.4
Diaper Rash Total	248	35.9	67	34.4

Source: Grant et al. "Diaper Rashes in Infancy: Studies on the Effects of Various Methods of Laundering," (19).

Brown and Wilson (4) also tested the performance of home laundries in washing diapers. Two loads of 12 soiled diapers each were soaked for 12 hours in water and detergent, washed in an automatic washer at 140° to 144°F for 20 minutes, given four spray rinses, a full-water rinse for 2 minutes at 100°F, and two additional spray rinses. Each load was then dried for 40 minutes in a home gas dryer. Results from two samples taken from each load are shown in Table 10.

[1] See comment Appendix D, page 46.

TABLE 10

TEST RESULTS FOR HOME-LAUNDERED DIAPERS

Sample	Organisms Isolated	Colony Count	Agar-Plate Test
Load 1 - Diaper 1	*E. coli*, nonhemolytic streptococci, *B. subtilis*	9,300 per sq in. of fabric	A faint zone of partial inhibition
Diaper 2	*E. coli*, nonhemolytic streptococci, *B. subtilis*	11,100 per sq in.	No zone of inhibition
Load 2 - Diaper 1	Nonhemolytic strepto-cocci, gram positive and negative saprophytic bacilli	8,200 per sq in.	No zone of inhibition
Diaper 2	Gram positive and negative saprophytic bacilli	9.700 per sq in.	No zone of inhibition

Source: Brown, Claude, and Frederic Wilson, "Diaper Region Irritations: Pertinent Facts and Methods of Prevention," (4).

These results show much higher bacterial counts than are allowed by NIIS diaper services (no more than two colonies per square inch).

It is important to note, however, that these bacterial counts were not specifically correlated with the development of diaper rash in infants wearing tested diapers. The significance of the results lies in the fact that bacteria present in a diaper can break down urea into ammonia, a known skin irritant which can initiate a chain reaction of rash development. But, some factors other than bacteria can and do contribute to diaper rash development, notably frequency of changing.[1] The bacteria present in home-laundered diapers should therefore be viewed as one potential cause of rash.

[1] See comment Appendix D, page 47.

Brown and Wilson also indicate that "home-washed diapers may have a pH of 9.5" (4) or higher from improper rinsing. This compares unfavorably to the 4.5 to 6.5 pH required by the NIIS, and the 7.0 pH reported for disposables. The higher or more alkaline pH is quite different from normal skin, which has a pH of 5.5 ± 1.5, and can in itself be an irritant.

A third study comparing home-laundered to commercially-laundered diapers was done at the University of Illinois Medical College, for the American Institute of Laundering (now International Fabricare Institute) (64). Investigators tested diapers which had been laundered in six private homes. In five of the homes diaper processing consisted of a cold soak followed by one hot suds and three rinses. In the sixth home, a fourth rinse was added. Results of the home diaper laundering are shown in Table 11. As indicated, bacterial count after the third rinse was 168,388; when the fourth rinse was added, average count was reduced to 149,400. As shown in Table 12, commercially laundered diapers, by contrast, were rendered sterile after the third suds, to which two quarts of 1 percent sodium hypochlorite per 300-pound load were added.

As in Brown's study, no direct correlation between diaper rash incidence and bacterial count is made; again, it can only be assumed that a sterile diaper is less likely to produce conditions favorable for diaper rash development.[1]

Jordan et al. (25) examined the effectiveness of sodium hypochlorite in destroying Sabin type II poliovirus under household laundry conditions. This virus, known to be resistant to many germicides, was found to be susceptible to the virucidal action of sodium hypochlorite bleach, when used at the

[1] See comment Appendix D, page 48.

TABLE 11

BACTERICIDAL EFFICIENCY OF HOME DIAPER WASHING

Operation	Average Bacterial Counts Per Cu Cm Wash Water
Cold Soak	2,248,033
1st Suds	1,983,000
1st Rinse	1,171,033
2nd Rinse	719,940
3rd Rinse	168,388

Source: "The Sanitary Aspects of Commercial Laundering," Special Report for the American Institute of Laundering, (64).

TABLE 12

BACTERICIDAL EFFICIENCY OF A COMMERCIAL DIAPER FORMULA[a/]

Operation	Supplies Used	Temperature	Time in Minutes	Average Bacterial Other Per Cu Cm
1st Cold Rinse	--	65°F	5	1,678,333
2nd Cold Rinse	--	65°F	5	1,621,200
1st Suds	Soap and Alkali	110°F	10	720,300
2nd Suds	Soap and Alkali	125°F	10	84,333
3rd Suds	Soap and Alkali plus 2 quarts 1% soldium hypochlorite per 300 lb load	145°F	10	Sterile
1st Rinse	--	165°F	3	Sterile
2nd Rinse	--	175°F	3	Sterile
3rd Rinse	--	175°F	3	1
4th Rise	--	175°F		Sterile
5th Rinse	--	140°F		Sterile
Sour	Sodium acid fluoride	120°F		Sterile
Boric acid bath plus bluing		100°F		Sterile

Source: "The Sanitary Aspects of Commercial Laundering," Special Report for the American Institute of Laundering, (64).

recommended belach level of 200 ppm available chlorine. The authors note, however, that the virus was destroyed at water temperatures of 130°F and above without the addition of bleach; but at 110°F (the lower range of household laundry temperatures), bleach was requisite for viral destruction.

3. The Health Implications of Disposal of Single-Use Diapers Contaminated with Urine and Feces: As a result of increased use and subsequent discard of disposable diapers, general concern over the public health consequences of fecal matter in solid waste has increased in recent years. The basis for this concern centers around the occurrence of bacterial and viral pathogens in fecal matter and the potential for these pathogens to leach into ground or surface water supplies. In evaluating the potential threat or lack thereof inherent in land disposal of single-use diapers, one must first assess the occurrence (numbers and types) of pathogens involved, and secondly, the resulting effect of such conditions as measured by their ability to survive in and leach from the landfill environment and come into contact with human beings.

a. Occurrence of Pathogens in Disposed Diapers

Bacteria: As the subject of several fairly recent studies (1, 11, 59), the bioload of raw residential solid waste has been shown to contain densities of fecal coliforms and fecal streptococci in excess of one million organisms per gram. The presence of these organisms, which are normal inhabitants of the large intestine of man and other warm-blooded animals, is commonly assumed to indicate a strong likelihood of the presence of other intestinal organisms which may be pathogenic. One such bacterial pathogen which has been observed in solid waste in Salmonellae.

Viruses: In addition to bacteria, raw solid waste also contains a variety of potential human viral pathogens, the leaching source of which is fecal matter. Investigating the occurrence of viruses as a function of typical soiled disposable diaper load in a sanitary landfill, Peterson (59) determined that, by wet weight, soiled disposable diapers represent 0.6 to 2.5 percent of mixed municipal waste. Finding one-third of these diapers to contain fecal matter at an average of 60 grams of feces per diaper, Peterson calculated the average amount of human fecal matter in solid waste to be about 0.04 percent by wet weight. In two separate areas of the country, viruses were detected in 15 percent and 2.9 percent of fecal samples from area A (Ohio) in February and April, respectively, and 16.7 percent of samples from area B (Kentucky) in July. Poliovirus 3 was found in both sampling areas, and echovirus 2 was found in two samples from area B. The poliovirus 3 density ranged from 16 to 1,920 plaque-forming units (PFU) per gram, with an average of about 390 PFU per gram. Densities of the echovirus 2 (positive samples) were 1,440 and 960 PFU per gram.

Further perspective on the occurrence and potential significance of viruses in human fecal matter is provided by Dr. John Fox, an epidemiologist. Based on virus watch data that he collected across the U.S., Dr. Fox prepared an opinion statement on the "Viral Infection Hazard of Disposable Diapers" (17), the results of which are summarized in Table 13.

As shown in the table, the most common virus group likely to occur in human feces is poliovirus. However, the health threat posed by these viruses is minimized by typically low virulence of vaccine-derived

TABLE 13

PREVALENCE AND SIGNIFICANCE OF VIRUSES SHED IN FECES

Virus Group	Occurrence (Percent of Diapers)	Severity of Associated Disease	Population Immunity Level (Percent)	Assumed Health Threat
Poliovirus	20	a/	790	Small
Nonpoliovirus	1 to 20	Minor to severe	13 to 75	Small to Moderate
Hepatitis				
Type A	2	Moderate	"High"	Small
Type B	1×10^{-4}	Severe	"Low"	Small
Adenovirus	4	Minor	50	Small

Source: Fox, John P., "Viral Infection Hazard of Disposable Diapers--Opinion Statement," Professor of Epidemiology, University of Washington

a/ While the potential for reversion of vaccine strains to wild types may exist to some limited extent on passage through man, normal disease potential of vaccine strains is very low.

strains which presently make up practically all of existing poliovirus flora in the U.S., and by the probably high prevalence of immunity of the population. The nonpolio enterovirus group is diverse and potentially widespread in occurrence in fecal matter. Furthermore, type-specific immunity is variable and tends toward the low end of probability, thereby presenting a seemingly great health threat potential. Fortunately, medical experience indicates that only extremely infrequently are these viruses the cause of serious illness. In virus watch studies conducted by Dr. Fox, 50 percent of all detected infections were subclinical and 80 percent of the related illnesses were minor respiratory. The overall potential health threat posed by this group of virus is therefore difficult to assess, but is certainly less than severe. Type A hepatitis virus is a relatively benign pathogen causing temporary disability and to which there is a high probability of immunity in the population. Furthermore, the probability for its occurrence in soiled diapers is quite low. On the other hand, Type B hepatitis virus is a tremendously virulent pathogen to which there is a low probability of immunity in the population. The health significance for this virus is, however, again minimized by the extremely low probability of its occurrence in soiled diapers. Adenoviruses are of little health concern because of the benign character of diseases they may cause in humans and the relatively low probability of their occurrence in soiled diapers.

b. Fate of Pathogens in the Landfill Environment: In the above discussion, it has been shown that human bacterial and viral pathogens can occur in and be isolated from solid waste, and that one potentially significant source of such pathogens is human fecal matter discarded in disposable diapers. However, to gain a better appreciation for the extent of the health threat, it is necessary to look at the fate of microorganisms in the landfill environment and the extent to which viable organisms leach from this environment.

Bacteria: Blannon and Peterson (1) investigated the survival of fecal coliforms and fecal streptococci in a full-scale sanitary landfill over an 11-month leachate production period utilizing mixed municipal solid waste. The results of this investigation revealed that high densities of fecal coliforms and fecal streptococci occurred in leachates during the first 2-month leaching period, with a rapid die-off of fecal coliforms noted 3 months after placing the fill. Fecal streptococci persisted past the 3-month sampling period. Furthermore, the 18-inch clay soil lining underneath the solid waste was observed to offer poor filtration action on the bacteria. In view of these findings, the authors concluded "...that leachate contamination, if not controlled, may add a pollutional load to the recreational and groundwater supplies and present a risk to the public using these waters."

In an attempt to determine the effect on leachate bioload, Cooper et al. (7) added fecally contaminated diapers to a simulated sanitary landfill. Overall, large numbers of bacteria of potential sanitary significance were present.

However, the high background levels of fecal coliforms and fecal streptococci made it impossible to measure the impact of the addition of feces and diapers. The low ratio of fecal coliform to fecal streptococci in freshly collected and ground refuse indicated animal waste (cats, dogs, etc.,) to be the most predominant source of these indicator organisms.

Further information on bacterial decay rates is provided by Engelbrecht (11). Fecal coliforms, fecal streptococci and Salmonellae typhimurium was added to whole leachate at two different temperatures (22°C and 55°C) and at two different pH values (5.3 and 7.0). Persistence of enteric bacteria in leachate was found to be less at the higher temperature and lower pH value. The order of stability in the leachate at 55°C at both pH values was: S. typhimurium > Fecal streptococci >> Fecal coliforms.

Viruses: In a continuation of the same study cited above, Cooper et al. also assessed the presence of viruses in leachate under normal conditions and with the addition of fecally contaminated diapers. The dosage of feces added was approximately 0.02 percent by weight, roughly equivalent to the amount found by Peterson in the previously mentioned study. Virus recovered from the leachate of the inoculated fill amounted to 150 and 2,310 PFU per gallon during the second and third weeks of leachate production, respectively. The control landfill produced 380 PFU per gallon of leachate the third week only.

Noteworthy here is the fact that in each case where viruses were detected in leachate, the associated landfill had been brought to field capacity (saturation point) over a 3-week period to simulate exaggerated rainfall conditions. No viruses were detected in leachate from fills brought to field capacity gradually over a 15-week period to simulate normal rainfall conditions for the area.

After the third week of production, all samples were negative. Since the control was also positive, the authors concluded that the addition of viruses through human feces had no discernable effect on the recovery of viruses.

At the termination of the experiment, the contents of the control fill and two fills to which soiled disposable diapers had been added were removed and assayed for the presence of viable viruses. No viruses were recovered from these materials, indicating that both indigenous and added viruses did not survive at detectable levels through the test period.

In a study by Sobsey et al. (72) the survival and fate of two enteroviruses (polioviruses type 1 and echovirus type 7) in simulated sanitary landfills was examined. After inoculating the solid waste contents of the fills with large quantitites of the above enteroviruses, the fills were saturated with water over a 3-1/2 week period to produce leachate, which was then analyzed for viruses. Although 80 percent of the total leachate produced by each fill over the test period was so analyzed, no viruses were detected. Furthermore, analysis of the refuse itself following the conclusion of the leachate analysis revealed no detectable viruses.

In part, this outcome is explained by the tendency of viruses to adsorb onto components of the solid waste and thus resist leaching. A further explanation lies in the determined natural toxicity of the leachate itself. The leachate was evaluated to determine the extent of its toxicity to viruses. More than 95 percent of inoculated viruses were inactivated over a 2-week exposure period at 20°C and more than 99 percent were inactivated within 6 days at 37°C.

The results of the above investigation were duplicated by Engelbrecht (11) in a similar experiment, using poliovirus, reovirus and Rous sarcoma to seed the simulated landfills. No viruses were recovered from leachate samples collected throughout the 76-day test period. As was the case above, inactivation studies showed the leachate to be toxic to viruses.

c. Conclusion: Evidence has been presented to indicate that fecal material in soiled disposable diapers may represent as [redacted] percent by weight of normal mixed municipal refuse, and that they may be a significant contributor of microorganisms of potential sanitary significance. However, it has also been shown that the normal bioload of solid waste without diapers is extremely high, due mainly to the presence of fecal matter from domestic animals. This source also contains large numbers of microorganisms of potential sanitary significance.

Due to this large naturally-occurring bioload in solid waste, attempts to demonstrate an increase in bioload from the addition of fecal contamination from diapers to 0.02 percent by weight have been unsuccessful. These findings thus establish that, at 0.02 percent by weight, fecal contamination from diapers does not add an amount of either bacteria or viruses in the leachate which can be detected over and above the background level.

Attempts at determining the public health significance of the bioload from solid waste have centered around occurrence of viable organisms in leachate. In general, the physical characteristics of the landfill environment are inhospitable to survival and growth of microorganisms. In addition, the leachate emanating from a landfill appears to be toxic.

However, it has been clearly demonstrated that viable bacteria can and do leach from the landfill in large numbers, thereby representing a source of contamination to ground and/or surface water supplies and a possible health threat to anyone using this water as a potable water supply. Unlike bacteria, experiments measuring virus occurrence in leachate have revealed conflicting results. One investigator was able to detect viruses from a rapidly saturated fill while others, using similar techniques, were not. It is fairly well-established, however, that leachate is quite toxic to viruses and that adsorption of viruses to solid waste components does occur. It has been shown that more than 99 percent of all inoculum viruses can be inactivated within 6 days at 37°C following introduction into landfill leachate. And yet, one investigator has detected viruses in leachate up to 3 weeks after onset of leachate production. In view of the lack of consistency in the published literature on the topic, no clear understanding of the public health threat represented by viruses in solid waste can be reached.

With regard to public health significance of disposing of fecally contaminated disposable diapers in the solid waste stream, conclusions are even more difficult to reach. However, to the extent that such material does contain microorganisms which may leach into water supplies, some potential for a public health threat to the consumers of that water may exist. However, the actual bioload contribution from this source is yet unclear, as in the relationship between degrees of contamination of the water supply and the relationship to disease development. Therefore, no final statement on the public health significance of discarding disposable diapers into the solid waste stream can be made.

Based on the foregoing data, several conclusions can be formulated:

1. Although disposable diapers were associated with a greater incidence of diaper rash than hospital-laundered cloth diapers in one study, they performed as well as commercially laundered diapers in another study. On the basis of these conflicting results, no definitive statement can be made regarding the relative effects of the two types of diapers in inhibiting rash development.

2. The average home-laundered diaper is inferior to both the disposable and commercially laundered diaper in terms of sterility and pH balance.[1] Although no precise relationship exists between bacterial count and type of bacteria present in a diaper and the development of diaper rash, bacteria do contribute to the incidence of rash. An NIIS diaper service undoubtedly provides the superior laundering method, with its maximum allowable count of 20 colonies per square inch. A regular commercial laundry, while probably not meeting this exacting standard, would likely produce a more sterile diaper than a home laundry due to higher wash temperatures, longer cycles, and types of additives used.[1] Disposables also meet a high standard of sanitation, with less than two colonies of bacteria per square inch; and they provide a favorable pH balance averaging 7.0.

V. SHEETS

Health and sanitation concerns relating to institutional bedding are among the most significant within the scope of this study. Not only are

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1 See comments Appendix D, page 59.

linens subjected to a greater degree of contamination in the hospital or nursing home setting (the primary institutional environments being considered here), but the users of these linens tend to be much more susceptible to infection than is the general populace. Because of these considerations, bedding for institutional applications must meet rigorous standards of cleanliness and sanitation to ensure that its role in cross-infection is kept to an absolute minimum.

The patient bed sheet, which is the focus of this investigation, is a virtual repository of bacteria. Several studies have emphasized the significance of skin desquamation in spreading microorganisms; the average human desquamates an entire layer of skin over a 1- to 2-day period, which is in large part deposited onto the bed sheet when the patient is hospitalized or otherwise bedridden. These skin scales, as established in a study by Davis and Noble, harbor a variety of potentially pathogenic bacteria. Additionally, the patient may excrete urine or feces onto the sheet, or he may have wounds which produce pus and/or blood. All of these factors interact to render the bed sheet contaminated, and thus the object of intense scrutiny in evaluating institutional standards of health and sanitation.

Greene (20) states two general contamination control objectives within the hospital:

1. "(To) minimize the microbial contamination level of the environment by curtailing dissemination of contaminants from soiled and used fabrics.

2. (To) minimize the probability of microbial transmission from infected reservoirs to susceptible hosts by destroying or removing microbes on used linen before it is reissued to patients and personnel."

The first concern relates primarily to linen handling--making and stripping of patient beds, transport of linens to, from and within the hospital laundry--while the second issue focuses on the effectiveness of laundering techniques in destroying bacteria.

Greene notes that improper linen handling is a major cause of airborne contamination; he cites studies which have shown significant increases in bacterial counts in areas where soiled linens were being shaken, removed from laundry chutes, and stripped from patient beds. As discussed in an earlier section, this type of agitation represents a major factor in the release of microorganisms from fabrics.

A 1971 study by Litsky and Litsky compared bacterial shedding during bed-stripping of reusable and disposable linens in a nursing home environment. The Litskys' work was based on earlier studies which had concluded that "measures adopted to stop fiber shedding from cotton goods must...assume a high priority in the reduction of the hospital loads to which the debilitated hospital patient is exposed," (28, page 33). The Litskys compared the conventional reusable cotton sheets to a newer disposable sheeting material to determine whether the airborne particles generated during bed-making could be minimized. Air samples were collected: (1) prior to bed-making; (2) during bed-making; and (3) during bed-stripping, in an actual patient room housing four ambulatory patients. Additionally, air samples were taken in a laboratory chamber where clean and soiled reusable and disposable linens were shaken to release adherent particles.

Tables 14 through 17 present the results of these tests. As shown in Table 14, airborne bacterial counts of viable organisms resulting from bed-stripping of disposable sheets were approximately 86 percent less than those taken during stripping of reusables; during bed-making, counts for disposables were 60 percent less. Counts of nonviable particles are shown in Table 15; again, counts were markedly reduced for disposables. In laboratory chamber tests, the disposables again showed significantly lower counts of viable microorganisms and nonviable particles, on three different types of linen articles. Table 17 indicates that even the clean reusables shed 2 to 3 times more (nonviable) particles than did the clean disposables. The authors venture the following suppositions to explain their findings: "(1) The surface of the disposable linen is smoother and thereby produces fewer particles of lint which may become airborne vectors bearing microorganisms; and (2) the weave of the disposable fabric is such that the pore size is smaller than cotton and thereby entraps more microbes," (Page 34).

Repeated attempts during the course of this study to elicit additional data regarding sanitation of disposable sheets for patient beds were largely unsuccessful. In the absence of data from the appropriate association and from manufacturers, we can only observe that, although disposable bed sheets may have an advantage over reusables in reduced bacterial shedding, sufficient information is not available to formulate general conclusions regarding their sanitation.

Turning to reusable sheets, it is obvious that both of Greene's concerns are relevant. Not only must they be properly laundered so that bacteria are destroyed, but they must be handled in such a way as to prevent

TABLE 14

COUNTS OF VIABLE AIRBORNE MICROORGANISMS DURING BED-MAKING WITH DISPOSABLE AND REUSABLE LINENS

	Number of Microorganisms Per Ft^3 of Air	
Activity	Reusable Linens	Disposable Linens
None	39	21
Bed-Making	103	42
Bed-Stripping	312	47

Source: Litsky, Bertha, and Warren Litsky, "Bacterial Shedding During Bed-Stripping of Reusable and Disposable Linens as Detected by the High-Volume Air Sampler," (28).

TABLE 15

COUNTS OF NONVIABLE AIRBORNE PARTICLES DURING BED-STRIPPING WITH DISPOSABLE AND REUSABLE LINENS

	Average Particle Count x 10^3 per 100 Seconds	
Activity	Reusable Linens	Disposable Linens
Normal	2,021	579
Stripping of Bed 1	2,088	656
Stripping of Bed 2	2,215	756
Stripping of Bed 3	2,355	755

Source: Litsky, Bertha, and Warren Litsky, "Bacterial Shedding During Bed-Stripping of Reusable and Disposable Linens as Detected by the High-Volume Air Sampler," (28).

TABLE 16

NUMBER OF VIABLE MICROORGANISMS DISPERSED INTO THE AIR BY SHAKING OF NATURALLY SOILED LINENS

	Number of Microorganisms Per Ft^3 of Air					
Minutes After	Pillow Case		Bottom Sheet		Flat Sheet	
Shaking	Reusable	Disposable	Reusable	Disposable	Reusable	Disposable
4	148	61	4,790	262	2,630	209
5	130	37	4,700	127	1,940	175
6	369	21	3,070	173	1,470	108
7	60	23	1,780	137	967	100
8	101	45	1,060	109	554	54
10	69	8	456	49	317	23

Source: Litsky, Bertha, and Warren Litsky, "Bacterial Shedding During Bed-Stripping of Reusable and Disposable Linens as Detected by the High-Volume Air Sampler," (28).

TABLE 17

NUMBER OF NONVIABLE AIRBORNE PARTICLES DISPERSED INTO THE AIR BY SHAKING OF LINENS FOR 1 MINUTE IN LABORATORY CHAMBER

Time in Seconds After Shaking	Average Particle Count x 10^3 Per 100 Seconds[a/]											
	Pillow Case				Bottom Sheet				Flat Sheet			
	Disposable		Reusable		Disposable		Reusable		Disposable		Reusable	
	Clean	Soiled	Clean	Soiled	Clean	Soiled	Clean	Soiled	Clean	Soiled	Clean	Soiled
0	59	77	60	87	62	185	175	100	78	126	187	209
200	54	56	51	57	65	180	179	210	61	90	180	230
800	22	16	25	49	60	164	157	201	52	81	166	189
1,300	10	38	17	38	50	74	101	167	47	62	89	130

Source: Litsky, Bertha, and Warren Litsky, "Bacterial Shedding During Bed-Stripping of Reusable and Disposable Linens as Detected by the High-Volume Air Sampler," (28).

a/ Expressed as counts x 10^3 above the base line count of the chamber prior to installation of linen.

recontamination. The Joint Commission on the Accreditation of Hospitals (JCAH) requires that hospitals launder their linens at a temperature of 160° for a total exposure time of 25 minutes. At this temperature and time, virtually all pathogenic bacteria are killed without the necessity of using chemical additives; however, many hospital laundries, such as one visited in Kansas City, Missouri, do employ bleach, sour and softener, and some add a bacteriostatic agent as well. Hospitals are also required to have separate rooms for clean and soiled linens, so that bacteria released during the sorting process will not contaminate clean linens which are being folded and loaded onto carts.

The significance of water temperature in the laundering of hospital linens is verified by a study performed by Walter and Schillinger in 1975 (80). As part of their investigation, bed linens from the isolation section of a hospital were checked for bacterial counts before and after laundering, with the laundering process employing a range of water temperatures. Table 18 shows the results of five of these tests.

TABLE 18

NUMBERS OF BACTERIA PER SQUARE CENTIMETER FROM SOILED HOSPITAL ISOLATION PATIENT LINEN BEFORE AND AFTER LAUNDERING

Cycle	Run 1	Run 2	Run 3	Run 4	Run 5
Washing Temperature (F)	100	100	110	110	120
Before Laundering Mean Bacterial Count	70	288	758	9,550	6
After Laundering Mean Bacterial Count	0.0	23	0.0	3.98	

Source: Walter, William, and John Schillinger, "Bacterial Survival in Laundered Fabrics," (80).

The exceedingly high bacterial count in Run 4 (prelaundering) was the result of a patient's leg wound draining onto the linen; however, even at the relatively low temperature of 110°, the postlaundering count was reduced to approximately 4 organisms per square centimeter. Overall, Walter and Schillinger found that none of the water temperatures they employed gave consistently adequate results in terms of bacterial destruction. They recommend a water temperature of 140° for 10 to 13 minutes, followed by drying, for linens used in health care facilities. They also note that bleach provides an added degree of safety.

Recontamination is also of concern in the consideration of reusable hospital linen. Although sheets may be rendered free of all pathogens by the laundering process, they may be recontaminated during subsequent stages of drying, ironing, folding, and distributing. The study by Church and Leosli (6), which was referenced in the chapter on general sanitation concerns, investigated recontamination problems in a hospital laundry as well as in a commercial laundry. The findings were quite similar: fabrics became recontaminated during water extraction in the spin dryer and during the folding process, with high bacterial counts found near the sorting table, near the extractor at the end of the extraction process and near the dryer and folding table. As noted in the earlier reference to Church and Leosli's study, these recontamination problems are related to laundry layout; measures such as improved ventilation and screening of areas showing high bacterial counts are recommended to decrease bacterial redeposition.

In the investigation of sheets in the institutional setting, as well as the examination of other cloth products within the scope of this study, it becomes obvious that adequate sanitation can be achieved, given the proper elements of laundry technique, handling methods and prevention of recontamination. Undoubtedly, because of the regulations of the JCAH, hospital linens achieve a higher and more consistent degree of sanitation than any of he other products, with the possible exception of diapers laundered by a diaper service. This emphasis is reassuring in light of the necessity for providing a relatively aseptic environment for the hospital patient.

VI. DISPOSABLE AND REUSABLE FOODSERVICE1/ WARE[1]

A. Introduction

Public health personnel have long been concerned with the role of improperly cleaned eating utensils in the spread of communicable disease. Early evidence supporting this concern was presented by Ravenel and Smith in 1909 (26). Their investigation of a typhoid fever outbreak implicated eating utensils as the link in the chain of transmission between the carrier host and the affected population.

In 1919 and 1920, Cumming (26) and his associates reported the results of their extensive epidemiological investigations into utensil/disease relationships. Looking at influenza among Army troops, patrons of commercial eating establishments, and influenza-pneumonia occurrences in institutions, these investigators amassed a significant amount of evidence indicating improperly sanitized food utensils as a leading avenue of transmission of

1/ The term "foodservice," when used as an adjective, is considered to be one word, in accordance with contemporary usage. However, titles of references and quotations cited in this section often utilize the original two word or hyphenated format.

[1] See comments Appendix J, page 13-16.

sputumborne and intestinal infections. In 1933, MacDonald and Freeborn (26) concluded a review of their own and others' work in this area by making the following points:

1. "There is undoubted evidence of the transmission of some of the communicable diseases through the medium of improperly disinfected eating utensils in private homes and public eating places;

2. There is lack of appreciation on the part of the public of the possible danger of disease transmission through improperly sterilized eating utensils;

3. The sanitation of many restaurants, hotels, etc., is far below the accepted standard of cleanliness and safety; and

4. One of the best means of preventing many of the sputum-borne and intestinal infections both sporadically and epidemically is by means of proper sterilization."

As a result of these and other similar findings, the U.S. Public Health Service was prompted to draft regulations to govern the washing, storage and use of foodservice utensils. After field trials, this ordinance and code was revised and published in 1940 under the title Ordinance and Code Regulating Eating and Drinking Establishments--Recommended by the U.S. Public Health Service. The code, subsequently revised in 1943 and again in 1962, has been adopted by the majority of the states and over 1,000 county and municipal health jurisdictions. A proposed revision, which would change the method for recording sanitation violations and establish a new scoring system for classifying restaurant sanitation, was published in the October 1974 Federal Register.

This section of the report will examine the standards governing foodservice ware, both reusable and disposable, and then will present the results of the literature review undertaken to determine the compliance of the products specified within the scope of this study (paper and plastic cups and plates, melamine and china plates, and glassware).

B. Standards

1. U.S. Public Health Service "Model Food Service Sanitation Ordinance and Code": As an integral part of the foodservice industry, reusable and disposable utensils are regulated by certain standards to ensure their sanitation. The most significant standard is the U.S. Public Health Service "Model Food Service Sanitation Ordinance and Code (1962)." This standard was established as a guideline for states and municipalities to follow in their regulation of the foodservice industry. Currently, 44 of the 50 states have adopted this Model Ordinance as the basis for their sanitation codes. In turn, the states recommend the ordinance to municipalities as a guideline in the establishment of local standards. Although municipalities are not required to adopt the ordinance, their standards must be at least as stringent. Additionally, the states may receive assistance in regulating foodservice establishments through the Food Service Sanitation Program (FSSP), a voluntary, cooperative service provided by FDA. Generally, the states retain jurisdiction over nursing homes, interstate carriers, and areas not governed by a municipal or local health authority; additionally, the state health agencies act in an advisory capacity to the municipalities within their boundaries.

The PHS Model Ordinance, as a generally accepted sanitation code, provides specific regulations relating to foodservice ware, both reusable and disposable. The relevant provisions of the Ordinance are as follows:

Section D: Food Equipment and Utensils

1. Sanitary Design, Construction, and Installation of Equipment and Utensils. This subpart provides that "all...utensils shall be so designed and of such material and workmanship as to be smooth, easily cleanable, and durable, and shall be in good repair; and the food-contact surfaces of such ...utensils shall, in addition, be easily accessible for cleaning, nontoxic, corrosion resistant, and relatively nonabsorbent." It also specifies that "single-service articles shall be made from nontoxic materials." This regulation is augmented by the FDA's Food, Drug and Cosmetic Act, which governs the composition of food packaging materials under its food additive provision.

   The Ordinance provides the following explanation for its cleanability standard: "Items of equipment and utensils which are poorly designed and constructed, and which are not kept in good repair, are difficult to clean thoroughly and are apt to harbor accumulations of food and other soil which supports bacterial growth." The durability standard is also expanded to include the following: "All...utensils shall be so durable under normal conditions and operations as to be resistant to denting, buckling, pitting, chipping, crazing and excessive wear; and shall be capable of withstanding repeated scrubbing, scouring, and the corrosive action of cleaning and sanitizing agents and food with which they come in contact."

2. Cleanliness of Equipment and Utensils. The second subpart provides that:

   * All eating and drinking utensils shall be thoroughly cleaned and sanitized after each usage.

   * After cleaning and prior to use, all food-contact surfaces of equipment and utensils shall be so stored and handled as to be protected from contamination.

   * All single-service articles shall be stored, handled, and dispensed in a sanitary manner, and shall be used only once.

   * Foodservice establishments which do not have adequate and effective facilities for cleaning and sanitizing utensils shall use single-service articles.

   The Ordinance provides the following explanation for its cleaning and sanitizing regulations: "Regular, effective cleaning and sanitizing of equipment, utensils, and work surfaces minimizes the chances for contaminating food during preparation, storage, and serving, and for the transmission of disease organisms to customers and employees. Effective cleaning will remove soil and prevent the accumulation of food residues which may decompose or support the rapid development of food-poisoning organisms or toxins. Application of effective sanitizing procedures destroys those disease organisms which may be present on equipment and utensils after cleaning, and thus prevents the transfer of such organisms to customers or employees, either directly through tableware, such as glasses, cups, and flatware, or indirectly through the food."

"Improper storage of equipment and utensils, subsequent to cleaning and sanitizing, exposes them to contamination and can nullify the benefits of these operations. Accordingly, storage and handling of cleaned or sanitized equipment and utensils, and single-service articles, must be such as to adequately protect these items from splash, dust, and other contaminating materials."

Subpart 2 describes the procedures considered adequate in washing and sanitizing utensils. The initial washing cycle involves preflushing or prescraping to remove excess food particles, washing in suitable detergent either by hand or by machine, and sanitizing by one of the following methods[1]:

a. Immersion for at least 1/2 minute in clean hot water at a temperature of at least 170°F.

b. Immersion for at least 1 minute in a sanitizing solution containing:

1 See comments Appendix J, pages 38-39.

- At least 50 ppm of available chlorine at a temperature not less than 75°F; or
- At least 12.5 ppm of available iodine in a solution having a pH not higher than 5.0 and a temperature of not less than 75°F; or
- Other sanitizing solution determined by the health authority to be equivalent in strength to 50 ppm of chlorine.

Other types of machines, devices, facilities and procedures may be approved if they provide bactericidal effectiveness "as demonstrated by an average plate count per utensil surface examined, of not more than 100 colonies." Specific regulations are promulgated for manual washing, such as the requirement for three sinks for washing, rinsing and sanitizing utensils; and for machine washing, including the stipulation that wash-water temperature shall be at least 140°F (160°F in single-tank conveyor machines), with 180°F water at the manifold for sanitization in the final rinse (if hot water sanitization is used).
This subpart also provides regulations regarding storage of single-service articles. They must be stored in closed cartons or containers and handled and dispensed in such a way as to prevent contamination.[1]

[1] See comments Appendix J, pages 26-27.

The health departments of the six states not using the PHS Model Ordinance were contacted during this study to determine what regulations they have adopted for foodservice ware. Only three states--Nebraska, Iowa and Maine--responded to these inquiries. In these states, foodservice regulations are basically similar to those of the Model Ordinance, except that Iowa has not established standards for single service ware.

2. National Sanitation Foundation Standards: In addition to the mandatory standards adopted by local governments in accordance with the Model Ordinance, many manufacturers of foodservice ware and equipment voluntarily comply with standards established by the National Sanitation Foundation (NSF). The Public Health Service, in order to encourage uniformity of standards, cooperates wth NSF and other organizations in the development of consistent criteria. Two NSF standards of special interest in this study are NSF Standard No. 36 for Dinnerware and NSF Standard No. 3 for Commercial Spray-Type Dishwashing Machines.

The NSF Dinnerware Standard relates to new, reusable dinnerware intended for use in foodservice establishments. It sets forth basic requirements of cleanability, durability, shape and contour much like the standards found in the USPHS Model Ordinance. However, NSF establishes a testing procedure for determining cleanability and durability to which dinnerware must be subjected in order to receive the NSF seal. Durability is determined by exposing the dinnerware to 150 cycles of normal "use environment," including washing, rinsing, sanitizing, stacking, and knife cutting, and then testing its cleanability. Cleanability following exposure must be not less than 98.5 percent of initial cleanability, tested by laboratory methods involving precise soiling techniques, consistent washing procedures, and counting of soil residuals by the use of radioisotopes.

The NSF Standard for Commercial Dishwashing Machines designates water temperature requirements, flow pressures, prewashing procedures, stacking techniques and other variables for the different types of commercial dishwashing machines on the market. The Standard basically follows the Model Ordinance in its temperature specifications and related factors in achieving acceptable levels of sanitation for permanent ware.

3. Single Service Standards: The single service industry has its own policing mechanism--the Food Protection Laboratory of the Syracuse Research Corporation. The Laboratory has been testing single service cups since 1947, and plates, since 1967, utilizing methods specified in Public Health Service Publication 1465, Fabrication of Single Service Containers and Closures for Milk and Milk Products. Both the laboratory and its testing personnel are certified by the USPHS, under FDA.

Single service container manufacturers routinely submit product samples to the Food Protection Laboratory, where their conformance with the bacteriological standards of Publication 1465 is tested. Products may not show evidence of coliform bacteria, and no more than one colony of noncoliform bacteria is allowable per square centimeter of food or beverage contact surface (50 colonies per 8 square inches).

C. Compliance of Reusable Foodservice Ware (Permanent Ware)

As is the case with cloth products, the major health concerns relating to permanent foodservice ware are its cleanability and the effectiveness of washing procedures in producing sanitary cups, plates and glassware. And, like fabric laundering, dishwashing encompasses a wide range of variables, including water temperature, chemical additives, handling techniques and the degree of competence exhibited by personnel. The history of foodservice sanitation has been summarized in "Single Use Cups and Plates: A Review of the Available Literature," (26) a brief synopsis of which follows:

Since the early 1900's, when disease transmission was first linked to unsanitary utensils, the literature has addressed virtually all of these variables. In the 1940's, investigators noted that ignorance among foodservice workers as to proper washing times, temperatures and detergents resulted in sanitation problems. By the late 1940's, surveys of dishwashing practices in commercial establishments continued to show high bacterial counts on washed foodservice ware; however, at that time many facilities were still employing manual washing procedures, while in cases where machines were being used, workers often operated these machines improperly. Kleinfeld and Buchbinder concluded at this time that "satisfactory dishwashing practice lies in conversion to machine and the intelligent operation of this satisfactory equipment."

In 1950, "Minimum Requirements for Effective Machine Dishwashing" were developed by the Committee on Sanitary Engineering and Environment of the National Research Council. The Committee set a standard of less than 100 microorganisms per utensil surface, which they believed could be consistently attained through current dishwashing methods. (This standard has been continued through the USPHS Model Ordinance.)

Within the institutional setting, inadequacies in foodservice ware sanitizing practices have also been found to relate to poor processing techniques rather than to the type of ware or the equipment available to clean and sanitize it. Wehrle (82) reiterated the reliability of proper machine dishwashing in his study of "Food Service Procedures on Communicable Disease Wards," in which he states that disposables, though used for convenience, are not necessary (even for patients with highly infectious diseases) "since the usual mechanical dishwasher, properly maintained and operated, will remove hazardous microorganisms likely to be found on any eating utensil," (Page 466)[1]. Investigators such as Litsky, Lloyd, Jopke and Hass in the late 1960's and early 1970's reemphasize the problems of poor sanitation techniques among hospital foodservice workers, as well as improper environmental exposure of clean utensils.

The preceding synopsis suggests that the sanitation of foodservice ware has remained an active concern of health professionals over the years. In evaluating the sanitary status of permanent foodservice ware, three major foci of discussion emerge:

1. The cleanability of the permanent ware surface; i.e., its resistance to cracking, scratching and chipping, all of which render the product less amenable to thorough cleaning;

2. The effectiveness of dishwashing practices; i.e., the efficiency of machines, water temperatures used, detergents added and the competence of machine operators;

3. Handling and storage of dishes after washing; i.e., impacts of airborne contaminants and contamination from the soiled hands of hospital

personnel. Also involved in handling is the possibility of breakage of china and glassware.[1]

The following sections of this report will address each of these factors and will present the results of the numerous studies which have investigated permanent ware sanitation.

a. Surface Cleanability: The issue of cleanability was most significant in the 1950's, when reusable plastic foodservice ware was initially being marketed. Whereas china had been the dominant dinnerware product for centuries, the new plastics were a relatively unknown entity which were closely scrutinized to determine their comparability to chinaware.

China has a very hard, nonporous, nonabsorbent, and highly durable surface which is easily cleanable. In a 1953 study, Ridenour and Armbruster (63) compared the cleanability of china to that of plastic (type not specified). They found that 98 to 99 percent and over of various types of test bacteria could be removed from the china surfaces, while plastic showed only a 56 to 84 percent rate of bacteria removal. China surfaces also provided a high degree of cleanability after a period of natural wear and in the presence of a food film buildup, while plastic performed much less favorably in these two areas. Presumably, the surfaces of the early plastic dishes, unlike today's plastic utensils, were softer and more susceptible to scratching, scoring and deterioration through normal usage, thus reducing their degree of cleanability.

Mallman et al. (33) found no significant differences between melamine and vitreous china in cleanability, bacterial survival, and staining.

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[1] See comments Appendix J. pages 31-33.

Mallman's findings are consistent with the current status of the two products. Refinements in the composition of melamine have resolved early cleanability problems. The manufacturers of 99 percent and over of all melamine currently marketed in the United States comply with the NSF Dinnerware Standard.[1/] As previously described, this standard specifies that permanent ware must be able to withstand rigorous testing of its durability, cleanability, shape and contour.

In light of this fact, early studies indicting plastic permanent ware can no longer be considered relevant, and melamine should now be viewed as equivalent to china in surface cleanability.

b. Effectiveness of Washing and Sanitizing Procedures: The effectiveness of washing and sanitizing procedures for permanent ware is summarized by Mallman in his study of "Sanitation with Modern Detergents," (32) "Any discussion of cleaning and sanitizing must be prefaced by commenting upon personnel...A cleaning procedure is no better than the worker. No matter how good the cleaning agent is, its usefulness will depend entirely upon how the worker uses it--the concentration--the time of application--the amount of brushing--collectively spell the degree of cleaning attained. The cleaning attained is determined by the worker," (32, Page 54). Thus, the human factor is ultimately of far greater significance than are the washing and sanitizing procedures themselves. Although there is a trend toward mechanization of detergent dispensing and other elements within the total process, human variables still play a role in utensil sanitation.

1/ Dave Ettinger of Silite, Inc., in telephone interview.

With this understanding, it is important to present briefly the factors which contribute to the washing and sanitizing of foodservice ware:

(1) Preflushing or Prescraping: This action is usually provided by water pressure during a prerinse cycle, which removes the gross soil and excess food particles, thus assisting in the actual washing process.

(2) Water Temperature: Maximum soil removal appears to occur at temperatures from 130° to 140°F. Lower temperatures tend not to remove fats, and higher temperatures can cook proteins, causing them to adhere to utensil surfaces. Higher temperatures (170° or above) are, of course, required in the final rinse for sanitation.

(3) Chemical Detergents: The detergent supplements the action of the water and enhances removal of the grease film left by fats. Types and amounts of detergents should be selected in accordance with water composition, and detergent solutions should be maintained with a minimum of suspended soil, so as to prevent redeposition of bacteria on cleaned utensils.

(4) Rinsing/Sanitizing: This last step can be accomplished with hot water at 170° or above or with chemicals. The latter method is effective only if the dishes have been thoroughly cleaned, since sanitizing agents cannot penetrate food particles or food film (32).

As discussed in the previous section on foodservice standards, certain portions of the foregoing process are closely regulated by health agencies. Though the type and amount of detergent and precise wash water temperature are not specified in the Model Ordinance, sanitization procedures are clearly defined and, of course, require proper preparation of the utensils through washing so that sanitization will be effective.

Despite the existence of fairly standardized washing and sanitizing procedures and of the regulatory activity supplied through FSSP, the Model Ordinance, and state and local health agencies, concern continues to exist over the degree of compliance of foodservice establishments with these procedures and regulations. The major study of restaurant compliance encountered during the course of this investigation was undertaken by the General Accounting Office in 1974 (61). At GAO's request, the Food and Drug Administration inspected, from January through March 1974, 185 restaurants selected at random from 14,736 restaurants in nine metropolitan cities. Results were recorded on the Food Service Establishment Inspection Report, based on the regulations stipulated within the FDA Model Ordinance. Sample results were projected to apply to the 14,736 restaurants in the original inventory. Overall, 89.8 percent were considered to be "inadequate," and thus, according to the GAO, "insanitary."

The term "inadequate," as defined in the study, means that "Significant public health violations exist. Restaurants could be operating under conditions where food may have become contaminated with filth or rendered injurious to health. Deficiencies should be corrected immediately."[1/]

In its response to the GAO Report, the National Restaurant Association (NRA) (49) points out that: (1) The sample upon which the survey

1/ It is important to note that a restaurant can exhibit many violations not related to foodservice ware; e.g., insect or rodent infestation, improper refrigeration, etc.

is based is not distributed proportionately to the distribution of the total estimated universe; e.g., in city E, the total inventory of restaurants is 8,927, or 60.6 percent of the estimated universe (14,736), whereas the sample size for city E was only 35, or 18.9 percent of total sample size (185). While the sample within each city may be considered representative of restaurant conditions in that particular city, it is not valid to total the samples and project an overall percentage of restaurants exhibiting "insanitary" conditions.[1/] The term "insanitary" is used synonymously with the word "inadequate." Although the study did find a majority of restaurants sampled in each city to be "inadequate," it does not necessarily follow that they are unsanitary. By the GAO's own definition, these restaurants "could be" operating under conditions potentially injurious to human health. The distinction must be made, as it has throughout this report, between the potential for health problems and the existence of definably pathogenic conditions. Again, there is no clear relationship between "inadequate" foodservice sanitation and an attendant threat to the public health.

Although the GAO study should not, in light of the preceding discussion, be interpreted as a flawless indictment of restaurant sanitation, its findings in regard to sanitation of foodservice ware are noteworthy for the purposes of the present investigation. Table 19 shows the percentage of the total restaurants sampled, exhibiting violations related to foodservice ware.

1/ This analysis of the statistical sampling procedure was confirmed by consultations with two MRI statisticians.

TABLE 19

SUMMARY OF SANITATION VIOLATIONS RELATING TO FOODSERVICE WARE

Item	Number of Violative Restaurants	Percent of Sample in Violation
Tableware clean to sight and touch	24	12.9
Utensils and equipment preflushed, scraped, or soaked	2	1.0
Tableware sanitized	52	28.1
Facilities for washing and sanitizing equipment and utensils approved, adequate, properly constructed, maintained and operated	100	54.0
Wash and sanitizing water clean	9	4.8
Wash water at proper temperature	7	3.7
Adequate and suitable detergents used	2	1.0
Cleaned and sanitized utensils and equipment properly stored and handled; utensils air-dried	116	62.7
Suitable facilities and areas provided for storing utensils and equipment	77	41.6
Single-service articles properly stored, dispensed and handled	117	63.2

Source: "Report to the Congress by the Comptroller General of the United States: Federal Support for Restaurant Sanitation Found Largely Ineffective," (61).

As shown in the table, the major violations (involving more than half the restaurants sampled) relate to inadequate facilities for washing and sanitizing equipment and utensils, inadequate storage and handling of utensils and equipment; and inadequate storage, dispensing and handling of single service items. (The latter problem will be addressed in a later section on single service ware.) Since most facilities complied with the requirements regarding clean water, proper water temperature and adequate detergents, the assumption can be made that the deficiencies centered around the design and/or layout of dishwashing machines and the human variables previously mentioned.

The implications of these violations are difficult to assess. While 54 percent of the restaurants were reported as having inadequate washing and sanitizing facilities, only 28 percent showed failure to comply with the requirement that tableware be sanitized. This inconsistency would indicate, once again, that the ultimate level of sanitation of foodservice ware in commercial establishments is dependent upon a wide range of variables, which cannot be fully addressed through the vehicle of health inspection reports.

The GAO, however, implies that these violations contribute substantially to the "100,000 persons (who) became ill from foodborne diseases contracted in restaurants during 1970," (Page 1). This statistic, credited to the Center for Disease Control (CDC), disagrees with the actual CDC report (16) which shows a total of 24,448 persons becoming ill in 1970 as a result of 371 outbreaks, 114 of which occurred in foodservice establishments. Furthermore, very little information exists on the numbers and types of microorganisms typically found on serviceware utensils in foodservice establishments after washing.[1]

Relating to the practical relationship between the sanitary condition of machine-washed utensils and the associated public health threat, Dr. Marcus Harowitz of the Center for Disease Control in Atlanta offered the opinion that "the inoculum count of microorganisms left on foodservice ware after washing would likely be too low to cause disease," (52). However, the entire area of dose/response relationships between pathogenic organisms and disease is poorly understood and little documented.[2]

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1 See comments Appendix J. pages 27-30.

2 See comments Appendix J. pages 30-31.

Although it is accepted fact, even by the NRA, that there are problems in achieving total sanitation of foodservice ware in commercial foodservice establishments, inadequacies such as were found in the GAO study cannot be directly related to disease transmission. However, in the normal tradition of protective public health measures, precautions are taken to protect and preserve the public health whenever there is even a suspected potential for harm.

Another area in which foodservice ware has been studied is the use of beverage glasses in hotels and motels. Dr. Bailus Walker of the Environmental Health Administration undertook a 4-year bacteriological study of such glasses (78), and found that over 90 percent were unacceptable from the standpoint of bacteriological and aesthetic standards. The bacteriological standard of 100 organisms per glass was exceeded in over 80 percent of the glasses examined; and over 50 percent of these glasses contained pathogenic organisms, including streptococci and staphylococci.

Dr. Walker attributes this finding to the fact that in 40 of the 66 hotels/motels surveyed, the glass washing procedure involved rinsing the glasses in the wash basin with "hot" water, drying them with a bath towel and then repackaging them in bags labelled, "THIS WATERGLASS IS SANITIZED FOR YOUR PROTECTION." Although such practice was not the established policy of the hotel or motel, it was followed by the housekeepers as a time-saving, convenience measure.

Table 20 shows the bacterial count of beverage glasses rinsed in the hotel or motel rooms. Standard plate counts ranged from 1,000 organisms per glass to 100,000,000 organisms per glass, with Staphylococcus aureus

TABLE 20

BACTERIAL CONTENT OF BEVERAGE GLASSES WASHED AND SANITIZED IN HOTEL/MOTEL ROOMS

Location	Hotel/Motels Surveyed	Number of Glasses Examined	Standard Plate Count (Per Glass) Arithmetic Mean	Standard Plate Count (Per Glass) Range	Staphylococcus Aureus[a]	Streptococci[a]
Chicago	5	25	3.4×10^6	$2.4 \times 10^6 - 6.1 \times 10^6$	10/25	5/25
Cleveland	5	25	4.1×10^5	$1.0 \times 10^5 - 5.1 \times 10^5$	5/25	5/25
Detroit	2	10	6.0×10^6	$4.0 \times 10^6 - 7.0 \times 10^6$	5/10	2/10
Frankfort, KY	2	10	3.6×10^6	$2.5 \times 10^6 - 5.0 \times 10^6$	2/10	4/10
Lexington, KY	2	10	5.3×10^6	$3.1 \times 10^6 - 6.5 \times 10^6$	10/10	7/10
Minneapolis	4	20	4.3×10^7	$2.3 \times 10^7 - 7.0 \times 10^7$	5/20	--
New Orleans	3	15	9.1×10^6	$5.6 \times 10^6 - 9.7 \times 10^6$	15/15	5/15
Newark	3	15	3.3×10^5	$2.0 \times 10^5 - 5.1 \times 10^5$	8/15	11/15
Nashville	2	10	6.0×10^6	$2.0 \times 10^6 - 9.1 \times 10^6$	--	10/10
Philadelphia	5	25	8.3×10^7	$4.0 \times 10^7 - 10.0 \times 10^7$	18/25	20/25
Pittsburgh	2	10	1.0×10^3	$1.0 \times 10^3 - 2.0 \times 10^3$	3/10	10/10
Washington, D.C. (Maryland-Virginia)	5	25	5.0×10^6	$3.0 \times 10^6 - 7.0 \times 10^6$	20/25	8/25

Source: Walker, Bailus, Jr., "Bacterial Content of Beverage Glasses in Hotels," (78).
a/ Number of glasses positive/number of glasses examined.

and streptococci appearing on from 20 percent to 100 percent of the glasses tested. In contrast, as shown in Table 21, glasses washed in the central commissary, using standardized washing and sanitizing procedures, showed considerably lower counts. Although standard plate counts were higher than accepted bacteriological standards in all cases, no pathogenic organisms were detected in the commissary-washed glasses.[1] The author attributes this finding to the possibility of unnecessary handling which occurs between washing, prepackaging and distribution of the glasses to the rooms.

Several investigators have studied foodservice ware sanitation within the institutional setting. Lloyd et al. (30) surveyed the dishwashing facilities of five large (500 to 1,000-bed) hospitals and one children's orphanage in 1970 to determine the washing and sanitizing efficiencies of dishwashing machines. Microbiological testing was performed on the wash water of the dishwashers, the rinse water, the dish surfaces following washing and rinsing, and the air surrounding the dishwashing area. Table 22 shows the results of the wash and rinse water tests, in which staphylococci and enterococci were noted in the wash water at two institutions; and one showed staphylococci in the rinse water. The authors note that the water temperatures during the wash and rinse cycles were lower than has been recommended, attributing their microbiological findings to this fact. However, as shown in Table 23, dishware which had been washed and rinsed showed counts below the accepted microbiological standard in every case but one. Additionally, the number of airborne microorganisms was not found to be significantly affected by either activity or inactivity in the area of the dishwashing machines, indicating that the processing of the foodservice ware did not produce an increased bioload in the surrounding environment.

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[1] See comments Appendix J, page 37.

TABLE 21

BACTERIAL CONTENT OF BEVERAGE GLASSES WASHED IN CENTRAL COMMISSARY

Location	Hotel/Motels Surveyed	Number of Glasses Examined	Standard Plate Count (Per Glass) Arithmetic Mean	Range	Coliform (Per Glass) Arithmetic Mean	
Chicago	2	10	1,000	500 - 1,500	100	100 - 450
Cleveland	3	15	900	200 - 1,000	100	100 - 500
Detroit	3	10	600	400 - 1,000	200	100 - 300
Frankfort, KY	1	5	750	500 - 1,200	110	100 - 500
Lexington, KY	2	10	800	650 - 1,700	80	50 - 100
Minneaspolis	2	10	900	500 - 1,270	200	150 - 540
Newark	1	10	700	500 - 1,460	400	300 - 900
New Orleans	2	10	550	450 - 1,060	300	200 -1,000
Nashville	2	10	670	539 - 1,560	294	105 - 550
Philadelphia	3	15	1,000	500 -18,000	500	400 -1,100
Pittsburgh	2	10	1,200	1,000 - 1,400	700	300 - 900
Washington, D.C. (Maryland-Virginia)	3	15	1,000	900 - 1,600	90	50 - 700

Source: Walker, Bailus, Jr., "Bacterial Content of Beverage Glasses in Hotels," (78).

TABLE 22

THE OCCURRENCES OF DIFFERENT TYPES OF MICROORGANISMS IN WASH AND RINSE WATER SAMPLES COLLECTED FROM DISHWASHING MACHINES IN SELECTED MEDICAL INSTITUTIONS

Types of Organisms Tested	A	B	C	D	E	F
	Average Number Organisms per Millimeter of Water Samples[a]					
	Wash Water					
Total Count	59	1,250	230	155	3	--
Aerobic Spores	1	190	1	138	0	45
Anaerobic Spores	0	35	10	--	--	114
Coliforms	0	0	0	0	0	0
Staphylococci	0	250	0	0	10	10
Pseudomonas	0	0	0	0	0	0
Enterococci[b]	0	280	0	0	0	16
Molds	0	2	0	0	--	--
	Rinse Water					
Total Count	130	230	35	14	0	--
Aerobic Spores	1	180	0	7	0	53
Anaerobic Spores	0	1	1	--	--	190
Coliforms	0	0	0	0	0	0
Staphylococci	0	20	0	0	0	0
Pseudomonas	0	0	0	0	0	0
Enterococci[b]	0	0	0	0	0	0
Molds	0	0	0	--	--	--

Source: Lloyd et al. "Bacteriological Observations of Hospital Commissary Environments," (30).

a/ Average bacterial counts obtained from the three collected wash and rinse water samples.

b/ Enterococci counts were based on most probably numbers per 100 millimeter of water samples.

TABLE 23

BACTERIAL CONTAMINATION ON PRETREATED AND WASHED AND RINSED EATING UTENSILS COLLECTED FROM SELECTED INSTITUTIONS

Institution	Average Number Bacteria Recovered From Duplicate Samples of Dishware[a/] Pretreated[b/]	Washed/Rinsed
A	30	20
B	110	45
C	TNTC[c/]	45
D	180	120
E	TNTC	20
F	TNTC	20

Source: Lloyd et al. "Bacteriological Observations of Hospital Commissary Environments," (30).

a/ Counts obtained from membrane filters.

b/ The counts shown represents those taken right after scraping.

c/ TNTC--too numerous to count.

Wehrle (82) in a previously mentioned study of foodservice on communicable disease wards, reports that normal foodservice ware washing and sanitizing procedures are adequate in removing even highly infectious organisms from utensils used for patients with communicable diseases. He stresses that the problems in handling these utensils lie with personnel who often fail to wash their hands properly before and after touching the dishes, rather than with the sanitizing procedures themselves. Wehrle suggests a cycle involving prewash at 140° to 160°F, wash cycle of 160°F, and a flow rinse at 180°F. The significance of Wehrle's study is that, given proper personnel training, the facilities and processes available in the institutional setting are capable of producing sanitized foodservice ware, even when that ware has been heavily contaminated.[1]

1 See comments Appendix J, pages 24-26.

Another study, by Jopke et al. (24) of 21 hospitals in the Twin Cities area, reaffirms the effectiveness of institutional washing procedures. From a total of 6,600 samples from dinner plates, cups, and glasses (among other products), the authors found very low microbial counts immediately after washing, reflecting the operating effectiveness of all dishwashing machines. The results of this test are presented in Table 24.

TABLE 24

MICROBIAL CONTAMINATION ON HOSPITAL TABLEWARE IMMEDIATELY AFTER WASHING

Type of Tableware[a/]	Number of Samples	Mean (Average) Count	Percentage Distribution of Microbial Counts (%)		
			0	1-50	50
Plates	627	13.9	71	25	4
Trays	627	24.2	65	25	10
Cups	315	7.4	51	46	3
Glasses	313	3.9	65	34	1
Spoons	105	17.5	73	19	8
Forks	105	11.6	84	10	6
Knives	105	7.6	72	21	7

Source: Jopke et al. "Microbial Contamination on Hospital Tableware," (24).
a/ Expressed as colonies/utensils for the flatware and colonies/rodac plate for the other types of tableware (spoons, forks, knives).

c. Handling and Storage Factors: While Jopke's study found that washing and sanitizing procedures in the hospitals studied were effective, "handling and environmental exposure emerged as the critical factors in tableware contamination," (Page 31). The authors note that "the degree of contamination increases with the length of time between after washing and before use, a period when the tableware is exposed to both environmental and personnel contamination," (Page 31).

Table 25 shows the microbial counts of tableware during storage. As shown, the mean counts on all items except dinner plates and trays increased during storage. This can be explained by the fact that plates and trays are often better protected from airborne contamination than cups, glasses, and flatware, which may be stored on open shelves. Also, since plates and trays are stacked, less individual surface area is exposed to personnel and environmental contaminants. Finally, Table 26 indicates counts taken on tableware immediately prior to use. As indicated, the three products of particular concern to this study--plates, cups and glassware, showed slightly lower mean counts at this point than during storage; however, there were fewer samples showing a zero bacterial count prior to use than during the storage period. Based on their findings, the authors recommend several improvements to decrease microbial contamination of tableware. Included are decreased handling of tableware by personnel, the storage of sanitized plates in mobile bins or self-leveling storage bins, and the storage of sanitized cups, glasses in the same rack and cylinder in which they were sanitized.

In a sequel to the previous study, Jopke et al. (23) examined the effects of air conditioning on microbial airborne contamination in hospital dishwashing facilities and resultant contamination of tableware. They found that the presence or absence of air conditioning was the one variable with the greatest effect on airborne microbial quality, with air-conditioned hospitals showing levels one-third less than those in nonair-conditioned facilities. Results of these tests are shown in Table 27.

TABLE 25

MICROBIAL CONTAMINATION ON HOSPITAL TABLEWARE DURING STORAGE

Type of Tableware[a/]	Number of Samples	Mean (Average) Counts	Percentage Distribution of Microbial Counts (%)		
			0	1-50	50
Plates	630	5.5	64	34	2
Trays	629	10.4	60	35	5
Cups	315	15.2	34	59	7
Glasses	314	15.8	38	55	7
Spoons	104	30.3	59	31	10
Forks	105	35.4	57	32	11
Knives	105	42.4	55	36	9

Source: Jopke et al. "Microbial Contamination on Hospital Tableware," (24).
a/ Expressed as colonies/utensils for the flatware and colonies/rodac plate for the other types of tableware.

TABLE 26

MICROBIAL CONTAMINATION ON HOSPITAL TABLEWARE BEFORE USE

Type of Tableware[a/]	Number of Samples	Mean (Average) Counts	Percentage Distribution of Microbial Counts (%)		
			0	1-50	50
Plates	628	3.4	77	22	1
Trays	629	11.2	54	42	4
Cups	315	14.6	24	71	5
Glasses	313	10.3	36	60	4
Spoons	105	109.5	53	27	20
Forks	105	72.6	55	30	15
Knives	105	34.1	49	39	12

Source: Jopke et al. "Microbial Contamination on Hospital Tableware," (24).
a/ Expressed as colonies/utensils for the flatware and colonies/rodac plate for the other types of tableware.

TABLE 27

MICROBIAL AIRBORNE CONTAMINATION WITH AND WITHOUT AIR CONDITIONING SYSTEMS IN HOSPITAL DISHWASHING FACILITIES

Type of Ventilation	Number of Hospitals	1st Visit		2nd Visit		3rd Visit		Total	
		Number of Samples	Mean (Average)	Number of Samples	Mean (Average)	Number of Samples	Mean (Average)	Number of Samples	Mean (Average)
With Air Conditioning	14	1,075	10.8	1,109	10.9	277	10.3	2,461	10.8
Without Air Conditioning	7	555	40.1	553	27.3	138	28.0	1,246	33.1

Source: Jopke et al. "Air Conditioning Reduces Microbiologic Levels in Hospital Dishwashing Facilities," (23) A final consideration in the handling of permanent foodservice ware is breakage. Of the three types of products being considered in this study--melamine, china, and glass--glass undoubtedly presents the greatest hazard from the standpoint of accidental breakage. Glass tends to shatter, scattering splintered fragments over a wide area. China, although it also may be broken, separates into a smaller number of pieces, which are predominantly of right angle formation. These pieces are not as sharp as the glassware fragments and are therefore easier to pick up without risk of injury (18). Melamine is resistant to breakage and although a severe impact could cause fracture, the pieces would be unlikely to cause injury.

D. Compliance of Disposable Foodservice Ware (Single Service)

As discussed in the section on standards, single service container manufacturers routinely submit samples of their products to the Syracuse Research Corporation (SRC) Food Protection Laboratory (an independent laboratory) for testing. Testing determines conformance with the bacteriological standard, stated in PHS Publication 1465, of no allowable coliform bacteria, and no more than one colony of noncoliform bacteria per square centimeter of food or beverage contact surface.

As experts in the field of single service ware testing, SRC has found that "these products consistently meet the standards of the PHS." According to Mr. Jack B. Friers, Manager of the Food Protection Laboratory, "Based upon these results, it is our opinion that single service containers have an excellent sanitary quality and are safe for their intended use."

Friers also believes that the difference in bacteriological standards between permanent ware (no more than 100 colonies per 8 square inch area) and single service ware (no more than 50 for the same area) "are not significant ...and that both standards should be meaningful in their field of use," (51).

In support of SRC's experience, a 1-month analysis of disposable foodservice ware at Elmhurst Hospital in 1968 (21) showed all items tested to be free of coliform organisms and well within the generally recognized bacteriological standard. Table 28 shows these results.

Two studies were submitted which question the sanitary quality of single service food containers. The first, called the "Eight Hospital Study," (15) tested disposable paper items taken from normal storage during a 1-week period in eight hospitals. The results of the tests, done in the hospitals' own laboratories, are presented in tabular form, as shown in Table 29. (Items applicable to the present study have been asterisked.) According to the study results, microbial counts for the 9 ounce cold drink cup were "too numerous to count" at one hospital, but were 0 in the other 7; all counts for the hot drink cup were 0; 4 of the 8 counts for the 9 inch plate were unacceptable (2 being "too numerous to count"); and 2 of the foam cup counts were above acceptable levels.

The "Eight Hospital Study" is questionable for a number of reasons: First, exact methodologies for testing are not included in the report. Second, since each hospital performed its own tests in its own laboratory, conditions could not be expected to be consistent among the eight facilities. Third, the Rodac plate method used to determine microbial counts is intended for

TABLE 28

BACTERIOLOGICAL SAMPLING OF DISPOSABLE FOODSERVICE WARE AT ELMHURST HOSPITAL

Sample Number	Area Tested in Square Centimeters	Number of Items Tested	Top or End	Bacterial Count Per Item 2	3	4	5	6	Bottom or End	Number of Items Exceeding Standard	Coliform Test	Controls Water	Air	Agar
1	185	7	0	0	0	0	0	0	0	0	Negative	0	0	0
2	131	7	0	0	0	0	0	0	0	0	Negative	0	0	0
3	108	7	0	0	0	0	0	0	0	0	Negative	0	0	0
4	169	7	20	0	0	18	0	0	0	0	Negative	0	0	0
5	132	7	0	0	0	0	0	0	0	0	Negative	0	0	0
6	44	7	0	0	0	0	0	0	0	0	Negative	0	0	0
7	138	7	0	0	0	0	0	0	0	0	Negative	0	0	0
8	75	7	0	0	0	0	0	0	0	0	Negative	0	0	0
9	200	7	0	0	0	0	0	0	0	0	Negative	0	0	0
10	314	7	0	0	0	0	0	0	0	0	Negative	0	0	0
11	47	7	0	0	0	0	0	0	0	0	Negative	0	0	0
12	99	7	0	0	0	0	0	0	0	0	Negative	0	0	0
13	133	7	18	2	2	7m[a]	4m	10m	0	0	Negative	0	0	0
14	934	7	0	0	0	0	0	0	0	0	Negative	0	0	0
15	140	7	0	0	0	0	0	0	0	0	Negative	0	0	0
16	169	7	0	0	0	0	00	0	0	0	Negative	0	0	0
17	133	7	0	0	0	0	0	0	0	0	Negative	0	0	0
18	185	7	0	0	0	0	0	0	0	0	Negative	0	0	0

Source: "Hospital Study of Patient Feeding on Single Service," Single Service Institute, (21).

a/ Mold.

TABLE 29

RESULTS OF THE "EIGHT HOSPITAL STUDY" (20 COLONIES PER 16 CM^2 MINIMUM ACCEPTABLE LEVEL) COLONIES PER 16 CM^2 (RODAC PLATE)

Sample (All Paper)	Facility 1	2	3	4	5	6	7	8
4 ounce cup[a]	0	9	0	0	TNTC	TNTC	0	0
9 ounce cup[a]	0	0	0	0	0	TNTC	0	0
Hot drink cup[a]	0	0	0	0	0	0	0	0
9 inch plate[a]	0	27	7	0	2	31	TNTC	TNTC
6-3/4 inch plate	7	0	15	9	0	54	0	11
Soup bowl	0	0	9	0	TNTC	5	0	9
Vegetable bowl	TNTC	0	0	0	31	0	0	0
Additional Items Tested								
Foam cups[a]	57	--	--	--	39	--	17	--
Individual sugar packets	TNTC	--	--	--	TNTC	--	TNTC	--
Individual salt packets	TNTC	--	--	--	57	--	TNTC	--

Source: Foodborne Outbreaks: Annual Summary, 1970, (15).

a/ TNTC--too numerous to count.

testing flat surfaces; thus, its efficacy for rounded cup surfaces is questionable.[1/] These reservations would suggest that the results of the "Eight Hospital Study" may not be scientifically acceptable.

The second study is the Rosner-Hixon Report (65), in which disposable plates (type not specified) were tested to determine the degree of bacterial contamination. Three cartons from each of six manufacturers were represented in the test. One plate was taken from the top of the stack, one from the middle and one from the bottom; additionally, two more plates were removed from the top of other stacks from each carton. The plates were swabbed with sterile water, and plate counts were performed; the results appear in Table 30.

As indicated, all of the plates from the bottom of the stacks were sterile; however, two samples from the middle showed counts of 300 and 3,100 respectively, while the top samples showed fairly high levels of contamination in three of the six cartons. The implication, of course, is that the top plates were more subjected to exposure and to contamination during packaging and handling. The Rosner-Hixon Report has been questioned because of its lack of detailed description of methodology, of personnel and facilities used in the testing, and for its limited number of samples, considered not to be representative of the total number of products under consideration. Additionally, for the purposes of the present study, there is concern over the fact that the type of "disposable" plates is not specified.

1/ Confirmed by consultation with MRI bacteriologist.

TABLE 30

TEST RESULTS FROM THE ROSNER-HIXON REPORT

Manufacturer	Carton Number	Top	Middle	Bottom
A	1	0-200-0	0	0
	2	200-0-0	300	0
	3	200-0-0	0	0
B	1	0-0-0	0	0
	2	0-0-0	0	0
	3	0-0-0	0	0
C	1	0-0-80,000	0	0
	2	0-0-0	0	0
	3	0-0-0	0	0
D	1	0-0-0	0	0
	2	0-0-0	0	0
	3	0-0-0	0	0
E	1	400-0-1,000	3,100	0
	2	100-1,000-0	0	0
	3	0-0-0	0	0
F	1	0-0-0	0	0
	2	0-0-0	0	0
	3	0-0-0	0	0

Source: "The Sanitary Aspects of Single-Service (Disposable) Ware," Permanent Ware Institution, (65).

NOTE: 0 denotes a number less than 100.

SRC, in a response to these two studies, questions not only the scientific quality of the investigations, but also the results. According to the manager of the Food Protection Laboratory, "Occasionally somewhat higher bacterial counts are found in the exposed top item of the stack than in other parts of the stacks, but we have not encountered the extremely high counts reported in the study. We have found that single service items within a stack (other than the top item) are consistently low or zero in bacterial contamination levels."

In light of the above reservations, the position of SRC, and the fact that these were the only two studies encountered in an extensive literature review which indict disposable foodservice ware from a sanitation standpoint, the "Eight Hospital Study" and the Rosner-Hixon Report do not present substantial or conclusive evidence indicating the sanitary quality of single service items. However, in light of the finding by the GAO that 63.2 percent of sampled commercial establishments do not properly store, dispense and handle single service articles, it is possible to conclude that problems may well exist in the handling of those products; and that these problems could represent the potential for disease transmission. Again, it is not the products themselves but the human factor which may threaten sanitation.[1]

In order to ascertain the attitudes of public health professionals toward disposable products, the Environmental Health Administration undertook a national survey in 1976, in which questionnaires were mailed to 3,000 individuals, randomly chosen from the directory of state food and drug officials and the membership of public and environmental health organizations.[2] These

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1 See comments Appendix J, pages 33-35.

2 See comments Appendix J, page 35.

organizations included the National Environmental Health Association, the Association of Food and Drug Officials of the United States, the Conference of Local Environmental Health Administrators, the Association of State and Territorial Health Officers, the International Association of Milk, Food and Environmental Sanitarians, Inc., and the American Public Health Association (Section on the Environment). About 2,760 persons returned questionnaires, providing a 92 percent response rate.

Table 31 categorizes the respondents according to their positions and organizations. As indicated, 45 percent of those returning questionnaires are public and environmental health administrators at the state and local level, and 41 percent are state and local sanitarians. These categories represent those individuals most directly responsible for health regulation in commercial and institutional foodservice establishments. Of the respondents, 83 percent have at least 6 years experience in their respective fields, with 57 percent indicating 11 or more years of experience.

TABLE 31

POSITIONS AND ORGANIZATIONS OF RESPONDENTS

Position and Organization	Number of Respondents	Percent of Respondents[a]
Public/Environmental Health Administrators (State and Local)	1,245	45
Officials of Professional Public/Environmental Health Organizations	18	1
Sanitarians (Field Level--State and Local Agencies)	1,145	41
Public/Environmental Health Academicians	67	2
Environmental Health Scientists (State and Local)	240	9
Public Health Officials (in Federal Agencies)	45	2
Total	2,760	100

Source: Walker and Price, "The Health Profession's Attitude Toward Single-Use Food and Beverage Containers," (79).

a/ Percentages are rounded to the nearest integer.

Table 32 presents a listing of the benefits the respondents attribute to single-use foodservice items. Of the public health professionals, 69 percent consider sanitation-related factors to be the main benefits of these products, including the reduction in the potential for cross-infection, the reduction in disease transmission (if properly stored and handled), the provision of a consistently high level of food sanitation, and the reduction in human involvement in the sanitizing process.[1] Conversely, 71 percent of the respondents recognize that disposables present disadvantages in terms of solid waste volume, litter, and disposal problems; this breakdown is shown in Table 33.[1] However, 80 percent believe that the benefits of disposables are greater than the disadvantages, 11 percent feel benefits and disadvantages are fairly equal, and only 6 percent think the disadvantages outweigh the benefits. Finally, when asked how much disposable foodservice ware contributes to sanitation levels in foodservice facilities, 74 percent of the respondents felt they "contributed very much," 16 percent felt they "contributed somewhat," and 9 percent believed they "contributed slightly." These results are presented in Table 34. Accordingly, 74 percent of the respondents felt that sanitation levels would definitely decrease if disposables were eliminated and that they would definitely increase if disposables were required.

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[1] See connents Appendix J, pages 35-36.

TABLE 32

PUBLIC HEALTH BENEFITS DERIVED FROM PAPER AND PLASTIC SINGLE-USE PRODUCTS

Benefit[a]	Number of Respondents	Percent of Respondents[b]
Reduce the possibility of cross-infection	421	15
If properly stored and handled, reduce transmission of diseases	866	31
Practical and economical means for food service facilities to operate when reusable products are impractical	208	8
Eliminate the need for dishwashing facilities	426	15
Provide a consistently high level of food sanitation	385	14
Reduce human involvement required for cleaning and sanitizing	243	9
Convenience	128	5
Conserve energy	47	2
No real public health benefit	36	1
Total	2,760	100

Source: Walker and Price, "The Health Profession's Attitude Toward Single-Use Food and Beverage Containers," (79).

a/ Benefits were listed by respondents.

b/ Percentages are rounded to the nearest integer.

TABLE 33

DISADVANTAGES DERIVED FROM PAPER AND PLASTIC SINGLE-USE PRODUCTS

Disadvantage[a]	Number of Respondents	Percent of Respondents[b]
Contribute to solid waste disposal problems	782	28
Add to the volume and bulk of solid waste	485	18
Increase litter	474	17
Contribute to disposal problems, especially with plastics that are nonbiodegradable	229	8
Increase need for additional storage space	237	9
Poor quality of some of the disposable products	98	4
Limited acceptance in all restaurants by consuming public	396	14
Increasing cost of disposable products	59	2
Total	2,760	100

Source: Walker and Price, "The Health Profession's Attitude Toward Single-Use Food and Beverage Containers," (79).

a/ Disadvantages were listed by respondents.

b/ Percentages are rounded to the nearest integer.

TABLE 34

CONTRIBUTION OF PAPER AND PLASTIC CUPS AND PLATES TO SANITATION LEVELS IN FOOD SERVICE FACILITIES

Public Health Professional	Contribute Very Much		Contribute Somewhat		Contribute Slightly		Do Not Contribute At All		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Public/Environmental Health Administrators	876	70	207	17	153	12	9	1	1,245	45
Officials of Professional Public/Environmental Health Organizations	10	56	6	33	--	--	2	11	18	1
Sanitarians	978	85	129	11	30	3	8	1	1,145	41
Public/Environmental Health Academicians	38	57	14	21	9	13	6	9	67	
Environmental Health Scientists	112	47	69	29	50	21	9	4	240	
Public Health Officials in Federal Agencies	29	64	7	16	7	16	2	4	45	
Total	2,043	74	432	16	249	9	36	1	2,760	100

Source: Walker and Price, "The Health Profession's Attitude Toward Single-Use Food and Beverage Containers," (79).
Number: Number of respondents.
Percent: Percent of respondents (percentages are founded to the nearest integer).

The role of single-use foodservice ware in the overall realm of sanitation cannot be denied. As specified in the Model Ordinance, single-service items must be used in foodservice establishments (or institutions) where there are inadequate facilities for washing and sanitizing permanent ware. Single-service items may be recommended in isolation units of hospitals, particularly if there is concern over the sanitary quality of permanent ware being processed through the hospital kitchen. Single-service products are also necessary at public events, outdoor gatherings, and other such occasions when the "commercial foodservice establishment" may consist only of a small booth or stand, certainly not equipped to wash and sanitize dishes.

Within the commercial or institutional setting where there are facilities for washing and sanitizing permanent ware, it is extremely difficult to make direct comparisons between reusables and disposables. As previously discussed, the impact of human variables, from day to day, from restaurant to restaurant or institution to institution, negates virtually every attempt to quantify differences in the sanitary status of disposables versus reusables. As correctly stated by the Single Service Institute, "the only precise way to assess the health values of disposables versus reusables would be to survey the bacteriological quality of one versus the other by testing the utensils in food-serving establishments just prior to their use," (48). And even then, the scope of the investigation would have to be massive in order to be equitable.

Additionally, bacteriological standards alone do not measure the capacity of foodservice ware (or any other product) to transmit disease; the most such standards can do is to indicate potential for disease transmission.

The problem in assessing sanitation standards on foodservice ware is summarized quite effectively by Bailus Walker, the author of several studies in this field: "Anderson in an extensive review of the epidemiological basis of environmental sanitation in 1943 stated 'I wish I could cite evidence that the lack of decent cleanliness in handling dishes in food establishments is likely to result in demonstrable diseases, for I would welcome a basis for enforcing better dishwashing. And yet I know of no evidence of this character.' ...Almost four decades later there is still little or no evidence of this character. Questions involving the health effects of environmental bioloads are particularly prone to uncertainty and the health impact of various environmental levels of microorganisms on food or beverage contact surfaces are often unknown, and not infrequently unknowable." (78, page 10)[1]

[1] See comments Appendix J, pages 16-20.

APPENDIX A

<u>ADDITIONAL TESTING DATA</u>

TABLE I

EFFECTS OF THE USE OF DISINFECTANTS IN RINSE WATER AT THE HOT WATER SETTING

Participant Number	Treatment	Active Ingredients (ppm)	Number Bacteria per Milliliter Wash Water	Number Bacteria per Milliliter Rinse Water	Number Bacteria per Square Inch	Detergent
1	None	0	80	30	50	Anionic
	Quaternary	200	640	< 10	0	Nonionic
	Phenolic (B)	125	90	10	< 10	Anionic
	Phenolic (E)	250	40	20	0	Nonionic
	Phenolic (E)	250	40	< 10	25	Nonionic
3	None	0	1,400	180	--	Nonionic
	None	0	1,180	6,400	--	Nonionic
	None	0	8,200	4,600	925	Anionic
	None	0	1,300	610	3,500	Anionic
	None	0	1,000	340	550	Anionic
	Quaternary	200	14,000	70	--	Nonionic
	Quaternary	200	2,100	< 10	225	Nonionic
	Quaternary	200	2,100	20	100	Anionic
	Phenolic (B)	125	4,600	30	50	Anionic
	Phenolic (B)	250	700	< 10	< 25	Anionic
	Phenolic (C)	125	1,300	220	25	Nonionic
	Phenolic (C)	125	180	10	< 25	Anionic
	Phenolic (E)	125	2,700	50	< 25	Nonionic
	Phenolic (E)	125	1,200	30	125	Anionic
	Phenolic (E)	250	760	< 10	< 25	Nonionic
	Phenolic (E)	250	17,000	1,580	1,200	Anionic
	Phenolic (E)	250	2,100	30	75	Anionic
4	None	0	4,400	1,670	--	Nonionic
	None	0	5,400	2,800	1,500	Anionic
	None	0	1,150	1,660	710(M)	Anionic
	None	0	31,000	20,300	25,600	Nonionic
	None	0	330	1,070	--	Nonionic
	Quaternary	200	3,900	20	50	Nonionic
	Quaternary	200	650	0	< 25	Anionic
	Quaternary	200	1,800	0	< 25	Anionic
	Quaternary	135	2,500	10	--	Nonionic
	Quaternary	135	2,200	< 10	--	Nonionic
	Quaternary	135	7,600	0	--	Anionic
	Quaternary	135	170	0	-- --	Anionic
	Quaternary	135	6,700	30	--	Anionic
	Quaternary	33	1,550	610	--	Anionic
	Phenolic (B)	125	1,900	10	300	Anionic

TABLE I (concluded)

Participant Number	Treatment	Active Ingredients (ppm)	Number Bacteria per Milliliter Wash Water	Number Bacteria per Milliliter Rinse Water	Number Bacteria per Square Inch	Detergent
	Phenolic (B)	250	2,600	< 10	250	Anionic
	Phenolic (C)	65	4,600	1,200	1,075	Anionic
	Phenolic (C)	125	84,000	4,900	100	Nonionic
	Phenolic (C)	125	17,400	< 10	225	Anionic
	Phenolic (C)	125	16,900	1,700	275	Anionic
	Phenolic (E)	250	460	220	< 25	Nonionic
	Phenolic (E)	250	1,000	80	50	Nonionic
	Phenolic (E)	250	1,000	10	200	Anionic
	Phenolic (E)	250	6,200	330	350	Anionic
5	None	0	10,500	32,000	--	Nonionic
	None	0	500	800	1,600	Nonionic
	Quaternary	200	690	< 10	< 25	Nonionic
	Quaternary	200	20	0	< 25	Anionic
	Phenolic (E)	125	230	40	25	Anionic
	Phenolic (E)	250	510	30	25	Anionic
	Phenolic (E)	250	90	20	0	Nonionic
	Phenolic (E)	250	940	15,300	25	Nonionic
6	None	0	180	1,360	--	Nonionic
	None	0	770	1,580	--	Anionic
	Quaternary	200	240	< 10	< 25	Nonionic
	Quaternary	200	470	0	< 25	Anionic
	Phenolic (C)	125	120	50	100	Anionic
	Phenolic (C)	125	120	50	100	Anionic
	Phenolic (E)	250	60	0	< 25	Anionic
7	None	0	851	2,110	125	Anionic
	None	0	410	2,300	75	Anionic
	Phenolic (C)	125	2,900	80	25	Anionic

Source: "Disinfectants in Home Laundering," Paper presented May 16, 1962, during 48th midyear meeting, Chemical Specialties Manufacturers Association, Chicago, by Ethel McNeil and Eva A. Choper.

Note: B = Ortho-benzyl-parachlorophenol
C = Ortho-benzyl-para-chlorophenate potassium salt
D = Potassium salts of Ortho-phenyl-chlorophenol and Orthobenzyl-parachlorophenol
E = Ortho-benzyl-para-chlorophenate sodium salt
F = Chloro-ortho-phenylphenol
(M) = muslin sheeting

TABLE II

EFFECTS OF THE USE OF DISINFECTANTS IN WASH WATER AT THE HOT WATER SETTING

Participant Number	Treatment	Active Ingredients (ppm)	No. Bacteria per Milliliter: Wash Water	No. Bacteria per Milliliter: Rinse Water	No. Bacteria per Square Inch of Swatch	Detergent
3	None	0	1,400	180	--	Nonionic
	None	0	1,180	6,400	--	Nonionic
	None	0	8,200	4,600	925	Anionic
	None	0	1,300	610	3,500	Anionic
	None	0	1,000	340	550	Anionic
	Quaternary	200	800	170	--	Nonionic
	Quaternary	200	90	350	--	Nonionic
	Quaternary	200	120	10	--	Nonionic
	Quaternary	200	80	20	25	Nonionic
	Phenolic (C)	125	20	280	--	Nonionic
	Phenolic (C)	125	80	70	50	Anionic
	Phenolic (D)	100	20	140	<25	Anionic
	Phenolic (E)	250	30	30	0	Nonionic
	Phenolic (E)	250	50	30	100	Anionic
	Phenolic (E)	250[a]	70	<10	0	Anionic
4	None	0	4,400	1,670	--	Nonionic
	None	0	5,400	2,800	1,500	Anionic
	None	0	1,150	1,660	710(M)	Anionic
	None	0	31,000	20,300	25,600	Anionic
	Quaternary	200	40	<10	750(M)	Nonionic
	Quaternary	200	190	520	300	Nonionic
	Quaternary	200	90	160	50	Nonionic
	Phenolic (B)	250[a]	200	30	<25	Anionic
	Phenolic (C)	250	20	380	100	Anionic
	Phenolic (C)	125	450	550	1,900	Nonionic
	Phenolic (C)	125	10	60	75(M)	Anionic
	Phenolic (D)	100	20	80	850	Anionic
	Phenolic (E)	375	10	210	2,500	Nonionic
5	None	0	10,500	32,000	--	Nonionic
	None	0	500	800	1,600	Nonionic
	Quaternary	200	<10	20	50	Nonionic
	Phenolic (C)	125	100	1,390	150	Nonionic
	Phenolic (E)	250	<10	640	<25	Nonionic

Source: "Disinfectants in Home Laundering," Paper presented May 16, 1962, during 48th midyear meeting, Chemical Specialties Manufacturers Association, Chicago, by Ethel McNeil and Eva A. Choper.

a/ Disinfectant used at concentration of 160 ppm in wash and 90 ppm in rinse.

TABLE III

EFFECTS OF THE USE OF DISINFECTANTS IN RINSE WATER AT THE WARM WATER SETTING

Participant Number	Treatment	Active Ingredients (ppm)	No. Bacteria per Milliliter		No. Bacteria per Square Inch of Swatch	Detergent
			Wash Water	Rinse Water		
1	None	0	12,300	1,900	--	Anionic
	None	0	8,400	7,000	--	Anionic
	None	0	20,500	3,300	1,800	Anionic
	None	0	2,810	1,130	--	Nonionic
	None	0	14,000	1,200	200	Nonionic
	None	0	2,120	870	--	Nonionic
	Quaternary	200	5,700	0	--	Nonionic
	Quaternary	200	64,000	<10	50(M)	Nonionic
	Phenolic (B)	125	12,000	<10	50	Anionic
	Phenolic (C)	125	4,200	70	<25	Anionic
	Phenolic (C)	85	6,300	370	850	Nonionic
	Phenolic (E)	250	8,300	50	25	Nonionic
	Phenolic (E)	250	6,100	80	<25	Anionic
	Phenolic (E)	250	7,800	100	25	Anionic
2	None	0	117,000	2,800	650	Anionic
	Quaternary	200	83,000	<10	0	Anionic
3	None	0	340,000	41,000	3,750	Anionic
	Quaternary	200	324,000	<10	75	Anionic
	Phenolic (D)	75	1,250,000	35,700	850	Nonionic
	Phenolic (E)	250	33,000	170	<25	Anionic
4	None	0	340,000	38,000	650	Anionic
	Quaternary	200	141,000	30	500	Nonionic
	Quaternary	200	417,000	<10	--	Anionic
	Phenolic (E)	250	270,000	3,600	700	Anionic
5	None	0	72,000	19,000	700	Anionic
	Quaternary	200	11,500	0	<25	Nonionic
	Phenolic (E)	250	6,500	30	275	Nonionic

Source: "Disinfectants in Home Laundering," Paper presented May 16, 1962, during 48th midyear meeting, Chemical Specialties Manufacturers Association, Chicago, by Ethel McNeil and Eva A. Choper.

TABLE IV

EFFECTS OF THE USE OF DISINFECTANTS IN WASH WATER AT THE WARM WATER SETTING

Participant Number	Treatment	Active Ingredients (ppm)	No. Bacteria per Milliliter Wash Water	No. Bacteria per Milliliter Rinse Water	No. Bacteria per Square Inch of Swatch	Detergent
1	None	0	12,300	1,900	--	Anionic
	None	0	8,400	7,000	--	Anionic
	None	0	20,500	3,300	1,800	Anionic
	None	0	2,810	1,130	--	Nonionic
	None	0	14,000	1,200	200	Nonionic
	None	0	2,120	870	--	Nonionic
	Quaternary	200	20	170	125(M)	Nonionic
	Quaternary	200	120	680	1,300	Nonionic
	Phenolic (B)	250	<100	150	--	Nonionic
	Phenolic (C)	125	310	520	25(M)	Nonionic
	Phenolic (C)	125	330	170	675(M)	Nonionic
	Phenolic (D)	100	40	<10	25(M)	Nonionic
	Phenolic (F)	95	190	60	1,000(M)	Anionic
	Phenolic (F)	95	1,300	1,000	<25(M)	Nonionic
	Phenolic (F)	165	90	20	25	Nonionic
2	None	0	117,000	35,000	22,250	Nonionic
	Quaternary	200	20	10	100	Nonionic
3	None	0	340,000	41,000	3,750	Anionic
	Phenolic (E)	250	12,800	3,700	75	Nonionic
4	None	0	340,000	38,000	650	Anionic
	Quaternary	200	70	2,000	25	Nonionic
	Quaternary	200	690	2,400	1,100	Nonionic
	Phenolic (D)	100	10,300	2,900	525	Anionic
	Phenolic (E)	250	16,500	13,300	1,175	Anionic
	Phenolic (E)	250	480	4,700	200	Anionic
5	None	0	72,000	19,000	700	Anionic
	Quaternary	200	20	40	40	Nonionic
	Phenolic (E)	250	4,700	580	25	Anionic

Source: "Disinfectants in Home Laundering," Paper presented May 16, 1962, during 48th midyear meeting, Chemical Specialties Manufacturers Association, Chicago, by Ethel McNeil and Eva A. Choper.

TABLE V

EFFECT OF THE USE OF CHLORINE BLEACH IN WASH WATER

Participant Number	Available Chlorine (ppm) Beginning of Wash Cycle	Number Bacteria per Milliliter: Wash Water	Number Bacteria per Milliliter: Rinse Water	Number Bacteria per Square Inch of Swatch	Available Chlorine (ppm): End of 6 Minutes	Available Chlorine (ppm): End of Wash Cycle	Available Chlorine (ppm): End of Rinse Water	Detergent
3	None	210	620	125	--	--	--	Synthetic Anionic
	320	10	10	75	--	--	--	Synthetic Anionic
8	None	160	650	150	--	--	--	Synthetic Anionic
	None	5,500	3,900	4,400	--	--	--	Synthetic Anionic
	320	< 10	< 10	< 25	--	--	--	Synthetic Anionic
	320	< 10	< 10	< 25	--	--	--	Synthetic Anionic
	320	< 10	< 10	< 25	--	--	--	Synthetic Anionic
	320	< 10	< 10	< 25	93	78	3.5	Synthetic Anionic
	320	< 10	< 10	< 25	49	40	18	Soap
	160	< 10	< 10	< 25				Synthetic Anionic
9	None	36,000	41,000	875				Synthetic Anionic
	320	100	60	50				Synthetic Anionic
	320	< 10	10	25				Synthetic Anionic
	320	< 10	< 10	50	13.5	10.6	0.1	Synthetic Anionic
	320	10	< 10	25	15	11	0.1	Synthetic Anionic
	160	10	30	< 50	9	8	0.07	Synthetic Anionic

Source: "Disinfectants in Home Laundering," Paper presented May 16, 1962, during 48th midyear meeting, Chemical Specialties Manufacturers Association, Chicago, by Ethel McNeil and Eva A. Choper.

TABLE VI

ORIGINAL INOCULUM COUNT, INITIAL COUNT BEFORE WASH, SURVIVAL AFTER WASH, SURVIVAL AFTER DRYING, AND REDEPOSITION COUNT OF STAPHYLOCOCCUS AUREUS AT VARIOUS WATER TEMPERATURES AND DETERGENT CONCENTRATIONS ON NYLONS AND COTTON FABRICS

(Numbers Are Counts per Square Inch of Fabric)

	Water Temperature	Detergent Concentration (percent)	Wash No.	0-Inoc. x 10^6	Initial Count x 10^6	Survival After Wash x 10^6	Survival After Dry x 10^6	Redeposition x 10^6
140°	Hot	none	1	850	28	0	0	0.000001
	Hot	none	2	2500	191	0.005000	0.001000	0.003000
	Hot	none	3	235	375	0	0	0.000001
	Hot	0.1	1	4900	101	0.000048	0.000025	0.000054
	Hot	0.1	2	252	1231	0.000001	0.000001	0.000002
	Hot	0.1	3	236	2558	0	0	0
	Hot	0.2	1	4900	142	0.000014	0.000008	0.000014
	Hot	0.2	2	1300	705	0	0.000001	0.000001
	Hot	0.2	3	168	745	0.000003	0	0
	Hot	0.4	1	4900	143	0.000005	0.000007	0.000005
	Hot	0.4	2	1400	705	0.000001	0.000001	0
	Hot	0.4	3	41	749	0.000001	0.000001	0
100°	Warm	none	1	1450	133	13.000000	0.006560	0.270000
	Warm	none	2	2500	191	29.770000	0.102000	0.235600
	Warm	none	3	236	375	1.100000	0.001320	0.033000
	Warm	0.1	1	6800	97	0.193000	0.007775	0.055000
	Warm	0.1	2	1500	521	2.030000	0.001597	0.100500
	Warm	0.1	3	168	745	0.540000	0.004527	0.041500
	Warm	0.2	1	6800	97	0.240000	0.002915	0.001200
	Warm	0.2	2	1500	521	1.610000	0.001195	0.030500
	Warm	0.2	3	168	745	0.070800	0.000524	0.013900
	Warm	0.4	1	6800	150	0.000225	0.000067	0.000146
	Warm	0.4	2	252	1232	0.131900	0.000842	0.016800
	Warm	0.4	3	41	749	0.000301	0.000001	0.000042
60°	Cold	none	1	2500	22	10.400000	0.023266	1.400000
	Cold	none	2	2.36	2557	73.000000	0.478000	5.600000
	Cold	none	3	41	372	34.320000	0.254000	29.790000
	Cold	0.1	1	252	931	1.900000	0.000503	0.061000
	Cold	0.1	2	168	488	1.840000	0.000502	0.081400
	Cold	0.1	3	90	160	0.045600	0.011000	0.006300
	Cold	0.2	1	252	123	31.500000	0.013337	0.113700
	Cold	0.2	2	41	934	21.180000	0.011494	30.230000
	Cold	0.2	3	90	160	3.870000	0.115000	5.460000
	Cold	0.4	1	1400	705	0.446900	0.000091	0.008400
	Cold	0.4	2	4100	934	12.200000	0.001526	0.046500
	Cold	0.4	3	895	160	28.340000	0.000705	0.039400

Source: Witt and Warden, "Can Home Laundries Stop the Spread of Bacteria in Clothing?" (85).

TABLE VII

ORIGINAL INOCULUM COUNT, INITIAL COUNT BEFORE WASH, SURVIVAL AFTER WASH, SURVIVAL AFTER DRYING AND REDEPOSITION COUNT OF STAPHYLOCOCCUS AUREUS AT VARIOUS WATER TEMPERATURES AND DETERGENT CONCENTRATIONS ON WOOL, NYLON AND COTTON FABRIC

(Numbers Are Counts per Square Inch of Fabric)

	Water Temperature	Detergent Concentration (percent)	Wash No.	O-Inoc. x 10^6	Initial Count x 10^6	Survival After Wash x 10^6	Survival After Dry x 10^6	Redeposition x 10^6
140°	Hot	none	1	9900	16	0	0	0
	Hot	none	2	202	658	0.050000	0.003040	0.209500
	Hot	none	3	41	341	0.069700	0.007485	0.075000
	Hot	0.1	1	9900	16	0.000001	0.000001	0
	Hot	0.1	2	202	1293	0.028957	0.001037	0.023540
	Hot	0.1	3	33	1560	0	0.000008	0
	Hot	0.2	1	9900	1600	0	0	0
	Hot	0.2	2	161	1073	0	0	0
	Hot	0.2	3	34	16	0.015000	0.004539	0.003240
	Hot	0.4	1	9900	16	0	0	0
	Hot	0.4	2	161	2337	0	0.000003	0.000370
	Hot	0.4	3	41	104	0.000148	0.000001	0.000402
100°	Warm	none	1	1450	159	0.252200	0.016200	0.003000
	Warm	none	2	202	6586	0.669200	0.093000	0.050800
	Warm	none	3	41	341	53.150000	0.050000	1.500000
	Warm	0.1	1	1450	159	0.333700	0.009213	0.053700
	Warm	0.1	2	202	1293	0.033700	0.017000	0.023600
	Warm	0.1	3	33	1560	13.440000	0.025240	2.574000
	Warm	0.2	1	850	32	0.014228	0.000016	0.001128
	Warm	0.2	2	161	1073	0.039000	0.002919	0.071000
	Warm	0.2	3	41	310	0.003771	0.000016	0.000337
	Warm	0.4	1	850	164	0.627770	0.000188	0.130810
	Warm	0.4	2	161	2337	1.200000	0.000002	0.212000
	Warm	0.4	3	41	104	0.357600	0.000163	0.049300
60°	Cold	none	1	202	66	48.450000	4.700000	6.960000
	Cold	none	2	41	1700	48.400000	0.090000	9.260000
	Cold	none	3	41	10	57.860000	0.803000	2.430000
	Cold	0.1	1	202	1293	37.840000	0.100000	5.490000
	Cold	0.1	2	33	1560	21.880000	0.002870	3.140000
	Cold	0.1	3	41	104	31.260000	0.015187	3.880000
	Cold	0.2	1	161	1073	7.770000	0.001336	0.930000
	Cold	0.2	2	41	310	3.435000	0.001219	0.060600
	Cold	0.2	3	41	104	11.830000	0.205192	2.040000
	Cold	0.4	1	161	2337	26.040000	0.007615	2.700000
	Cold	0.4	2	41	310	3.510000	0.004171	0.710000
	Cold	0.4	3	70	217	0.183800	0.035000	0.038000

Source: Witt and Warden, "Can Home Laundries Stop the Spread of Bacteria in Clothing?" (85).

APPENDIX B

BIBLIOGRAPHY AND CONTACT LIST[1]

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Washington, D.C. 20460

Dear Mr. Peterson:

MRI recently has been advised by EPA that a final report on our "Study of Environmental Impacts of Disposables Versus Reusables" (MRI Project No. 4010-D) will not be published. Instead, EPA will publish the report in draft form through the National Technical Information Service, U.S. Department of Commerce. Inasmuch as a final report will not be prepared, we would like to make a few brief comments regarding the draft report.

The MRI report fully met all the goals of the program as specifically defined in the scope of the contract and as communicated during the course of the study by the EPA project monitors. MRI's task was to gather and present data with limited inputs regarding value judgments. Some typographical errors revealed during the review period (Vol. 1A, Table 5; Vol. 1B, Tables E7, E8, and E9) have been corrected. In each instance involving statistical data, the correct values had been used in the computer analysis; i.e., the errors occurred in transferring the numbers from the printouts to the summary tables. Thus, the corrections do not affect the basic information presented in the draft report.

One further point of clarification: Your November 1977 letter to those receiving copies of the draft report for review mentioned that "there are problems with the study." As you and I discussed over the phone, these "problems" are not with the technical content of the report but stem from the facts that:

(1) the comments concerning the draft report have divergent opinions; and

(2) EPA will make no attempt to respond to the comments. The letter further states that "the report is technically incomplete." The report is incomplete only in that it is being published in draft form, and is not a final report that incorporates responses to all the comments submitted during the review period.

Since completion of the draft in April 1977, many companies, trade organizations, and environmental groups, among others, have had the opportunity to review the report and submit comments to EPA. These comments addressed such topics as the need for the study, the scope of work, the methodology employed, the underlying assumptions, and the accuracy of the data. Understandably, the comments of some of the respondents lacked objectivity because many of the companies and organizations have vested interests in the products included in our study. In some instances, different organizations expressed conflicting opinions on the same issues. Therefore, when evaluating the comments, the reader should take into consideration the source and intended purpose of each comment.

This report, even in its draft version, contains useful information about ways in which selected disposable and reusable products affect national resources, the environment, and health problems.

Sincerely,

Richard O. Welch

Richard O. Welch
Senior Industrial Research Analyst

ROW:qa

APPENDICES

REVIEW COMMENTS

As part of the normal review process, a draft of the study was sent to 36 organizations. These organizations had taken an active role in the preparation of the study. Eleven review comments were received.

An examination of the comments, which express widely divergent opinions, led to a decision to print the study in draft form with the comments attached. This decision was based on a review of the time and monetary resources that would have been required to blend the review comments and the draft study into a "final" report.

The review comments are included as separate appendices, in alphabetical order, as follows:

Organization	Appendix
American Paper Institute - Bleached Paperboard Division	A
American Paper Institute - Tissue Division	B
American Restaruant China Council	C
Diaper Service Accreditation Council	D
Environmental Action Foundation	E
Ethyl Corporation	F
International Nonwoven Disposables Association	G
National Wildlife Federation	H
Permanent Ware Institute	I
Single Service Institute	J
Society of the Plastic Industry	K

APPENDIX A

American Paper Institute, Inc.
260 Madison Avenue, New York, N.Y. 10016/(212) 883-8000
cable address: AMPAPINST New York
Bleached Paperboard Division

June 27, 1977

Mr. Harry Butler
U.S. Environmental Protection Agency
Office of Solid Waste Management Programs
401 "M" Street, NW Room 2107
Washington, DC 20460

Dear Mr. Butler:

RE: Draft Report for MRI Project No. 4010-D, "Study of Environmental Impacts of Disposables vs. Reusables", Volume I and II.

As you know, the American Paper Institute is the trade association that represents the primary producers of pulp, paper and paperboard. The association is divided into a number of product groups each of which represents the interests of various sectors of the paper and paperboard industry. Our Tissue Division has been asked to comment on the above captioned report because of its interest in paper towels, paper napkins and disposable diapers. The interests of the remaining paper products in this Draft Report - paper cups and paper plates - are covered at the API by the Bleached Paperboard Division, which is part of the Paperboard Group. Although you have not asked the Bleached Paperboard Division to comment on this Draft Report, we feel compelled to do so, not only because this Division was a major source of data for the Draft Report, but also because we wish you to be fully aware that we have made a careful review and analysis of this Draft Report and find it in need of major revision.

We have conducted this analysis in close cooperation with the Single Service Institute, the association representing the converters of single service plates and cups, both paper and plastic. Because we have worked so closely with the Single Service Institute, we do not find any reason to submit a separate analysis of this Draft Report as it relates to paper plates and cups. We fully support and endorse the comments and recommendations of the SSI, as expressed in their covering letter dated June 27, 1977. The accompanying analysis by Arthur D. Little of Volume I and that by the Single Service Institute's Public Health Advisory Council of Volume II are, we feel, responsible, accurate and comprehensive.

We thus express our strong recommendation that the Office of Solid Waste Management Programs receive these critiques with the attention they deserve and, in turn, take the necessary steps to modify this Draft Report.

Sincerely,

Stuart J. McCampbell
Manager

SJMrv

APPENDIX B

American Paper Institute, Inc.
260 Madison Avenue, New York, N.Y. 10016 / (212) 883-8000
cable address: AMPAPINST New York

Tissue Division

June 28, 1977

Mr. Charles Peterson
Resource Recovery Division
AS463
Environmental Protection Agency
Washington, D. C. 20460

Dear Mr. Peterson:

This responds to your request for comments on the Draft Report for MRI Project No. 4010-D, "Study of Environmental Impacts of Disposables vs. Reusables," Volumes I and II.

The American Paper Institute's Tissue Division is the United States trade association for the sanitary paper products industry. Our member companies manufacture over 80% of the total sanitary paper products produced in the United States. Our interest on this occasion relates to three of the products studied in 4010-D -- paper towels, paper napkins, and disposable diapers.

After review and analysis of the Draft Report -- including careful cross-comparison with input from a study covering the same ground conducted for us by Arthur D. Little, Inc. -- we find that the MRI Draft Report is noticeably incomplete and contains a great many errors. The net result is potentially damaging to the interests of the products with which it deals, the companies which make them, and the consumers who use them. A particularly disturbing aspect is that the Draft Report does not state, or bring out in any way, many key positive observations or values related to the cited sanitary paper products -- for instance:

Overall perspective is not provided: no mention is made of the fact that the three disposable paper products evaluated contribute, altogether, less than 1.5% of total U.S. municipal solid waste -- nor is there any mention that these products are made almost entirely from a wholly renewable and totally biodegradable material resource (cellulosic fiber).

Despite considerable editorializing, there is no observation in the Draft Report to indicate that a majority of the most-favorable environmental/resource findings in the Draft Report are for the disposable products -- e.g., that in virtually every instance, the disposables are shown to excel over the cloth reusables in enabling users to conserve on our all-important energy and water resources, and are equally superior with respect to helping to reduce air and water pollution.

Nor does the Draft Report even attempt to set forth the many product performance and economic benefits that the sanitary paper products offer -- many of which simply cannot be matched by their reusable cloth counterparts. Some effort has been made to provide a health and sanitation comparison of the products, but it is relatively incomplete literature survey with no well-drawn conclusions based on a preponderance of the available evidence.

As stated, the Draft Report contains a large number of clearly incorrect or questionable facts and assumptions. These are summarized and discussed in detail in the attachment. These errors inevitably present many comparisons which are misleading and potentially damaging to the subject paper products and to the paper industry as a whole -- not to mention being a source of potential embarrassment to EPA if the Draft Report should be accepted. The magnitude of this can be illustrated by the fact that correction of the described errors will result in totally-reversed findings of the Draft Report in approximately 20% of its basic relative impact findings.

Because the Draft Report contains many flaws -- particularly omissions of data which EPA and industry agreed at the outset would be absolutely essential to any attempt to evaluate the net societal impact of disposable paper products as compared with reusable cloth ones -- it clearly is inadequate as it stands to serve as a basis for policy determination. We therefore strongly recommend that EPA declare the Draft Report invalid and unacceptable and so advise all recipients who might otherwise quote or use parts of the Draft Report out of context with consequent damage to EPA and industry's products. (As you know, at least one such mis-use of the Draft Report already has appeared in the Baltimore Sun.)

If instead it should be concluded that the Project must be carried forward, then we respectfully request that in equity to our industry and the consuming public, major revisions must be made to the Draft Report. The errors should be corrected and the balance of the requirements in the original contract should be fulfilled.

On the other hand, should there be a disposition to proceed with the Draft Report without correction or revision, we ask then for an opportunity to meet with you at your early convenience so that we might mutually agree on a plan under which we can adequately convey correct information to those to whom the Draft Report has been exposed.

A completely detailed discussion supporting the above statements is attached. We stand ready to review it, provide evidence and otherwise support any segment of this with you, the research contractor, or any recipients of the Draft Report who may question or incorrectly interpret it.

We much appreciate the opportunity you have provided to present our findings and views on this subject.

Respectfully submitted,

Roger B. Bognar, Manager
American Paper Institute
Tissue Division

RBB:jg

Attachment

American Paper Institute - Tissue Division Comments

On Draft Report for MRI Project No. 4010-D

"Study of Enviromental Impacts of Disposables Versus Reusables", Volumes I and II

American Paper Institute - Tissue Division Comments

On Draft Report for MRI Project No. 4010-D

"Study of Environmental Impacts of Disposables Versus Reusables", Volumes I and II

Our sanitary paper products industry group endorses effort to gain perspective in the environmental and resource impacts area. However, we also believe the potential usefulness of Draft Report #4010-D should be appraised in terms of several limitations that our study of its contents have indicated. These are discussed in the following sections of this commentary:

INCOMPLETE AND MISLEADING NATURE OF DRAFT REPORT

MRI Project No. 4010-D was originated to implement EPA interest in source (or waste) reduction -- meaning (as we understand it) reduction in the consumption of materials to help conserve resources, reduce pollution, and reduce additions to the solid waste stream. With reference to this, Project 4010-D was established to "identify product shifts that may be desirable from an environmental point of view and to assess the economic and other impacts of such shifts."

In an initial proposal forwarded by the research contractor for this project, Midwest Research Institute (MRI), it was stated that paper towels, paper napkins, and disposable diapers would be compared with their reusable cloth counterparts in part because these items "provide equivalent consumer satisfaction." During the early industry-EPA discussions on this, it was brought out that these and other household sanitary paper products offer product performance advantages, including particularly health and sanitation benefits, that their cloth counterparts simply cannot match; also that to discourage or restrict the use of such household sanitary paper products could inevitably create serious dislocations in the general economy, the gross national product, and our national labor force.

As a result of these discussions, EPA revised its contract with MRI and the research contractor was asked to not only compare the selected products in the seven specified environmental and resource impact areas, but also to determine "relative performance benefits," to report on the "sanitation and public health aspects of the disposable/reusable systems," and to survey the several economic factors that would "characterize and describe ... the disposable/reusable products industry."

It is obvious that any attempt to draw conclusions related to encouraging or discouragir the products of an established U.S. industry must be approached in total perspective -- i.e., should be based on facts relating to all aspects of the many trade-offs involved. However, the Draft Report that has been submitted not only contains many errors (discussed below), it does not go beyond the requested environmental impact comparisons and a limited amount of health and sanitation information. It specifically does not report comparative product performance benefits, nor any observations bearing upon the relative economic impacts of the product areas studied.

We accordingly submit that as it stands the Draft Report is noticeably incomplete and inadequate to serve the purpose for which it was intended. But actually the problem goes deeper. What information is presented in the Draft Report is of questionable utility because there are many important limitations to the methodology it necessarily employs -- for example:

1. Seven environmental and resource impact comparisons are made on each set of compared products. No attempt is made (properly, we think) to assign relative importance to each impact area, but the question remains who is qualified to say how the findings should be weighted and thus combined to reach any type of intelligent conclusion? Is energy more important today (or in 1980) than is process solid waste? Is quantity of raw water usage more important than atmospheric emissions? We believe many would answer "yes" to both questions, but the point is who is to say so, and just how much so? Hence energy and water remain just 2 of 7 factors studied, with implied equal weighting.

2. Assumptions are always dangerous in an analysis, but in this instance the technique employed makes almost more use of assumptions than of verifiable facts. To illustrate, in the so-called current "bottle battle," the number of trips a returnable bottle makes before it is lost or broken is an absolutely key figure, yet in the face of widely varying consumer habits, an assumption has to be made as to a representative number for returnable bottle trips -- and it may not be the right number. The same thing is true here: how many uses does a cloth towel receive before it is washed? How many washings does a cloth diaper receive before it is discarded? How hot does the average commercial laundry heat its water (and thus affect the amount of energy used)? Certainly the soundness of the assumptions made will strongly influence the results.

3. Good data are essential to a study like this, but are often virtually impossible to obtain. Very large scale and scientific surveys are required to get good averages when dealing with a quantification of the all-important consumer habits. The funding of this particular project at MRI permitted little or no such broad-scale surveying. Consumer practices and values change rapidly, and data which

may appear in published literature -- upon which MRI has been forced heavily to rely -- are usually out of date even before they appear in print.

Finally, the Draft Report is misleading because, as it stands, it contains many errors of fact or assumption as discussed below.

MISTAKES AND OMISSIONS IN THE DRAFT REPORT

For the purpose of commenting upon the Draft Report, we have made a careful comparison of input, calculations, and findings as between the EPA's MRI contractor and industry's A. D. Little, Inc. contractor, which was commissioned to make the identical study. Of the 42 basic resource and environmental impact comparisons made (see page 20), we found that with but few exceptions, the relative ratings assigned to either disposables or reusables in each comparison varied remarkably. To illustrate, our analysis shows that the impact values assigned by MRI to either disposables or reusables in the 42 comparisons (84 actual values) varied by more than 10% (either way) from the values assigned by ADL in 72 instances, or approximately 86% of the total value assignments. (This includes value assignments which vary more than 30% from each other in 59 instances, or 70% of the cases!)

We believe few would disagree that given the same questions and the same ground to cover, (the exact same source for data was used in the case of the disposable products studied) two of America's foremost research organizations could logically be expected to emerge much closer than this to each other's findings, if indeed the findings are sufficiently well founded to be actionable. This observation is in no way meant to be critical of either research organization; it is rather meant to dramatize the point that the basic concept and methodology of this type of research are highly questionable. In any event, there is room to question that environmental and resource impact comparisons sufficiently reliable for product policy determinations can be made with a satisfactory degree of accuracy when the calculations must rest upon so many assumptions and be compounded by the obvious difficulties of securing reliable data.

Factual Errors

Our review of the Draft Report indicates the following mechanical or data-gathering errors. (NOTE: In a subsequent section of this commentary, a summary is provided of those impact values which are assigned in the Draft Report which will be totally reversed (i.e., the low or most favorable value awarded to either the disposable or reusable product will be quite the other way around) when the mistake is corrected.)

1. In Table 5, page 11, the value for atmospheric emissions assigned to disposable diapers is incorrectly carried forward from Appendix Table F-5. Instead of 2.232 the value carried forward should be 1.232. Correction entirely reverses the Draft Report finding -- i.e., awards the low value to disposable diapers rather than to cloth diapers washed at home.

2. Similarly, in the same Table 5, Page 11, the value for atmospheric emissions assigned to cloth diapers/home laundered/use 25 is incorrectly carried forward from Appendix Table F-5. Instead of 0.789 the value carried forward should be 1.789. This error significantly understates this impact for cloth diapers.

3. In assessing cloth product impacts, the Draft Report improperly bases its estimate of fiber impact data on California statistics for cotton growing. This is inaccurate for two reasons: (a) the average yield/acre in California is about double the U.S. average yield (i.e., 900-1,000 lbs./acre versus 400-500 lbs./acre), and (b) relatively fine grades of cotton are grown in California and these are rarely used in cloth towel, napkin or diaper production. This deviation has major impact on the accuracy of the study findings in all seven basic environmental comparisons for each type of product and laundering situation.

4. Similarly, the Draft Report makes no allowance for the extensive amount of irrigation water utilized in cotton growing. Irrigation is important in every

cotton growing region of the U.S. except the Texas high plains. Since irrigation water is primarily well water or potential drinking water capable of use for other industrial purposes, it should be considered as a substantial resource impact in the cotton-growing process. This omission materially understates the Draft Report's findings of cloth "Process Water Volume."

5. The Draft Report has understated raw material flow quantities factored into the cloth product evaluations. This results from using excessively high conversion yields for spinning/weaving (about 8% too great) and conversion (about 2% too great). The Draft Report uses figures apparently valid for synthetic fiber processing rather than cotton fiber processing. The uniformity of cotton fibers is far less than synthetic fibers, meaning that cotton cannot be spun and woven as efficiently. With these differences we estimate the Draft Report requirement for cotton fibers is about 12% to 14% understated. This is a major difference and it affects the validity of the Draft Report findings in all seven REPA comparison areas for all six of the product/laundering comparisons made.

6. Again, the Draft Report's material flow estimates are too low for polyester fiber systems employed in cloth napkin manufacture. The inaccuracy is in relatively invalid conversion yield data. The amounts by which the MRI estimates of requirements per pound of polyester resin produced appear too low are: Ethylene Glycol - .06; DMT - .10; p-Xylene - .22; and Oil - .27. It is not physically possible, for example, even assuming 100% polymerization of DMT, to produce one pound of polyester resin from 0.97 pounds of DMT. The estimates for p-Xylene and oil are significantly understated, possibly involving mathematical mistakes. The net effect dramatically decreases the raw material and energy impact values assigned to polyester. This affects all seven comparisons in the home-laundered cloth napkin area.

7. Related again to home-laundered cloth napkins, the Draft Report appears to have understated the natural gas producing step significantly, failing to recognize that nearly 6,000 lbs. of natural gas must be processed in order to get 1,000 lbs. of natural gas liquids. The Draft Report assumes natural gas containing about 17% (by weight) gas liquids, whereas current gas from off-shore wells or very deep land wells contain less than 10% gas liquids -- thus even more natural gas must be processed to get the necessary gas liquids for ethylene production. This error affects the impact values assigned in all seven categories for home-laundered cloth napkins.

8. In calculating impacts from the home laundering of cloth, the Draft Report incorrectly uses a washing load weight of 12 pounds for each load. A current figure is only about half of this -- e.g., about 5.7 pounds. The 12 lbs. is approximately the rated capacity for current "large load" washers. Current washer ownership is about 55% large load and 45% normal load. The average mixed load for a large load machine is about 5.9 lbs. and for a normal load machine about 5.4 lbs. This difference has a tremendous impact on all seven REPA categories for all three home laundered cloth products.

9. A closely related mistake in the Draft Report, we believe, is the use of a quantity of hot water (25 gallons) per home washing load that does not permit a warm water rinse. Home laundry usage and practice data do not show that cold water rinsing is significant in the care of cotton textiles. One of the principal reasons is discussed in Volume II of Project 4010-D; on page 29 it is clearly pointed out that cold water washing is unsatisfactory from a sanitation stand-point. The same considerations are naturally at work in the rinsing process. Furthermore, not all new washers make provisions for hot water washing and cold water rinsing. A pronounced degree of warm water rinsing is thus clearly indicated, meaning a figure for hot water usage of more like 35 gallons per load should be

used -- i.e., 40% more hot water with consequent impact on energy usage. This deviation profoundly affects the impact values assigned all home-laundered cloth products in the study.

10. The Draft Report significantly understates effluent loading by waterborne wastes from home and commercial laundering. This is because a municipality's sewage treatment process has been considered part of the home or commercial washing systems. This results in about an 80% reduction of detergent additives thrown into effluent, and, we believe, is wrong: the point source discharge from homes or laundries is untreated water thrown onto the environment and we feel logic says it should be evaluated with gross, not net, impact values. This understates the Water Pollution impact values assigned to cloth reusable products in every comparison area.

11. In computing Process Solid Waste for cloth products, the Draft Report does not appear to make provision for packaging material used for either commercial or home laundry detergent additives. This omission understates the Process Solid Waste value for all home or commercially laundered cloth products in the study.

12. The Draft Report has overstated atmospheric emission data for all disposable products. It has taken the quantity of air pollutants per 1,000 pounds of production as reported by upwards of 60% of the producing plants in an industry survey and proportionately increased this figure to 100%. At the same time the Draft Report states it assumes the non-reporting mills have the same available discharge as the reporting mills. This clearly is a statistical or projectional-type calculating mistake.

13. The Draft Report is also questionable in totaling the pounds of various types of atmospheric emissions without relative weighting, thus treating all as having

the same degree of impact. This appears to be wrong because Federal ambient air standards assign different health ratings to different type emissions, ranging on the values scale from 1 for carbon monoxide to 125 for hydrocarbon.

14. The REPA impacts for disposables are overstated in the towel data for situations in which a cloth towel is used more than once between washings. This traces to an apparent mistake in MRI methodology. In computing data in this instance, MRI divided total laundering impacts by the number of uses between washing, but did not also divide the calculated total manufacturing impacts by the same number of uses.

15. Three discrepancies made in figuring commercial laundry energy requirements for washing cloth products, apparently understating them in a major way, are noted in Appendix E. First, the temperatures specified as standard for laundering kitchen towels in Table #-4 are much higher than those subsequently used to calculate BTU's to heat the water in Table #-5. If the higher temperatures are used in the calculation, the energy requirements are increased by 60%!

Second, the natural gas requirements for commercial laundering as shown on Table E-6 are different than those shown on Tables E-7 through E-9. Third, the energy calculations shown on Table E-5 do not agree with those implied in Tables E-6 through E-9.

Invalid Assumptions

There also appear to be at least two seriously invalid assumptions used to prepare the Draft Report:

1. Perhaps the most misleading assumption made in the Draft Report is that related to the findings on energy consumption for the disposable products. MRI has

concluded that wood wastes (principally bark, hogged wood, and black liquor) when burned should be counted in with energy consumed on an energy equivalent basis rather than to be included in raw material the same as all other wood used to make the disposable products. The Draft Report reasoning seems to be that wood wastes are an energy source in the same way that plastics feedstocks are. It is true that pulping operations burn wood wastes to provide process energy, but this hardly means that this waste is confirmed as a fuel source; the waste is burned primarily to recover costly pulping chemicals and to avoid having to dispose of the waste stream in some other manner.

Further, each pound of wood waste burned reduces the demand for purchased energy in the pulping operation by about 7,000 BTU's. Since most of the purchased energy is derived from scarce hydrocarbon resources, and wood wastes are plentiful, equating energy from wood waste to energy from hydrocarbons distorts reality. The only way a fair picture would be provided would be to count wood wastes as a raw material resource.

Clearly, if a pulp mill is brought on stream or closed down, the impact felt on the national energy pool is described by the purchased energy requirements -- not by total energy requirements. To charge a process for internally-generated energy derived from waste unfairly penalizes the process relative to those which use only purchased energy.

2. Another assumption we feel is invalid relates to the computing of commercial laundry energy requirements in the Draft Report. The data used seem unusually optimistic, apparently being based on "theoretical" energy requirements derived from equipment/process specifications secured form the Linen Supply Association of America. If so, the energy requirements are understated because these theorectical calculations are rarely achieved in actual field operations.

SHORTCOMINGS IN HEALTH AND SANITATION REVIEW

The Draft Report does not present a well-rounded discussion or evaluation of the health and sanitation aspects of paper towels, paper napkins, and disposable diapers as compared with their reusable cloth counterparts. Attention is focussed almost entirely upon describing "concerns" that have been raised about the products, with little effort to present health and sanitation benefits that one or the other type of product uniquely or importantly offers. In addition, the Draft Report:

1. Fails to survey the available literature adequately,

2. Fails to examine all aspects of certain "concerns",

3. Has not carefully examined some of the quoted research in order to avoid using findings in a misleading way, and

4. Fails to draw conclusions based on a pre-ponderance of evidence.

Failure to Survey Literature Adequately

Nearly half of the section in the Draft Report on diaper health "concerns" deals with potential skin irritation, or rash, as associated with disposable diapers or related to bacteria resulting from inadequate laundering of cloth diapers. Only two references are cited relative to the causes of diaper rash, yet over the last 50 years there are probably a few hundred published papers dealing with this subject.

In a similar vein, at least six causes of diaper rash other than bacteria are listed, yet no references are cited for these, nor is there any discussion of their relative importance in the overall rash question.

Also, in discussing bacterial and viral concerns related to diaper disposal in solid waste, only five references are cited. There are at least 16 other references (see Appendix) which would have been surveyed and would have provided much more perspective on the question.

<u>Failure to Examine All Aspects of Certain "Concerns"</u>

An example of this is found in the lengthy discussion devoted to the "general concern over the public health consequences of fecal matter in solid waste." This is a reasonable question to raise and study -- with respect to which the disposable diaper industry has sponsored considerable research at leading universities and professional research institutions, resulting in a preponderance of evidence that no public health problems of significance are presented. However, the observation we wish to make here is that there is no mention at all in the Draft Report of similar-type public health concerns related to storing soiled cloth diapers in homes (awaiting laundering or diaper service pick-up) -- or related to the flushing of infant soil into toilets and sewers.

It is a well established fact that most sewage treatment is very poor at removing some viruses. Even good secondary sewage treatment facilities discharge 1,000 to 50,000 virus units per day per person served, leaving 5 to 10% of sewage virus in the effluent discharged to rivers, lakes or oceans. The result is that viruses are often found in sewage treatment residues, such as the sewage sludge that frequently is spread on dumps or over tilled land. There are many published research studies on this, yet none are referenced, analyzed nor reported in the Draft Report.

<u>Misleading Use of Some Findings</u>

An example is found at page 40 of the Draft Report, relating to a <u>study</u> which is quoted to the effect that the incidence of diaper rash is significantly greater with disposable diapers than with cloth diapers. The facts are that the quoted study was conducted to help determine the economics of disposable vs. cloth diapers. The included rash lata was accumulated in an incidental and non-controlled manner, and as a virtual afterthought to the study. The authors stated that the rashes associated with disposables were "... caused, undoubtedly, by diaper tightness" as the result of use of diapers too small for the baby's size. But nothing to this effect is mentioned in the Draft Report.

An additional example of less than careful checking and reporting appears in the four pages devoted by the Draft Report to the diaper laundry service industry "Accreditation Program" which is operated by that industry's trade association group, the National Institute of Infant Services. This program is represented as requiring very high standards in the commercial washing of cloth diapers, an observation which is doubtless correct. However, although the Draft Report indicates that something "less than half" of the NIIS member services are so accredited, the facts (according to NIIS literature) are that not more than a quarter of its more than 100 coast-to-coast members are so accredited. This is an easy-to-ascertain fact and reporting it correctly would have a significant bearing on the degree to which the commercial laundering of cloth diapers can be said to be highly efficient from a sanitation standpoint. More importantly, the Draft Report fails to make any mention of the fact that cloth diapers washed commercially comprise less than 10% of all diapering done today. In other words, no perspective is supplied as to the relative importance of the commercial laundering of cloth diapers.

Failure to Draw Conclusions Based on a Preponderance of Evidence

The Draft Report presents a series of observations from the review of literature and contacts with interested parties, but fails to draw conclusions based on the judged weight of the evidence. Examples follow:

Towels and Napkins: After nearly 40 pages of reporting findings on cloth products from the standpoint of potential for contamination, the Draft Report states "in view of the lack of substantive evidence establishing cloth towels, cloth napkins and sponges as sources of pathogenic organisms, to which normal exposure would likely cause infection, MRI can formulate no definitive conclusion as to the relative health and sanitation status of paper versus cloth towels versus sponges, or paper versus cloth napkins. This conclusion is reached despite the following previous quotes:

- Page 2 -- "Scientific studies have shown that fabrics can harbor microorganisms which can be transmitted from person to person."

- Page 3 -- "The microorganisms may survive for a relatively long period of time under favorable conditions."

- Page 6 -- "Other authors have reported cases of illness directly traced to contaminated fabrics, etc."

- Page 7 -- "A cloth towel used in the kitchen for wiping kitchen spills can easily be contaminated by hand contact," and "spilled foods or liquids can provide excellent media which can support the growth of bacteria."

- Page 8 -- From a study entitled "A Bacteriological Investigation of Towels", "The phenomena of communicability and invasiveness are complex and controlled by many factors, but, other things being equal, the contact with large numbers of potential pathogens must obviously increase the chance of infection."

- Page 36 -- "But the paper towel, used only once and then discarded, would virtually eliminate this potential for cross-contamination."

- Page 36 -- "In the home setting, cloth napkins are often used for several days before they are laundered, creating increased potential for bacterial transmission.

Mixed in with the above and similar observations is a lengthy discussion of laundering cloth products, with respect to which the Draft Report says "the inherent potential for disease transmission can be virtually eliminated by proper laundering techniques." This quote is shortly followed, however, by a significant quote attributed to the USDA "Neither the water temperature nor the detergents used under today's home laundering conditions can be relied on to reduce the number of bacteria in fabrics to a safe level" and (2) references to several studies which, taken altogether, illustrate that it is quite questionable how many commercial laundries utilize water that has been heated to the extent that laundry standards-setting bodies recommend for assured bactericidal effectiveness.

To summarize on this point, despite having documented the unquestionable tendency of fabrics to collect and harbor pathogens, despite having shown that most home laundering is relatively ineffectual in eliminating the pathogens, despite having reflected that even the more efficient commercial laundries may not regularly achieve laundering conditions required to do the same, despite having reported the relatively very low bacterial counts on household sanitary paper products, the Draft Report does not even acknowledge in its conclusion on towels and napkins that the weight of evidence thus points to the considerable risks of human cross-contamination with cloth towels, while a paper towel used once and discarded eliminates virtually any chance at all of this. Indeed, the stated Draft Report conclusion simply says, as discussed above, that "no definitive conclusions" can be formulated. This has to reflect either bias or relative failure to cross-evaluate the available evidence.

Diapers: The same suggestion of bias or perhaps failure to amply weigh the evidence is reflected in the Draft Report write-ups on the question of the relative safety of disposing of soiled diapers in solid waste. After quoting studies indicating that viral pathogens can be present in infant soil contained in disposable diapers (about which there is no argument) and then quoting some (but not all) of the research sponsored by the disposable diaper industry at leading American universities, the Draft Report states that "in view of the lack of consistency in the published literature ... no clear understanding of the public health threat represented by viruses in solid waste can be reached." This is despite (1) the fact that in the three studies cited, one investigator was able to detect viruses from a rapidly saturated landfill but none were able to detect viruses in leachates from normally-saturated landfills; and (2) the fact that all the authors cited agree that viruses and bacteria are present in municipal solid waste, and all found no viruses in normal leachate samples. Actually, there is even more research to support these findings than was cited in the Draft Report. In any event, the logical conclusion is that while there is some likelihood of finding viruses where unusually rapid leaching takes place, there is negligible likelihood where normal leaching occurs.

Along similar lines, the Draft Report contains conflicting statements. On page 57 it says that "at 0.02% by weight, fecal contamination from diapers does not add an amount of either bacteria or viruses in the leachate which can be detected over the background level." Yet on Page 58, discussing the same subject, the Draft Report says "However, the actual bioload from the source is yet unclear ... Therefore, no final statement on the public health significance of discarding disposable diapers into the solid waste stream can be made."

To summarize, while for many questions of this nature no final statement is ever quite in order, it seems unquestionable that the Draft Report, to accurately assess the available evidence, should bring out and comment upon the preponderance of evidence that indicates the disposal of soiled diapers in solid waste has not introduced any public health problems of significance.

DISPOSABLE PRODUCT BENEFITS NOT REPORTED

As mentioned earlier, it is incorrect to assume that the usage benefits afforded a onsumer by a household sanitary paper product will be the same as are afforded by a cloth product counterpart. Therefore, in making an overall cross-comparison of the two types of product here under review, it is mandatory that the unique or "plus" benefits available only with one or the other product be factored in. The following will illustrate many singular disposable product benefits that have not been reported and thus reflect relative failure to consider the consumer interest:

1. Paper towels offer a much wider range of uses than cloth towels. Research with consumers shows that there are at least 20 major and distinct household uses for paper towels, whereas cloth towels are considered beneficial and appropriate almost entirely for body and dish drying. Particularly unique uses of paper towels are for wiping up grease or messy spills, draining greasy or wet foods, and lintless cleaning of windows or mirrors. A consumer would have to keep several cloth towels at hand to even come close to the performance versatility of a roll of paper towels, and the cloth towels would not suit many purposes at all.

   Paper towels offer unmistakably clean surfaces for tasks where this is especially important. They are available virtually free of microorganisms where this is necessary or desirable. This contrasts with cloth towels and sponges, which tend to remain wet between uses and thus favor growth of microorganisms (salmonella, etc.) on their surfaces.

2. Paper napkins have no practical alternative when it comes to being [redacted] utilitarian and economical for use in the home, restaurants or institutions. For example, paper napkins cost food service operators about $1.65 a thousand; the cloth alternative would run to $40-$50 a thousand considering initial costs, laundering, pilferage. The same economics are at work in home situations, where paper napkins cost only about 2/5th of a cent versus more than 3¢ for cloth napkins after all costs including laundry are factored in.

Paper napkins also offer the spill and grease absorbency advantages that are true also for paper towels, and they eliminate health risks that can be present with improperly-washed cloth.

3. Disposable diapers are used for over half of all diaper changes in the U.S. because they offer unique benefits. Special construction enables them to keep babies' skin drier, eliminating need to "double diaper" and requiring fewer changes. They present clean, fresh surfaces each time with no risk of carry-over microorganisms from improper laundering. By eliminating laundering time they help many mothers to hold jobs, and by their very availability they are a boon to many inner-city mothers without laundering facilities. Their many advantages over cloth diapers are recognized by over 3,300 U.S. hospitals from coast to coast which now use the disposable product in their OB or pediatric wards. Approximately 75% of all babies born today in U.S. hospitals are first diapered in disposable diapers.

ECONOMIC IMPACTS NOT REPORTED

The research contractor for Project No. 4010-D has not furnished any comparative data on subject disposable and reusable projects of an economic nature. Clearly no attempts to cross-evaluate relative benefits and contribution to society can be soundly made without factoring in such considerations as relative cost to use the competitive products including laundering, contribution of the particular product category to total employment, the gross national product, etc.

Thus it is that the Draft Report does not bring out such considerations as these:

1. Consumer usage of paper towels, paper napkins and disposable diapers has created a multi-billion dollar industry which provides employment directly for at least

30,000 persons. The paper towels, paper napkins and disposable diaper industries have an estimated fixed capital investment of over one billion dollars, with an annual new capital investment rate of over 100 million dollars annually. Any restriction on this activity will not only seriously affect consumer interest, but will have obvious implication on our national economy.

2. The quality of U.S. life as reflected in economic considerations is vastly affected by household sanitary paper products. Working women in our economy increasingly rely on disposable paper products to enable them to function as both homemaker and wage earner. Working mothers find disposable diapers a virtual necessity. The economic structure of most food service operations in cafeterias, luncheonettes, institutions, et al, mandates the use of sanitary paper products such as towels and napkins.

3. Sanitary paper products are often the most economical alternative for many common household tasks. As one example, according to figures prepared by A. D. Little, Inc., when allowance for mothers' time and effort to launder cloth diapers is taken into consideration (even at the minimum wage scale), cloth diapers laundered at home are found to be the most expensive option for baby diapering -- about 12.3¢ each, while disposable diapers will cost the least (about 9.3¢ each) and cloth diapers commercially-laundered somewhat more (about 9.8¢ each).

Many additional aspects to the economic comparison of disposable and reusable products could be cited, but the important point is that as the Draft Report stands, no economic mentions or comparisons are made, and thus the consumer interest is particularly ignored and potentially impaired.

RELATIVE DISPOSABLE/REUSABLE FINDINGS IN DRAFT REPORT

It is of particular importance to note that even before the correction of the many errors that penalize disposables in the Draft Report, it still shows the majority of lower (most favorable) resource and environmental impact values for the sanitary paper products. As noted earlier, seven selected resource and environmental comparisons were made on three paper products, with a breakdown in the cloth napkin and diaper areas as between home-laundered items on the one hand and commercially-laundered on the other hand. There is also a breakdown in the cloth towel area to reflect comparison when the towel is used just once between washings (the case when the towel has been stained or heavily soiled when used), and when the cloth towel is used more than once between washings (five uses is calculated in the Draft Report). Hence there are a total of 42 basic comparisons. (This excludes the findings quoted in the Draft Report for sponges, which simply are not a widely-used nor practical alternative for several of the most important uses of paper or cloth towels in the kitchen -- e.g., drying dishes, or hands or face, etc.).

Among the basic comparisons, the Draft Report finds lower (most favorable) environmental/resource impacts for the disposable paper products in 21 of the instances and one additional measurement is a "tie." Thus the disposable products enjoy half or more of the plus values.

Of more significance, should the Draft Report comparisons be revised to correct the errors and omissions discussed above, according to our calculations, household disposable paper products would emerge with the lower impact values in apparently another 8 additional measurements. This would give the three household paper products a total of 29 of the 42 most favorable ratings.

A comparison of these net findings by individual product categories and breakdowns is shown below:

	Towels		Napkins		Diapers		
	1 Use	5 Uses	Home Laundered	Commercially Laundered	Home Laundered	Commercially Laundered	Total
As Draft Report Stands:							
Disposable lower impact	5	1*	6	5	5	0	22
Reusable lower impact	2	6	1	2	2	7	20
Allowing for Corrections:							
Disposable lower impact	5	5	5	6	5	3	29
Reusable lower impact	2	2	2	1	2	4	13

*This comparison actually is a "tie."

As indicated, with revision of the Draft Report along lines discussed, five of the six category comparisons will net out in disposable' favor by a 5 to 2 or larger margin of superiority. A brief discussion by product types follows:

Paper Towels

As noted earlier, when cloth towels are used once between washing (as would be the case when towels are used to clean up "spills", etc.), the Draft Report shows that the alternative, paper towels, has the lowest or most favorable REPA values in 5 instances and the cloth towels in just 2 instances.

However, when the cloth towel is used 5 times (or more) between uses, the Draft Report suggests that the cloth towel would emerge with the most favorable values in 6 instances and tie in the seventh instance. The A. D. Little, Inc. analysis shows that this is wrong; and that when the Draft Report is corrected, 4 of the Draft Report findings will be completely reversed (the energy, process water volume, water pollution, and process solid waste comparisons). Thus even in the case of cloth towels used 5 times between washings, paper towels emerge with the lowest or most favorable environmental ratings in 5 of the comparisons and cloth towels in 2.

Napkins

The Draft Report awards paper napkins a total of 6 lowest or most favorable environmental/resource impact rating advantages over cloth napkins laundered at home. Our analysis shows that in one instance(Raw Materials) MRI has understated the value computed for the disposable products. This traces to the invalid assumption discussed in point #6 on page 6, and when corrected will revert the disposable product advantage over cloth to a 5-2 ratio.

In the comparison of paper napkins with cloth napkins laundered commercially, our anlaysis shows the net finding on most favorable impact values for the disposable product is affected in reverse. The advantage shown for reusable napkins by the Draft Report in the raw material area is reversed, so that the overall count becomes 6-1 in favor of paper napkins rather than 5-2.

Diapers

The Draft Report shows disposable diapers, as compared with cloth diapers laundered at home, to have lowest/most favorable impact values in 5 of the 7 environmental/resource categories. Correction of the Draft Report as discussed will add to the degree of advantages over cloth in all categories, but will not change this favorable ratio.

In the commercially-laundered cloth diaper area, corrections of the Draft Report will cause 3 of the findings to reverse in favor of the disposable product (energy, waterborne waste, and process water volume), bringing the count on lowest or most favorable values to 3 for disposables and 4 for cloth.

As mentioned earlier, these impact areas wherein the disposable product is rated less favorably are ones in which significant additional factors should be taken into consideration. The first area is raw materials, wherein wood from trees is the basic resource and is a totally renewable resource. The second area is solid waste, wherein the basic material is completely biodegradable. This leaves only atmospheric emissions as an area of apparent disposables deficiency, but even this is challengeable (see pages 5 & 8). In any event, a very key point is that commercially-laundered cloth diapers account for less than 10% of the total diapering market, meaning that 90% or more of the consumer usage of diapers falls into the area where cloth, if used, is laundered at home -- and is the area in which the disposable diaper emerges with a 5 to 2 margin of environmental/resource superiority.

To summarize, the cloth reusable products emerge overall with lesser impacts in the raw material and post-consumer solid waste comparisons. This comes as no surprise when it is remembered that single-use products are being compared with multiple-use items. However, not only do the disposables show lesser impacts in a larger number of the comparisons -- including the important areas of energy and water usage -- but, as mentioned above, the raw materials used are a totally renewable resource, and the basic material (cellulose) is totally biodegradable.

Further perspective is furnished by the facts that (1) the three sanitary paper products under consideration contribute only about 1.5% by volume to total municipal solid waste; and (2) wood fibers used in these products amount to only a little over 2% of the total fiber used by the paper industry. As much as 20% of these total fiber requirements come from waste paper, and approximately 30% come from sawmill and logging residues. This is one of the highest ratios at this time, in the use of recovered materials in all United States industry.

REFERENCES

Most facts used in this commentary are supported by the following research specially conducted by the American Paper Institute on the disposables/reusables questions posed by EPA Project No. 4010-D:

Resource and Environmental Profile Analysis of Selected Disposable Vs. Reusable Diapers, Napkins and Towels, A. D. Little, Inc., March 1977.

Comparative Analysis of Selected Characteristics of Disposable and Reusable Towels, Napkins, and Diapers, A. D. Little, Inc., three separate volumes prepared in March and April 1977.

A Comprehensive Study of Consumer Usage and Attitudes Concerning Paper Products, Market Facts, Inc., March 1977.

A Comprehensive Study of Consumer Usage and Attitudes Concerning Disposable Diapers, Market Facts, Inc., November 1976.

Exploratory Consumer Evaluation Attitudes Towards Paper Towels and Napkins, Consumer Diagnostics, Inc., October 1976.

Other facts used in this commentary are supported by research or experience of API-Tissue Division member companies.

In all cases, inquiries pertaining to this privately-funded research -- most of it conducted by leading U. S. independent research organizations -- should be addressed to American Paper Institute - Tissue Division, Mr. Roger B. Bognar, Manager, 260 Madison Avenue, New York, N. Y. 10016.

6/28/77

APPENDIX

Some Additional Literature References on Microorganisms

and Viruses in Relationship to Solid Waste

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14. Engelbrecht, R. S., and Amirhor, P., "Biological Impact of Sanitary Landfill Leachate on the Environment," Presented at Second Nat. Conf. on Complete Water Reuse, Amer. Inst. Chem. Eng., Chicago (1975).

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APPENDIX C

AMERICAN RESTAURANT CHINA COUNCIL, INC.

328 N. PITT STREET
ALEXANDRIA, VA. 22314
PHONE (703) 548 2588

June 24, 1977

Mr. Charles Peterson
Project Officer
Disposables Reusables Contract (AW-463)
United States Environmental Protection Agency
Office of Air and Waste Management
Washington, D.C. 20460

Dear Mr. Peterson:

We appreciate the opportunity to comment on the draft report comparing selected disposable and reusable products as submitted to you by the Midwest Research Institute.

It is our hope that our comments will be considered in the preparation of the final report and that, in particular, our recommendations on continued studies be given careful consideration.

Sincerely,

Irving J. Mills
Executive Director

IJM/jm

Encl.

COMMENTS ON THE DRAFT REPORT
OF
ENVIRONMENTAL IMPACTS
OF
DISPOSABLES VERSUS REUSABLES

Irving J. Mills
Executive Director
AMERICAN RESTAURANT CHINA COUNCIL, INC.
328 N. Pitt Street
Alexandria, Virginia 22314

(703) 548-2588

June 24, 1977

ii-e

We have arranged our comments in the order you requested in the transmittal letter covering the draft report dated April 1, 1977 entitled "Study of Environmental Impacts of Disposables versus Reusables."

I. FACTUAL ERRORS

1. Volume 1A, REPA, printed page 14, Cold drink containers (9 fluid ounces), references made to this information having been submitted by the American Restaurant China Council. The nomenclature of "cold drink container" is non-existent in our industry. We do not claim authorship nor are we a source of reference for the phrase.

2. Volume II, Health Considerations, printed page 125, the correct address of the American Restaurant China Council, Inc. should read 328 N. Pitt Street, Alexandria, Virginia 22314, (703) 548-2588, Irving J. Mills.

II. INVALID ASSUMPTION

That public health and sanitation considerations have a valid place in a study originally contracted for the purpose of studying environmental impacts of disposables versus reusables.

We cannot ignore the fact that an unknown amount of taxpayers money was wasted because of the pressure applied by disposable interests which aborted and modified the original contract #68-01-2995.

Undoubtedly the lack of an economic study on post consumer waste is the result of such deviation of purpose.

Fortunately, on printed page 107, Volume II, the entire matter of health considerations in disposables versus reusables was laid to rest in the quotation,

> "Questions involving the health effects of environmental bioloads are particularly prone to uncertainty and the health impact of various environmental levels of microorganisms on food or beverage contact surfaces are often unknown, and infrequently unknowable."

What is now needed is to go back to the intent of the original contract and in much greater depth.

III. <u>COMMENTS AND RECOMMENDATIONS</u>

1. We feel this report totally fails to explore the original core issue - <u>THE SERIOUSNESS OF AMERICA'S SOLID WASTE PROBLEM AND ITS TOTAL COST TO THE NATION</u>.

   We believe, too, an applied assumption has been made which is invalid when the economic aspects of the work done by MRI are not presented "due to lack of data".

   No study of disposables versus reusables will ever be useful to the President, Congress, and the general public until the full cost impact is studied in depth. For example, the economic costs of post consumer waste must be known to anyone attempting an objective study of disposables versus reusables. The economic study called for in the original contract must go forward and be expanded.

The Pelham, New York, landfill is an excellent example of improper land disposal practices. This mountain of garbage peaks at 140 feet at the present time and covers 75 acres. It is being fed at a rate of five million pounds of garbage daily.

The cost of this open dump economically, as well as environmentally, to say nothing of its safety hazard, should be studied in detail as a current "today problem" with far reaching implications of taking place tomorrow in other communities.

We believe that the encouragement of reliance on high technology forms of solid waste disposal, in effect encourages the growth of solid waste. In any study on the environmental impacts of disposables versus reusables that, too, must be considered.

Solid waste reduction, not disposal, is the key issue. Any objective study should recognize that it takes 6900 disposable plates to do the job of one single reusable plate. That is simple, real world solid waste management everyone can understand.

2. The energy crisis cannot be divorced from a study of disposables versus reusables and we strongly suggest the inclusion of a meaningful energy discussion in future studies. Specifically;

   A. Establish a list of our nations' natural resources based on current available technology.

   B. Determine our annual usage of these natural resources for both disposables and reusables.

   C. Study our resource availability and product use recommending to the nation allocations of energy and raw materials based on a best use concept.

   D. Establish a "watch dog" committee that would keep score and report to the nation the products that are a serious drain on our most vital resources, such as petroleum and forest products.

   E. Develop an oversight committee that will keep tabs on the social and environmental cost in total of producing and disposing of various products, such as disposables and reusables.

We are not recommending nationalization of our vital resources or even that the Environmental Protection Agency unilaterally set up oversight committees. We do, however, believe it mandatory that the study undertaken in the original contract be explored to a logical conclusion as outlined above.

3. We recommend that sizeable increases be made in the allocation of funds for research into all of the above vital areas and that the results be widely publicized. The voters of this country must be shown there is no such thing as a "throw away". IF THE COST OF DISPOSING OF DISPOSABLES WAS PART OF THE ORIGINAL PRICE TAG, THE ATTITUDE OF THIS NATION TOWARDS DISPOSABLES WOULD, WE SUBMIT, CHANGE PERCEPTIBLY.

Further, the Environmental Protection Agency, under the Resource Conservation and Recovery Act, of 1976, must work with the various states to offer financial assistance in implementing that law. It seems to us that there should be some provision to insure that while the federal government is giving funds to the states for resource conservation, the state governments are not spending their own money in a counterproductive manner in the name of environmental health programs.

In summary, we believe that the contracted study performed by Midwest Research Institute was a reasonable and objective first step in understanding the issues involved. It is, in our opinion, regretable that the original contract was modified with the result that emphasis was shifted, distorted, and aborted from the original purpose. Now that the advocates of disposables and single service merchandise have had their health considerations explored, it is time to return to the fundamentals; environmental impact, solid waste accumulation, resource availability, and a study of the social and economic price the nation is really paying for a "throw away" society.

DIAPER SERVICE ACCREDITATION COUNCIL

Ruth P. Livesey
Executive Director

June 14, 1977

Mr. Charles Peterson

Project Officer
Disposables/Reusables Contract (AW-463)
United States Environmental Protection Agency
Washington, DC 20460

Dear Mr. Peterson:

We thank you for the opportunity to review the study of impact on the environment of disposables vs reusables. Our interest, as you can readily understand, lies in diapering and we will confine our comments there.

Our consultants wish to compliment MRI for the fine achievement in putting together this document. We look forward to its dissemination.

We do have a few suggestions.

The formula furnished by the American Institute of Laundering must date back many years. Boric acid rinse has not been used for diapers in many years. There were cases of severe skin burn from this material and at least one death. Over the years other means of sanitizing have been found without the resulting harm to the infant.

We would like to suggest that the discussion of diaper processing be consolidated in one area. In that discussion, one very significant and important part of the approved present-day treatment has been omitted in the text. I refer to impregnation of the fabric with an EPA-approved bacteriostat.

Sterility is commendable in any diaper prepared for storage. But this sterility is fleeting the moment the diaper is exposed to air. Far better, according to some physicians, is the diaper that is free from disease-producing bacteria, but which is also bacteriostatic. Such a diaper remains "clean" during shelf life. The bacteriostat is stimulated to action in the presence of moisture from the infant's skin. It then retards the growth of bacteria deposited on the diaper.

This is very important. Many kinds of bacteria break down urine into Urea and produce ammonia. Ammonia is highly irritating to the skin and opens it to secondary invaders in the form of any bacteria that may be present. These invaders are no longer kept out by the acid mantle of the skin and can cause disease.

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The use of the bacteriostat to retard the growth of bacteria is therefore beneficial until such time as the mother can change the infant.

Bacteriostats are not easy to use successfully. Even if available to the mother for home washing, the automatic home machine is not adapted for their proper use.

There are several places in the text where "sterility" is used in terms of degrees. "Sterility" is an absolute. It is therefore incorrect to say that one product is "more sterile" than another. Instead we suggest "a diaper of better sanitary quality than . . ." as on page 59.

On page 39 there is reference to a paper by Brown, Tyson & Wilson, with only part of the name shown. We suggest that the entire authorship be included, or the usual form "Brown et al."

On page 42, there is reference to a trade name "Diaseptic Process." Instead the sentence might read: "The laboratory assisted in the establishment of processing guidelines."

Again, bacteriostatic impregnation was omitted from these guidelines. We feel it is more important than softness and absorbency, although these factors are important for comfort.

On page 52, there is discussion of the virus population in feces. As you know, Dr. Mirdza Peterson made a study of the sanitary landfill for EPA, which study was reported in September 1974 in AJPH. In your document there is almost no mention of a host of strains of Escherichia coli, some quite virulent. The American Academy of Pediatrics has been concerned about intestinal involvement in infants and diarrhea caused by E. coli. The theory is that they do spread far and wide in ground water.

On page 44, bleach is included with quaternary ammonium compounds as a bacteriostatic agent. It is more properly a bactericide. Bleach is used in diaper service processing with hot water of 160^{o} to kill any bacteria present.

For your convenience, I am enclosing a modern diaper formula, which you will note eliminates boric acid and includes a quaternary ammonium compound and fabric softener.

If we can be of further help, please call on us again.

Sincerely yours,

Mrs. Ruth P. Livesey
Executive Director

Enc:

CC: Dr. Coursin
Dr. Spahr
Fred Wilson
T. J. Skillman, Jr.

Operation	Supplies Used	Temperature	Time in Minutes
Flush	15" waterlevel	100°	2
Flush	Same level	110°	2
Flush	15" water level	140°	2
Break	15" Soap	160°	4
Suds	15" Soap	174°	5
Suds	15" Soap	176°	5
Strip	15" Ortho Phosphate	172°	5
Bleach	15" Sodium hypochlorite	150°	7½
Rinse	15" Water	140°	2
Rinse	15" Water	120°	2
Sour	7" Zinc Silico fluorite	110°	5
	Quaternary ammonium compound		
	Fabric softener		

Reprinted from the American Journal of Public Health
Vol. 64, Number 9, September 1974
Printed in U.S.A.

Soiled Disposable Diapers: A Potential Source of Viruses

MIRDZA L. PETERSON, PhD

Introduction

The average production of solid waste in the United States is 5.3 pounds per capita per day, or more than 300 million tons annually.[1] Although it is recognized that the disposal of solid waste is fundamentally a health problem,[2] the biological threat to health caused by human pathogens carried by or in association with the waste has not been explored. Excreta and products of animals have long been a part of municipal solid waste. The appearance of soiled disposable diapers in this waste creates a situation that increases the amount of human excreta in solid waste, and thus adds another dimension to the health hazard of the solid waste. Viruses, in particular, are a source of concern since babies are the most effective carriers of enteroviruses and have generally been immunized with live polio vaccine. In an early study that we conducted in 1971 on the occurrence of viruses in municipal solid waste, the expected enteric virus density in this waste was calculated to be about 32 virus units per 100 gm.[3]

The present investigation describes the amount of soiled disposable diapers found in municipal solid waste, the amount and types of enteric viruses found in these diapers, and the implication to public health of their appearance in solid waste.

Materials and Methods

Sampling of Waste and Detection of Virus

Municipal solid waste collected from an area in Cincinnati, Ohio (area A), and from an area in northern Kentucky (area B) was delivered to a pilot laboratory where the waste was separated. The diapers picked from the waste were placed in sterile plastic bags and brought to the laboratory for processing. A 5-gm portion of fecal material was removed from each disposable diaper and concentrated for virus by methods described elsewhere.[3-6]

Results and Discussion

Amount of Soiled Disposable Diapers in Municipal Solid Waste

A total of 8.2 tons of waste was separated. The results obtained from the studies showed that, by wet weight, 0.6 to 2.5 per cent of solid waste was soiled disposable diapers (Table 1). Because approximately 33 per cent of the diapers contained fecal matter and each pound (wet weight) of feces-soiled diapers contained an average of 60 gm of feces, the average amount of fecal matter in solid waste was calculated to be about 0.2 gm per 1 pound (wet weight).

Isolation of Viruses from Fecally Contaminated Disposable Diapers

Of the 84 fecally contaminated disposable diapers tested, nine contained viruses (Table 2). Viruses were detected in 15 per cent and 2.9 per cent of samples from area A collected during February and April, respectively; 16.7 per cent of samples from area B contained viruses during July.

Poliovirus 3 was recovered from disposable diapers in both sampling areas and echovirus 2 was found in two

IV-D

TABLE 1—Amount of Soiled* Diapers in Municipal Solid Waste, 1971

Sampling			Amount of Diapers	
Area	Date	Total waste Separated	Soiled	Feces-contaminated
		lb†	% total waste‡	
A	February	800	2.5	1.0
A	April	9,200	0.9	0.3
B	July	2,800	0.6§	0.2§
B	July	3,600	0.8§	0.3§

* Includes diapers contaminated with urine or feces.
† Pounds (wet weight).
‡ Percentage (wet basis).
§ Mean values obtained from multiple samples.

TABLE 2—Percentage of Virus Isolations from Fecally Contaminated Disposable Diapers, by Area and Month, 1971

Sampling		No. of Samples Tested	Samples Containing Viruses	
Area	Date		No.	%
A	February	20	3	15.0
A	April	34	1	2.9
B	July	30	5	16.7

TABLE 3—Isolation of Viruses from Fecally Contaminated Disposable Diapers from Areas A and B, 1971

Area	Month	Sample No.	Total PFU/Gm	Virus Types
A	February	29	320	Polio 3
		31	160	Polio 3
		39	16	Polio 3
B	April	53	32	Polio 3
B	July	90	1920	Polio 3
		94	240	Polio 3
		98	65	Polio 3
		107	1440	Echo 2
		112	960	Echo 2

samples from area B (Table 3). The poliovirus 3 density varied from 16 to 1.920 plaque-forming units (PFU) per gm, with an average of about 390 PFU per gm. The average virus density in the spring months was 130 PFU per gm and that in July 740 PFU per gm (Table 3). These densities were considerably lower than those reported in direct examination of feces of older children.[7,8] Since the fecal matter removed from these collected diapers was usually mixed with urine and since the latter invariably had a strong ammonia odor, the lower virus densities detected in this study could result from dilution of feces with urine and from a rise in pH. Kelly and Sanderson[9] have shown a maximum enteric virus density of 20 units per 100 ml of sewage during the cold months and 400 units per 100 ml during the warm months. This difference reflects the difference and nature of the virus carriers who contributed the viruses to these two types of wastes.

Seven strains of the poliovirus 3 isolated from diapers were tested for their d and T (rct/40) markers in an effort to determine whether the strains isolated were of vaccine or wild types.[10] The results indicated that six of the isolates had clearly defined d+ marker characteristics, and one was doubtful (d±); six strains showed T+ markers, and one was T± (Table 4). These results suggest either that some of the vaccine strains of poliovirus 3 have yielded progeny with reverted dT markers or that wild strains were circulating in areas A and B. If poliovirus 3 vaccine accounted for the positive tests, the isolates were progeny with both markers different from the vaccine strain. Studies have shown that a significant portion of vaccinated children excrete viral progeny with reverted dT markers.[11] Upon serial human passage, these strains may undergo a further change associated with a further increase in neurovirulence and eventually reach a degree of virulence comparable to that of wild polioviruses.

The effect of polio vaccination on virus recovery and the relationship between the relative incidence of viral infections and the prevalence of viruses in solid waste cannot be assessed from these studies. A continuing surveillance of virus in solid waste together with that of families for polio vaccination and infections might thus clarify these points and point to the role of solid waste in the spread of virus infections and disease. Hopefully, such a study will be initiated.

Until such diapers are excluded from solid waste or until an effective method can be developed to disinfect such diapers before they are mixed with the solid waste, these virus-laden materials will continue to present a potential threat to the health of those who handle the solid waste during collection and constitute a feeding ground for disease vectors and a source of contamination of ground water when the waste is disposed in improperly constructed

TABLE 4—Genetic Character of Poliovirus 3 Isolates

Strain	Log_{10} Virus Titer			Markers	
	Bicarbonate overlay, 37°C		High bicarbonate overlay, 40°C		
	High	Low		d	T
February isolates (area A)	5.8	5.8	5.7	+	+
	5.9	5.8	5.8	+	+
	6.0	5.8	5.7	+	+
April isolate (area A)	5.3	4.9	4.3	+	+
July isolates (area B)	5.3	4.0	5.3	±	+
	5.7	4.9	5.3	+	+
	5.6	5.0	5.3	+	+

landfills. The alternative for management of these and other virus-containing wastes should be carefully assessed before any definitive action is undertaken.

ACKNOWLEDGMENTS

The author is grateful to Dr. Shih Lu Chang for his valuable suggestions throughout the course of this study, and for reviewing the manuscript; to the members of the Disposal Technology and Laboratory Support Services Branches, for valuable technical assistance; and to Dr. Milford H. Hatch, Center for Disease Control, Atlanta, Georgia, for identifying two poliovirus isolates.

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This study was made at the Solid Waste Research Laboratory, U.S. Environmental Protection Agency, National Environmental Research Center, Cincinnati, Ohio. Dr. Peterson is a Senior Research Microbiologist with the U.S. Environmental Protection Agency, Clinical Environmental Research Laboratory, University of North Carolina, Chapel Hill, North Carolina 27514. These data were presented, in part, at the Seventy-Second Annual Meeting of the American Society for Microbiology in Philadelphia, Pennsylvania, in April, 1972.

In terms of the sanitary qualities of paper towels and napkins, the literature does provide one piece of data on unused paper towels which can be presumed to relate to paper napkins as well. Test data supplied by the American Paper Institute (47) indicates that typical total bacterial counts of paper toweling from one manufacturer average 180 organisms per square foot. This may be compared to the FDA Sanitation Code (14) standard of 100 organisms per foodservice product contact surface. Depending on the size of the towel or napkin being considered, the API count could be either slightly inferior or slightly superior to the FDA standard. However, it should also be pointed out here that the FDA standard itself may not be based on any real evidence linking degree of microbial contamination to attendant public health threat.

The literature has also compared typical paper towel counts to bacterial counts on commercially-laundered cloth products in hand-drying applications (40, 47, 8); in each comparison, paper toweling has been shown to harbor significantly fewer bacteria than cloth toweling. While this type of data cannot be related directly to conditions likely to prevail in the home kitchen or commercial restaurant facility, it is still reasonable to assume that paper would show fewer bacteria than would cloth towels or napkins.

However, in view of the lack of substantive evidence establishing cloth towels, cloth napkins and sponges as sources of pathogenic organisms, to which normal exposure would likely cause infection, MRI can formulate no definitive conclusion as to the relative health and sanitation status of paper versus cloth towels versus sponges, or paper versus cloth napkins.

IV. DIAPERS

The disposable diaper has become an increasingly popular product for infant care in the home. More than 2,800 hospitals have adopted the disposable diaper for use in their newborn nurseries. Seventy-five percent of all babies born in hospitals are first diapered in disposable diapers (9), and many parents continue this method of diapering in the home situation. Unquestionably, the disposable diaper provides an element of convenience not offered by the conventional cloth diaper. The disposable is merely removed and discarded, whereas the cloth diaper must be soaked, laundered, dried, folded, and returned to storage. In the hospital situation, utilization of cloth diapers adds a significant burden to the laundry facility; in the home, parents either assume the extra work themselves or employ a commercial diaper service.

Aside from convenience considerations, both disposable and reusable diapers present certain health and sanitation concerns which have been raised in the course of this study:

1. The possibility of increased skin irritation or rash associated with the use of disposable diapers.

2. The ineffectiveness of home laundering of cloth diapers compared to commercial laundering.

3. The health implications of disposing of single-use diapers contaminated with urine and feces.

In order to understand the significance of diapering in the overall health of the baby, it is important to understand the role of the diaper in inhibiting or encouraging skin rashes. Grant, Street and Fearnow (19) list two of the most common causes of diaper rash as: (1) Monilial or bacterial infection; and (2) Ammonial contact dermatitis. The diaper provides a moist, warm environment conducive to the growth of bacteria, which may originate from an improperly laundered diaper, from the infant's skin (especially if the skin is not cleansed following defecation), and from the excreted stools and urine. Other factors in rash development are laundry chemical residuals in the diaper, maceration (softening of the skin by wetness causing increased permeability), marked changes in skin pH, and metabolic wastes in stools.

Brown, ~~and Tyson~~ Tyson & Wilson (3), in studying diaper dermatitis, found that a 2-stage process exists in the development of dermatitis. In the first stage, bacteria act on the urea present in urine, decomposing it into ammonia, which is in itself irritating to the skin. The infant who is not cleaned after defecation, not changed frequently, or who wears plastic pants over diapers (thereby enhancing the moist, warm environment of the diaper region) is much more susceptible to ammonial dermatitis.

The second stage of the process involves the secondary invasion of already-irritated skin by pathogenic bacteria. Brown et al isolated Staphylococcus aureus and Beta hemolytic streptococci (both known pathogens) in babies with rash, but only one incident of Staph aureus and two incidents of Streptococci were found in the babies without rash.

Thus, bacteria in the diaper region contribute to dermatitis by producing ammonia and also by invading the site of primary infections caused by the ammonia. Both the disposable and cloth diaper can produce conditions favorable to bacterial growth; however, actual hygienic practices of changing the baby frequently and cleaning him adequately are still of major importance.

1. The Possibility of Increased Skin Rash Associated with the Use of Disposable Diapers: A 1968 study performed by Silverburg and Glaser (70) at the Long Island Jewish Hospital showed that the incidence of diaper rash was significantly greater with disposable diapers than with cloth diapers. Two plastic-backed disposable diapers and one paper-backed disposable were compared with cloth diapers in the newborn and premature nurseries. Results are presented in Table 7.

The results indicate that in all cases except one, cloth showed a statistically significant improvement in protecting against diaper rash over either plastic-backed or paper-backed disposables. Additionally, only 9.4 cloth diapers were used per baby per day in the newborn unit, compared to 10.4 per day for the disposables; in the premature unit, 7.8 cloth diapers were used per baby per day, compared to 10.0 disposables. However, the authors did not attempt to explain the results of their study nor did they postulate any reason for the difference.

2. The Ineffectiveness of Home Diaper Laundering Compared to Commercial Laundering: The effectiveness of the cloth diaper in retarding bacterial growth and diaper rash is based on how the diaper is laundered. Within the home setting prescribed in this study, diapers would be laundered either in the home (or in a self-service laundry comparable to home facilities) or by a commercial establishment, in many cases a diaper service.

TABLE 7

DIAPER RASH INCIDENCE IN DISPOSABLES COMPARED TO CLOTH

Type of Diaper	Number of Babies	Number of Diaper Changes	Percent of Babies Developing Rash
		Newborn Nursery	
Plastic-backed disposable #1	225	2,752 (3 weeks)[a/]	4.5%
Plastic-backed disposable #2	225	3,364 (4 weeks)	1.0%[b/]
Paper-backed disposable	225	1,668 (7 weeks)	2.5%
Cloth	173	2,092 (4 weeks)	0.3%
		Premature Nursery	
Plastic-backed disposable #1	67	2,648 (3 weeks)	10.2%
Plastic-backed disposable #2	67	4,135 (4 weeks)	5.8%
Paper-backed disposable	67	3,864 (7 weeks)	2.6%
Cloth	64	3,711 (4 weeks)	0.9%

Source: Silverberg, Alvin and David Glaser, "Disposable Versus Reusable Linen in the Nursery--Results of a Comparative Study," (70).

a/ Inconsistencies in number of changes compared to number of babies and test time can be attributed to fluctuations in the length of stay for each baby.

b/ Not statistically significant in comparison to cloth.

The diaper service industry has been in existence since 1932. Through its association, the National Institute of Infant Services (NIIS), this industry has monitored its operations through an independent medical laboratory--Philadelphia Medical Laboratory (formerly Usona Bio-Chem Laboratory). The laboratory established the "Diaseptic Process," a specific method for laundering diapers so they will meet certain standards of sanitation, aesthetic quality, pH balance, softness, and absorbency. This process has been considered standard in the industry, and its effectiveness is checked by taking regular samples of commercially laundered diapers and submitting them to the laboratory for testing.

The 100 members (representing the most active diaper services throughout the U.S.) of NIIS must maintain the following standards:

1. The service must submit one random sample per month, taken from a finished package of diapers, to a specified medical laboratory. The sample must be free of all pathogenic bacteria or fungi and may contain no more than 20 colonies of nondisease-producing bacteria per 8 square inches of fabric. (This compares to a standard of less than two colonies per square inch for disposable diapers.[1/])

2. The sample diaper must read within the range of 4.5 to 6.5 pH by the colorimetric procedure (compared to pH of 7.0 in disposables prior to use[1/]).

3. The sample will be tested for zone of inhibition (bacteriostatic effectiveness) against <u>Staph</u> <u>aureus</u>.

1/ Results from individual disposable diaper manufacturers' continuous quality control testing programs, as reported by the American Paper Institute.

4. Diapers served to customers must be soft to the touch and free from stiffness.

5. Diapers served to customers must be so absorbent that water added drop by drop enters the fabric immediately.

6. Diapers served to customers must be free from stains, tears, and excessive wear. (A package selected at random should show no greater than 3 percent substandard diapers.)

Additionally, in 1970, NIIS established a Diaper Service Accreditation Council which is now composed of two pediatricians, a public health director, a bacteriologist, and three industry representatives. The Council formulated an accreditation program which requires site inspection, self-analysis procedures, and rigorous in-plant standards in order for a service to merit accreditation. Although less than half of the NIIS member services are currently accredited, the Institute plans to require accreditation for all of its members within the next 3 years. In addition to administering the accreditation program, the Council advises the industry on new laundry detergents, new bacteriostats and other additives to ensure their safety and effectiveness. This monitoring is especially important in light of several laundry components found during the 1960's to cause adverse effects on infants. Trichloro carbanilide (TCC), a bacteriostat used in laundry softeners, was found to produce free aniline, a known toxin, when exposed to high heat. In premature nurseries where diapers are autoclaved, this reaction led to the development of cyanosis and methemoglobulinemia in some infants. Another substance, sodium pentachlorophenate, an antimildew agent, caused two deaths and a number of cases of illness in two separate hospitals. Both of these cases emphasize the need for careful evaluation and usage of chemicals in laundering diapers.

Diapers can, of course, be laundered commercially outside of a diaper service, or by a service which is not a NIIS member. In either case, the diaper would be processed according to the standards described in the section on general laundering. In most instances, as discussed in this section, the commercially laundered diaper would be washed at higher temperatures for longer periods of time and would be more effectively rinsed than a home-laundered diaper.

This conclusion is borne out by the Grant, Street and Fearnow study in which the authors compared the incidence of significant diaper rash reported by 1,197 mothers attending a well-baby clinic as it related to the method of laundering (disposables, commercial diaper service, or home washing) used more than 50 percent of the time. Diapers washed by a diaper service were associated with the lowest incidence of diaper rash--24.4 percent. Disposables showed about the same incidence as the commercially laundered cloth diapers. However, the home-laundered diaper was associated with the significantly greatest incidence of diaper rash, at 35.6 percent. These results are shown in Table 8.

The authors attribute their findings to the fact that commercially laundered diapers are virtually sterile and are thoroughly rinsed of all chemical contaminants. Additionally, bacteriostatic agents such as bleach and quaternary ammonium compounds used in commercial diaper services are

Not sterile but bacteriostatic

TABLE 8

INCIDENCE OF DIAPER RASH ACCORDING TO METHOD OF DIAPER LAUNDRY

	Diaper Service		Disposable Diaper		Home Washed	
	Number	%	Number	%	Number	%
Total	74	--	236	--	887	--
Diaper Rash (2 Days or Less)	11	14.9	37	15.7	201	22.6
Diaper Rash (Over 2 Days)	7	9.5	24	10.0	114	12.9
Diaper Rash Total	18	24.4	61	25.0	315	35.6

Source: Grant et al. "Diaper Rashes in Infancy: Studies on the Effects of Various Methods of Laundering," (19).

cited as inhibitors of rash. Even with multiple rinses, the home-laundered diaper failed to meet the standards of the commercially washed product, as shown in Table 9. These results confirm the fact that home laundry does not render as sterile a product; i.e., adequate rinsing alone does not solve the problem.

TABLE 9

EFFECT OF NUMBER OF RINSES OF HOME-LAUNDERED DIAPERS ON INCIDENCE OF DIAPER RASH

	1 to 3 Rinses		Over 3 Rinses	
	No.	%	No.	%
Total	692	--	195	--
Diaper Rash 2 Days or Less	162	23.5	35	20.0
Diaper Rash Over 2 Days	86	12.4	28	14.4
Diaper Rash Total	248	35.9	67	34.4

Source: Grant et al. "Diaper Rashes in Infancy: Studies on the Effects of Various Methods of Laundering," (19).

Brown and Wilson (4) also tested the performance of home laundries in washing diapers. Two loads of 12 soiled diapers each were soaked for 12 hours in water and detergent, washed in an automatic washer at 140° to 144°F for 20 minutes, given four spray rinses, a full-water rinse for 2 minutes at 100°F, and two additional spray rinses. Each load was then dried for 40 minutes in a home gas dryer. Results from two samples taken from each load are shown in Table 10.

TABLE 10

TEST RESULTS FOR HOME-LAUNDERED DIAPERS

Sample	Organisms Isolated	Colony Count	Agar-Plate Test
Load 1 - Diaper 1	*E. coli*, nonhemolytic streptococci, *B. subtilis*	9,300 per sq in. of fabric	A faint zone of partial inhibition
Diaper 2	*E. coli*, nonhemolytic streptococci, *B. subtilis*	11,100 per sq in.	No zone of inhibition
Load 2 - Diaper 1	Nonhemolytic streptococci, gram positive and negative saprophytic bacilli	8,200 per sq in.	No zone of inhibition
Diaper 2	Gram positive and negative saprophytic bacilli	9.700 per sq in.	No zone of inhibition

Source: Brown, Claude, and Frederic Wilson, "Diaper Region Irritations: Pertinent Facts and Methods of Prevention," (4).

These results show much higher bacterial counts than are allowed by NIIS diaper services (no more than two colonies per square inch).

It is important to note, however, that these bacterial counts were not specifically correlated with the development of diaper rash in infants wearing tested diapers. The significance of the results lies in the fact that bacteria present in a diaper can break down urea into ammonia, a known skin irritant which can initiate a chain reaction of rash development. But, some factors other than bacteria can and do contribute to diaper rash development, notably frequency of changing. The bacteria present in home-laundered diapers should therefore be viewed as one potential cause of rash.

Brown and Wilson also indicate that "home-washed diapers may have a pH of 9.5" (4) or higher from improper rinsing. This compares unfavorably to the 4.5 to 6.5 pH required by the NIIS, and the 7.0 pH reported for disposables. The higher or more alkaline pH is quite different from normal skin, which has a pH of 5.5 ± 1.5, and can in itself be an irritant.

A third study comparing home-laundered to commercially-laundered diapers was done at the University of Illinois Medical College, for the American Institute of Laundering (now International Fabricare Institute) (64). Investigators tested diapers which had been laundered in six private homes. In five of the homes diaper processing consisted of a cold soak followed by one hot suds and three rinses. In the sixth home, a fourth rinse was added. Results of the home diaper laundering are shown in Table 11. As indicated, bacterial count after the third rinse was 168,388; when the fourth rinse was added, average count was reduced to 149,400. As shown in Table 12, commercially laundered diapers, by contrast, were rendered sterile after the third suds, to which two quarts of 1 percent sodium hypochlorite per 300-pound load were added.

As in ~~Brown's~~ the study of Brown et al, no direct correlation between diaper rash incidence and bacterial count is made; again, it can only be assumed that a ~~sterile~~ diaper free from pathogenic bacteria is less likely to produce conditions favorable for diaper rash development.

Jordan et al. (25) examined the effectiveness of sodium hypochlorite in destroying Sabin type II poliovirus under household laundry conditions. This virus, known to be resistant to many germicides, was found to be susceptible to the virucidal action of sodium hypochlorite bleach, when used at the

TABLE 11

BACTERICIDAL EFFICIENCY OF HOME DIAPER WASHING

Operation	Average Bacterial Counts Per Cu Cm Wash Water
Cold Soak	2,248,033
1st Suds	1,983,000
1st Rinse	1,171,033
2nd Rinse	719,940
3rd Rinse	168,388

Source: "The Sanitary Aspects of Commercial Laundering," Special Report for the American Institute of Laundering, (64).

TABLE 12

BACTERICIDAL EFFICIENCY OF A COMMERCIAL DIAPER FORMULA[a/]

Operation	Supplies Used	Temperature	Time in Minutes	Average Bacterial Other Per Cu Cm
1st Cold Rinse	--	65°F	5	1,678,333
2nd Cold Rinse	--	65°F	5	1,621,200
1st Suds	Soap and Alkali	110°F	10	720,300
2nd Suds	Soap and Alkali	125°F	10	84,333
3rd Suds	Soap and Alkali plus 2 quarts 1% soldium hypo-chlorite per 300 lb load	145°F	10	Sterile
1st Rinse	--	165°F	3	Sterile
2nd Rinse	--	175°F	3	Sterile
3rd Rinse	--	175°F	3	1
4th Rise	--	175°F		Sterile
5th Rinse	--	140°F		Sterile
Sour	Sodium acid fluoride	120°F		Sterile
Boric acid bath plus bluing		100°F		Sterile

Source: "The Sanitary Aspects of Commercial Laundering," Special Report for the American Institute of Laundering, (64).

Eastat

recommended belach level of 200 ppm available chlorine. The authors note, however, that the virus was destroyed at water temperatures of 130°F and above without the addition of bleach; but at 110°F (the lower range of household laundry temperatures), bleach was requisite for viral destruction.

3. <u>The Health Implications of Disposal of Single-Use Diapers Contaminated with Urine and Feces</u>: As a result of increased use and subsequent discard of disposable diapers, general concern over the public health consequences of fecal matter in solid waste has increased in recent years. The basis for this concern centers around the occurrence of bacterial and viral pathogens in fecal matter and the potential for these pathogens to leach into ground or surface water supplies. In evaluating the potential threat or lack thereof inherent in land disposal of single-use diapers, one must first assess the occurrence (numbers and types) of pathogens involved, and secondly, the resulting effect of such conditions as measured by their ability to survive in and leach from the landfill environment and come into contact with human beings.

a. <u>Occurrence of Pathogens in Disposed Diapers</u>

<u>Bacteria</u>: As the subject of several fairly recent studies (1, 11, 59), the bioload of raw residential solid waste has been shown to contain densities of fecal coliforms and fecal streptococci in excess of one million organisms per gram. The presence of these organisms, which are normal inhabitants of the large intestine of man and other warm-blooded animals, is commonly assumed to indicate a strong likelihood of the presence of other intestinal organisms which may be pathogenic. One such bacterial pathogen which has been observed in solid waste in Salmonellae.

Viruses: In addition to bacteria, raw solid waste also contains variety of potential human viral pathogens, the leaching source of which is fecal matter. Investigating the occurrence of viruses as a function of typical soiled disposable diaper load in a sanitary landfill, Peterson (59) determined that, by wet weight, soiled disposable diapers represent 0.6 to 2.5 percent of mixed municipal waste. Finding one-third of these diapers to contain fecal matter at an average of 60 grams of feces per diaper, Peterson calculated the average amount of human fecal matter in solid waste to be about 0.04 percent by wet weight. In two separate areas of the country, viruses were detected in 15 percent and 2.9 percent of fecal samples from area A (Ohio) in February and April, respectively, and 16.7 percent of samples from area B (Kentucky) in July. Poliovirus 3 was found in both sampling areas, and echovirus 2 was found in two samples from area B. The poliovirus 3 density ranged from 16 to 1,920 plaque-forming units (PFU) per gram, with an average of about 390 PFU per gram. Densities of the echovirus 2 (positive samples) were 1,440 and 960 PFU per gram.

Further perspective on the occurrence and potential significance of viruses in human fecal matter is provided by Dr. John Fox, an epidemiologist. Based on virus watch data that he collected across the U.S., Dr. Fox prepared an opinion statement on the "Viral Infection Hazard of Disposable Diapers" (17), the results of which are summarized in Table 13.

As shown in the table, the most common virus group likely to occur in human feces is poliovirus. However, the health threat posed by these viruses is minimized by typically low virulence of vaccine-derived

TABLE 13.

PREVALENCE AND SIGNIFICANCE OF VIRUSES SHED IN FECES

Virus Group	Occurrence (Percent of Diapers)	Severity of Associated Disease	Population Immunity Level (Percent)	Assumed Health Threat
Poliovirus	20	a/	790	Small
Nonpoliovirus	1 to 20	Minor to severe	13 to 75	Small to Moderate
Hepatitis				
Type A	2	Moderate	"High"	Small
Type B	1×10^{-4}	Severe	"Low"	Small
Adenovirus	4	Minor	50	Small

Source: Fox, John P., "Viral Infection Hazard of Disposable Diapers--Opinion Statement," Professor of Epidemiology, University of Washington

a/ While the potential for reversion of vaccine strains to wild types may exist to some limited extent on passage through man, normal disease potential of vaccine strains is very low.

strains which presently make up practically all of existing poliovirus flora in the U.S., and by the probably high prevalence of immunity of the population. The nonpolio enterovirus group is diverse and potentially widespread in occurrence in fecal matter. Furthermore, type-specific immunity is variable and tends toward the low end of probability, thereby presenting a seemingly great health threat potential. Fortunately, medical experience indicates that only extremely infrequently are these viruses the cause of serious illness. In virus watch studies conducted by Dr. Fox, 50 percent of all detected infections were subclinical and 80 percent of the related illnesses were minor respiratory. The overall potential health threat posed by this group of virus is therefore difficult to assess, but is certainly less than severe. Type A hepatitis virus is a relatively benign pathogen causing temporary disability and to which there is a high probability of immunity in the population. Furthermore, the probability for its occurrence in soiled diapers is quite low. On the other hand, Type B hepatitis virus is a tremendously virulent pathogen to which there is a low probability of immunity in the population. The health significance for this virus is, however, again minimized by the extremely low probability of its occurrence in soiled diapers. Adenoviruses are of little health concern because of the benign character of diseases they may cause in humans and the relatively low probability of their occurrence in soiled diapers.

b. Fate of Pathogens in the Landfill Environment: In the above discussion, it has been shown that human bacterial and viral pathogens can occur in and be isolated from solid waste, and that one potentially significant source of such pathogens is human fecal matter discarded in disposable diapers. However, to gain a better appreciation for the extent of the health threat, it is necessary to look at the fate of microorganisms in the landfill environment and the extent to which viable organisms leach from this environment.

Bacteria: Blannon and Peterson (1) investigated the survival of fecal coliforms and fecal streptococci in a full-scale sanitary landfill over an 11-month leachate production period utilizing mixed municipal solid waste. The results of this investigation revealed that high densities of fecal coliforms and fecal streptococci occurred in leachates during the first 2-month leaching period, with a rapid die-off of fecal coliforms noted 3 months after placing the fill. Fecal streptococci persisted past the 3-month sampling period. Furthermore, the 18-inch clay soil lining underneath the solid waste was observed to offer poor filtration action on the bacteria. In view of these findings, the authors concluded "...that leachate contamination, if not controlled, may add a pollutional load to the recreational and groundwater supplies and present a risk to the public using these waters."

In an attempt to determine the effect on leachate bioload, Cooper et al. (7) added fecally contaminated diapers to a simulated sanitary landfill. Overall, large numbers of bacteria of potential sanitary significance were present.

However, the high background levels of fecal coliforms and fecal streptococci made it impossible to measure the impact of the addition of feces and diapers. The low ratio of fecal coliform to fecal streptococci in freshly collected and ground refuse indicated animal waste (cats, dogs, etc.,) to be the most predominant source of these indicator organisms.

Further information on bacterial decay rates is provided by Engelbrecht (11). Fecal coliforms, fecal streptococci and Salmonellae typhimurium was added to whole leachate at two different temperatures (22°C and 55°C) and at two different pH values (5.3 and 7.0). Persistence of enteric bacteria in leachate was found to be less at the higher temperature and lower pH value. The order of stability in the leachate at 55°C at both pH values was: S. typhimurium > Fecal streptococci >> Fecal coliforms.

Viruses: In a continuation of the same study cited above, Cooper et al. also assessed the presence of viruses in leachate under normal conditions and with the addition of fecally contaminated diapers. The dosage of feces added was approximately 0.02 percent by weight, roughly equivalent to the amount found by Peterson in the previously mentioned study. Virus recovered from the leachate of the inoculated fill amounted to 150 and 2,310 PFU per gallon during the second and third weeks of leachate production, respectively. The control landfill produced 380 PFU per gallon of leachate the third week only.

Noteworthy here is the fact that in each case where viruses were detected in leachate, the associated landfill had been brought to field capacity (saturation point) over a 3-week period to simulate exaggerated rainfall conditions. No viruses were detected in leachate from fills brought to field capacity gradually over a 15-week period to simulate normal rainfall conditions for the area.

After the third week of production, all samples were negative. Since the control was also positive, the authors concluded that the addition of viruses through human feces had no discernable effect on the recovery of viruses.

At the termination of the experiment, the contents of the control fill and two fills to which soiled disposable diapers had been added were removed and assayed for the presence of viable viruses. No viruses were recovered from these materials, indicating that both indigenous and added viruses did not survive at detectable levels through the test period.

In a study by Sobsey et al. (72) the survival and fate of two enteroviruses (polioviruses type 1 and echovirus type 7) in simulated sanitary landfills was examined. After inoculating the solid waste contents of the fills with large quantitites of the above enteroviruses, the fills were saturated with water over a 3-1/2 week period to produce leachate, which was then analyzed for viruses. Although 80 percent of the total leachate produced by each fill over the test period was so analyzed, no viruses were detected. Furthermore, analysis of the refuse itself following the conclusion of the leachate analysis revealed no detectable viruses.

In part, this outcome is explained by the tendency of viruses to adsorb onto components of the solid waste and thus resist leaching. A further explanation lies in the determined natural toxicity of the leachate itself. The leachate was evaluated to determine the extent of its toxicity to viruses. More than 95 percent of inoculated viruses were inactivated over a 2-week exposure period at 20°C and more than 99 percent were inactivated within 6 days at 37°C.

The results of the above investigation were duplicated by Engelbrecht (11) in a similar experiment, using poliovirus, reovirus and Rous sarcoma to seed the simulated landfills. No viruses were recovered from leachate samples collected throughout the 76-day test period. As was the case above, inactivation studies showed the leachate to be toxic to viruses.

c. Conclusion: Evidence has been presented to indicate that fecal material in soiled disposable diapers may represent as much as 0.02 percent by weight of normal mixed municipal refuse, and that they may be a significant contributor of microorganisms of potential sanitary significance. However, it has also been shown that the normal bioload of solid waste without diapers is extremely high, due mainly to the presence of fecal matter from domestic animals. This source also contains large numbers of microorganisms of potential sanitary significance.

Due to this large naturally-occurring bioload in solid waste, attempts to demonstrate an increase in bioload from the addition of fecal contamination from diapers to 0.02 percent by weight have been unsuccessful. These findings thus establish that, at 0.02 percent by weight, fecal contamination from diapers does not add an amount of either bacteria or viruses in the leachate which can be detected over and above the background level.

Attempts at determining the public health significance of the bioload from solid waste have centered around occurrence of viable organisms in leachate. In general, the physical characteristics of the landfill environment are inhospitable to survival and growth of microorganisms. In addition, the leachate emanating from a landfill appears to be toxic.

However, it has been clearly demonstrated that viable bacteria can and do leach from the landfill in large numbers, thereby representing a source of contamination to ground and/or surface water supplies and a possible health threat to anyone using this water as a potable water supply. Unlike bacteria, experiments measuring virus occurrence in leachate have revealed conflicting results. One investigator was able to detect viruses from a rapidly saturated fill while others, using similar techniques, were not. It is fairly well-established, however, that leachate is quite toxic to viruses and that adsorption of viruses to solid waste components does occur. It has been shown that more than 99 percent of all inoculum viruses can be inactivated within 6 days at 37°C following introduction into landfill leachate. And yet, one investigator has detected viruses in leachate up to 3 weeks after onset of leachate production. In view of the lack of consistency in the published literature on the topic, no clear understanding of the public health threat represented by viruses in solid waste can be reached.

With regard to public health significance of disposing of fecally contaminated disposable diapers in the solid waste stream, conclusions are even more difficult to reach. However, to the extent that such material does contain microorganisms which may leach into water supplies, some potential for a public health threat to the consumers of that water may exist. However, the actual bioload contribution from this source is yet unclear, as in the relationship between degrees of contamination of the water supply and the relationship to disease development. Therefore, no final statement on the public health significance of discarding disposable diapers into the solid waste stream can be made.

Based on the foregoing data, several conclusions can be formulated:

1. Although disposable diapers were associated with a greater incidence of diaper rash than hospital-laundered cloth diapers in one study, they performed as well as commercially laundered diapers in another study. On the basis of these conflicting results, no definitive statement can be made regarding the relative effects of the two types of diapers in inhibiting rash development.

2. The average home-laundered diaper is inferior to both the disposable and commercially laundered diaper in terms of sterility and pH balance. Although no precise relationship exists between bacterial count and type of bacteria present in a diaper and the development of diaper rash, bacteria do contribute to the incidence of rash. An NIIS diaper service undoubtedly provides the superior laundering method, with its maximum allowable count of 20 colonies per square inch. A regular commercial laundry, while probably not meeting this exacting standard, would likely produce a ~~more sterile~~ diaper of better sanitary quality than a home laundry due to higher wash temperatures, longer cycles, and types of additives used. Disposables also meet a high standard of sanitation, with less than two colonies of bacteria per square inch; and they provide a favorable pH balance averaging 7.0.

V. SHEETS

Health and sanitation concerns relating to institutional bedding are among the most significant within the scope of this study. Not only are linens subjected to a greater degree of contamination in the hospital or nursing home setting (the primary institutional environments being considered here), but the users of these linens tend to be much more susceptible to infection than is the general populace. Because of these considerations, bedding for institutional applications must meet rigorous standards of cleanliness and sanitation to ensure that its role in cross-infection is kept to an absolute minimum.

The patient bed sheet, which is the focus of this investigation, is a virtual repository of bacteria. Several studies have emphasized the significance of skin desquamation in spreading microorganisms; the average human desquamates an entire layer of skin over a 1- to 2-day period, which is in large part deposited onto the bed sheet when the patient is hospitalized or otherwise bedridden. These skin scales, as established in a study by Davis and Noble, harbor a variety of potentially pathogenic bacteria. Additionally, the patient may excrete urine or feces onto the sheet, or he may have wounds which produce pus and/or blood. All of these factors interact to render the bed sheet contaminated, and thus the object of intense scrutiny in evaluating institutional standards of health and sanitation.

Greene (20) states two general contamination control objectives within the hospital:

1. "(To) minimize the microbial contamination level of the environment by curtailing dissemination of contaminants from soiled and used fabrics.

2. (To) minimize the probability of microbial transmission from infected reservoirs to susceptible hosts by destroying or removing microbes on used linen before it is reissued to patients and personnel."

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action
foundation

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May 19, 1977

Mr. Charles Peterson
Project Officer
Disposables/Reusables Contract (AW-463)
Office of Solid Waste
U.S. Environmental Protection Agency
Washington, D.C. 20460

Dear Mr. Peterson,

Enclosed please find our comments regarding the draft report by the Midwest Research Institute concerning the impacts of disposables versus reusables.

Overall, we found it to be a fair report. We feel that the REPA approach is a good one, however, we think that because toxicity and persistence are not taken into account, the REPA approach does not present a complete approach to the problem of balancing the impacts of various products. However, it is a start.

Thank you for the opportunity to reveiw this report. If you have any questions, feel free to contact me.

Yours,

Marchant Wentworth
Solid Waste Project

COMMENTS ON THE

DRAFT REPORT OF

ENVIRONMENTAL IMPACTS OF DISPOSABLES VERSUS REUSABLES

BY

MARCHANT WENTWORTH
ENVIRONMENTAL ACTION FOUNDATION
DUPONT CIRCLE BUILDING, SUITE 724
WASHINGTON, D.C. 20036
202-659-9682

MAY 19, 1977

I. Factual Errors

There were no direct errors of fact that we observed in the report. If errors were made, they do not appear to be of a magnitude to change the conclusions of the report.

II. Invalid Assumptions

While we feel that the REPA approach to quantifying impacts of selected products is a good one, the technique fails to include toxicity and persistence of various pollutants in the analysis. In many cases, this omissions could well lead to erroneous conclusions about the impacts of the various products studied. For example, the data reveal that in the production of chlorine and caustics we could expect the loss of 0.183 lb of mercury for every 1,000 lbs of chlorine or caustics that are produced. Yet, according to the data presented on the amount of mercury emitted during this process, we find a total of 0.000735 lbs of mercury escaped into the air and water through the production of chlorine and caustics through electrolysis - a net difference of 0.17565 lbs apparently unaccounted for. Ignoring this problem for a moment and returning to the initial emissions problem, we find that, in spite of the relatively small amount of mercury emissions for a chlorine production of 1,000 pounds, these data indicate that, nationally, chlorine and caustic production caused a release of over 3,500 lbs of mercury into the environment. This impact was ignored by this study and the assumption was made that all emissions are equal. Unfortunately, our present knowledge of the toxicity and persistence of mercury lead us to the fact that all emissions are not created equal. This problem of mercury emissions is just one example of how the REPA approach fails to take into account public health and safety impacts of various pollutants. There are other examples.

We realize that a detailed "weighting" of the various pollutants is perhaps beyond the scope of this particular study. But more mention should be made of the real-life impacts of some of the pollutants that have been listed in this study. A mere cataloging of the amounts is not enough.

Turning to the other areas of the study, we found that presenting the data around a specific use factor -i.e. 1,000 uses - is valuable but perhaps incomplete. The picture presented in many cases was that the impacts were not cumulative for any one product. In other words, the impacts of 2,000 uses would not necessarily twice that of 1,000 uses. Thus, a range of use factors would present more useful data for a real life situation.

Another parameter that was not mentioned was time. Although a difficult factor to figure into the equation, it obviously plays a crucial role. For example, how long it takes 1,000 spills to occur in a given place is obviously a factor in judging laundering and other use factors. Also the type of spill was not mentioned. This too plays a part in deciding use factors.

Another fact of life that could be mentioned in the report is the fact that a shift from reusables to disposables is generally made across the board. Generally speaking, the shift involves not just a single product, but an entire range of products. We suspect that the cumulative impacts of this decision are larger than the sum of the parts. Thus, it might not be strictly accruate to consider what the impact of a single product shift might be wihout considering the influence that decision might have other products.

Again concerning the basic REPA approach, we disagree with the assumption that no relative weighting of the virgin materials based on availability or scarcity was necessary. The explanation that "timber growth exceeds the timber cut annually at present in this country" fails to explain why timber is not in short supply. The other materials mentioned, limestone, salt, sand, etc., while not in short supply, will be increasingly expensive as extraction and refining costs continue to rise. Lacking an economic section of this report, some mention should be made in this draft as to the relative importance of these materials.

Another invalid assumption presented in the report is that turbidity and heat were not included in the report as pollutants because there was "no acceptable way to quantify their impacts." There are, of course, existing water standards on both of these parameters. Both can be measured and can have injurious effects

ETHYL CORPORATION

ETHYL TOWER
451 FLORIDA
BATON ROUGE, LA. 70801

June 29, 1977

Mr. Charles Peterson
Environmental Protection Agency
Office of Solid Waste Management Programs
Resource Recovery Division AW-463
401 M Street, S.W.
Washington, D.C. 20460

Dear Mr. Peterson:

A review of the Study of Environmental Impacts of Disposables versus Reusables within our company, as well as among major polyethylene resin manufacturers contacted by us, resulted in the attached comments directed to that part of the study on disposable diapers and more specifically as it pertains to the production and use of low density polyethylene resins and films in that product.

Because of the complexities involved in a study of this magnitude, it can be expected there will be significant differences of opinion and fact in the other areas reviewed but not commented on here.

In addition to the above, and because of the study's stated lack of conclusive evidence on public health aspects of disposable diaper, the lack of consistency of published literature and the need for current updated information, we take the position that no use should be made of the base data without considerable additional work being undertaken.

I would appreciate being kept informed of the status and further updating of this study.

Sincerely yours,

Michael J. Zobrist

Michael J. Zobrist
Marketing Manager
VisQueen Division

MJZ:cs

Attachment

INVALID ASSUMPTIONS

1. Reference Page C-37 Figure C-5, Page C-38 paragraph 2 and Table C-24.

   The yield of Ethylene appears to be too high.
   The January 5, 1976, issue of Chemical Engineering shows yield numbers as follows:

Type of Feed	Pounds of Feed Per 1000 lbs. Ethylene
Ethane	1244
Propane	2112
Naptha	3707

   Essentially this same information is discussed on page C-36 in paragraph 6 but not followed through in calculation.

2. Reference Pages C-38 to C-40.

   The following are quotes from major manufacturers of low density polyethylene resin.

   "The energy required for pollution control, as well as process additions, atmospheric emissions, solid waste, etc., described in Table C-24 would all vary significantly with the feedstock."

   "We take exception to the natural gas supposedly used since we use little or none for heating or power. The figure of 20 pounds of additives is much too high for a disposable resin, as we ship it. The atmospheric emission figures are far too high, at least in our case. Hydrocarbons for example, might be 0.5 lbs. In the case of waterborne waste, the figures given in the report are much too high for a modern plant."

   "The numbers shown in Table C-25 appear reasonable. However, these could vary widely depending on plant size, location, and other factors. The section of this table entitled 'Waterborne Wastes' is unclear."

   "The paragraph concerning low density film manufacture is inaccurate. As you know, most people can blow film at more than 125 pounds/hour and that the water bath process is no longer used. We again take exception to the amount of water supposedly used since the blown film process uses hardly any at all and the chill cast process uses recycled water. Our laboratory takes exception to the power usage of 245 kilowatt-hour per 1,000 pounds of film, believing it should be substantially less."

3. Reference Page C-40, <u>Low Density Polyethylene Film Manufacture</u>

   Actual water requirements used in our plants for manufacture of film used in the disposable diaper average closer to 50 gallons per 1,000 pounds of film as opposed to the "1780 gallons per 1,000 pounds LDPE film" used in the study.

association of the nonwoven fabrics industry

June 22, 1977

Mr. Charles Peterson
Project Officer
Disposables/Reusables Contract (AW-463)
Office of Solid Waste Management Programs
U. S. Environmental Protection Agency
Washington, D. C. 20460

Re: Draft Report MRI Project #4010-D
Study on Environmental Impacts of Disposables vs. Reusables

Dear Mr. Peterson:

INDA is an international trade association composed of over 100 industrial corporations who manufacture a wide variety of products including diapers, bed sheets and pillowcases, drapes and gowns used in hospital operating rooms, catamenials and related products.

As President of the Association, I am addressing you relative to the above entitled study.

A detailed analysis of the voluminous report leads us to the conclusion that the work which has been undertaken is incomplete and subject to erroneous interpretation or misapplication by those who have not studied the background and use conditions in great depth. For example, the laundering impact quotients established in the diaper premise relate only to the cloth diaper. If only a cloth diaper is used, any wetting will result in additional laundering impacts covering bed clothing, nightgowns, etc. If an impermeable covering is used to prevent this (plastic pants), then a heat incubator is created where rapid bacterial growth takes place, drastically affecting the health impact content in another part of the study.

The purpose of my pointing out this example of incompleteness is to emphasize that similar problems exist in almost every aspect of the study. Clearly those who conducted the study and prepared the data are fully aware of the shortcomings and the misunderstandings which can result therefrom. Our concerns do not lie with them, but rather with those who are less well informed who may eventually be privy to these findings.

We, therefore, urge you in the strongest way possible, to totally discard this work and in no way make it any part of official records, reference works, open, or closed file materials, or in any way endorse or appear to endorse these findings for any work by the Environmental Protection Agency or any other organization except that originally

(cont'd.)

y to HEADQUARTERS: 10 East 40 St., New York, NY 10016/212-686-9170
WASHINGTON OFFICE: 1619 Massachusetts Ave., N.W., Washington, DC 20036/202-462-0086

intended by this study. In the event that the Environmental Protection Agency should decide to retain this study, in any form, either on open or closed files, then we most insistently urge that a copy of this letter be included as an official part of that document.

We submit that the analysis of any disposable vs. reusable product lines encompasses a highly complex set of values which requires, in addition to many of the missing factual data as set forth above, the inclusion of quality of life quotients and economic impact analyses which have been completely ignored. We stand ready to offer whatever help possible in reaching a fully informed and properly intelligent decision as it relates to our national needs and priorities should such occasion arise.

Very truly yours,

INDA

Robert W. Sullivan, President

RWS:rs

National Wildlife Federation

112 16TH ST., N.W., WASHINGTON, D.C. 20036 Phone 202—797-680

June 28, 1977

Mr. Charles Peterson, Project Officer
Disposables/Reusables Contract (AW-463)
Office of Solid Waste
U. S. Environmental Protection Agency
401 M Street, S.W.
Washington, D.C. 20460

Dear Chuck:

Thank you for giving me the opportunity to review and comment upon the draft of the "Study of Environmental Impacts of Disposables Versus Reusables" prepared by the Midwest Research Institute (MRI) for the Environmental Protection Agency (EPA). Since my comments are brief and fairly general, I will confine them to the body of this letter. I will be happy to elaborate upon any point which I raise at your request.

I would like to start by complimenting MRI for an outstanding job. To my knowledge, they are the first to embark upon such a gigantic task and considering its magnitude and all of the considerations which must be made, MRI performed a remarkable survey. I can find no fault with any of the factual data which they provide and found a great deal of it useful.

My negative reactions fall mainly in the area of assumptions which MRI has made. I think that to be fair, it must be remembered that MRI was given an enormous assignment and only meager resources to accomplish those tasks. In the introduction, MRI itself noted that it just could not accomplish an adequate analysis of the economic aspects. This, of course, severely limits the value of the study. As MRI states, before legislation is undertaken which would "result in deletions and additions of products in the marketplace" a comprehensive economic survey "sufficiently funded" should be considered.

MRI is asked to compare a whole variety of reusable items to the throwaway items that are being marketed as substitutes. Compiling data on most of the substitutes seems to have been fairly simple. These are mostly items that are used once and then thrown away. It was in talking about the reusable items that most assumptions were made. Some of these assumptions are just too limited, especially those relating to the home, non-commercial use of such items.

To cite an example, I would note the discussion of cloth towels and napkins compared to those made from paper. The whole procedure of "counting spills" is suspect. The relative size of the spills is never addressed, nor is the time span over which these "spills" are taking place. Both of these are important factors that will influence the life expectancy of the cloth items and the frequency of the need for washing.

To proceed further, the discussion of environmental effects of washing the cloth items seems questionable to me. MRI goes to great lengths to determine just how much space the cloth items will take up in the average washload and, therefore, how much of the pollution from that washload results from the subject items. In discussing commercial use of cloth towels and napkins, there is no question of the validity of the environmental impacts that result from the washing of loads composed entirely of towels and napkins. In the home, however, washloads are not handled the same way they are commercially. Most homes have a set a wash schedule. In my home, I do my laundry once a week. The number of cloth napkins and towels I have to wash is marginal. I would do the same number of loads whether I had the cloth items or was using paper substitutes and discarding them. To break down the washload and assign a set "environmental impact" on the washing of the cloth towels and napkins is as valid as saying for every use of paper substitutes washloads are being done in which the water, energy, etc. are being under-utilized because there is less wash in the load!

My major concern about these kinds of misleading assumptions is that it is essential that they be placed in proper perspective. Since MRI is trailblazing in this field, more or less, we can hope that future studies will build upon MRI's base. The danger now is that some of the conclusions which MRI is basing on these shaky assumptions might be lifted out of the context of the study and used as facts as opposed to the projections which they in fact are.

I hope my comments have been useful. If I can be of further assistance, or you wish some clarification, please contact me.

Sincerely,

J. Mark Sullivan

J. MARK SULLIVAN
Solid Waste Project Director

111 East Wacker Driv
Chicago, Illinois 6060
312/644-6610

June 24, 1977

Mr. Charles Peterson
Project Officer
Disposables/Reusables Contract (AW-463)
United States Environmental Protection Agency
Office of Air and Waste Management
Washington, D.C. 20460

Dear Mr. Peterson:

Thank you for the opportunity to review and comment on the draft report of the contract study comparing selected disposable and reusable products done for you by the Midwest Research Institute.

Reactions of the Permanent Ware Institute are very similar to those of the American Restaurant China Council, there being several major companies which are members of both organizations. To facilitate your review of replies, we are attaching copy of those comments submitted by the American Restaurant China Council which we also strongly endorse.

Along with the American Restaurant China Council, we hope these comments will be considered both in the preparation of the final report and in consideration of any future studies.

Cordially,

Iris Laine

Iris Laine
Executive Secretary

IL/cg

Enc.

COMMENTS ON THE DRAFT REPORT

OF

ENVIRONMENTAL IMPACT

of

DISPOSABLES VERSUS REUSABLES

MRI Project No. 4010-D

Iris Laine
Executive Secretary
PERMANENT WARE INSTITUTE
111 East Wacker Drive
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June 24, 1977

Comments have been arranged in the order requested in transmittal letter from the United States Environmental Protection Agency forwarding draft report of "Study of Environmental Impacts of Disposables versus Reusables," letter dated April 18, 1977.

I. <u>FACTUAL ERRORS</u>

Volume II, Health Considerations, printed page 125: The individual at the Permanent Ware Institute to whom correspondence should be addressed is: Iris Laine, Executive Secretary. John Fanning, the name given, is PWI's vice president and not located at the association's headquarters office.

II. <u>INVALID ASSUMPTION</u>

That public health and sanitation considerations have a valid place in a study originally contracted for the purpose of studying environmental impacts of disposables versus reusables.

We cannot ignore the fact that an unknown amount of taxpayers money was wasted because of the pressure applied by disposable interests which aborted and modified the original contract #68-01-2995.

Undoubtedly the lack of an economic study is the result of such deviation of purpose.

Fortunately, on printed page 107, Volume II, the entire matter of health considerations in disposables versus reusables was laid to rest in the quotation,

> "Questions involving the health effects of environmental bioloads are particularly prone to uncertainty and the health impact of various environmental levels of microorganisms on food or beverage contact surfaces are often unknown, and infrequently unknowable."

What is now needed is to go back to the intent of the original contract and in much greater depth.

III. <u>COMMENTS AND RECOMMENDATIONS</u>

1. We feel this report totally fails to explore the original core issue -- THE SERIOUSNESS OF AMERICA'S SOLID WASTE PROBLEM AND ITS TOTAL COST TO THE NATION.

   We believe, too, an implied assumption has been made which is invalid when the economic aspects of the work done by MRI are not presented "due to lack of data."

No study of disposables versus reusables will ever be useful to the President, Congress, and the general public until the full cost impact is studied in depth. For example, the economic costs of post consumer waste must be known to anyone attempting an objective study of disposables versus reusables. The economic study called for in the original contract must go forward and be expanded.

The Pelham, New York, landfill is an excellent example of improper land disposal practices. This mountain of garbage peaks at 140 feet at the present time and covers 75 acres. It is being fed at a rate of five million pounds of garbage daily.

The cost of this open dump economically, as well as environmentally, to say nothing of its safety hazard, should be studied in detail as a current "today problem" with far reaching implications of taking place tomorrow in other communities.

We believe that the encouragement of reliance on high technology forms of solid waste disposal, in effect encourages the growth of solid waste. In any study on the environmental impacts of disposables versus reusables that, too, must be considered.

Solid waste reduction, not disposal, is the key issue. Any objective study should recognize that it takes 6900 disposable plates to do the job of one single reusable plate. That is simple, real world solid waste management everyone can understand.

2. The energy crisis cannot be divorced from a study of disposables versus reusables and we strongly suggest the inclusion of a meaningful energy discussion in future studies. Specifically;

   A. Establish a list of our nations' natural resources based on current available technology.

   B. Determine our annual usage of these natural resources for both disposables and reusables.

   C. Study our resource availability and product use recommending to the nation allocations of energy and raw materials based on a best use concept.

   D. Establish a "watch dog" committee that would keep score and report to the nation the products that are a serious drain on our most vital resources, such as petroleum and forest products.

E. Develop an oversight committee that will keep tabs on the social and environmental cost in total of producing and disposing of various products, such as disposables and reusables.

We are not recommending nationalization of our vital resources or even that the Environmental Protection Agency unilaterally set up oversight committees. We do, however, believe it mandatory that the study undertaken in the original contract be explored to a logical conclusion as outlined above.

3. We recommend that sizeable increases be made in the allocation of funds for research into all of the above vital areas and that the results be widely publicized. The voters of this country must be shown there is no such thing as a "throw away". IF THE COST OF DISPOSING OF DISPOSABLES WAS PART OF THE ORIGINAL PRICE TAG, THE ATTITUDE OF THIS NATION TOWARDS DISPOSABLES WOULD, WE SUBMIT, CHANGE PERCEPTIBLY.

Further, the Environmental Protection Agency, under the Resource Conservation and Recovery Act, of 1976, must work with the various states to offer financial assistance in implementing that law. It seems to us that there should be some provision to insure that while the federal government is giving funds to the states for resource conservation, the state governments are not spending their own money in a counter-productive manner in the name of environmental health programs.

In summary, we believe that the contracted study performed by Midwest Research Institute was a reasonable and objective first step in understanding the issues involved. It is, in our opinion, regretable that the original contract was modified with the result that emphasis was shifted, distorted, and aborted from the original purpose. Now that the advocates of disposables and single service merchandise have had their health considerations explored, it is time to return to the fundamentals; environmental impact, solid waste accumulation, resource availability, and a study of the social and economic price the nation is really paying for a "throw away" society.

APPENDIX J

Single Service Institute

250 PARK AVENUE • NEW YORK, N.Y. 10017 • (212) 697-4545

June 28, 1977

Mr. Charles Peterson
Project Officer
Resource Recovery Division
Office of Solid Waste Management Programs
U.S. Environmental Protection Agency
Washington, D.C.

Dear Mr. Peterson:

Re: "Study of Environmental Impact of Disposables Vs. Reusables", (Disposables/Reusables Contract AW-463, MRI Project # 4010-D), dated April 1, 1977.

The Single Service Institute submits two enclosed papers which cover in detail our reactions to the sections on disposable and reusable food service ware. These critiques bear out fully our strong conviction that the MRI report is inadequate and must be substantially revised before it can be considered valid.

When the study was announced, SSI's first reaction was that it would serve no useful purpose. In particular we criticized the proposed study's concentration on environmental impacts to the exclusion of such important considerations as sanitation, public health, economic factors and convenience. Without consideration of all of these factors a REPA study is of little value in the development of public policy on environmental matters.

Although we held serious reservations about the MRI study, the industry wished to make a positive contribution to as meaningful a report as possible and so cooperated fully with EPA. While much of the information offered has been used by MRI in its draft report, there is at least one crucial and damaging omission of materials which will be described later.

The two volumes of MRI's report have been analyzed by our staff, by member companies and by expert consultants. The latter include Arthur D. Little, Inc., for the REPA report and a panel of public health professionals for the Health Considerations report.

The report suffers from the lack of an economic impact study. There is no appraisal of the potential economic consequences of policy options that might impinge on the distribibition and use of disposables and reusables. These economic consequences are of obvious concern to the single service industry (and to its suppliers, customers and related industries), where many thousands of livelihoods and many hundreds of millions of dollars in investments are involved. But beyond this, by omitting economic considerations, the report also ignores the entire area "economics-in-use" -- the comparative costs of using either disposables or reusables in actual food rvice operations, the economic and management factors that lead ood service operators to choose one utensil system or the other or to combine both.

Also totally ignored, and closely related to economic considerations, is the factor of convenience. "Convenience" is a term for very specific and important benefits provided by single service utensils. Convenience means flexibility -- the ways in which paper and plastic cups and plates allow food service establishments to design their operations to meet a variety of customer needs and demands. From fast foods to take-out, from self-service to vending machines to school lunch service to family dining with ease and safety -- single service permits versatility and flexibility in the design of food service operations. Single service also plays an important role for working mothers -- a large and growing segment of the population. For them, as well as for thousands of food service operators in both commercial and institutional settings "convenience" in fact turns out to be "necessity".

Beyond these major concerns, following are some of the specific criticisms of the MRI REPA report with references to the ADL Critique where these are elaborated:

1. The report appears biased toward reusables (ADL Critique, p.11).

2. It ignores the problem of product comparability and fails to point out those instances where disposables and reusables are not equivalent..... (p. 12-13).

3. It presents misleading environmental impact totals ... (p. 11-12).

4. It omits any discussion of solid waste recovery technologies, including energy recovery from paper and plastic waste materials...(p.14).

5. The report contains inconsistent data ... (p.14).

6. It makes highly questionable assumptions regarding wood wastes and trim, and does not include any impacts for saucers as integral to the major part of the reusable hot drink system... (p.17-21).

7. Finally the report substantially understates the impacts related to the washing of permanent ware... (p.22-32).

These major flaws along with other deficiencies of lesser significance plus technical errors are fully discussed in the accompanying critique of the MRI REPA report.

Similar analysis of shortcomings of the Health Considerations report is also presented for your consideration. We see the major problems in the Health document as follows:

1. The MRI health report does not include the results of the Syracuse Research Corporation's comparative microbiological study of disposable and reusable food service ware in food service establishments... (SSI Health Critique, pp. 13-16).

2. The health report dismisses the potential hazards of food service ware in communicable disease wards and completely ignores the American Hospital Association's recommendations for the use of disposables ... (pp. 22-23).

3. The report selectively and improperly quotes from an important statement by a leading public health scientist, and improperly manipulates statistical findings in a professional paper... (pp. 16-20).

4. The MRI health report seriously errs in its appraisal of the potential hazard of disease transmission by means of food service ware and grossly underestimates the prevalence of food poisoning in the United States... (pp. 9-13).

5. The MRI report consistently tends to minimize the health protection afforded by bacterial standards established for food service... (pp. 10-11).

6. The report fails to evaluate the sources quoted or suggest their relative significance... (pp. 22, 31, 37).

7. Finally, the listed authors of the MRI report on Health Considerations do not appear to be expert in microbiology, a prerequisite for proper evaluation of the scientific literature in this field and of the technical issues involved ... (p. 5).

The key question now arises: What is to be done? The Single Service Institute respectfully recommends that both the REPA and Health Considerations volumes be substantially revised and that this revision take into account the comments we have made in our critiques of the MRI report. We feel that the report should not be published, released or kept on hand as a "file" item available for reference.

We take this urgent position for a number of reasons. First, the present version of the report is inadequate. It fails to clear the air with respect to the issues surrounding "disposables versus reusables", and can be of little or no use in the complex task of formulating meaningful public policy on environmental problems.

Second, the report, even though it is considered preliminary and even if it is not widely released and publicized, will be a potential source of misuse and damage. The report has already been leaked to a Washington columnist who has used it as the basis of a premature story in the daily press.

The potential is there for damage not only to the issues and public understanding of them, but to an industry which provides valuable products and plays a responsible role in seeking solutions for our real environmental problems. It is an industry that directly employs more than 28,000 people in communities throughout the nation, with a capital investment of over $700,000,000 and annual sales approaching a billion dollars.

In addition, the single service industry is linked to a network of suppliers and customers, with many more employees and their own substantial capital investments. For example, over 45,000 persons are employed in wholesaling and distributing operations in which single service products represent a major merchandise line. An estimated 8,000 employees are involved in the manufacture of paperboard for single-use cups and plates in plants with a capital investment of $500 million. An entire and growing industry -- fast foods -- is built and operates around the availability of single service items. The Department of Commerce's projection is that in 1977 there will be 53,018 franchised fast-food establishments with sales of over $16 billion.

The single service industry recognizes the need for protection of our vulnerable environment. As citizens, we and our employees are hurt when the environment suffers. But actions toward solutions of environmental problems must be based on full and accurate information, on comprehensive and conclusive data, on thorough and unassailable technical analyses, and on a deep understanding of the needs of people.

We urgently request a re-thinking and re-writing of the MRI report. To this end, we hope that our comments will be helpful.

Sincerely,

Robert W. Foster

Robert W. Foster
Executive Vice President

RWF/mc

Encls.

CRITIQUE OF THE MIDWEST RESEARCH INSTITUTE

"STUDY OF ENVIRONMENTAL IMPACTS OF DISPOSABLES VERSUS REUSABLES"

Report to:

Single Service Institute

June 1977

Elliot H. Barber

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LIST OF FIGURES AND TABLES

EXECUTIVE SUMMARY

A. PURPOSE AND SCOPE

Midwest Research Institute has recently published a study commissioned by the Environmental Protection Agency in which it examined the environmental impacts of selected disposable and reusable cups and plates using the REPA approach. It is generally accepted that the REPA approach is heavily dependent on a variety of qualifications, assumptions and subjective evaluations and that the results of the analysis are limited by these subjective aspects. Since the production of disposable cups and plates is very important to member companies, the Single Service Institute wants to assure itself that the assumptions and subjective evaluations which bear heavily on the final outcome of the study are reasonable and realistic. Thus, the Institute has asked ADL to review the methodology, assumptions and subjective evaluations in the MRI study and comment on the overall reasonability and accuracy of MRI's REPA comparisons and conclusions.

B. FINDINGS

We do not feel that the MRI report presents a reasonable and accurate comparison of disposables versus reusables. Our major criticisms of the report are that it:

- *Appears Biased Toward Reusables:*

  The apparent bias of the summary comparing reusable versus disposables is no doubt unintentional. However, terms denoting product ranking are only used when reusables have lower REPA impacts. In addition, it contains three instances of speculation beyond the scope of the study; while none of the speculative situations are commercially important, they are presented as a potential scenario for reducing impact of reusables.

- *Ignores the Issue of Product Comparability:*

  A basic assumption underlying a REPA comparison of competing products is that they are reasonably equal in usefulness. MRI does not point out those instances where disposables and reusables are not equivalent (e.g., fast food businesses) and that these instances limit the usefulness of a disposable versus reusable comparison.

- *Presents Misleading Impact Totals:*

  Adding REPA values in each category results in sums which are not accurate reflections of resource use and environmental impact. For example, the sums for raw materials do not distinguish between scarce and plentiful (or renewable) resources: summation treats these impacts as equivalent. The impact totals for energy likewise do not distinguish between scarce and relatively available energy sources.

- *Omits Discussing Solid Waste Incineration Technologies:*

  Although futuristic technologies relevant to reusable products are discussed, MRI does not mention energy recovery from cellulosic and plastic waste materials. While consideration of these technologies do not eliminate solid waste impacts for disposables and reusables, solid waste is greatly reduced and valuable energy can be recovered.

- *Contains Inconsistent Data:*

  The summary data for reusable products presented in the Appendix are not consistent with those data reported in the main report. Since the on-site impact data for the specific process steps are consistent with the tables in the main body, those in the Appendix appear to be wrong.

- *Includes Three Questionable Assumptions:*

1. Wood Wastes are Counted as Energy Consumed

   The MRI assumption that wood wastes should be counted as energy is questionable and inconsistent with its position on hydrocarbon fuels. Material scarcity and its viability as a major energy source are the important criteria used to classify plastics feedstocks as an energy source rather than a raw material. Wood wastes meet neither criteria; therefore, should be counted as raw materials.

2. REPA Impacts for Waste Trim

   MRI also assumes that the process producing a reusable waste material should be charged with the environmental impacts created by that waste. Recycled waste in fact reduces the total demand for virgin raw materials and as such paper process wastes are pulp substitute coproducts. If these were internally recycled, credit for the environmental impacts as a wood pulp substitute would automatically be given. If it is preferential to recycle this in another process, that process should be charged with the pulping impacts associated with the waste products.

3. Reusable Hot Drink System Does Not Include Saucers

   MRI does not include saucers in the reusable hot drink system. This is clearly a serious omission and significantly understates the REPA impacts for reusable cups.

- *Includes Understated Permanent Ware Washing Impacts:*

  While MRI does not reveal its sources for commercial permanent ware washing impacts, its treatment of data suggests that the impacts are based on equipment specifications obtained from suppliers. These data rarely reflect what actually exists in a commercial operation. Our data suggest that the impacts are understated. Since more than 90% of the total REPA impacts are associated with the washing process, the understatement is significant.

- *Improperly Treats Data for Process Solid Waste and Waterborne Wastes:*

  MRI uses an average process solid waste density of 74 lbs/cubic foot to estimate the land fill impacts; this understates the impacts for lighter solid waste streams. Finally, MRI also mistakenly treats BOD and COD as separate waterborne wastes while in fact COD includes those pollutants included as BOD plus others.

C. RECOMMENDATIONS

We recommend that the SSI press for the following revisions in order to make the MRI report a more meaningful document.

1. Revise the chapters summarizing the reusable versus disposable comparisons to:

   -- remove terms suggesting product ranking
   -- strike process technology speculation

2. Recognize and discuss those cases in which disposables and reusables have different product utility.

3. Discuss the impact of solid waste energy recovery technologies.

4. Revise MRI's position on:

   -- wood wastes to classify it as a raw material rather than energy
   -- recyclable waste products to charge REPA impacts to those industries using such wastes and credit those processes which provide it
   -- the reusable cup definition to include reusable saucers and impacts associated with them

5. Correct the inconsistencies and errors in the report.

I. CHARACTERISTICS OF A REPA ANALYSIS

REPA means resource and environmental profile analysis. The approach is an analytical tool that permits resource and environmental comparisons to be made between specific products manufactured from different materials which have similar end uses.

There are six basic REPA impact categories. Energy, materials, and water are inputs to the product system. Solid waste, atmospheric emissions and waterborne wastes are outputs from the product system. Figure 1 shows that the analysis measures these impacts through a complete product life cycle.

Taking a paper cup as an example, the REPA study would begin in the area of woodlands harvesting. The study would then progress through pulp and paperboard production, cup converting and use/discard/final disposal. The analysis also includes impacts associated with the transportation of these materials and products from site to site, and any recycling that takes place within the production process.

A. STRENGTHS

The comprehensive systems concept which the study employs allows for a broader assessment of a product system's overall impact in terms of resource depletion and environmental degradation than most other analytical methods. Unlike studies which focus on only a single impact category, e.g., water pollution, this analysis measures impacts from six different major categories. Also, unlike studies which focus on only a single manufacturing step, e.g., pulp/paperboard making, this analysis considers impacts at each stage of a product's life -- beginning at the raw materials point of origin and ending with the final disposal of the product. For these reasons, the analysis can be a helpful decision-making tool for both public institutions and private

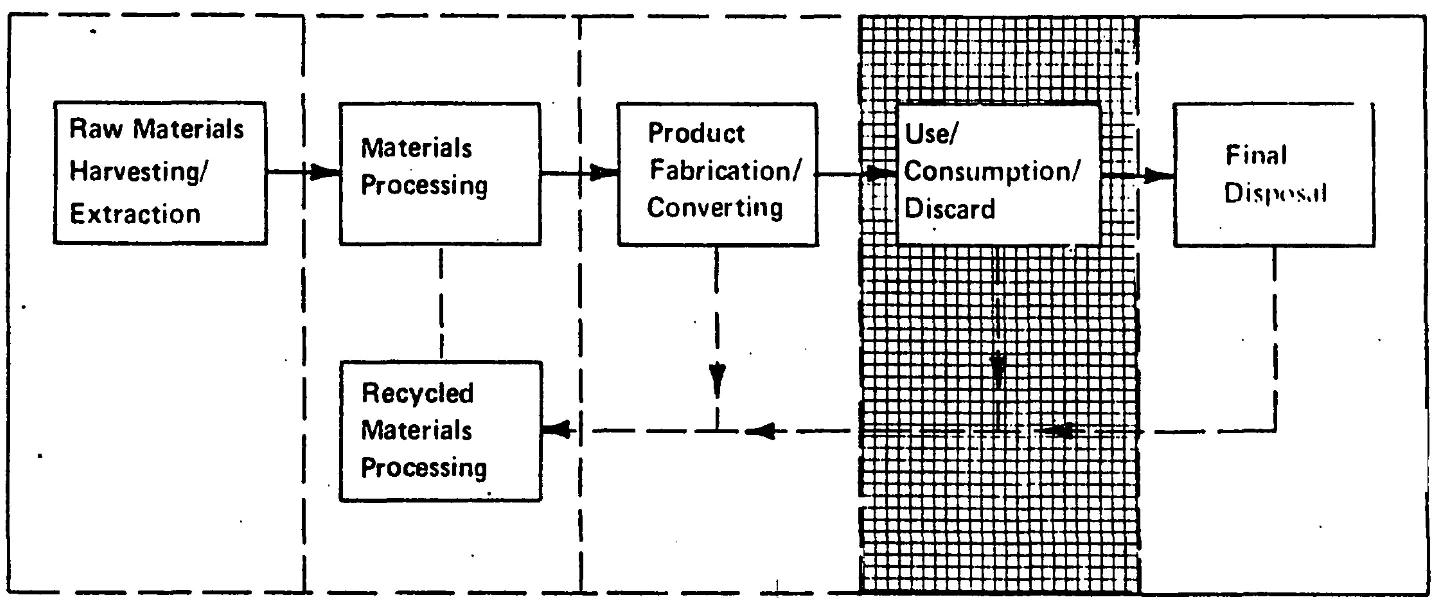

FIGURE 1

REPA FLOW DIAGRAM

corporations. Public agencies can use this analysis as one input to public policy formulation. Private corporations can use the analysis to identify processes or operations that have abnormally high REPA values and that may benefit from corrective action that could result in increased overall operating efficiency and lower production costs.

B. WEAKNESSES

PERSPECTIVE -- As previously mentioned, single service products must be viewed from many perspectives -- functional, economic and public health and other social factors as well as environmental. This analysis deals with only the environmental perspective. Thus, there is a danger that certain readers will view these studies with too narrow a perspective. This danger is enhanced by the wide variety of audiences that will probably have access to the study. Dramatic quantitative comparisons are sometimes easily taken out of context. For example, the losing product in any one REPA comparison could still have an insignificant impact on environmental quality.

DANGER OF GENERALIZATION -- Extrapolations of REPA findings from studied products to the general product class can be dangerous. The analysis is specific to the products being studied and cannot be applied to other products that may (1) contain different amounts of raw material; (2) involve other fabricating processes; or (3) have different usage characteristics. Also, the analysis involves only the six impact categories previously discussed. For example, it does not include consideration of factors such as toxicological effects, community desires or social values. Thus, generalizing from specific REPA conclusions to broader observations regarding a product's overall value in our society can be highly misleading.

SUBJECTIVE EVALUATIONS -- Many subjective evaluations and assumptions are required in order to keep the scope of a REPA study manageable. Assumptions that have an important impact on REPA results include:

- *The Comparability of Products Studied*

A key assumption in the analysis is that products being compared (e.g., a disposable versus reusable plate) are substitutable for each other. In the real world, this is often not the case. In many situations, the products being compared may be complementary to each other.

- *Usage Assumptions*

The assumptions relating to the use and reuse of reusable products are critical for two reasons. First, the reuse portion of the total life cycle for reusable products is dominant as far as REPA impacts are concerned. For many REPA impacts, and particularly for energy, the values related to reuse (e.g., washing and drying) account for well over half of the total impact category. Second, these reuse parameters are subject to a great deal of variability and uncertainty; in many instances it is difficult to pin down these numbers precisely. Thus, assumptions relating to reuse, such as washing efficiency, and water temperature, and a sensitivity analysis developed to put the uncertainty around these assumptions into proper perspective are critical to the outcome of the analysis.

- *Time Frame*

REPA studies are typically undertaken on a static basis. Thus, potential technological improvements that could result in more efficient operations, lower energy intensity or greater material productivity in the future are not quantitatively considered. Given trends toward lighter weight or less energy intensive disposable products, it is appropriate that these are introduced qualitatively in the analysis.

C. POLICY ACTIONS AND THE REPA ANALYSIS

Given the significant weakness inherent in a REPA analysis, great care must be taken when setting public or private policy based solely on a REPA analysis. If a REPA analysis is properly and objectively conducted, it is valuable as one tool among several for guiding policy decisions. If improperly done or if any assumptions made are not based on a thorough industry understanding, the analysis will have little meaning and be without value as far as public or private policy decisions are concerned. It is our opinion that this REPA analysis, since it involves many critical assumptions and large uncertainties in the data inputs, runs a great risk of being of limited usefulness.

II. GENERAL COMMENTS ON REPORT

A. SUMMARY APPEARS BIASED TOWARD REUSABLES

Several aspects of the summary comparing reusable and disposables suggest that it is biased toward reusable products. While much of the interproduct comparisons simply state which class has higher or lower impacts, in several instances the emotional term "favor" is resorted to. Reference to a "most favorable REPA profile" appears on page 7. Of the three instances where the term "favor" is used, all refer to instances in which reusable products have lower REPA impacts.

In addition, the summary contains process technology speculation outside the scope of the report which casts reusables in a more "favorable" light. On page 7 reference is made to a product which is not specified in the product list on page 4 or graphically presented in Figure 3 on page 42. On page 9, there is speculation about a commercial cold water system but the report flatly states that commercial cold water wash systems were not encountered. On page 17, chemical sanitization of permanent dishware is described which to date is not commercially significant. In no instance does the summary speculate in favor of disposable products. We feel that any potentially biased references, especially those involving speculation should be stricken from a responsible, rigorous study or at least grouped together in an appropriately identified section of the report.

B. THE REPA IMPACT TOTALS ARE MISLEADING

Adding the REPA values to each category results in sums which are not accurate reflections of resource use and environmental impact. As presented in this report, all the components of any category are added together to give a single, supposedly all inclusive, number.

However, the size of this number does not necessarily reflect the real impact on the environment. For example, even though paper products consume substantial quantities of raw materials, more than 90% of this material is wood, limestone and salt. None of these materials is currently in short supply nor is it likely to be in the near future. In addition, more than 70% of the raw materials consumed is wood fiber which is a renewable resource. Therefore, even though disposables consume substantially more resources than reusables, the impact on potentially scarce world resources is not as large as the numbers would suggest.

A second case in point is the energy totals. More than 60% of the energy requirements for reusables is derived from natural gas. Disposable products rely on natural gas for less than 30% of the energy need. The shortage of natural gas in the United States is most acute, therefore, the energy mix for reusable products is environmentally more significant than for disposable products.

MRI should not ignore these issues but rather present an impartial discussion of the limitations of the REPA totals in order to try to insure that the REPA data be used responsibly.

C. REPA ANALYSIS IGNORES PRODUCT UTILITY

The REPA analysis does not establish equivalent product utility. Because the REPA analysis requires quantification of environmental impacts, the analysis cannot include more subjective considerations such as economic benefits, social impacts and quality of life differences implied by each product being compared. This limitation is even more apparent in the study of reusables versus disposables. A basic assumption underlying the use of a REPA analysis is that any two products which are being compared are reasonably equal in usefulness. If this condition is not true, then policy decisions based totally on a REPA analysis will have significant economic, social and life style impacts.

Reusables and disposables are not always equivalent functionally. While at a very simplistic level reusables and disposables can be thought of as suitable alternatives for a given task, disposables are usually chosen because they offer benefits not possible from reusables. As an example, the fast food industry is totally dependent on disposables and could not exist in its present form without them. Part of the utility of disposables is that the consumer can take the cup, plate and napkins with them. If only reusable products were available, fast food customers would be required to bring their own napkins, utensils, food containers, and beverage containers or eat the food at the restaurant site. Thus, the restaurant floor space and number of employees would have to be larger to accommodate laundering and dishwashing facilities.

At the other end of the spectrum, the fanciest of restaurants would seldom entertain the idea of using disposable products. The image of fine china, glassware and table linens is a subjective criterion which a REPA analysis cannot possibly quantify.

The REPA analysis need not ignore these issues. Rather it should recognize that they exist and properly identify and characterize them in order to minimize the possibility of REPA comparisons being made out of context.

D. INADEQUATE DISCUSSION OF KEY FUTURE TECHNOLOGIES

While MRI does speculate on process technologies such as cold water commercial washing practices and chemical sanitization of permanent ware, no mention is made of energy recovery technologies based on municipal waste streams. For the past several years, much has been written about incinerating solid waste materials to recover energy for municipal use and at least one firm has developed a commercially viable route to "synthetic fuels" from cellulosic waste materials. Much work is currently under way to recover energy from plastics and other materials. It is not considered prudent in this analysis to credit each system with the heat content of the raw materials based on energy recovery systems but this process should be described and the impact on energy and post consumer solid waste categories mentioned. The BTU content of various waste materials is shown in Table 1 and the REPA impacts for energy and post consumer waste before and after heat recovery incineration are shown in Table 2.

E. INCONSISTENCY OF SUMMARY TABLES IN APPENDIX F

We note that the data for reusable systems presented in Tables F-6, F-7, and F-8 in Appendix F do not correspond to the corresponding 51-60 summary tables in the main body of the report. The primary discrepancy lies in the input data. The detailed summary tables 51-60 do appear consistent with the on-site REPA impact data for individual process steps suggesting the summary tables in the Appendix contain an error. This inconsistency should be checked and eliminated.

TABLE 1

HEAT CONTENT OF SELECTED INDUSTRIAL SOLID WASTE PRODUCTS

	Heat Content (BTU/lb -- dry)	Ash (weight %)
Corrugated Board and Paper Products	7600	5.0
Hardwood	8300	3.0
Textiles	8000	3.0
Plastics	14,600	1.5
Metals, Glass	120	95.0
Misc. Rubber	11,300	15.0
Food Waste	8400	5.0

Source: H. Hollander & J. D. Lesslie, AATCC Symposium "The Textile Industry and the Environment 1973" page 101.

TABLE 2

ENERGY AND POST CONSUMER SOLID WASTE IMPACTS FOR DISPOSABLE AND REUSABLE SYSTEMS WITH AND WITHOUT ENERGY RECOVERY INCINERATION PROCESSES

(impact/million uses)

	Without Incineration		With Incineration	
	Energy (MM BTU)	Post Consumer Solid Waste (cu. ft.)	Energy (MM BTU)	Post Consumer Solid Waste (cu. ft.)
Glass Tumbler	204	1.8	204	1.8
Polypropylene Tumbler	209	1.4	208	0.1
Paper Cup -- 9 oz. cold drink	416	241	310	14.9
Polystyrene Cup -- thermoformed	697	187	509	13.7
China Cup	611	4.9	611	4.9
Melamine Cup	591	5.3	584	0.5
Paper Cup -- 7 oz. hot drink	356	237	251	14.7
Polystyrene Cup	571	761	507	4.7
China Plate	439	8	439	8.0
Melamine Plate	402	6	394	0.6
Paper Plate -- white uncoated	453	368	206	22.8
Polystyrene Plate -- foam	1479	4582	1164	23.0

Assumption: Density of ash 75 lbs/cu. ft.; ash residue is 8% by weight of waste stream.

III. QUESTIONABLE ASSUMPTIONS IN THE REPA ANALYSIS

A. WOOD WASTES COUNTED AS ENERGY

MRI identifies two alternatives for treating organic hydrocarbons consumed as raw materials: (1) count it as raw materials or (2) count it as energy. MRI prefers option 2 and the basic argument it presents states that "counting organic hydrocarbons as a raw material equivalent to limestone is not equitable since hydrocarbons are scarce and limestone is not." Since hydrocarbons represent the major source of energy in the United States, MRI feels that counting raw material hydrocarbons as energy more accurately reflects current environmental concerns.

Using the same logic, MRI states that wood fiber used as raw material should be counted as a material resource rather than as an energy source because (1) wood is not in short supply and (2) "cellulosic materials are not now a viable (fuel) energy source in the same way that plastics feedstocks are."

MRI seems to feel, however, that wood wastes (principally kraft black liquor) when burned should be counted as their energy equivalent. The logic is apparently that wood wastes are in short supply or that they are a viable multi-use (fuel) energy source in the same way that plastics feedstocks are. Pulping operations do burn wood wastes to provide process energy, but that hardly confirms the viability of these as a fuel source. After costly pulping chemicals have been recovered from black liquor wastes, it along with other wood wastes are burned to recover valuable energy thereby avoiding disposal of waste stream in an environmentally unacceptable manner.

As a further consideration, each pound of wood wastes burned reduces the demand for purchased energy in the pulping operation by about 7000 BTU's. Since most purchased energy is derived from relatively scarce hydrocarbon resources and, at least at the pulp mill, wood waste is <u>not</u> scarce, counting energy from wood waste equal to energy from hydrocarbons distorts reality. A more accurate picture would exist if wood wastes are counted as raw material resources rather than as energy.

Finally, if a pulp mill is brought on stream or closed down, the impact felt on the national energy pool is described by the purchased energy, <u>not</u> total energy requirement. To charge any process for internally generated energy derived from waste materials unfairly penalizes that process relative to those which use only purchased energy.

B. REPA IMPACTS FOR WASTE TRIM

Recycling of waste materials reduces the total systems need for virgin raw materials. For each pound of trim waste recycled, one less pound of wood pulp is required for producing paper products. The recycled raw materials are not disposed of in any solid waste stream, rather they are used as raw material substitutes in other processes. The only question of policy in the REPA analysis is which process should be charged with (and given credit for) the environmental impacts associated with the production of the pulp which gets reused.

MRI has adopted the position that the process which generates the waste trim should be charged with the environmental impacts.

If waste materials have no alternate use values then this approach is justified. But for process wastes which can be recycled into other processes, an equally valid alternative in our opinion is to allocate the REPA impacts associated with the raw material content in the waste material. In the instance of cup and plate stock producers, the REPA impacts associated with the pulp content in the waste trim should be allocated to it and be absorbed by those processes using it. If the waste material were not available, those processes relying on waste trim would have to purchase additional virgin pulp and would in that instance incur the same REPA impacts which we suggest should be allocated to the waste trim. This approach favors neither the process generating nor the process using the trim wastes. It also avoids the inconsistent position of charging the cup and plate stock producers with trim waste impacts when -- for good product sanitation reasons -- internally recycling of trim wastes is not acceptable.

Table 3 shows our estimate of the REPA impacts which should be allocated to the pulp substitute trim waste in the bleached kraft paperboard process. These values, although small, should be credited to the disposable product systems and charged to any other process choosing to use these wastes in place of virgin pulp.

C. DEFINITION OF THE REUSABLE CUP SYSTEM

MRI is not specific in the report as to what the reusable cup system includes. It is obvious that, unless the data are specifically limited to ceramic mugs, MRI has omitted the impacts from saucers which are usually used with standard coffee or tea cups. While we have not developed data on the relative percentages of cup/saucer units versus mugs in use, we have assumed that 50% of the reusable cup users involve the cup/saucer units. We have estimated the REPA impacts for 500,000 mugs plus 500,000 cup/saucer units based on MRI data and this is shown in Table 4. It is clear that the omission of saucers has resulted in seriously underestimated REPA impacts for the hot drink system.

TABLE 3

REPA IMPACT CREDITS FOR TRIM WASTE RECYCLE

(impacts/million units)

	Impacts/ lb Pulp	Cold Drink Cups	Hot Drink Cups	Plates
Raw Materials (lbs)[1]	1.003	3109	4423	4985
Energy (MM BTU)[2]	0.009	27.6	39.4	44.4
Process Water (MM Gal)	0.013	40.3	57.3	64.6
Process Solid Waste (cu. ft.)	0.002	6.2	8.8	9.9
Atmospheric Emission (lb)[2]	0.044	136.1	193.7	218.4
Water Pollution (lb)	0.020	62.0	88.2	99.4
Post Consumer Solid Waste (cu. ft.)	--	--	--	--

[1]Scrap credit quantities are:

	Scrap
Cold Drink Cups	3100 lbs
Hot Drink Cups	4410 lbs
Plates	4970 lbs

[2]Energy credit for scrap as pulp substitute less transportation impacts (0.1 MM BTU and 0.3 lbs atmospheric emission) for each system.

Source: Arthur D. Little, Inc., Estimates

TABLE 4

REPA IMPACTS FOR HOT DRINK REUSABLE SYSTEMS

(impacts/million uses)

	China Cups		Melamine Cups	
	Without Saucers	With Saucers	Without Saucers	With Saucers
Raw Materials (lbs)	4778	5693	3718	4102
Energy (MM BTU)	434	611	421	591
Process Water (M Gal)	200	218	201	219
Industrial Solid Waste (cu. ft.)	42	64	29	45
Atmospheric Emission (lbs)	1408	2142	1272	1938
Waterborne Wastes (lbs)	1142	1247	1100	1184
Post Consumer Solid Waste (cu. ft.)	3.3	4.9	3.5	5.3

Source: Arthur D. Little, Inc., Estimates

IV. DATA SOURCE

A. DISPOSABLE CUPS AND PLATES

MRI's principal source for the environmental impact data on disposable cups and plates was information submitted by the Single Service Institute and the data included in MRI's report are consistent with that which was submitted. Since ADL assisted with developing this information, we sought no further checks on the reasonableness of the plate and cup data.

B. REUSABLE CUPS AND PLATES

1. Manufacturing Processes

The overall manufacturing scheme, the flow of raw material and the reasonableness of the key REPA impact data for each step were checked for each reusable raw material. While we did not independently determine the REPA impacts for each process step, we did use ADL in-house data and industry expertise to confirm that raw material and energy requirements were neither significantly understated nor overstated. Since the REPA impacts from the manufacture of reusables contributes such a small percentage to the total REPA impacts, we did not check impacts other than raw materials and energy.

2. Washing Process

Permanent ware washing is the most critical process step with regard to estimating the total REPA impacts for reusables. As shown in Table 5, washing contributes over 85% of the total energy impact; therefore, even a small error in these data will significantly affect the REPA totals. For this reason, we independently determined the REPA impacts for permanent tableware washing.

TABLE 5

ENERGY IMPACTS FOR REUSABLE TUMBLERS, CUPS AND PLATES

(impacts/million uses)

	Process Steps	Washing Process
Glass Tumblers	3%	97%
Polypropylene Tumblers	5%	95%
China Cups	6%	94%
Melamine Cups	3%	97%
China Plates	14%	86%
Melamine Plates	6%	94%

Note: All estimates based on data for service lives of 1000 uses.

Source: MRI Report -- "Study of Environmental Impacts of Disposables Versus Reusables"

Although MRI does not reveal their sources for permanent ware washing data, the wash equipment is characterized as a flight-rack commercial dishwasher commonly found in large institutional and commercial settings. It seems apparent from the REPA impact calculations on pages E-1 through E-4 that MRI used equipment specification data supplied by equipment producers to determine the theoretical REPA impact data for permanent ware washing.

This approach is deficient for the following reasons:

1. Flight rack commercial dishwashers are not the most common type of dishwashers in restaurants today.

2. Equipment specifications tend to be "optimum" numbers and are not usually realized after one or two years of operation.

3. MRI assumes continuous one hour operation to determine the REPA impacts for dishwashing when, in reality, continuous operation for washing dishes is approached only in the largest institutional and commercial settings. In many discontinuous operations, the wash water must be reheated before reuse thereby greatly increasing the energy consumed.

The actual REPA impacts for a flight rack washing system could, therefore, be as much as 10-20% higher. We attempted to obtain information from china ware associations and dishwasher manufacturers in order to check MRI's data, but both groups were uncooperative.

Published data by Molzahn and Montag at Iowa State University (The Cornell H.R.A. Quarterly, May 1974) suggests that MRI's data are somewhat understated. Table 6 compares the average energy requirements for reusable tableware washing according to MRI (Table E2 on page E3) with data in the Molzahn and Montag study. It suggests that MRI's data are significantly understated. We do recognize that the mix of permanent ware is not identical in both comparisons; and this may explain some of the data differences, but it is not likely to explain it all.

TABLE 6

ENERGY AND WATER REQUIREMENTS
FOR FLIGHT RACK DISHWASHERS

(per million items)

	MRI[1]	Molzahn and Montag[2]
Energy		
Electric (M KWH)	11.3	22.0
Natural Gas (M cu. ft.)	146	165
Water Volume (M Gal.)	138	145

[1]Averages of data presented in Table E-2, page E-3, of MRI report "Study of Environmental Impacts of Disposables Versus Reusables."

[2]G. M. Molzahn and G. M. Montag, The Cornell H.R.A. Quarterly, Volume 15, No. 1, (May 1974), page 98.

We were successful in developing data on the most common type of dishwasher found in restaurants today. Our source was a major dishwashing detergent supplier who requested that its identity remain confidential. The data obtained was the average one month operating requirements for six different restaurants geographically distributed throughout the United States. These average data are shown in Table 7. The REPA impacts for process solid waste, atmospheric emissions and waterborne waste are estimated in Table 8 and are based on MRI data. Table 9 lists the total REPA impacts for washing one million tumblers, cups, cup/saucer units and plates. It should be noted that these estimates are themselves optimistic since we assumed that racks are completely loaded with only one kind of permanent ware item. This may not be true in actual service where racks may be washed only partially loaded. It is not likely, however, that operating efficiencies lower than 90% would be tolerated except in the smallest of restaurants.

It is apparent that MRI's data are understated as shown in Table 10. The reason for this understatement is either that single rack, time cycle washers are less efficient than flight rack washers or that the "theoretical approach" used by MRI based on equipment producers' specifications understates average field consumptions. Since we could not develop any data on flight rack washers, we assumed that the single rack, time cycle washers are less efficient than flight rack washers.

Based on sales of permanent ware items to restaurants and instituional groups, we estimate that about 55% of permanent ware is washed in single rack, time cycle washing units and 45% in flight rack type washing units. Therefore, we have reestimated the REPA impacts (Table 11) for permanent ware washing assuming that 55% of the permanent ware is washed in the single rack, time cycle washer. (The data for cups assumes that half of the uses are cup and saucer units and half are mugs used without saucers). These data indicate that the REPA data for all impacts except raw materials, process water and waterborne wastes are significantly understated.

TABLE 7

DATA FOR SINGLE RACK/TIME CYCLE WASHER

ENERGY	2000 Loads	Per Load
Natural Gas (cu. ft.)		
Soak Water	500	0.25
Dishwasher	6380	3.19
Total Natural Gas	6880	3.44
Electric: Booster Heater (KWH)	436.2	0.22
Tank Heater (KWH)	307.9	0.15
Pump (KWH)	20.8	0.01
Total Electric (KWH)	764.9	0.38
Total BTU (000)	15,656	7.83
WATER		
Soak/Rinse (gal.)	451	0.23
Fill (gal.)	1818	0.91
Final Rinse (gal.)	2318	1.16
Total Water (gal.)	4587	2.30
DETERGENT		
Powder (lbs)	75.0	0.038
Rinse Additives (lbs)	11.3	0.006
Total Detergent	86.3	0.044

ITEMS WASHED	Units/Load
Tumblers	36
Cups	16
Saucers	30
Plates	20

Source: Arthur D. Little, Inc., Estimates

TABLE 8

REPA IMPACT ESTIMATES -- SINGLE RACK/TIME CYCLE WASHING UNIT

(impacts/million items)

	Tumblers	Cups	Cups/Saucers	Plates
Process Solid Waste (cu. ft.)				
Electric	16.3	36.7	56.3	29.4
Detergent (packaging)	1.2	2.8	4.2	2.2
Total	17.5	39.5	60.5	31.6
Atmospheric Emissions (lbs)				
Natural Gas	201	452	692	361
Electric	549	1235	1894	988
Total	750	1687	2586	1349
Waterborne Wastes (lbs)				
Natural Gas	18	41	63	33
Electric	94	213	326	170
Washing (20% of detergent)	244	550	843	440
Total	356	804	1232	643

Source: Arthur D. Little, Inc., Estimates

TABLE 9

REPA IMPACTS FOR DISH WASHING WITH SINGLE RACK/TIME CYCLE WASHER

(impacts/million items)

	Tumblers	Cups	Cups and Saucers	Plates
Raw Materials (lbs)	1222	2750	4217	2200
Energy (MM BTU)	218	489	750	392
Process Water (M Gal)	64	144	220	115
Process Solid Waste (cu. ft.)	17.5	39.5	60.5	31.6
Atmospheric Emission (lbs)	750	1687	2586	1349
Waterborne Waste (lbs)	356	804	1232	643
Post Consumer Solid Waste (cu. ft.)	--	--	--	--

Source: Arthur D. Little, Inc., Estimates

TABLE 10

ADL VERSUS MRI ENERGY ESTIMATES FOR PERMANENT WARE WASHING

(MM BTU/million items)

	Tumblers	Cup	Saucer	Plates
MRI -- Flight Rack Washer	180	407	--	362
ADL -- Single Rack/Time Cycle	218	489	261	392

Source: Arthur D. Little, Inc., Estimates

TABLE 11

REPA IMPACTS FOR WASHING

(million uses)

	Tumblers			Cups			Plates		
	MRI	ADL	AVG.*	MRI**	ADL	AVG.*	MRI	ADL	AVG.*
Raw Materials (lbs)	1531	1222	1361	4520	3484	3950	3212	2200	2655
Energy (MM BTU)	179	218	200	508	620	570	362	392	379
Process Water (M Gal)	86	64	74	243	182	209	173	115	141
Industrial Solid Waste (cu. ft.)	13	18	16	36	50	44	25	32	29
Atmospheric Emission (lbs)	540	750	656	1528	2137	1863	1086	1349	1231
Waterborne Waste (lbs)	389	356	371	1368	1018	1176	813	643	720
Post Consumer Solid Waste (cu. ft.)	--	--	--	--	--	--	--	--	--

*Note: This average is weighted 45% for MRI's estimate (based on flight rack washers) and 55% for ADL's estimates (based on single rack washers).

**Estimates assuming load density for saucers 1.5 x cup density

Source: Arthur D. Little, Inc., Estimates

3. Service Life Assumptions

MRI tries to avoid the issue of product service life by claiming that any service life above about 100 washing cycles does not significantly affect the total REPA estimates. While this is reasonably true, a rigorous analysis would provide the reader with an estimate of the actual service life for glasses, cups and plates in order to make the sensitivity analysis meaningful.

Published data on service life suggest that between 1000-2000 uses is a reasonable estimate for most permanent ware. Rippe and Montag at Iowa State University (The Cornell H.R.A. Quarterly, November 1969, page 70) report service lives ranging from about one year for cups to nearly nine for salad plates. The estimate of service life for items in this study is 1.1 years for cups and 4.7 years for dinner plates. Assuming a usage rate of 3-5 times per day for cups and 1-2 times per day for plates, the service life (assuming 300 days operation) in number of uses is 990-1650 uses for cups (probably true for glasses as well) and 1410-2820 for plates. These estimates were considered reasonable by two major restaurants in the Boston area as well. MRI quotes a service life estimate for plates of 6900 uses, but we cannot justify so large a number. Therefore, we feel that all comparisons are better made at 1000 uses for reusable tableware items.

V. TREATMENT OF DATA

A. ESTIMATES OF SOLID WASTE IMPACTS

We do not believe MRI's methodology for estimating process solid waste impacts is suitable to a credible comparison of reusables and disposables. MRI appears to have used a standard density estimate of 74 pounds per cubic foot in converting pounds of process solid waste into cubic feet in landfill displaced. This practice favors the disposable products and penalizes the reusable products since the process waste streams from paper processes are lighter than for glass and possibly plastic manufacturing processes. A more rigorous process would be to independently estimate the solid waste density of each process waste stream and measure that impact as cubic feet rather than as pounds.

MRI attempts this in their estimate of post consumer solid waste impacts. An estimate of the solid waste density for each product is made in order to more accurately estimate the waste disposal impact. While we accept the estimate as reasonable, we doubt that 100% compaction is achievable and rather that 60-70% is a better estimate of short- to mid-term compaction of discarded waste material.

B. ESTIMATES OF WATERBORNE WASTES

MRI has overstated the waterborne waste impact estimates by adding BOD and COD numbers. BOD is defined as biological oxygen demand and is a measure of the waste streams demand for oxygen from its surroundings as biodegradable carbonaceous materials decay. Because this number is difficult and time consuming to measure, a second measure of the oxygen demand -- COD -- was defined. COD is defined as the chemical oxygen demand based on permanganate oxidation of chemically degradable carbonaceous material. Since some chemically degradable materials are non-biodegradable, COD numbers always come out higher than BOD; however, COD always includes that carbonaceous material which was measured as BOD. Thus, to add BOD and COD numbers would be to double count BOD pollutant numbers.

C. REUSABLE USAGE ASSUMPTIONS

MRI does not adequately present a sensitivity analysis for the highly uncertain service life assumptions. It is clearly pointed out that, at service lives greater than about 200 for plates and cups, the impact of this variable is small. But the reader is not given any information as to what the service life is or could be and how large a range around this estimate is considered reasonable. A rigorous analysis could estimate the actual service life and include REPA impacts at upper and lower service life estimates.

VI. ALTERNATE REPA IMPACT SCENARIOS

Tables 12-14 present alternate REPA impact scenarios which we believe are "more representative" of reality. We have included in these tables:

- Revised raw material and energy totals based on classifying wood wastes as raw materials rather than energy
- REPA impact credits for waste trim
- Revised estimates of permanent ware washing impacts
- Revised estimates of china plate service lives
- Reusable saucers for one-half of the reusable cup uses

We have used MRI's data for flight rack dishwashers since we do not have an independent estimate for this type of washing unit. It is likely that MRI's data are understated; therefore, the REPA data for reusable products may also be understated by 5-10%.

It should further be noted that both the MRI and ADL data are based on full dish racks. In some instances this situation is not achieved; therefore, the REPA impacts will be understated. We cannot estimate the extent to which partial loads increase the washing impacts but can state that to the extent partial loads are significant, the actual REPA impacts for permanent ware washing will be higher than the estimates we provide.

TABLE 12

COLD DRINK SYSTEM -- ALTERNATE REPA IMPACT ESTIMATES

(impacts per million uses)

	Glass Tumbler	Polypropylene Tumbler	Paper Cup	Polystyrene Cup
Raw Materials (lbs)	1503	1372	26,448	1484
Energy (MM BTU)	204	209	416	697
Water (M Gal)	74	75	105	51
Industrial Solid Waste (cu. ft.)	17	16	49	31
Atmospheric Emission (lbs)	680	718	1478	1963
Waterborne Wastes (lbs)	376	375	205	266
Post Consumer Solid Waste (cu. ft.)	1.8	1.4	241	187

Source: Arthur D. Little, Inc., Estimates

TABLE 13

HOT DRINK SYSTEM -- ALTERNATE REPA IMPACT ESTIMATES

(impacts/million uses)

	China Cup/ Saucer[1]	Melamine Cup/Saucer[1]	Paper Cup	Polystyrene Cup
Raw Materials (lbs)	5693	4102	38,239	1655
Energy (MM BTU)	611	591	356	571
Water (M Gal)	218	219	135	30
Industrial Solid Waste (cu. ft.)	64	45	66	16
Atmospheric Emission (lbs)	2142	1938	1425	1854
Waterborne Wastes (lbs)	1247	1184	213	253
Post Consumer Solid Waste (cu. ft.)	4.9	5.3	237	761

[1] Assumption: China and melamine cups are used with saucer. Saucer impacts assumed equal to cup impacts.

Source: Arthur D. Little, Inc., Estimates

<u>TABLE 14</u>

<u>PLATE SYSTEM -- ALTERNATE REPA IMPACT ESTIMATES</u>

(impacts/million uses)

	China Plate	Melamine Plate	Paper Plate	Polystyrene Plate
Raw Materials (lbs)	5263	2814	56,780	4087
Energy (MM BTU)	439	402	453	1479
Water (M Gal)	153	151	232	102
Industrial Solid Waste (cu. ft.)	60	30	88	70
Atmospheric Emission (lbs)	1645	1310	1813	4924
Waterborne Wastes (lbs)	822	727	265	609
Post Consumer Solid Waste (cu. ft.)	8	6	368	4582

Source: Arthur D. Little, Inc., Estimates

VII. MATHEMATICAL ERRORS AND TYPOS

The following is a list of mathematical and typographical errors we found during the course of our critique on the MRI report "Study of Environmental Impacts of Disposables Versus Reusables."

Page	Line	Error
7	33	41 should be 42
11	5	column 1 should be 1.785 column 7 should be 1.232
14	16-21	error in estimating waterborne waste impact
27	30-31	statement belongs in different study
28	7	garbled sentence
30	4	far should be for
52	38	cotton-rayon should be polyester-rayon
76	4	column 1 should be ∿6.0
C-19 } C-22 }	Air poll. estimates	improperly estimated
C-59		particulate .32 should be 3.32
C-73	Title	9-ounce should be 7-ounce
D-9	22	81 should be 61
D-23	Water volume	should be 36,375 gal.
E-5	4 last para.	waste should be wash
E-13	Table E-11	18.2 should be 1.82
R-3	Ref. 33	Arthur D. Little, Inc.
R-5	Ref. 69	Arthur D. Little, Inc.

Comments and Reactions

of

THE SINGLE SERVICE INSTITUTE

concerning

Volume II
Health Considerations
Final Draft Report

Study of Environmental Impact
of
Disposables versus Reusables
(MRI Project No. 4010-D)

Submitted to:

United States Environmental Protection Agency
Office of Solid Waste Management Programs
401 M Street, S.W.
Washington, D.C. 20460
Date of Submission
June 28, 1977

10-5

In response to the United States Environmental Protection Agency's request for comments on the Final Draft Report, Study of Environmental Impact of Disposables Versus Reusables (MRI Project No. 4010-D), the Single Service Institute submits the following analysis and review of Volume II, Health Considerations, Section VI, Disposable and Reusable Foodservice Ware.

Review Procedure

The Single Service Institute felt that the subject areas relating to disposable and reusable foodservice ware covered in Volume II, Health Considerations, were of such a technical, highly specialized nature, that the most meaningful review would not be that of laymen but of professionals in the field of public health -- sanitarians, environmental scientists, members of the academic community in public health and environmental sciences.

Accordingly, copies of Volume II, Health Considerations, were sent to the following members of the Single Service Institute's Public Health Advisory Council:

Dr. George Kupchik, Program Director and Professor, Environmental Health Sciences, School of Health Sciences, Hunter College of the City University of New York.

Dr. William Walter, Acting Vice President for Academic Affairs and former Chairman, Department of Microbiology, Montana State University, Bozeman, Montana.

Dr. Sam H. Hopper, Professor of Public Health and Director, Graduate Program in Health Administration, School of Medicine, Indiana University, Indianapolis, Indiana.

Following their individual review of Volume II, members of this group met in Chicago on May 6, 1977, for a comprehensive and detailed discussion of the Health Considerations report. The report as a whole, and the individual comments and reactions of the members of the group, were subjected to searching and objective professional analysis.

The members of the professional review panel prepared the following commentary on Volume II, Health Considerations, representing a consensus of the reactions and observations of the group.

Summary of Review Panel's Comments

General Reactions

The MRI report omits important data, improperly manipulates other data and seriously misquotes a most significant statement by a leading public health scientist.

The report is flawed by errors in methodology, fact and interpretation. It claims to provide a consensus of the available literature and professional opinion but actually does neither.

The report does nothing to promote adequate understanding of the health issues involved in the disposables versus reusables question and fails to provide an objective summary of current knowledge of these issues.

The report should not be used as a guide in the formulation of public policy.

Major Flaws

1. The MRI report does not include the results of the Syracuse Research Corporation's comparative microbiological study of reusable and disposable foodservice ware in food service establishments. These results demonstrated conclusively that disposables were consistently of significantly better bacteriological quality. (See pages 13-16.)

2. The report dismisses the potential hazards of foodservice ware in communicable disease wards, completely ignoring the American Hospital Association's recommendations for the use of disposables. (See pages 22-23.)

3. The report manipulates the statistical findings of an article by Dr. Bailus Walker, Jr., entitled "The Health Profession's Attitudes Toward Single-Use Food and Beverage Containers." (See pages 35-36.)

4. The report omits highly significant sections of a concluding statement by Dr. Walker in an article entitled "Bacterial Content of Beverage Glasses in Hotels." In the missing sentences Dr. Walker stresses the need to render eating and drinking utensils free of pathogens and to reduce bacterial counts to the safe levels specified in public health codes and ordinances. (See pages 16-20.)

5. The MRI report dismisses the findings of higher-than-acceptable standard plate counts and the presence of coliform organisms on beverage glasses washed in hotel commissaries, as described in Dr. Walker's article "Bacterial Content of Beverage Glasses in Hotels." Coliform organisms are recognized as indicators of unsanitary conditions. (See page 37.)

6. The report does not evaluate the sources quoted or suggest their relative significance. It quotes extensively from a 1963 address by a hospital pediatrician and from a telephone conversation, and gives these sources at least equal weight with the results of scientific studies. (See pages 22, 24, 31, 37.)

7. None of the listed authors of the MRI report on Health Considerations is a member of the American Society for Microbiology. Recognized expertise in microbiology would seem to be a prerequisite for proper evaluation of the scientific literature in this field and of the technical issues involved.

Invalid Assumptions

1. The MRI report states that available dishwashing procedures are capable of producing sanitized foodservice ware, on the assumption that operating personnel are properly trained. All reports in the literature, however, indicate that such training is broadly lacking or inadequate. (See pages 24-26.)

2. On the basis of a telephone conversation with an official of the Center for Disease Control in Atlanta, the report assumes that "microorganisms left on foodservice ware after washing would likely be too low to cause disease." Such an unqualified statement would be challenged by most epidemiologists and environmental scientists. (See pages 30-31.)

3. The report seriously errs in its appraisal of the potential hazard of disease transmission by means of foodservice ware and grossly underestimates the prevalence of food poisoning in the United States. (See pages 9-13.)

4. The MRI report consistently tends to minimize the health protection afforded by bacterial standards established for foodservice ware. Yet in other environmental and public health areas the Environmental Protection Agency continuously seeks to develop protective standards. (See pages 10-11.)

Other Flaws

1. The MRI report does not refer to the 1976 Revision of the Food Service Sanitation Manual of the U.S. Food and Drug

Administration, which requires the use of single service utensils for mobile facilities and temporary foodservice operations. (See pages 26-27.)

2. The report does not consider the demerit scale set for deficiency items in the model inspection reports of the FDA. Proper consideration would tend to diminish substantially the significance of the specific deficiency noted for storage, dispensing and handling of single service articles. (See pages 27-29.)

3. The report minimizes the problem of breakage and safety of reusables although there are studies indicating this is a serious health problem. (See pages 31-33.)

4. The report refers to the use of chlorine and other chemicals as satisfactory sanitizing solutions but does not consider the potential carcinogenic and other toxic hazards of the reaction products discharged with dishwashing wastewaters. (See page 38.)

5. The MRI report fails to credit single service articles with widespread professional support for their sanitation values as evidenced by resolutions passed by the National Environmental Health Association and the International Association of Milk, Food and Environmental Sanitarians at national meetings. (See page 36.)

General Appraisal, Volume II, Health Considerations
(disposable and reusable foodservice ware)

The value of the report must be judged in terms of the extent to which it may contribute to several important purposes:

1. Does it promote adequate understanding of the public health and sanitation issues involved in the use of single service and reusable food and beverage utensils?
2. Is it a useful, representative summary of up-to-date knowledge and thinking on the part of sanitarians and environmental health scientists relating to "disposables versus reusables?"
3. Is the report likely to be useful as a guide in the formulation of public policy with regard to "disposables versus resuables?"

A close reading of the report shows that these key questions must be answered negatively. As currently conceived and written, the foodservice ware section of the report can only be judged inadequate and in need of substantial revision.

Critical analysis of this section of the Health Considerations report shows it to be flawed by serious errors of methodology, fact and interpretation. In one specific instance, there is a grave misuse of a key quotation from a public health authority. This is inexcusable.

As presently organized, the foodservice ware section of the report is a grab-bag of facts, suppositions and references which obscure the issues surrounding "disposables versus reusables."

Overall, the report is without direction or form, proceeds toward no resolution or recommendations, and therefore is of little or no value as a guide to the development of public policy.

If Volume II, Health Considerations, is published in its present form, we anticipate that there will be widespread cirticism of the report's contents by public health professionals.

In the following pages, the report will be analyzed in detail, starting with its major flaws and continuing on to lesser errors, weaknesses, and inconsistencies. As far as possible, in accordance with the request of Mr. Charles Peterson, EPA Project Officer, the review panel's criticisms will be grouped as (1) factual errors; (2) invalid assumptions; and (3) other.

Major Flaws, Foodservice Ware Section, Volume II

Exception must be taken to the report's handling of health and sanitation aspects in three major respects:

1. Appraisal of the potential seriousness of disease transmission via foodservice ware.
2. Omission of the Syracuse Research Corporation research findings submitted by the Single Service Institute.
3. Misuse of a crucial, summary statement by Dr. Bailus Walker, Jr., Director, Environmental Health Administration, District of Columbia.

Points 2 and 3 actually relate directly to the issues raised in connection with point 1, but are considered serious enough to be dealt with as separate items.

Disease Transmission Potential

The foodservice ware section consistently "downgrades" the public health dangers and implications of improper foodservice sanitation levels.

On page 82 of the report, for example: "The distinction must be made, as it has throughout this report, between the potential for health problems and the existence of definably pathogenic conditions. Again, there is no clear relationship between 'inadequate' foodservice sanitation and an attendant threat to the public health."

On page 106: "Additionally, bacteriological standards alone do not measure the capacity of foodservice ware (or any other product) to transmit disease; the most such standards can do is to indicate potential for disease transmission."

In response to this statement, many public health professionals would immediately raise the question: "Isn't that enough?" And in raising this question, such professionals would really be expressing a basic, operational viewpoint toward public health responsibilities and actions quite different from that of the report.

The attitude of the report seems to be that provable numerical links between sanitation levels and the incidence of foodborne disease must be demonstrated before public health issues are deemed live and urgent.

The position of public health professionals, on the other hand, is that if the facts in a given situation reveal that the "potential for disease transmission" presents a reasonable danger to the public, then preventive action is called for. This is comparable to the rationale for other "preventive" programs by the federal government -- the strictures against lead in gasoline, for example. It is worth noting that, in upholding EPA regulations on lead additives in gasoline, the U.S. Court of Appeals in March, 1976, in effect made the case for the public health viewpoint of preventive action despite less than 100 percent certainty on health issues. The following is from the Court's decision:

> "Sometimes, of course, relatively certain proof of danger or harm from such modifications can be readily found. But, more commonly, 'reasonable medical concerns' and theory long precede certainty. Yet the statutes -- and common sense -- demand regulatory action to prevent harm, even if the regulator is less than certain that harm is otherwise inevitable.

"Undoubtedly, certainty is the scientific ideal -- to the extent that even science can be certain of its truth. But certainty in the complexities of environmental medicine may be achievable only after the fact, when scientists have the opportunity for leisurely and isolated scrutiny of an entire mechanism. Awaiting certainty will often allow for only reactive, not preventive, regulation."

The problem, of course, is that one can never "prove" the "non-incidence" of foodborne disease to be the happy result of proper sanitation of foodservice ware. One simply cannot prove beyond doubt that, because certain acceptable levels of sanitation prevailed, a given number of cases of foodborne disease therefore failed to occur. There simply are no statistics for occurrences that did not occur.

But the weight of opinion among public health professionals is that the higher the number of bacteria on the surfaces of eating utensils, the greater the chance of disease transmission. That is why standards set for bacterial counts -- both total plate counts and microbial indicator (or pathogen) counts -- are important. When such counts exceed public health limits, the experts responsible for protecting public health are professionally concerned and prepared to take action. In public health matters, professional practitioners don't wait for people to die. Their job is prevention, and they take it seriously.

Consistent with the Midwest Research Institute report's downplaying of the potential for disease transmission via foodservice ware is its treatment of statistics for the actual incidence of foodborne diseases contracted in foodservice establishments. On page 84, after first referring to "100,000 persons (who) become ill from foodborne diseases contracted in restaurants during 1970," the MRI report goes on to make this statement: "This statistic, credited to the Center for Disease Control (CDC), disagrees with the actual CDC report (16) which shows a total of 24,448 persons becoming ill in 1970 as a result of 371 outbreaks, 114 of which occurred in foodservice establishments."

Apart from this confusion of numbers, the MRI report's authors might have consulted the most recent CDC figures, issued in 1976 for the year 1974. This Annual Summary of Foodborne and Waterborne Disease Outbreaks (Department of Health, Education and Welfare Publication No. (CDC) 76-8185) offers a figure of 456 outbreaks involving 15,489 cases of foodborne illness, by far the greatest number of outbreaks ever reported to the CDC. Of these outbreaks, the place of outbreak is specified in 183 instances, of which 49 percent are designated as foodservice establishments.

What is important is that the CDC summary, pointing to great gaps in the reporting of foodborne illnesses, emphasizes that "the number of outbreaks of foodborne disease reported by the surveillance system clearly represents a minute fraction of the total number that occur." In short, the cases reported are just the tip of the iceberg, as most public health professionals are fully aware.

How big is the iceberg? In 1969, one indication appeared in the National Academy of Sciences' Publication No. 1683, "Evaluation of the Salmonella Problem," which estimated two million human cases of salmonella each year, at a total cost to the economy of at least $300 million annually.

In 1971, the National Conference on Food Protection heard figures for foodborne illness ranging up to 11 million cases a year.

Because of the reporting problems already mentioned, comprehensive, accurate statistics on foodborne illnesses contracted in foodservice establishments are now unavailable, although the number of actual cases undoubtedly exceed those reported. It is unrealistic, however, to base public health policies on the "minute fraction" of cases officially reported to CDC. And it is no service to the health and welfare of the American public to treat a large problem as though it were a small problem.

Public health professionals, although they may come up with varying numbers, agree generally that the numbers for foodborne illness are large, and therefore that sanitation in foodservice operations is a matter of substantial and genuine concern.

It follows from this that anything that might contribute to improvement in sanitation levels should be given serious consideration. In the comparative study of disposable versus reusable foodservice ware, the sanitation issue must be seen in proper perspective, and proper weight must be given to studies showing the comparative bacterial levels of disposables and reusables.

Omission of SRC Research Findings

Proper weight is precisely what was not given to one key study of the comparative bacterial levels of disposable and reusable foodservice ware. This study, conducted by the Food Protection Laboratory of the Syracuse Research Corporation (SRC), is entitled

"Comparative Study of Potential Health Hazards Associated with Disposable and Reusable Food Service Items." It was submitted to MRI by the Single Service Institute as part of the single service industry's effort to cooperate with EPA.

The SRC research not only was not given proper weight -- it was omitted entirely, both from the text of Volume II, Health Considerations, and from the bibliography of reference materials.

This omission is particularly mystifying in view of the following paragraph on page 106 of the MRI report:

> "Within the commercial or insitutitional setting where there are facilities for washing and sanitizing permanent ware, it is extremely difficult to make direct comparisons between reusables and disposables. As previously discussed, the impact of human variables, from day to day, from restaurant to restaurant or institution to institution, negates virtually every attempt to quantify differences in the sanitary status of disposables versus reusables. As correctly stated by the Single Service Institute, 'the only precise way to assess the health values of disposables versus reusables would be to survey the bacteriological quality of one versus the other by testing the utensils in food-serving establishments just prior to their use,' (48). And even then, the scope of the investigation would have to be massive in order to be equitable."

The omitted SRC study is exactly responsive to the research requirements set forth in that paragraph. The authors of the MRI report explicitly agree with the research definition as stated in a quote from the Single Service Institute. This definition formed the basis of the SRC study, the design for which was formulated by members of the Single Service Institute's Public Health Advisory Council -- all public health professionals.

By taking "swab" tests of sample utensils according to approved public health procedures and by "testing the utensils in food-serving establishments just prior to their use," the SRC research did precisely what the MRI report asked for. Yet the MRI authors made no reference to the SRC study in their report.

According to the Midwest Research Institute, the SRC study results reached MRI too late to be incorporated into Volume II, Health Considersations, which was completed on November 4, 1976. However, this volumr was not issued at that time. It was not released for review until April 18, 1977, simultaneously with the issuance of the MRI REPA report, Volume I.

In the more than five months between completion and issuance of the Health Considerations report there was ample time for inclusion of the SRC study results, either in the text of the MRI report or as a reference in the bibliography. The SRC study findings are crucial to any comparison of sanitation values between disposable and reusable foodservice ware.

In brief, the SRC microbiological testing clearly shows large and meaningful differences between permanent ware and single service in both total plate counts and pathogen counts, as follows:

Average TPC, All Samples
(number of microorganisms)

Permanent Ware	Single Service
275	18

Average Bacterial Counts, Pathogens

	Staphylococcus	Streptococcus	Coliform
Permanent Ware	13	11	1
Single Service	less than 1	less than 1	less than 1

The MRI report concedes that such microbiological documentation is hard to come by. Yet here it is, and it goes to the heart of the sanitation issue. Why, then, doesn't it appear in the MRI report?

What does appear in the paragraph quoted earlier from the MRI report is this note of caution: "And even then, the scope of the investigation would have to be massive in order to be equitable."

This comment merits a mention of the scope of the SRC study. It was originally intended to be nationwide. However, a pilot study was undertaken first in 15 food service establishments selected at random in the Syracuse, New York, area.

In reviewing the results, the SSI Public Health Advisory Council noted the consistent pattern of substantial microbiological differences between permanent ware and single service at the test sites and decided that there was no point in going beyond the Syracuse area tests. They felt that the tests already completed were conclusive and representative, and that going to other cities and test sites would simply be repetitive and unnecessary.

The question remains open: Why did the MRI authors exclude the SRC study findings? Why this consistent downplaying of the sanitation issue?

Misuse of Dr. Walker's Statement

Further questions are raised by the MRI report's treatment of a highly significant statement by a leading public health scientist and administrator, Dr. Bailus Walker, Jr., Director, Environmental Health Administration, government of the District of Columbia. This statement appears in a study paper entitled

"Bacterial Content of Beverage Glasses in Hotels," submitted to MRI prior to its publication in the Journal of Environmental Health,* professional journal of the National Environment Health Association.

This is the way the statement reads as quoted in the MRI report, Volume II, Health Considerations, page 107:

> The problem in assessing sanitation standards on foodservice ware is summarized quite effectively by Bailus Walker, the author of several studies in this field: "Anderson in an extensive review of the epidemiological basis of environmental sanitation in 1943 stated 'I wish I could cite evidence that the lack of decent cleanliness in handling dishes in food establishments is likely to result in demonstrable diseases, for I would welcome a basis for enforcing better diswashing. And yet I know of no evidence of this character.' . . . Almost four decades later there is still little or no evidence of this character. Questions involving the health effects of environmental bioloads are particularly prone to uncertainty and the health impact of various environmental levels of microogranisms on food or beverage contact surfaces are often unknown, and not infrequently unknowable." (78, page 10)

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*Scheduled for publication in the October 1977 issue.

Now read the full statement by Dr. Walker as he wrote it and as it actually appeared in his paper:

> "Anderson[4] in an extensive review of the epidemiological basis of environmental sanitation in 1943 stated 'I wish I could cite evidence that the lack of decent cleanliness in handling dishes in food establishments is likely to result in demonstrable diseases, for I would welcome a basis for enforcing better dishwashing. And yet I know of no evidence of this character.'
>
> "Almost four decades later there is still little or no evidence of this character.
>
> "This does not mean that public health authorities should relax their efforts to ensure that eating and drinking utensils served the public are rendered free of pathogens or that the bacterial count is reduced to safe levels specified in public health codes and ordinance.
>
> "Questions involving the health effects of environmental bioloads are particularly prone to uncertainty and the health impact of various environmental levels of microorganisms on food or beverage contact surfaces are often unknown, and not infrequently unknowable. In addition, speculations, conflicts in evidence and theoretical extrapolations typify environmental monitoring and surveillance services. Yet public health laws, basic esthetics and common sense demand action to prevent harm even if the regulators or other responsible persons are less certain that harm is otherwise inevitable.

The underlined parts of Dr. Walker's full statement are the ones left out of the edited version in the MRI report. In omitting them, the authors of the MRI report, consciously or otherwise, substantially altered the significance and intent of Dr. Walker's commentary. This is clear from any objective reading and comparison of the two versions. It also happens to be the opinion of Dr. Walker, who has expressed strongly his feeling that his words have been misused.

By excising sections of Dr. Walker's statement, the MRI report leaves the reader with this sole impression: There is no evidence of a link between cleanliness in handling dishes in public eating places and the spread of disease, and the health effects of microorganisms present on contact surfaces are uncertain, unknown, or unknowable. The reader comes away with a sense of helplessness in the face of such lack of knowledge, and the implication is that not very much can be done about it.

However, when the missing passages are returned to Dr. Walker's statement it takes on quite a different tone -- a reaffirmation of professional responsibility and action with respect to levels of bacteria present on the surfaces of eating and drinking utensils. While acknowledging areas of uncertainty, Dr. Walker firmly rules out such uncertainty as a reason for relaxation of public health code standards concerning pathogens or bacterial counts. And his final sentence is a clear call for vigilance: "Yet public health laws, basic esthetics and common sense demand action to prevent harm even if the regulators or other responsible persons are less certain that harm is otherwise inevitable."

The Walker quotation -- or misquotation -- appears as the very last passage in the MRI report, Volume II, Health Considerations. It would seem to have been placed there purposefully as a kind of summing up of the facts and positions reviewed in the report. If indeed it was used in this way, it is not an accurate representation of current thinking among public health professionals. And the edited statement does a serious injustice to the author to whom it is attributed.

Perhaps most important, it shows deep misunderstanding of the seriousness of the sanitation issues in foodservice operations, and can only be seen in the context of the MRI report's general downplaying of sanitation as a concern in the comparison of disposable and reusable foodservice ware.

Volume II, Health Considerations, Foodservice Ware Section
Invalid Assumptions

On "Consensus,"
Page 1, Introduction and Methodology, bottom paragraph.

This paragraph reads as follows:

"In accordance with the contract scope of work, no original research was to be conducted in the development of information for this study. Yet, MRI believes that the report presents a consensus of the available literature and of the opinions of industry and government officials regarding the public health impacts of these selected disposable and reusable products."

Insofar as foodservice ware is concerned, the report does not present a consensus, either of the available literature or of the opinions of industry and government officials. As already pointed out, at least one highly significant research study -- the SRC microbiological comparison of permanent ware and single service -- was not included in the MRI report, although it was submitted as documentation. Its omission surely makes the "consensus" referred to somewhat less than complete.

As for the opinions of industry and government officials, the report may present a collection of opinions but it does not reflect any consensus or agreement. The report cannot presume to present a consensus of the opinions of public health professionals (many of whom are government officials) -- certainly not those public health professionals who have reviewed the MRI report and join in this appraisal of it.

On "disposables and communicable diseases"
Page 77, first paragaph

The MRI report here refers to an address given by Dr. Paul F. Wehrle in 1963. The second sentence of this paragraph reads as follows:

> Wehrle (82) reiterated the reliability of proper machine dishwashing in his study of "Food Service" Procedures on Communicable Disease Wards," in which he states that disposables, though used for convenience, are not necessary (even for patients with highly infectious diseases) "since the usual mechanical dishwasher, properly maintained and operated, will remove hazardous microorganisms likely to be found on any eating utensil," (Page 466).

The authors of the MRI report make no attempt to evaluate or verify this reference, simply dropping it in without comment as though it were unassailable. The assumptions of Wehrle's statement, however, are as invalid as its facts are wrong. Wehrle is specifically discussing procedures in hospitals, and even more specifically hospital procedures relating to "patients with highly infectious diseases." Although disposables are convenient, in this context they are not used <u>for</u> convenience but for genuine health and sanitation reasons. The American Hospital Association confirms this (and refutes Wehrle) in its standards for food service in caring for patients with contagious diseases, as the following citations show:

From "Food Service Manual for Health Care Institutions," American Hospital Association, 1972, Chicago, Ill., page 21.

> "An appropriate plan for serving food to patients in isolation should be developed with the nursing service. Disposable tableware is generally used instead of china, glass, and flatware, which must be sterilized before being returned to the dishwashing unit."

From "Infection Control in the Hospital," American Hospital Association, revised edition, 1970.

Page 49, under Specific Responsibilities Within Hospitals, The Foodservice Department:

"To develop procedures, and put them in writing, for cleaning and sanitizing trays and tableware after use in patient and personnel meal service. Service in isolation rooms should be planned in cooperation with the infection control committee and the nursing service, utilizing disposable materials whenever possible."

Page 51, under Equipment:

"Disposable service suitable for hospitals is now available and is used by some hospitals. Total disposable tray service is recommended for patients in isolation. Use of disposable trays, dishes, plastic flatware, and packaged condiments permits incineration of these items and eliminates sterilization problems."

Page 79, under Prevention and Control of Infection, Isolation Techniques and Procedures, Sanitation:

" . . . Disposable plates and utensils should be used for the isolation patient. If regular hospital dishes and utensils are used, they should be washed last. In either case the dirty dishes should be removed from the room in a plastic or wax paper bag."

The American Hospital Association and Wehrle clearly disagree on the special usefulness of single service in connection with the handling of contagious diseases. What is troubling about this example -- and there are others throughout the MRI report -- is the uncritical use of reference sources with no apparent effort either to evaluate statements cited or to double-check their validity.

On "personnel and dishwashing"
Page 90, bottom half of page

On Page 90, the MRI report again cites Dr. Paul F. Wehrle as an authority on the adequacy of dishwashing procedures, as follows:

> Wehrle (82) in a previously mentioned study of foodservice on communicable disease wards, reports that normal foodservice ware washing and sanitizing procedures are adequate in removing even highly infectious organisms from utensils used for patients with communicable diseases. He stresses that the problems in handling these utensils lie with personnel who often fail to wash their hands properly before and after touching the dishes, rather than with the sanitizing procedures themselves. Wehrle suggests a cycle involving prewash at 140° to 160°F, and a flow rinse at 180°F. The significance of Wehrle's study is that, given proper personnel training, the facilities and processes available in the institutional setting are capable of producing sanitized foodservice ware, even when that ware has been heavily contaminated.

A question must be raised in connection with this MRI comment on the Wehrle study: How likely and widespread is the "given" on which the statement rests its conclusion? "Given proper personnel training" is a very large "given" indeed. Proper personnel training is recognized by public health professionals as a critical area in foodservice sanitation. The widespread lack or inadequacy of such training is of great concern to public health agencies and one reason why they are moving toward certification programs and other efforts to improve sanitation by upgrading personnel. But if "proper personnel training" does not broadly hold true, then what happens to the conclusion that "the facilities and processes available in the institutional setting are capable of producing sanitized foodservice ware, even when that ware has been heavily contaminated"?

In a way, the MRI report responds to this question by making frequent reference to the human factor as a key (and questionable) element in the sanitizing process involving permanent ware. Like a refrain, the proviso about human variables keeps reappearing throughout the MRI report's foodservice ware section.

On page 76, second paragraph: "In the 1940's, investigators noted that ignorance among foodservice workers as to proper washing times, temperatures and detergents resulted in sanitation problems."

On page 77, end of first paragraph: "Investigators such as Litzky, Lloyd, Jopke and Hass in the late 1960's and early 1970's reemphasize the problem of poor sanitation techniques among hospital foodservice workers, as well as improper environmental exposure of clean utensils."

On page 79, bottom of page: "Thus, the human factor is ultimately of far greater significance than are the washing and sanitizing procedures themselves. Although there is a trend toward mechanization of detergent dispensing and other elements within the total process, human variables still play a role in utensil sanitation."

But, while including these provisos about the human factor, the MRI report seems unwilling to come to grips with the practical significance of this highly conditional element in the sanitizing process for permanent ware. If the effectiveness of dishwashing procedures is viewed as dependent on the performance of foodservice workers, the evidence would indicate, as stated earlier, that this is a very slender "given" indeed on which to base the protection of the public. It is a "given" which, as a matter of reality, many public health professionals today would not be ready to accept.

On Standards for Foodservice Sanitation

The MRI report devotes pages 69 through 73 to a summarization of the U.S. Public Health Service "Model Food Service Sanitation Ordinance and Code," as revised in 1962.

This document is now at the point of replacement by a further revision completed in 1976, bearing this title: Food Service Sanitation Manual, Including A Model Food Service Sanitation Ordinance, 1976 Revision, United States Department of Health, Education and Welfare, Public Health Service, Food and Drug Administration, Division of Food Service.

The latest revision is briefly referred to at the bottom of page 68 of the MRI report as a "proposed revision" published in the October 1974 Federal Register. An updating of this would seem to be in order, along with details of the changes recorded in the 1976 version.

This version, for example, for the first time distinguishes mobile and temporary food service from permanent food service establishments. Single service utensils are now required for all mobile facilities as well as for temporary foodservice operations not properly equipped for dishwashing.

For permanent foodservice establishments, the 1976 model ordinance no longer includes this provision of the 1962 version which appears on page 71 of the MRI report: "Foodservice establishments which do not have adequate and effective facilities for cleaning and sanitizing utensils shall use single-service articles." However, Food and Drug Administration officials have clearly confirmed in communications with Single Service Institute staff personnel that, although now not spelled out, this requirement still holds for permanent foodservice establishments. The dropping of this paragraph from the model ordinance suggests that the usefulness of single service when dishwashing facilities fail is now so fully recognized that it no longer needs to be spelled out, particularly with the clarification now on record with respect to mobile and temporary foodservice operations.

On The GAO Study of Restaurant Sanitation

Starting on page 81 of the MRI report, the authors make extended reference to the General Accounting Office study of restaurant compliance with foodservice ware sanitation requirements. The study was conducted by the Food and Drug Administration and involved inspections of 185 restaurants based on reporting standards set in the 1962 Model Ordinance. The key finding: 89.8 percent of the restaurants were considered to be "inadequate" and "insanitary."

SUMMARY OF SANITATION VIOLATIONS RELATING TO FOODSERVICE WARE

Item	Number of Violative Restaurants	Percent of Sample in Violation
Tableware clean to sight and touch	24	12.9
Utensils and equipment preflushed, scraped and soaked	2	1.0
Tableware sanitized	52	28.1
Facilities for washing and sanitizing equipment and utensils approved, adequate, properly constructed, maintained and operated	100	54.0
Wash and sanitizing water clean	9	4.8
Wash water at proper temperature	7	3.7
Adequate and suitable detergents used	2	1.0
Cleaned and sanitized utensils and equipment properly stored and handled; utensils air-dried	116	62.7
Suitable facilities and areas provided for storing utensils and equipment	77	41.6
Single-service articles properly stored, dispensed and handled	117	63.2

Public health professionals would agree with the authors of the MRI report that the GAO study "findings in regard to sanitation of foodservice ware are noteworthy for the purposes of the present investigation." But they would raise questions about the listing of violations with respect to foodservice ware.

As presented, all the types of violation in the summary table seem to be equal in their level of seriousness from a sanitation standpoint. For example, under the heading "Facilities for washing and sanitizing equipment and utensils approved, adequate, properly constructed, maintained and operated" some 54 percent of the sample are shown to be in violation. Under "Single-service articles properly stored, dispensed and handled," 63.2 percent are in violation. There is no evaluation of the relative seriousness with which sanitarians view these deficiencies and the others listed.

The fact is that there are different levels of gravity for the various types of violation, and a system of demerits defines these levels. For dishwashing procedures covering "sanitization rinse, clean, temperature, concentration, exposure time, equipment, utensils sanitized" the 1976 Model Ordinance allocates four demerits. But for "single-service articles, storage, dispensing, use" the Model Ordinance lists only one demerit.

Consideration of the demerit scale puts the violation percentages in a very different perspective from the way they appear in the table in the MRI report. Without clarification of the demerit scale, the summary table leaves a wide opening for misinterpretations and misuse of the statistics. Perhaps more important, it beclouds any attempt at rational comparison of disposable and reusable foodservice ware in terms of sanitation.

Continuing its discussion of the GAO study, the MRI report makes the following statement at the top of page 84:

> The implications of these violations are difficult to assess. While 54 percent of the restaurants were reported as having inadequate washing and sanitizing facilities, only 28 percent showed failure to comply with the requirement that tableware be sanitized. This inconsistency would indicate, once again, that the ultimate level of sanitation of foodservice ware in commercial establishments is dependent upon a wide range of variables, which cannot be fully addressed through the vehicle of health inspection reports.

This statement shows a lack of understanding of the inspection process. What seems to be an inconsistency between the 54 percent figure for inadequate washing and sanitizing facilities and the 28 percent for violations may be explained by the way inspections are often made. If an inspector checks the "inadequate washing and sanitizing facilities" category, with its four demerits, he may feel he has covered the situation and may not go on to "double-debit" by checking the "Tableware sanitized" category as well -- even though such double-debiting, with another four demerits, might well be justified in following the inspection form.

Another explanation of the seeming inconsistency lies in the possibility that some of the restaurants shown by the GAO to have inadequate washing and sanitizing facilities may have been using disposables as a substitute for reusables. This would account at least in part for the drop down to 28 percent for violations under the "Tableware sanitized" inspection category.

In any case, the apparent "inconsistency," as the MRI report terms it, in no way justifies the conclusion of the paragraph "that the ultimate level of sanitation of foodservice ware in commercial establishments is dependent on a wide range of variables, which cannot be fully addressed through the vehicle of health inspection reports." Many public health professionals would take exception to this.

On Dose/Response Relationships

At the bottom of page 84, the following paragraph appears as part of a discussion on disease transmission via foodservice ware:

> Relating to the practical relationship between
> the sanitary condition of machine-washed utensils

and the associated public health threat, Dr. Marcus Harowitz of the Center for Disease Control in Atlanta offered the opinion that "the inoculum count of microorganisms left on foodservice ware after washing would likely be too low to cause disease," (52). However, the entire area of dose/response relationships between pathogenic organisms and disease is poorly understood and little documented.

The quotation above, according to the Bibliography, is taken from a telephone conversation between Dr. Harowitz and Ronald S. Fellman, who is listed as one of the authors of the MRI report. Perhaps the full conversation contained more detail than is recorded in the report -- detail that might make the quotation both meaningful and analyzable. As it stands, the Harowitz statement is so broad and so without reference to specific circumstances that it cannot be taken seriously. As a flat statement, it would certainly be disputed by microbiologists, who would want to know how high a count is involved and what specific types of microorganisms might be present before appraising the disease-causing potential.

On Breakage and Safety

On page 77, the MRI report lists three major "foci of discussion" in evaluating the sanitary status of permanent ware, of which the third is described as follows:

3. Handling and storage of dishes after washing: i.e., impacts of airborne contaminants and contamination from the soiled hands of hospital personnel. Also involved in handling is the possibility of breakage of china and glassware.

The phrase "possibility of breakage" merits comment and amplification. Experience demonstrates that more than "possibility," there is a likelihood and even certainty that breakage will occur with permanent ware. Commercial and institutional users of permanent ware allow for an estimated amount of breakage in their budgeting and purchasing plans. They can't accurately predict the exact percentage of breakage, but they can predict that it will occur -- sometimes more, sometimes less than estimated.

What can also be predicted as more than a "possibility" is the danger of injuries from breakage of permanent ware. In this connection, recent figures from a survey by de Kadt Marketing and Research, Inc., of Greenwich, Connecticut, are instructive. These figures are from a consumer research study, not commercial or institutional, but the results are relevant. The de Kadt survey uncovered this startling fact: 26 percent of the households studied report injuries from broken drinking glasses during the past year. That figure is even higher -- 31 percent -- in households with children under the age of 13.

That's reality, not possibility. Perhaps not the same figures, but the same real dangers from permanent ware breakage exist in public eating places.

Recognition of these dangers by public health professionals is documented in "The Health Profession's Attitudes Toward Single-Use Food and Beverage Containers," by Dr. Bailus Walker, Jr., a study published in the February 1977 issue of the Journal of Food Protection (and quoted in the MRI report). According to Dr. Walker, Director of the Environmental Health Administration, Government of the District of Columbia, 51 percent of the public health professionals queried in his survey view the safety aspect (non-breakage) as "very important," while 27 percent see it as "somewhat important."

On Single Service and Sanitation

The second paragraph on page 101 of the MRI report reads as follows:

> In light of the above reservations, the position of SRC, and the fact that these were the only two studies encountered in an extensive literature review which indict disposable foodservice ware from a sanitation standpoint, the "Eight Hospital Study" and the Rosner-Hixon Report do not present substantial or conclusive evidence indicating the sanitary quality of single service items. However, in light of the finding by the GAO that 63.2 percent of sampled commercial establishments do not properly store, dispense and handle single service articles, it is possible to conclude that problems may well exist in the handling of those products; and that these problems could represent the potential for disease transmission. Again, it is not the products themselves but the human factor which may threaten sanitation. (Note: Italics by MRI.)

It is difficult to understand why the GAO report was brought back by the MRI authors at this point, since the GAO-generated facts repeated here were already covered much earlier on page 83 and the MRI authors seem to be reaching for the conclusions they draw from the facts.

What is known, and what the "Eight Hospital Study" and the Rosner-Hixon Report failed to refute, is the high sanitary quality of single service products as delivered to foodservice establishments and ready for use. This is confirmed not only by the Syracuse Research Corporation spokesman quoted by the MRI authors earlier on page 101, but most importantly by the SRC comparative microbiological research study which was omitted from the MRI report.

Factual Errors, Volume II, Health Considerations
(Foodservice Ware Section)

Page 101, bottom

In introducing the survey of the attitudes of public health professionals toward disposable products, the MRI report refers only to "the Environmental Health Administration."

There is no further identification given -- no indication of what government level or jurisdiction the "Environmental Health Administration" is linked to (in this instance, the District of Columbia). The survey's authors are referred to only in footnotes to tables drawn from the survey report.

In any case it was not the Environmental Health Administration that undertook the survey, but Dr. Bailus Walker, Jr., Director of the Environmental Health Administration, and Melba Price, Research Assistant of the E.H.A., in their personal, professional capacities.

Page 103

In discussing the survey of attitudes of public health professionals toward single service, the MRI authors take liberties with the figures in two of the tables drawn from the survey. In the first case, referring to Table 32 on page 104, the authors bunch together percentages for various "sanitation-related factors" as benefits of single service and produce a composite figure of 69 percent for these factors.

There is no 69 percent figure, either in Table 32 or in the text of the survey. And there is no indication by the MRI authors of the specific "sanitation-related factors" they selected from the table to come up with the 69 percent figure they use in their discussion.

The same manipulation occurs with respect to Table 33, also on page 104, in the authors' discussion of the disadvantages of single service. Here, they group together unspecified disadvantages of single service to produce a figure of 71 percent -- a non-existent number, either in the table or in the text of the survey.

Page 122, Bibliography

Number 60 in the bibliography listing reads as follows:

> "The Preventive Health Aspects of Single Service Products for Food Service and Packaging," Resolution Adopted by the American Public Health Association.

The American Public Health Association did not adopt such a resolution. The National Environmental Health Association did. So did the International Association of Milk, Food and Environmental Sanitarians.* Neither of the latter resolutions was listed in the bibliography.

In any case, there was no reference to such resolutions anywhere in the text of the MRI report. What professional sanitarians and environmental specialists have to say about the preventive health aspects of single service would seem to be directly relevant to the "Health Considerations" study undertaken by MRI and should have been included.

* See attached copies of these resolutions

Other Comments, Volume II, Health Considerations
(Foodservice Ware Section)

On Study of Hotel Beverage Glasses

In commenting on commissary-washed glasses studied in "Bacterial Count of Beverage Glasses in Hotels," by Dr. Bailus Walker, Jr., the MRI authors make the following statement:

> "Although standard plate counts were higher than accepted bacteriological standards in all cases, no pathogenic organisms were detected in the commissary-washed glasses."

What they failed to mention, however, and what was clearly shown in Table 21, page 88, is that the count of coliform bacteria was above standard. Coliform organisms are usually considered as indicators of unsanitary conditions.

The effect of the statement as written is to make it seem as though commissary-washed glasses are acceptable in terms of their bacteria counts, when in fact they are not acceptable. The results clearly demonstrate this.

On The Use of Sources

Many different types of "expertise" are drawn on by the authors of the MRI report -- papers written by specialists for professional journals, articles from trade magazines, official government publications, personal communications (telephone conversations, letters, memoranda).

But there is almost no attempt made to evaluate the sources used -- to place them in perspective or to suggest their significance. For the most part, it is a matter of "so-and-so said this" on the one hand, but "thus-and-thus said that" on the other. All sources seem to be equal in validity, weight and their contribution to the review of health considerations

There is an exception to this criticism: On pages 96 and 99 in their review of the "Eight Hospital Study" and the Rosner-Hixon Report, the MRI authors evaluate the methodology of these studies, find it wanting, and, in effect, apply a discount to the results.

This raises a question: Why an evaluation of these studies, but not of the others referred to in the MRI report? And a second question: Why use discredited studies in the first place? -- or at all?

A review of the literature in a given area need not simply be a listing of the literature nor an uncritical presentation of selected contents from the sources chosen. The use of sources by the MRI authors has the effect of turning the report into a catalogue, rather than an analysis.

Another Health Consideration: Toxicity

On page 73, in describing the standard procedures for washing and sanitizing reusables, reference is made to sanitizing solutions and the use of chlorine and other sanitizing agents.

It might have been useful and timely for the authors of the MRI report to have indicated here their awareness of the problems of concentrations of sanitizing agents and their toxicity potential. Chlorinated hydrocarbons are now under suspicion as possible cancer-producing substances. Sanitizing agents may give rise to toxic or carcinogenic substances that are discharged into waste water systems and may become part of the water supply.

Conclusion and Recommendations

It seems clear that the foodservice ware section of Volume II, Health Considerations, did not have the benefit of professional public health input in its design and execution. Had public health specialists been brought into the project, this section would not be the ambiguous, inconclusive, and only marginally useful work it now is.

To repeat, the foodservice ware section of the disposables versus reusables report, as now written, is inadequate and should be re-thought and revised.

It is hoped that the comments and criticisms herein submitted will be given serious consideration in any revision that is made for the publication of a final report.

Another recommendation: The benefit of professional thinking would be gained if the present version and any revision are submitted to the United States Food and Drug Administration for review by public health experts.

In conclusion the following paragraph from the National Environmental Policy Act of 1969 may be germane to the issues under discussion in the MRI report and this response:

> "A hazardous substance is an element or compound, designated by the Administrator, to be an imminent or substantial danger to the public health or welfare."
>
> (42 U.S.C., Paragraph 4332 (2) (c), 4344 (5) 1970, EPA #335, December 1972)

The same public health standard applies to foodservice ware as a potential transmitter of infectious diseases and foodborne illnesses. That such ware can be hazardous is demonstrated by the Syracuse Research Corporation comparative microbiological study of single service and permanent ware and other research efforts.

These potential hazards are central to the thinking and planning of public health professionals and agencies charged with protecting the health of the American people in public places.

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COMPARATIVE STUDY OF POTENTIAL HEALTH HAZARDS ASSOCIATED WITH DISPOSABLE AND REUSABLE FOOD SERVICE ITEMS

Syracuse Study

Cups and Plates

Prepared for

The Single Service Institute

by

The Food Protection Laboratory

Syracuse Research Corporation

September 1976

82-J

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I. INTRODUCTION

This report presents the results of a study conducted by the Syracuse Research Corporation comparing the sanitary quality of disposable and reusable food service items at the point of use. The study was conducted for the Single Service Institute by the Food Protection Laboratory of Syracuse Research Corporation, an independent research and development company.

The Food Protection Laboratory has had over twenty-five years of experience in testing utensils and materials associated with food packaging and serving. It is certified by the United States Public Health Service for the microbiological testing of raw materials and finished containers used for milk and milk products.

The specific purpose of this study was to compare the levels and types of bacterial contamination present on disposable and reusable food service items being used in commercial and institutional establishments. Seven hundred and forty-three food service items categorized as "Cups and Plates,"* both disposable and their reusable counterparts from fifteen food service establishments, were tested for total bacterial content and for three specific bacteria commonly associated with disease.

The results are summarized in Section II and detailed description of test procedures, results and recommendations in the sections that follow.

Field work for this report was conducted by Ms. T. Parrow and Ms. W. Persse of the Food Protection Laboratory. They were assisted in data analysis by Mr. L.C. Parrow and Dr. G. Butler of FPL; Professor Seymour Sacks, SRC Senior Statistician; and Professor K. Mehrotra, Syracuse University.

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*Category includes glasses and bowls.

II. SUMMARY OF RESULTS

Statistical analysis of the data indicate that:

1. In twelve of thirteen food service establishments, the average bacterial counts of disposable food service items were lower than those of reusable items. In two establishments only disposables were used.
2. In the specific bacteria categories of staphylococcus, streptococcus and coliform, disposables had significantly lower bacterial counts than corresponding reusable items in all but one case where, comparison was possible.

III. TEST PROCEDURES

Site Selection

Fifteen testing sites (food service establishments) were randomly selected in Syracuse for participation in this study. This was done by giving each establishment in Syracuse (as listed in the current yellow pages of the phone directory) a number and then generating a series of random numbers for selection. The statistical base for city and site selection is outlined in detail in Comparative Study of Potential Health Hazards Associated With Disposable and Reusable Food Service Items - Development of a Statistical Base and Test Protocol, February, 1976, Revised April, 1976.[1]

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[1] Prepared for Single Service Institute.

The fifteen sites and the number in each group consisted of:

1. Public Eating Establishments[1]

   a. Restaurants (7) - Establishments engaged in serving prepared food and beverages selected by the patron from a full menu. Waiter or waitress service was provided and the establishment had seating facilities for at least 15 patrons.[2]

   b. Cafeterias (2) - Establishments engaged in serving prepared food and beverages primarily through the use of a cafeteria line where the customer serves himself from displayed selections. Table and/or booth seating facilities were provided.

   c. Fast Food (2) - Establishments primarily selling limited lines of refreshments and prepared food items for consumption either on or near the premises or for "take home".

2. Institutional Feeding Establishments

   a. Hospitals (2)

   b. Schools (2)

The proposed selection of seven fast-food establishments, two family style restaurants and two cafeterias was not realized. Many of the fast-food establishments are chain operated, and the local manager could not authorize permission for testing on the premises. Ultimately, the selection of public eating establishments consisted of two fast-food establishments, two cafeteria style, and seven family style restaurants.

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[1] Definitions of Public Eating Establishments from 1972 Census of Retail Trade RC-72-A Series.

[2] These are identified as Family Style in computer data.

All restaurants participating in the study used both reusable and disposable food service items with the exception of the fast-food establishments which used disposable items exclusively. Although reusable utensils were used for in-house means by the family and cafeteria style restaurants, approximately half of these establishments had a moderate to heavy take-out service. Consequently, disposable items were well represented.

Point of Testing

Utensils were selected for testing at their point of use. In this study, point of use is defined as the location where utensils are stored in preparation for use by the customer or the establishment personnel serving the food.

Utensils Tested

Commonly used utensils chosen for testing included main course plates, sandwich or butter plates, sour and/or salad bowls, hot beverage cups and cold drink cups or glasses.

Surfaces Tested

The entire food contact and mouth contact surfaces of each utensil was swabbed, one utensil per swab. Cups and glasses were swabbed on all inner surfaces and around the lip. The top surface of each plate and the inner surface of bowls, up to the lip, were tested. The area tested for each item was recorded.

Sample Size

The number of samples tested was based upon the square root concept for selection of normal distribution of small populations. To assure an adequate representation of samples, a minimum of 7 items of each type were tested. In cases where fewer than 7 items were available, all available items were tested.

Testing Method

Materials:

1. Screw-capped tubes containing 5 mℓs of buffered rinse solution after autoclaving.
2. Q-tip cotton swabs, 6" wooden applicator stick, sterilized in capped glass tube.
3. Standard Methods agar (Difco)
   Staphylococcus Medium #110 (BBL)
   Streptosel Agar (BBL)
   M-Endo Broth (BBL)
   Nutrient Agar (BBL)
4. Sterile Millipore filter funnels
5. Sterile Millipore filter membranes, type HA, 0.45μ pore size
6. Sterile Millipore dishes
7. 100 x 15 mm sterile, disposable Petri dishes
8. Sterile 2.2 mℓ pipettes.
9. Quebec colony counter

Swab Method:

The swab method was performed according to recommendations in Chapter 16 of Standard Methods for the Examination of Dairy Products, Thirteenth Edition.

Testing was performed by removing a sterile swab from its container so that only the lower 2" of the swab stick is handled. The swab was immersed in a tube containing sterile buffered rinse solution, and the excess liquid squeezed out against the side of the tube. The moistened swab was then rubbed over the test surface 3 times, reversing direction between successive strokes. At the same time the swab was rotated between the fingers. The swab was returned to the tube of rinse solution, and the swab stick broken off so that the handled portion of the swab stick did not enter the tube.

Upon completion of the testing, the tubes containing the swabs were taken back to the Syracuse Research Corporation laboratory and plated. Chilling of the tubes was not necessary because of the short time lapse between testing and return to the laboratory. However, the tubes were refrigerated at the laboratory if media preparation prevented immediate plating.

Plating Procedure:

The tubes containing the swabs were manually shaken 50 times to dispense any microorganisms into the buffered rinse solution. The contents of each tube was aseptically dispensed by pipette into Petri dishes, appropriate media added, and incubated according to the following scheme:

1. Total plate count - 0.1 mℓ and 1.0 mℓ plus Standard Methods Agar. Incubated at 32°C for 48 hours.

2. Staphylococcus - 1 mℓ plus Streptosel Agar. Incubation at 35°C for 48 hours.

3. Streptococcus - 1 mℓ plus Streptosel Agar. Incubation at 35°C for 48 hours.

4. Coliform - 1 mℓ filtered through a sterile Millipore filter which is placed in a Millipore plate containing M-Endo Broth plus Nutrient Agar. Incubation at 35°C for 24 hours.

Media control plates were made from each bottle of medium, and incubated in the same manner as the inoculated plates. Buffered rinse water and air (laboratory) control plates were also made.

Bacterial Counts:

After incubation, the number of bacteria on each plate was counted and recorded. Stained slides of questionable bacterial colonies growing in the Staphylococcus #110 and Streptosel plates were microscopically checked to insure accurate tallies.

Sanitary Survey

Each establishment was evaluated according to handling practices and environmental conditions. These evaluations, Appendix A, are not stressed in this report because no standard method or rating system is available to evaluate the sanitary quality of an establishment with respect to its potential for bacterial growth.

The fifteen food service establishments were rated as poor, average or good according to the investigator's opinion of the overall cleanliness of the establishment and personnel, and the food and food service utensil handling practices.

IV - TEST DATA

TABLE 1-1

LOCATION - REGION: NORTHEAST
CITY: SYRACUSE
TEST SITE: 1
TEST TYPE: CAFETERIA
CATEGORY: CUPS & PLATES

SANITARY SUMMARY: DOOR, FLOORS, WALLS, CEILING OLD, DIRTY. EQUIPMENT, SINKS OLD, GREASE COATED. DEBRIS, DIRT ON FLOORS IN DINING AREA, TABLE SURFACES STICKY.

SERVICE	ITEM	SER NO	TPC	STAPH	STREP	E.COLI
DISPOSABLE	COLD CUP	1	130.0	.0	.0	.0
DISPOSABLE	COLD CUP	2	5.0	.0	.0	.0
DISPOSABLE	COLD CUP	3	.0	.0	.0	.0
DISPOSABLE	COLD CUP	4	.0	.0	.0	.0
DISPOSABLE	COLD CUP	5	.0	.0	.0	.0
DISPOSABLE	COLD CUP	6	.0	.0	.0	.0
DISPOSABLE	COLD CUP	7	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	8	10.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	9	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	10	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	11	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	12	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	13	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	14	5.0	.0	.0	.0
DISPOSABLE	HOT CUP PLAS LAM	15	.0	.0	.0	.0
DISPOSABLE	HOT CUP PLAS LAM	16	55.0	.0	.0	.0
DISPOSABLE	HOT CUP PLAS LAM	17	.0	.0	.0	.0
DISPOSABLE	HOT CUP PLAS LAM	18	.0	.0	.0	.0
DISPOSABLE	HOT CUP PLAS LAM	19	.0	.0	.0	.0
DISPOSABLE	HOT CUP PLAS LAM	20	.0	.0	.0	.0
DISPOSABLE	HOT CUP PLAS LAM	21	.0	.0	.0	.0
REUSABLE	CUP	50	.0	.0	.0	.0
REUSABLE	CUP	51	.0	.0	.0	.0
REUSABLE	CUP	52	10.0	.0	.0	.0
REUSABLE	CUP	53	70.0	.0	.0	.0
REUSABLE	CUP	54	40.0	.0	.0	.0
REUSABLE	CUP	55	145.0	35.0	.0	.0
REUSABLE	CUP	56	5.0	.0	.0	.0
REUSABLE	PLATE	57	50.0	.0	.0	.0
REUSABLE	PLATE	58	5000.0	.0	80.0	15.0
REUSABLE	PLATE	59	.0	.0	.0	.0
REUSABLE	PLATE	60	.0	.0	.0	.0
REUSABLE	PLATE	61	40.0	.0	.0	.0
REUSABLE	PLATE	62	55.0	.0	.0	.0
REUSABLE	PLATE	63	130.0	.0	.0	.0
REUSABLE	BOWL	64	800.0	85.0	20.0	.0
REUSABLE	BOWL	65	1100.0	75.0	.0	.0
REUSABLE	BOWL	66	435.0	25.0	.0	.0
REUSABLE	BOWL	67	20.0	.0	.0	.0
REUSABLE	BOWL	68	30.0	.0	.0	.0
REUSABLE	BOWL	69	130.0	25.0	5.0	.0
REUSABLE	BOWL	70	5550.0	710.0	2280.0	80.0
REUSABLE	BREAD & BTR PLT	71	5.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	72	TNTC	.0	.0	.0
REUSABLE	BREAD & BTR PLT	73	.0	10.0	.0	.0
REUSABLE	BREAD & BTR PLT	74	19950.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	75	15.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	76	20.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	77	.0	.0	.0	.0
	DISPOSABLE SUM		205.0	.0	.0	.0
	DISPOSABLE NUMBER		21.0	21.0	21.0	21.0
	DISPOSABLE AVERAGE		9.8	.0	.0	.0
	REUSABLE SUM		33600.0	965.0	2385.0	95.0
	REUSABLE NUMBER		27.0	28.0	28.0	28.0
	REUSABLE AVERAGE		1244.4	34.5	85.2	3.4

TABLE 2-1

LOCATION - REGION: NORTHEAST
CITY: SYRACUSE
TEST SITE: 2
TEST TYPE: FAMILY STYLE
CATEGORY: CUPS & PLATES

SANITARY SUMMARY: GOOD, FLOORS WALLS, CEILING GENERALLY CLEAN EXCEPT FOR DIRT BUILDUP IN HARD TO CLEAN AREAS OF FLOOR. DINING AREA CLEAN, NEAT.

SERVICE	ITEM	SER NO	TPC	STAPH	STREP	E.COLI
DISPOSABLE	COLD CUP	85	.0	.0	.0	.0
DISPOSABLE	COLD CUP	86	.0	.0	.0	.0
DISPOSABLE	COLD CUP	87	5.0	.0	.0	.0
DISPOSABLE	COLD CUP	88	.0	.0	.0	.0
DISPOSABLE	COLD CUP	89	10.0	.0	.0	.0
DISPOSABLE	COLD CUP	90	15.0	.0	.0	.0
DISPOSABLE	COLD CUP	91	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	92	10.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	93	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	94	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	95	5.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	96	5.0	5.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	97	10.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	98	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	109	175.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	110	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	111	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	112	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	113	.0	.0	.0	.0
REUSABLE	GLASS	121	45.0	.0	.0	.0
REUSABLE	GLASS	122	45.0	.0	.0	.0
REUSABLE	GLASS	123	5.0	.0	.0	.0
REUSABLE	GLASS	124	10.0	.0	.0	.0
REUSABLE	GLASS	125	15.0	.0	.0	.0
REUSABLE	GLASS	126	5.0	.0	.0	.0
REUSABLE	CUP	127	2400.0	.0	.0	.0
REUSABLE	CUP	128	750.0	.0	.0	.0
REUSABLE	CUP	129	60.0	.0	.0	.0
REUSABLE	CUP	130	10.0	.0	.0	.0
REUSABLE	CUP	131	2900.0	.0	.0	.0
REUSABLE	CUP	132	80.0	.0	.0	.0
REUSABLE	DINNER PLATE	148	295.0	155.0	65.0	.0
REUSABLE	DINNER PLATE	149	130.0	60.0	.0	.0
REUSABLE	DINNER PLATE	150	.0	.0	.0	.0
REUSABLE	DINNER PLATE	151	.0	.0	.0	.0
REUSABLE	DINNER PLATE	152	.0	.0	.0	.0
REUSABLE	DINNER PLATE	153	.0	.0	.0	.0
REUSABLE	DINNER PLATE	154	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	155	10.0	10.0	.0	.0
REUSABLE	BREAD & BTR PLT	156	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	157	5.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	158	5.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	159	15.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	160	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	161	40.0	.0	.0	.0
REUSABLE	CUP	162	1650.0	225.0	.0	.0
REUSABLE	CUP	163	45.0	.0	.0	.0
REUSABLE	CUP	164	10.0	.0	.0	.0
REUSABLE	CUP	165	65.0	.0	.0	.0
REUSABLE	CUP	166	5.0	.0	.0	.0
REUSABLE	CUP	167	950.0	20.0	.0	.0
REUSABLE	CUP	168	15.0	.0	.0	.0

	TPC	STAPH	STREP	E.COLI
DISPOSABLE SUM	235.0	5.0	.0	.0
DISPOSABLE NUMBER	19.0	19.0	19.0	19.0
DISPOSABLE AVERAGE	12.4	.3	.0	.0
REUSABLE SUM	9565.0	470.0	65.0	.0
REUSABLE NUMBER	33.0	33.0	33.0	33.0
REUSABLE AVERAGE	289.8	14.2	2.0	.0

TABLE 3-1

LOCATION - REGION: NORTHEAST
CITY: SYRACUSE
TEST SITE: 3
TEST TYPE: FAMILY STYLE
CATEGORY: CUPS & PLATES

SANITARY SUMMARY: POOR. WALLS, CEILING IN NEED OF CLEANING. DEBRIS ON KITCHEN FLOOR. EQUIPMENT GREASE COATED, FOOD RESIDUE IN FOOD HANDLING AREAS. DINING AREA GENERALLY CLEAN.

SERVICE	ITEM	SER NO	TPC	STAPH	STREP	E-COLI
DISPOSABLE	ALL PLASTIC CUP	201	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	202	5.0	5.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	203	5.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	204	10.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	205	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	206	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	207	5.0	.0	.0	.0
DISPOSABLE	PLATE	215	40.0	.0	.0	.0
DISPOSABLE	PLATE	216	.0	.0	.0	.0
DISPOSABLE	PLATE	217	200.0	.0	.0	.0
DISPOSABLE	PLATE	218	500.0	50.0	.0	.0
DISPOSABLE	PLATE	219	.0	.0	.0	.0
DISPOSABLE	PLATE	220	.0	.0	.0	.0
REUSABLE	DINNER PLATE	173	.0	.0	.0	.0
REUSABLE	DINNER PLATE	174	35.0	20.0	.0	.0
REUSABLE	DINNER PLATE	175	170.0	125.0	35.0	.0
REUSABLE	DINNER PLATE	176	5.0	5.0	.0	.0
REUSABLE	DINNER PLATE	177	45.0	.0	.0	.0
REUSABLE	DINNER PLATE	178	100.0	10.0	.0	.0
REUSABLE	DINNER PLATE	179	.0	5.0	.0	.0
REUSABLE	CUP	180	5.0	.0	.0	.0
REUSABLE	CUP	181	15.0	.0	.0	.0
REUSABLE	CUP	182	300.0	70.0	.0	.0
REUSABLE	CUP	183	215.0	25.0	.0	.0
REUSABLE	CUP	184	60.0	.0	.0	.0
REUSABLE	CUP	185	310.0	.0	30.0	.0
REUSABLE	CUP	186	750.0	.0	5.0	.0
REUSABLE	BOWL	187	95.0	35.0	5.0	.0
REUSABLE	BOWL	188	40.0	.0	.0	.0
REUSABLE	BOWL	189	1500.0	.0	5.0	.0
REUSABLE	BOWL	190	185.0	55.0	25.0	.0
REUSABLE	BOWL	191	50.0	20.0	5.0	.0
REUSABLE	BOWL	192	5.0	.0	.0	.0
REUSABLE	BOWL	193	20.0	.0	.0	.0
REUSABLE	GLASS	221	.0	.0	.0	.0
REUSABLE	GLASS	222	5.0	.0	.0	.0
REUSABLE	GLASS	223	.0	.0	.0	.0
REUSABLE	GLASS	224	5.0	.0	.0	.0
REUSABLE	GLASS	225	.0	.0	.0	.0
REUSABLE	GLASS	226	.0	.0	.0	.0
REUSABLE	GLASS	227	.0	.0	.0	.0
	DISPOSABLE SUM		765.0	55.0	.0	.0
	DISPOSABLE NUMBER		13.0	13.0	13.0	13.0
	DISPOSABLE AVERAGE		58.8	4.2	.0	.0
	REUSABLE SUM		3915.0	370.0	110.0	.0
	REUSABLE NUMBER		28.0	28.0	28.0	28.0
	REUSABLE AVERAGE		139.8	13.2	3.9	.0

TABLE 4-1

LOCATION - REGION: NORTHEAST
CITY: SYRACUSE
TEST SITE: 4
TEST TYPE: FAMILY STYLE
CATEGORY: CUPS & PLATES

SANITARY SUMMARY: AVERAGE. WALLS, CEILING FLOORS, GENERALLY CLEAN. FOOD PREPARATION CLEAN, NEAT TRASH, JANITORIAL SUPPLIES STORED IN SAME AREA. FOUL ODOR FROM DISHWASHER DRAIN.

SERVICE	ITEM	SFR NO	TPC	STAPH	STREP	E.COLI
DISPOSABLE	COLD CUP	250	15.0	.0	.0	.0
DISPOSABLE	COLD CUP	251	20.0	.0	.0	.0
DISPOSABLE	COLD CUP	252	5.0	.0	.0	.0
DISPOSABLE	COLD CUP	253	100.0	.0	.0	.0
DISPOSABLE	COLD CUP	254	15.0	.0	.0	.0
DISPOSABLE	COLD CUP	255	5.0	.0	.0	.0
DISPOSABLE	COLD CUP	256	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	257	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	258	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	259	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	260	10.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	261	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	262	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	263	20.0	.0	.0	.0
REUSABLE	BOWL	243	10.0	.0	.0	.0
REUSABLE	BOWL	244	TNTC	.0	.0	.0
REUSABLE	BOWL	245	5.0	.0	.0	.0
REUSABLE	BOWL	246	15.0	.0	.0	.0
REUSABLE	BOWL	247	440.0	.0	.0	.0
REUSABLE	BOWL	248	.0	.0	.0	.0
REUSABLE	BOWL	249	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	264	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	265	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	266	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	267	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	268	10.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	269	5.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	270	10.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	271	55.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	272	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	273	5.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	274	5.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	275	150.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	276	5.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	277	.0	.0	.0	.0
REUSABLE	GLASS	278	5.0	.0	.0	.0
REUSABLE	GLASS	279	5.0	.0	.0	.0
REUSABLE	GLASS	280	.0	.0	.0	.0
REUSABLE	GLASS	281	.0	.0	.0	.0
REUSABLE	GLASS	282	5.0	.0	.0	.0
REUSABLE	GLASS	283	.0	.0	.0	.0
REUSABLE	GLASS	284	5.0	.0	.0	.0
REUSABLE	CUP	285	30.0	5.0	.0	.0
REUSABLE	CUP	286	95.0	.0	.0	.0
REUSABLE	CUP	287	30.0	20.0	10.0	.0
REUSABLE	CUP	288	10.0	.0	.0	.0
REUSABLE	CUP	289	45.0	10.0	5.0	.0
REUSABLE	CUP	290	125.0	.0	35.0	.0
REUSABLE	CUP	291	.0	.0	.0	.0
REUSABLE	BOWL	313	175.0	.0	.0	.0
REUSABLE	BOWL	314	25.0	10.0	.0	.0
REUSABLE	BOWL	315	.0	.0	.0	.0
REUSABLE	BOWL	316	.0	.0	.0	.0
REUSABLE	BOWL	317	.0	.0	.0	.0
REUSABLE	BOWL	318	.0	.0	.0	.0
REUSABLE	BOWL	319	.0	.0	.0	.0
	DISPOSABLE SUM		190.0	.0	.0	.0
	DISPOSABLE NUMBER		14.0	14.0	14.0	14.0
	DISPOSABLE AVERAGE		13.6	.0	.0	.0
	REUSABLE SUM		1270.0	45.0	50.0	.0
	REUSABLE NUMBER		41.0	42.0	42.0	42.0
	REUSABLE AVERAGE		31.0	1.1	1.2	.0

TABLE 5.1

LOCATION - REGION: NORTHEAST
CITY: SYRACUSE
TEST SITE: 5
TEST TYPE: FAMILY STYLE
CATEGORY: CUPS & PLATES

SANITARY SUMMARY; GOOD. FLOORS, WALLS, CEILINGS CLEAN. WORKING AREA, EQUIPMENT IN KITCHEN KEPT CLEAN. DINING AREAS VERY CLEAN.

SERVICE	ITEM	SER NO	TPC	STAPH	STREP	E.COLI
DISPOSABLE	DINNER PLATE	333	15.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	334	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	335	15.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	336	15.0	.0	10.0	.0
DISPOSABLE	DINNER PLATE	337	5.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	338	15.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	339	15.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	340	10.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	341	5.0	10.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	342	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	343	5.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	344	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	345	.0	5.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	346	.0	5.0	.0	.0
REUSABLE	BOWL	361	80.0	.0	.0	.0
REUSABLE	BOWL	362	285.0	30.0	.0	.0
REUSABLE	BOWL	363	20.0	.0	.0	.0
REUSABLE	BOWL	364	.0	.0	.0	.0
REUSABLE	BOWL	365	.0	.0	.0	.0
REUSABLE	BOWL	366	.0	.0	.0	.0
REUSABLE	BOWL	367	10.0	.0	.0	.0
REUSABLE	PLATE	375	110.0	15.0	10.0	.0
REUSABLE	PLATE	376	400.0	85.0	15.0	.0
REUSABLE	PLATE	377	.0	.0	.0	.0
REUSABLE	PLATE	378	40.0	5.0	.0	.0
REUSABLE	PLATE	379	5.0	.0	.0	.0
REUSABLE	PLATE	380	.0	.0	.0	.0
REUSABLE	PLATE	381	5.0	.0	.0	.0
REUSABLE	GLASS	389	1650.0	60.0	.0	.0
REUSABLE	GLASS	390	130.0	5.0	.0	.0
REUSABLE	GLASS	391	550.0	270.0	.0	.0
REUSABLE	GLASS	392	.0	.0	.0	.0
REUSABLE	GLASS	393	500.0	195.0	.0	.0
REUSABLE	GLASS	394	.0	.0	.0	.0
REUSABLE	GLASS	395	.0	.0	.0	.0
REUSABLE	CUP	396	115.0	.0	.0	.0
REUSABLE	CUP	397	10.0	.0	.0	.0
REUSABLE	CUP	398	85.0	15.0	.0	.0
REUSABLE	CUP	399	35.0	.0	.0	.0
REUSABLE	CUP	400	20.0	.0	.0	.0
REUSABLE	CUP	401	5.0	5.0	.0	.0
REUSABLE	CUP	402	40.0	5.0	.0	.0
REUSABLE	BREAD & BTR PLT	410	155.0	10.0	.0	.0
REUSABLE	BREAD & BTR PLT	411	5.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	412	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	413	150.0	15.0	.0	.0
REUSABLE	BREAD & BTR PLT	414	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	415	10.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	416	.0	.0	.0	.0
	DISPOSABLE SUM		100.0	20.0	10.0	.0
	DISPOSABLE NUMBER		14.0	14.0	14.0	14.0
	DISPOSABLE AVERAGE		7.1	1.4	.7	.0
	REUSABLE SUM		4415.0	715.0	25.0	.0
	REUSABLE NUMBER		35.0	35.0	35.0	35.0
	REUSABLE AVERAGE		126.1	20.4	.7	.0

TABLE 5-1

LOCATION - REGION: NORTHEAST
CITY: SYRACUSE
TEST SITE: 6
TEST TYPE: FAMILY STYLE
CATEGORY: CUPS & PLATES

SANITARY SUMMARY: POOR. KITCHEN WALLS, CEILING, EQUIPMENT OLD, GREASE COATED. FLOORS VERY WORN, DIRTY. FLOORS IN COUNTER, DINING AREAS COVERED WITH DIRT, DEBRIS.

SERVICE	ITEM	SER NO	TPC	STAPH	STREP	E-COLI
DISPOSABLE	COLD CUP	417	.0	.0	.0	.0
DISPOSABLE	COLD CUP	418	.0	.0	.0	.0
DISPOSABLE	COLD CUP	419	.0	.0	.0	.0
DISPOSABLE	COLD CUP	420	.0	.0	.0	.0
DISPOSABLE	COLD CUP	421	.0	.0	.0	.0
DISPOSABLE	COLD CUP	422	.0	.0	.0	.0
DISPOSABLE	COLD CUP	423	.0	.0	.0	.0
DISPOSABLE	HOT CUP PLAS LAM	424	5.0	.0	.0	.0
DISPOSABLE	HOT CUP PLAS LAM	425	5.0	.0	.0	.0
DISPOSABLE	HOT CUP PLAS LAM	426	10.0	.0	.0	.0
DISPOSABLE	HOT CUP PLAS LAM	427	5.0	.0	.0	.0
DISPOSABLE	HOT CUP PLAS LAM	428	.0	.0	.0	.0
DISPOSABLE	HOT CUP PLAS LAM	429	.0	.0	.0	.0
DISPOSABLE	HOT CUP PLAS LAM	430	5.0	5.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	431	15.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	432	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	433	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	434	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	435	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	436	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	437	5.0	.0	.0	.0
REUSABLE	GLASS	438	95.0	.0	.0	.0
REUSABLE	GLASS	439	315.0	.0	.0	.0
REUSABLE	GLASS	440	1350.0	.0	5.0	.0
REUSABLE	GLASS	441	180.0	.0	.0	.0
REUSABLE	GLASS	442	155.0	.0	5.0	.0
REUSABLE	GLASS	443	610.0	.0	15.0	.0
REUSABLE	GLASS	444	610.0	.0	15.0	.0
REUSABLE	DINNER PLATE	445	20.0	.0	.0	.0
REUSABLE	DINNER PLATE	446	15.0	.0	.0	.0
REUSABLE	DINNER PLATE	447	.0	.0	.0	.0
REUSABLE	DINNER PLATE	448	1400.0	1070.0	5.0	.0
REUSABLE	DINNER PLATE	449	.0	.0	.0	.0
REUSABLE	DINNER PLATE	450	15.0	.0	.0	.0
REUSABLE	DINNER PLATE	451	225.0	40.0	.0	.0
REUSABLE	BOWL	452	70.0	10.0	5.0	.0
REUSABLE	BOWL	453	.0	.0	.0	.0
REUSABLE	BOWL	454	5.0	.0	.0	.0
REUSABLE	BOWL	455	60.0	25.0	10.0	.0
REUSABLE	BOWL	456	545.0	30.0	5.0	.0
REUSABLE	BOWL	457	50.0	5.0	.0	.0
REUSABLE	BOWL	458	250.0	.0	25.0	.0
REUSABLE	CUP	466	350.0	10.0	.0	.0
REUSABLE	CUP	467	55.0	15.0	.0	.0
REUSABLE	CUP	468	160.0	10.0	.0	.0
REUSABLE	CUP	469	125.0	15.0	.0	.0
REUSABLE	CUP	470	1000.0	215.0	245.0	.0
REUSABLE	CUP	471	660.0	120.0	30.0	210.0
REUSABLE	CUP	472	100.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	487	215.0	45.0	60.0	.0
REUSABLE	BREAD & BTR PLT	488	5.0	5.0	.0	.0
REUSABLE	BREAD & BTR PLT	489	10.0	5.0	.0	.0
REUSABLE	BREAD & BTR PLT	490	205.0	15.0	.0	.0
REUSABLE	BREAD & BTR PLT	491	1055.0	330.0	.0	.0
REUSABLE	BREAD & BTR PLT	492	25.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	493	10.0	.0	.0	.0
	DISPOSABLE SUM		50.0	5.0	.0	.0
	DISPOSABLE NUMBER		21.0	21.0	21.0	21.0
	DISPOSABLE AVERAGE		2.4	.2	.0	.0
	REUSABLE SUM		9945.0	1965.0	425.0	210.0
	REUSABLE NUMBER		35.0	35.0	35.0	35.0
	REUSABLE AVERAGE		284.1	56.1	12.1	6.0

TABLE 7-1

LOCATION - REGION: NORTHEAST
CITY: SYRACUSE
TEST SITE: 7
TEST TYPE: CAFETERIA
CATEGORY: CUPS & PLATES

SANITARY SUMMARY: POOR. DISHWASHING IN CONVERTED STORAGE AREA. CEMENT FLOORS, WALLS, CEILINGS IN POOR REPAIR. FOOD PREPARATION, SERVING AREAS NEED CLEANING.

SERVICE	ITEM	SER NO	TPC	STAPH	STREP	E.COLI
DISPOSABLE	ALL PLASTIC CUP	499	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	500	115.0	.0	45.0	.0
DISPOSABLE	ALL PLASTIC CUP	501	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	502	10.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	503	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	504	65.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	505	10.0	.0	.0	.0
DISPOSABLE	CHLD CUP	506	.0	.0	5.0	.0
DISPOSABLE	CHLD CUP	507	.0	.0	.0	.0
DISPOSABLE	COLD CUP	508	.0	.0	.0	.0
DISPOSABLE	COLD CUP	509	.0	.0	.0	.0
DISPOSABLE	COLD CUP	510	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	511	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	512	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	513	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	514	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	515	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	516	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	517	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	518	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	519	75.0	.0	15.0	.0
REUSABLE	PLATE	526	240.0	.0	50.0	.0
REUSABLE	PLATE	527	155.0	.0	15.0	.0
REUSABLE	PLATE	528	5.0	.0	.0	.0
REUSABLE	PLATE	529	400.0	285.0	10.0	.0
REUSABLE	PLATE	530	5.0	.0	.0	.0
REUSABLE	PLATE	531	5.0	5.0	.0	.0
REUSABLE	PLATE	532	1650.0	.0	.0	.0
REUSABLE	BOWL	533	280.0	.0	125.0	.0
REUSABLE	BOWL	534	5.0	.0	.0	.0
REUSABLE	BOWL	535	25.0	.0	.0	.0
REUSABLE	BOWL	536	285.0	.0	.0	.0
REUSABLE	BOWL	537	1800.0	.0	660.0	.0
REUSABLE	BOWL	538	130.0	.0	5.0	.0
REUSABLE	BOWL	539	240.0	.0	125.0	.0
REUSABLE	CUP	561	10.0	.0	.0	.0
REUSABLE	CUP	562	15.0	.0	10.0	.0
REUSABLE	CUP	563	5.0	.0	.0	.0
REUSABLE	CUP	564	45.0	.0	5.0	.0
REUSABLE	CUP	565	90.0	.0	45.0	.0
REUSABLE	CUP	566	5.0	.0	.0	.0
REUSABLE	CUP	567	10.0	.0	50.0	.0
REUSABLE	GLASS	568	.0	.0	.0	.0
REUSABLE	GLASS	569	5.0	.0	.0	.0
REUSABLE	GLASS	570	.0	.0	.0	.0
REUSABLE	GLASS	571	.0	.0	.0	.0
REUSABLE	GLASS	572	.0	.0	.0	.0
REUSABLE	GLASS	573	.0	.0	.0	.0
REUSABLE	GLASS	574	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	575	5.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	576	5.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	577	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	578	5.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	579	5.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	580	15.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	581	55.0	35.0	.0	.0
	DISPOSABLE SUM		275.0	.0	65.0	.0
	DISPOSABLE NUMBER		21.0	21.0	21.0	21.0
	DISPOSABLE AVERAGE		13.1	.0	3.1	.0
	REUSABLE SUM		5500.0	325.0	1100.0	.0
	REUSABLE NUMBER		35.0	35.0	35.0	35.0
	REUSABLE AVERAGE		157.1	9.3	31.4	.0

TABLE H-1

LOCATION - REGION: NORTHEAST
CITY: SYRACUSE
TEST SITE: R
TEST TYPE: FAMILY STYLE
CATEGORY: CUPS & PLATES

SANITARY SUMMARY: AVERAGE. WORKING DIRT ON FLOORS, EQUIPMENT. RECENTLY REMODELED, NEW WALLS, CEILINGS, EQUIPMENT. DISHWASHING BY HAND. FILM ON GLASSES.

SERVICE	ITEM	SER NO	TPC	STAPH	STREP	E.COLI
DISPOSABLE	ALL PLASTIC CUP	667	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	668	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	669	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	670	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	671	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	672	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	673	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	674	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	675	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	676	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	677	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	678	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	679	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	680	5.0	.0	.0	.0
DISPOSABLE	COLD CUP	681	20.0	.0	.0	.0
DISPOSABLE	COLD CUP	682	.0	.0	.0	.0
DISPOSABLE	COLD CUP	683	.0	.0	.0	.0
DISPOSABLE	COLD CUP	684	.0	.0	.0	.0
DISPOSABLE	COLD CUP	685	.0	.0	.0	.0
DISPOSABLE	COLD CUP	686	.0	.0	.0	.0
DISPOSABLE	COLD CUP	687	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	688	180.0	15.0	.0	.0
DISPOSABLE	DINNER PLATE	689	55.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	690	5.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	691	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	692	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	693	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	694	.0	.0	.0	.0
REUSABLE	CUP	589	40.0	35.0	.0	.0
REUSABLE	CUP	590	185.0	.0	.0	.0
REUSABLE	CUP	591	.0	.0	.0	.0
REUSABLE	CUP	592	5.0	.0	.0	.0
REUSABLE	CUP	593	5.0	.0	.0	.0
REUSABLE	CUP	594	20.0	.0	.0	.0
REUSABLE	CUP	595	.0	.0	.0	.0
REUSABLE	GLASS	596	300.0	10.0	.0	.0
REUSABLE	GLASS	597	2700.0	25.0	15.0	15.0
REUSABLE	GLASS	598	2200.0	.0	.0	.0
REUSABLE	GLASS	599	1450.0	.0	.0	.0
REUSABLE	GLASS	600	450.0	15.0	.0	.0
REUSABLE	GLASS	601	15550.0	60.0	45.0	5.0
REUSABLE	GLASS	602	10100.0	65.0	15.0	.0
REUSABLE	DINNER PLATE	603	5.0	.0	.0	.0
REUSABLE	DINNER PLATE	604	.0	.0	.0	.0
REUSABLE	DINNER PLATE	605	5.0	.0	.0	.0
REUSABLE	DINNER PLATE	606	.0	.0	.0	.0
REUSABLE	DINNER PLATE	607	15.0	.0	.0	.0
REUSABLE	DINNER PLATE	608	10.0	.0	.0	.0
REUSABLE	DINNER PLATE	609	20.0	.0	.0	.0
REUSABLE	CUP	610	35.0	.0	.0	.0
REUSABLE	CUP	611	25.0	.0	.0	.0
REUSABLE	CUP	612	5.0	.0	.0	.0
REUSABLE	CUP	613	65.0	.0	.0	.0
REUSABLE	CUP	614	20.0	.0	.0	.0
REUSABLE	CUP	615	15.0	.0	.0	.0
REUSABLE	CUP	616	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	634	10.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	635	5.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	636	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	637	65.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	638	20.0	5.0	.0	.0
	DISPOSABLE SUM		265.0	15.0	.0	.0
	DISPOSABLE NUMBER		28.0	28.0	28.0	28.0
	DISPOSABLE AVERAGE		9.5	.5	.0	.0
	REUSABLE SUM		33325.0	215.0	75.0	20.0
	REUSABLE NUMBER		33.0	33.0	33.0	33.0
	REUSABLE AVERAGE		1009.8	6.5	2.3	.6

TABLE 9-1

LOCATION - REGION: NORTHEAST
CITY: SYRACUSE
TEST SITE: 9
TEST TYPE: FAST FOOD
CATEGORY: CUPS & PLATES

SANITARY SUMMARY: GOOD. WALLS, CEILINGS CLEAN. FLOORS CLEAN EXCEPT IN HARD TO CLEAN AREAS. FOOD PREPARATION AREA, EQUIPMENT VERY CLEAN.

SERVICE	ITEM	SER NO	TPC	STAPH	STREP	E.COLI
DISPOSABLE	BREAD & BTR PLT	696	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	697	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	698	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	699	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	700	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	701	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	702	55.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	703	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	704	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	705	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	706	5.0	.0	.0	.0
DISPOSABLE	CHLD CUP	707	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	708	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	709	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	710	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	711	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	712	.0	.0	.0	.0
DISPOSABLE	BOWL	713	.0	.0	.0	.0
DISPOSABLE	BOWL	714	.0	.0	.0	.0
DISPOSABLE	BOWL	715	.0	.0	.0	.0
DISPOSABLE	BOWL	716	.0	.0	.0	.0
DISPOSABLE	BOWL	717	.0	.0	.0	.0
DISPOSABLE	BOWL	718	.0	.0	.0	.0
DISPOSABLE	BOWL	719	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	734	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	735	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	736	5.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	737	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	738	25.0	5.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	739	5.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	740	5.0	.0	.0	.0
	DISPOSABLE SUM		100.0	5.0	.0	.0
	DISPOSABLE NUMBER		31.0	31.0	31.0	31.0
	DISPOSABLE AVERAGE		3.2	.2	.0	.0
	REUSABLE SUM		.0	.0	.0	.0
	REUSABLE NUMBER		.0	.0	.0	.0
	REUSABLE AVERAGE		.0	.0	.0	.0

TABLE 10-1

LOCATION - REGION: NORTHEAST
CITY: SYRACUSE
TEST SITE: 10
TEST TYPE: FAST FOOD
CATEGORY: CUPS & PLATES

SANITARY SUMMARY: AVERAGE. KITCHEN AREA, OLD WALLS, CEILINGS IN NEED OF CLEANING, PAINTING. FLOORS DIRTY WITH BROKEN TILES. COUNTER FOOD PREPARATION, SERVICE AREA GENERALLY CLEAN.

SERVICE	ITEM	SER NO	TPC	STAPH	STREP	E-COLI
DISPOSABLE	CHLD CUP	776	20.0	.0	.0	.0
DISPOSABLE	CHLD CUP	777	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	778	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	779	10.0	.0	.0	.0
DISPOSABLE	CHLD CUP	780	5.0	.0	.0	.0
DISPOSABLE	CHLD CUP	781	5.0	.0	.0	.0
DISPOSABLE	CHLD CUP	782	.0	.0	.0	.0
DISPOSABLE	PLATE	783	5.0	.0	.0	.0
DISPOSABLE	PLATE	784	10.0	.0	.0	.0
DISPOSABLE	PLATE	785	.0	.0	.0	.0
DISPOSABLE	PLATE	786	5.0	.0	.0	.0
DISPOSABLE	PLATE	787	45.0	.0	.0	.0
DISPOSABLE	PLATE	788	.0	.0	.0	.0
DISPOSABLE	PLATE	789	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	799	35.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	800	20.0	10.0	5.0	.0
DISPOSABLE	ALL PLASTIC CUP	801	35.0	5.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	802	150.0	10.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	803	5.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	804	50.0	10.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	805	40.0	.0	.0	.0
REUSABLE	DINNER PLATE	762	.0	.0	.0	.0
REUSABLE	DINNER PLATE	763	30.0	.0	.0	.0
REUSABLE	DINNER PLATE	764	185.0	.0	.0	.0
REUSABLE	DINNER PLATE	765	.0	.0	.0	.0
REUSABLE	DINNER PLATE	766	20.0	20.0	.0	.0
REUSABLE	DINNER PLATE	767	25.0	5.0	.0	.0
REUSABLE	DINNER PLATE	768	25.0	15.0	.0	.0
REUSABLE	BREAD & BTR PLT	769	20.0	.0	15.0	.0
REUSABLE	BREAD & BTR PLT	770	25.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	771	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	772	5.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	773	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	774	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	775	.0	.0	.0	.0
	DISPOSABLE SUM		440.0	35.0	5.0	.0
	DISPOSABLE NUMBER		21.0	21.0	21.0	21.0
	DISPOSABLE AVERAGE		21.0	1.7	.2	.0
	REUSABLE SUM		335.0	40.0	15.0	.0
	REUSABLE NUMBER		14.0	14.0	14.0	14.0
	REUSABLE AVERAGE		23.9	2.9	1.1	.0

TABLE 11-1

LOCATION - REGION: NORTHEAST
CITY: SYRACUSE
TEST SITE: 11
TEST TYPE: FAST FOOD
CATEGORY: CUPS & PLATES

SANITARY SUMMARY: AVERAGE. FOOD PREPARATION AREA, EQUIPMENT KEPT CLEAN. FLOORS IN EATING AREA NEEDED SWEEPING. BACK ROOM (STORAGE) HAD OLD CEMENT FLOORS; CEILINGS, WALLS IN NEED OF PAINTING.

SERVICE	ITEM	SER NO	TPC	STAPH	STREP	E.COLI
DISPOSABLE	BREAD & BTR PLT	827	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	828	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	829	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	830	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	831	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	832	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	833	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	834	5.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	835	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	836	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	837	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	838	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	839	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	840	5.0	.0	.0	.0
DISPOSABLE	CHLD CUP	841	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	842	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	843	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	844	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	845	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	846	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	847	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	848	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	849	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	850	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	851	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	852	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	853	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	854	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	855	35.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	856	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	857	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	858	20.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	859	5.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	860	55.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	861	.0	.0	.0	.0
	DISPOSABLE SUM		125.0	.0	.0	.0
	DISPOSABLE NUMBER		35.0	35.0	35.0	35.0
	DISPOSABLE AVERAGE		3.6	.0	.0	.0
	REUSABLE SUM		.0	.0	.0	.0
	REUSABLE NUMBER		.0	.0	.0	.0
	REUSABLE AVERAGE		.0	.0	.0	.0

TABLE 12-1

LOCATION - REGION: NORTHEAST
CITY SYRACUSE
TEST SITE. 12
TEST TYPE: HOSPITAL
CATEGORY: CUPS & PLATES

SANITARY SUMMARY: GOOD. FLOORS, WALLS, CEILINGS AND EQUIPMENT VERY CLEAN. FOOD SERVICE, DINING AREAS VERY CLEAN.

SERVICE	ITEM	SER NO	TPC	STAPH	STREP	E.COLI
DISPOSABLE	BREAD & BTR PLT	926	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	927	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	928	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	929	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	930	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	931	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	932	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	933	210.0	.0	.0	.0
DISPOSABLE	CHLD CUP	934	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	935	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	936	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	937	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	938	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	939	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	940	95.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	941	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	942	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	943	20.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	944	5.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	945	15.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	946	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	947	15.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	948	10.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	949	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	950	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	951	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	952	10.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	953	.0	.0	.0	.0
DISPOSABLE	PLATE	961	.0	.0	.0	.0
DISPOSABLE	PLATE	962	.0	.0	.0	.0
DISPOSABLE	PLATE	963	.0	.0	.0	.0
DISPOSABLE	PLATE	964	.0	.0	.0	.0
DISPOSABLE	PLATE	965	.0	.0	.0	.0
DISPOSABLE	PLATE	966	.0	.0	.0	.0
DISPOSABLE	PLATE	967	.0	.0	.0	.0
REUSABLE	GLASS	866	.0	.0	.0	.0
REUSABLE	GLASS	867	10.0	.0	.0	.0
REUSABLE	GLASS	868	5.0	.0	.0	.0
REUSABLE	GLASS	869	20.0	.0	.0	.0
REUSABLE	GLASS	870	.0	.0	.0	.0
REUSABLE	GLASS	871	415.0	35.0	.0	.0
REUSABLE	GLASS	872	240.0	100.0	.0	.0
REUSABLE	BREAD & BTR PLT	894	30.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	895	10.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	896	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	897	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	898	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	899	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	900	.0	.0	.0	.0
REUSABLE	DINNER PLATE	901	140.0	.0	.0	.0
REUSABLE	DINNER PLATE	902	.0	.0	.0	.0
REUSABLE	DINNER PLATE	903	.0	.0	.0	.0
REUSABLE	DINNER PLATE	904	.0	.0	.0	.0
REUSABLE	DINNER PLATE	905	20.0	.0	.0	.0
REUSABLE	DINNER PLATE	906	.0	.0	.0	.0
REUSABLE	DINNER PLATE	907	.0	.0	.0	.0
REUSABLE	CUP	908	10.0	.0	.0	.0
REUSABLE	CUP	909	.0	.0	.0	.0
REUSABLE	CUP	910	.0	.0	.0	.0
REUSABLE	CUP	911	.0	.0	.0	.0
REUSABLE	CUP	912	.0	.0	.0	.0
REUSABLE	CUP	913	.0	.0	.0	.0
REUSABLE	CUP	914	.0	.0	.0	.0
REUSABLE	PLATE	915	5.0	.0	.0	.0
REUSABLE	PLATE	916	.0	.0	.0	.0
REUSABLE	PLATE	917	5.0	.0	.0	.0
REUSABLE	PLATE	918	.0	.0	.0	.0
REUSABLE	PLATE	919	.0	.0	.0	.0
REUSABLE	PLATE	920	.0	.0	.0	.0
REUSABLE	PLATE	921	.0	.0	.0	.0
	DISPOSABLE SUM		380.0	.0	.0	.0
	DISPOSABLE NUMBER		35.0	35.0	35.0	35.0
	DISPOSABLE AVERAGE		10.9	.0	.0	.0
	REUSABLE SUM		910.0	135.0	.0	.0
	REUSABLE NUMBER		35.0	35.0	35.0	35.0
	REUSABLE AVERAGE		26.0	3.9	.0	.0

TABLE 13-1

LOCATION - REGION: NORTHEAST
CITY: SYRACUSE
TEST SITE: 13
TEST TYPE: HOSPITAL
CATEGORY: CUPS & PLATES

SANITARY SUMMARY: GOOD. FLOORS, WALLS, CEILINGS AND EQUIPMENT VERY CLEAN. FOOD SERVICE, DINING AREAS VERY CLEAN

SERVICE	ITEM	SER NO	TPC	STAPH	STREP	E-COLI
DISPOSABLE	PLATE	999	40.0	.0	.0	.0
DISPOSABLE	PLATE	1000	10.0	5.0	.0	.0
DISPOSABLE	PLATE	1001	.0	.0	.0	.0
DISPOSABLE	PLATE	1002	.0	.0	.0	.0
DISPOSABLE	PLATE	1003	10.0	.0	.0	.0
DISPOSABLE	PLATE	1004	.0	.0	.0	.0
DISPOSABLE	PLATE	1005	40.0	10.0	.0	.0
DISPOSABLE	PLATE	1006	2450.0	.0	.0	.0
DISPOSABLE	PLATE	1007	.0	.0	.0	.0
DISPOSABLE	PLATE	1008	.0	.0	.0	.0
DISPOSABLE	PLATE	1009	.0	.0	.0	.0
DISPOSABLE	PLATE	1010	.0	.0	.0	.0
DISPOSABLE	PLATE	1011	.0	.0	.0	.0
DISPOSABLE	PLATE	1012	.0	.0	.0	.0
DISPOSABLE	PLATE	1013	160.0	3.0	.0	.0
DISPOSABLE	PLATE	1014	.0	.0	.0	.0
DISPOSABLE	PLATE	1015	.0	.0	.0	.0
DISPOSABLE	PLATE	1016	.0	.0	.0	.0
DISPOSABLE	PLATE	1017	.0	.0	.0	.0
DISPOSABLE	PLATE	1018	.0	.0	.0	.0
DISPOSABLE	PLATE	1019	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	1034	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	1035	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	1036	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	1037	.0	.0	.0	.0
DISPOSABLE	CHLD CUP	1038	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	1039	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	1040	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	1041	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	1042	.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	1043	20.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	1044	10.0	.0	.0	.0
DISPOSABLE	ALL PLASTIC CUP	1045	40.0	.0	.0	.0
REUSABLE	GLASS	992	.0	.0	.0	.0
REUSABLE	GLASS	993	.0	5.0	.0	.0
REUSABLE	GLASS	994	20.0	15.0	.0	.0
REUSABLE	GLASS	995	.0	.0	.0	.0
REUSABLE	GLASS	996	.0	.0	.0	.0
REUSABLE	GLASS	997	.0	.0	.0	.0
REUSABLE	GLASS	998	.0	.0	.0	.0
REUSABLE	ALL PLASTIC CUP	1051	.0	.0	.0	.0
REUSABLE	ALL PLASTIC CUP	1052	.0	.0	.0	.0
REUSABLE	ALL PLASTIC CUP	1053	.0	.0	.0	.0
REUSABLE	ALL PLASTIC CUP	1054	15.0	.0	.0	.0
REUSABLE	ALL PLASTIC CUP	1055	5.0	.0	.0	.0
REUSABLE	ALL PLASTIC CUP	1056	5.0	.0	.0	.0
REUSABLE	ALL PLASTIC CUP	1057	5.0	.0	.0	.0
REUSABLE	PLATE	1058	.0	.0	.0	.0
REUSABLE	PLATE	1059	.0	.0	.0	.0
REUSABLE	PLATE	1060	.0	.0	.0	.0
REUSABLE	PLATE	1061	.0	.0	.0	.0
REUSABLE	PLATE	1062	5.0	.0	.0	.0
REUSABLE	PLATE	1063	.0	.0	.0	.0
REUSABLE	PLATE	1064	.0	.0	.0	.0
REUSABLE	PLATE	1065	.0	.0	.0	.0
REUSABLE	PLATE	1066	.0	.0	.0	.0
REUSABLE	PLATE	1067	.0	.0	.0	.0
REUSABLE	PLATE	1068	.0	.0	.0	.0
REUSABLE	PLATE	1069	.0	.0	.0	.0
REUSABLE	PLATE	1070	.0	.0	.0	.0
REUSABLE	PLATE	1071	.0	.0	.0	.0

	TPC	STAPH	STREP	E-COLI
DISPOSABLE SUM	2780.0	18.0	.0	.0
DISPOSABLE NUMBER	33.0	33.0	33.0	33.0
DISPOSABLE AVERAGE	84.2	.5	.0	.0
REUSABLE SUM	55.0	20.0	.0	.0
REUSABLE NUMBER	28.0	28.0	28.0	28.0
REUSABLE AVERAGE	2.0	.7	.0	.0

TABLE 14-1

LOCATION - REGION: NORTHEAST
CITY: SYRACUSE
TEST SITE: 1
TEST TYPE: SCHOOL
CATEGORY: CUPS & PLATES

SANITARY SUMMARY: GOOD. KITCHEN AREA, DINING AREA VERY CLEAN. CUPBOARDS, SOME EQUIPMENT OLD, BUT KEPT VERY CLEAN.

SERVICE	ITEM	SER NO	TPC	STAPH	STREP	E-COLI
DISPOSABLE	BREAD & BTR PLT	1072	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	1073	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	1074	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	1075	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	1076	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	1077	.0	.0	.0	.0
DISPOSABLE	BREAD & BTR PLT	1078	.0	.0	.0	.0
DISPOSABLE	COLD CUP	1079	.0	.0	.0	.0
DISPOSABLE	COLD CUP	1080	.0	.0	.0	.0
DISPOSABLE	COLD CUP	1081	.0	.0	.0	.0
DISPOSABLE	COLD CUP	1082	.0	.0	.0	.0
DISPOSABLE	COLD CUP	1083	5.0	.0	.0	.0
DISPOSABLE	COLD CUP	1084	5.0	.0	.0	.0
DISPOSABLE	COLD CUP	1085	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	1086	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	1087	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	1088	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	1089	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	1090	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	1091	.0	.0	.0	.0
DISPOSABLE	DINNER PLATE	1092	.0	.0	.0	.0
REUSABLE	CUP	1100	5.0	.0	.0	.0
REUSABLE	CUP	1101	.0	5.0	.0	.0
REUSABLE	CUP	1102	.0	.0	.0	.0
REUSABLE	CUP	1103	.0	.0	.0	.0
REUSABLE	CUP	1104	25.0	[illegible]	5.0	.0
REUSABLE	CUP	1105	5.0	.0	.0	.0
REUSABLE	CUP	1106	20.0	5.0	.0	.0
REUSABLE	DINNER PLATE	1107	25.0	.0	.0	.0
REUSABLE	DINNER PLATE	1108	.0	.0	.0	.0
REUSABLE	DINNER PLATE	1109	.0	.0	.0	.0
REUSABLE	DINNER PLATE	1110	.0	.0	.0	.0
REUSABLE	DINNER PLATE	1111	.0	.0	.0	.0
REUSABLE	DINNER PLATE	1112	.0	.0	.0	.0
REUSABLE	DINNER PLATE	1113	55.0	.0	.0	.0
REUSABLE	PLATE	1114	.0	.0	.0	.0
REUSABLE	PLATE	1115	30.0	.0	.0	.0
REUSABLE	PLATE	1116	80.0	.0	.0	.0
REUSABLE	PLATE	1117	5.0	.0	.0	.0
REUSABLE	PLATE	1118	4400.0	25.0	.0	.0
REUSABLE	PLATE	1119	.0	.0	.0	.0
REUSABLE	PLATE	1120	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	1121	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	1122	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	1123	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	1124	.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	1125	5.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	1126	5.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	1127	.0	.0	.0	.0
	DISPOSABLE SUM		10.0	.0	.0	.0
	DISPOSABLE NUMBER		21.0	21.0	21.0	21.0
	DISPOSABLE AVERAGE		.5	.0	.0	.0
	REUSABLE SUM		4650.0	35.0	5.0	.0
	REUSABLE NUMBER		28.0	28.0	28.0	28.0
	REUSABLE AVERAGE		166.4	1.2	.2	.0

TABLE 15-1

LOCATION - REGION: NORTHEAST
CITY: SYRACUSE
TEST SITE: 15
TEST TYPE: SCHOOL
CATEGORY: CUPS & PLATES

SANITARY SUMMARY: GOOD. FLOORS, WALLS, CEILING AND EQUIPMENT VERY CLEAN. FOOD SERVICE, DINING AREAS VERY CLEAN.

SERVICE	ITEM	SER NO	TPC	STAPH	STREP	E.COLI
DISPOSABLE	COLD CUP	1191	.0	.0	.0	.0
DISPOSABLE	COLD CUP	1192	.0	.0	.0	.0
DISPOSABLE	COLD CUP	1193	.0	.0	.0	.0
DISPOSABLE	COLD CUP	1194	.0	.0	.0	.0
DISPOSABLE	COLD CUP	1195	.0	.0	.0	.0
DISPOSABLE	COLD CUP	1196	.0	.0	.0	.0
DISPOSABLE	COLD CUP	1197	.0	.0	.0	.0
DISPOSABLE	COLD CUP	1198	.0	.0	.0	.0
DISPOSABLE	COLD CUP	1199	.0	.0	.0	.0
DISPOSABLE	COLD CUP	1200	.0	.0	.0	.0
REUSABLE	DINNER PLATE	1142	30.0	.0	.0	.0
REUSABLE	DINNER PLATE	1143	5.0	.0	.0	.0
REUSABLE	DINNER PLATE	1144	10.0	.0	.0	.0
REUSABLE	DINNER PLATE	1145	.0	.0	.0	.0
REUSABLE	DINNER PLATE	1146	525.0	.0	.0	.0
REUSABLE	DINNER PLATE	1147	15.0	.0	.0	.0
REUSABLE	DINNER PLATE	1148	10.0	5.0	.0	.0
REUSABLE	BREAD & BTR PLT	1170	45.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	1171	145.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	1172	20.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	1173	20.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	1174	495.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	1175	150.0	.0	.0	.0
REUSABLE	BREAD & BTR PLT	1176	80.0	5.0	.0	.0
REUSABLE	CUP	1177	60.0	.0	.0	.0
REUSABLE	CUP	1178	30.0	5.0	.0	.0
REUSABLE	CUP	1179	250.0	40.0	5.0	.0
REUSABLE	CUP	1180	10.0	.0	.0	.0
REUSABLE	CUP	1181	5.0	.0	.0	.0
REUSABLE	CUP	1182	20.0	.0	.0	.0
REUSABLE	CUP	1183	65.0	5.0	.0	.0
REUSABLE	BOWL	1184	330.0	.0	.0	.0
REUSABLE	BOWL	1185	95.0	.0	.0	.0
REUSABLE	BOWL	1186	25.0	.0	.0	.0
REUSABLE	BOWL	1187	5.0	.0	.0	.0
REUSABLE	BOWL	1188	.0	.0	.0	.0
REUSABLE	BOWL	1189	5.0	.0	.0	.0
REUSABLE	BOWL	1190	.0	.0	.0	.0
	DISPOSABLE SUM		.0	.0	.0	.0
	DISPOSABLE NUMBER		10.0	10.0	10.0	10.0
	DISPOSABLE AVERAGE		.0	.0	.0	.0
	REUSABLE SUM		2450.0	60.0	5.0	.0
	REUSABLE NUMBER		28.0	28.0	28.0	28.0
	REUSABLE AVERAGE		87.5	2.1	.2	.0

TABLE 15-1

LOCATION - REGION: NORTHEAST MEANS AND DEVIATIONS
CITY: SYRACUSE
CATEGORY: CUPS & PLATES

		TOTAL	NUMBER	AVERAGE	STD.DEV.	MIN.	MAX.
TPC	DISPOSABLE	5920.00	337.00	17.57	138.44	.00	2450.00
	REUSABLE	109945.00	400.00	274.86	1454.74	.00	19950.00
STAPH	DISPOSABLE	158.00	337.00	.47	3.16	.00	50.00
	REUSABLE	5360.00	402.00	13.33	72.45	.00	1070.00
STREP	DISPOSABLE	80.00	337.00	.24	2.66	.00	45.00
	REUSABLE	4260.00	402.00	10.60	119.35	.00	2280.00
E-COLI	DISPOSABLE	.00	337.00	.00	.00	.00	.00
	REUSABLE	325.00	402.00	.81	11.25	.00	210.00

V. RESULTS AND DISCUSSION

The mean bacterial counts shown in Table 17-1 are based on the total surface area of each item tested.

Table 17-1

Comparison of Average Bacterial Counts of Disposable and Reusable Food Service Items

Items	Mean Bacterial Counts			
	Total Plate Count[a]	Staphylococcus[a]	Streptococcus[b]	Coliform[b]
Dishes				
Disposable	17.57	.47	.24	0.00
Reusable	274.86	13.33	10.60	.81

[a]Significant at 1% level

[b]Significant at 5% level

It is shown in Table 17-1 that not only were total plate counts substantially higher in reusable items, but also the numbers of Staphylococcus, Streptococcus and coliform organisms were also higher on reusable items.

Each establishment was evaluated according to handling practices and environmental conditions which might affect the sanitary quality of the food service items tested. Capsule comments on each establishment are given in Section IV and detailed evaluation information given in Appendix A.

The fifteen food service establishments were rated as poor, average or good as these terms applied to the general sanitary conditions of the establishment. The total number of items tested has been broken down in

Table 18-1 according to the number of items having a total bacterial count equal to or greater than 100,[1] less than 100 but greater than zero, and zero.

[1] The standard of less than 100 microorganisms per utensil surface is taken from "Minimum Requirements for Effective Machine Dishwashing," developed and published by the Committee on Sanitary Engineering & Environment, Division of Medical Sciences, National Research Council (Journal American Dietitian Association, 1950) as reported in Hospitals, 24:92, January, 1950.

Table 18-1

Data Breakdown According to Sanitary Quality of the Establishment

Est. No.	Rating[1]	Disposables: No. of items having bacterial counts of >100	<100	0	Reusables: No. of items having bacterial counts of >100	<100	0
1	P	1	4	16	10	12	6
3	P	2	5	13	8	13	7
6	P	0	7	14	19	12	3
7	P	1	4	6	9	19	7
	% Total	4.8	24.1	71.1	36.8	44.8	18.4
4	A	1	7	6	5	20	17
8	A	1	4	23	7	19	6
10	A	1	10	6	1	7	6
11	A	0	6	31	-	-	-
	% Total	3.1	28.1	68.8	14.8	52.3	22.9
2	G	1	7	11	7	18	7
5	G	0	9	5	10	14	11
9	G	0	6	25	-	-	-
12	G	1	7	7	3	9	23
13	G	2	7	24	0	6	22
14	G	0	5	19	1	11	16
15	G	0	0	10	6	18	3
	% Total	2.4	24.7	72.9	14.6	41.1	44.3

P - Poor, A - Average, G - Good.

[1] All establishments were surveyed by SRC on the test date in order to determine their general sanitary condition. Based upon the survey results, establishments were rated poor, average, or good, with respect to their general cleanliness.

The percentages developed in Table 18-1 can be examined for trends as is done in Table 19-1. Table 19-1 shows that in a comparison of good to poor rated restaurants, disposable items had an increase of 2.4% in items having over 100 bacteria, while reusable items showed a 22.2% increase.

Table 19-1

Comparison of General Sanitary Conditions
with Levels of Bacterial Counts

	% Greater than 100 counts	
	Disposable	Reusables
General Sanitary Conditions:		
Poor	4.8	36.8
Average	3.1	14.8
Good	2.4	14.6

Observations

The higher counts on reusable items probably result from the fact that they are handled much more than disposable items and are affected by dish-washing practices.

The potential for bacterial contamination at the point of use is present, of course, for both reusable and single service items. Reusables are subject to contamination resulting from excessive handling and improper washing.

Single service items are packed and stored in protective wrappers and generally handled directly only at the point of use.

What is perhaps most important is that single service items are used once and discarded. In SRC's opinion, the chance for contamination at the food serving establishment is less than that presented by reusables.

APPENDIX A

Sanitary Surveys

LOCATION. NE/Syracuse
TEST SITE: #1 (Cafeteria)
CATEGORY: dishes
DATE: 5/26/76

GENERAL:

F OOR - old, dirty

WA_LS - paint chipping

CEILINGS - soiled

EQUIPMENT - grease coated

WINDOW (SCREENS) - no windows
LIGHTING - adequate in kitchen, inadequate in dining & serving area
HANDWASHING FACILITIES Rest room dirty
& REST ROOM - handwashing sink in kitchen coated with grease and dirt
PERSONAL CLEANLINESS - street clothes, no hair restraints, hippie type
RODENTS AND INSECTS - no evidence
AREA CLEANUP - wet rag, "cleaned" tables were sticky
WASTE DISPOSAL - lined, uncovered trash can

STORAGE & HANDLING

DISPOSABLE - stored in boxes on floor & racks in a small room. Room dry, clean, but not immaculate.
REUSABLE - exposed behind service counter

DISHWASHING:

MACHINE
PRE-WASH PREP.- dishes sprayed
WASH SOLN. - Score
WASH TIME (TEMP.) - 60 sec. 140°F
RINSE TIME (TEMP.) - 10 sec. 180°F
DRY TIME (TEMP.) - air dry
COND. OF EQU . - old

MANUAL
WATER TEMP.
WASH -
RINSE -
SOAK TIME -
SOAP -
DRYING PROCEDURE -

GENERAL COMMENTS

Kitchen area in need of painting.
No table cloths or place mats.
Generally in need of a good cleaning.
Overall appearance was dingy, and dirty.
Many coffee cups were heavily stained with residue which rubbed off. Indicates inadequate dishwashing.

LOCATION: NE/Syracuse
TEST SITE: #2 (Family Style)
CATEGORY: dishes
DATE: 5/18/76

GENERAL:

FLOOR - dirty in corners

WALLS - clean

CEILINGS - clean

EQUIPMENT - clean except for grease and meat particles around broiler

WINDOW (SCREENS) - yes
LIGHTING - good
HANDWASHING FACILITIES
& REST ROOM - clean
PERSONAL CLEANLINESS - good
RODENTS AND INSECTS - no evidence
AREA CLEANUP - wet cloth
WASTE DISPOSAL - open, lined trash containers

STORAGE & HANDLING

DISPOSABLE - stored in basement on racks off floor. An opened poly bag of dinner plates was stored next to the broiler.
REUSABLE - exposed on shelves

DISHWASHING:

MACHINE
PRE-WASH PREP. - plates pre-washed by hand
WASH SOLN. - Impact
WASH TIME (TEMP.) - 195°F
RINSE TIME (TEMP.) - 150°F
DRY TIME (TEMP.) - air, silver dried by hand
COND. OF EQUIP. - good (new)

MANUAL
WATER TEMP.
WASH -
RINSE -
SOAK TIME -
SOAP -
DRYING PROCEDURE -

GENERAL COMMENTS

Restaurant was recently remodeled. Most equipment was new stainless steel. Generally clean and well kept.

LOCATION: NE/Syracuse
TEST SITE: #3 (Family Style)
CATEGORY: dishes
DATE: 6/8/76

GENERAL:

FLOOR - dirty

WALLS - dirty

CEILINGS - high drop ceilings, well lighted

EQUIPMENT - grease & old food buildup on kitchen equipment

WINDOW (SCREENS) - no screen on opened kitchen door, no screen on fan window
LIGHTING - good
HANDWASHING FACILITIES
& REST ROOM - good
PERSONAL CLEANLINESS - good
RODENTS AND INSECTS - no evidence
AREA CLEANUP - wet rag
WASTE DISPOSAL open trash can, unlined

STORAGE & HANDLING

DISPOSABLE - stored in sleeves under counter

REUSABLE - on wire racks in kitchen

DISHWASHING:

MACHINE
PRE-WASH PREP.- sprayed
WASH SOLN. - Impact
WASH TIME (TEMP.) - 3 min., 180°F
RINSE TIME (TEMP.) - 2 min., 220°F
DRY TIME (TEMP.) - air, silver hand dried
COND. OF EQUIP. - stainless, clean

MANUAL
WATER TEMP.
WASH -
RINSE -
SOAK TIME -
SOAP -
DRYING PROCEDURE -

GENERAL COMMENTS

Kitchen area generally dirty with greasy dust and food particles. Dishwashing and dish storage are generally clean.

LOCATION: NE/Syracuse
TEST SITE: #4 (Family Style)
CATEGORY: dishes
DATE: 6/16/76

GENERAL:

FLOOR - clean (tile)

WALLS - formica, clean

CEILINGS - clean

EQUIPMENT - stainless, clean

WINDOW (SCREENS) - no windows
LIGHTING - no light over sink, good in other areas
HANDWASHING FACILITIES
& REST ROOM - good
PERSONAL CLEANLINESS - very good
RODENTS AND INSECTS - no evidence
AREA CLEANUP - wet rag
WASTE DISPOSAL - plastic lined garbage pails, uncovered

STORAGE & HANDLING

DISPOSABLE - in wrappers on shelves in kitchen

REUSABLE - on shelves in kitchen

DISHWASHING:

MACHINE
PRE-WASH PREP.- scrape and pre-rinse
WASH SOLN. - Val-Chem
WASH TIME (TEMP.) - 5 min., 150°F
RINSE TIME (TEMP.) - 1 min., 180-195°F
DRY TIME (TEMP.) - air
COND. OF EQUIP. - good

MANUAL
WATER TEMP.
WASH -
RINSE -
SOAK TIME -
SOAP -
DRYING PROCEDURE -

GENERAL COMMENTS

Strong foul odor coming from dishwasher drain.
Generally clean and neat.

LOCATION: NE/Syracuse
TEST SITE: #5 (Family Style)
CATEGORY: dishes
DATE: 6/1/76

GENERAL:

FLOOR - clean

WALLS - clean

CEILINGS - clean

EQUIPMENT - clean

WINDOW (SCREENS) - windows did not open
LIGHTING - no light over sink, good in other areas
HANDWASHING FACILITIES
& REST ROOM - good
PERSONAL CLEANLINESS - good
RODENTS AND INSECTS - no evidence
AREA CLEANUP - wet rag stored under tray stand
WASTE DISPOSAL - lined, opened trash container

STORAGE & HANDLING

DISPOSABLE - stored in boxes and sleeves on shelves in separate room off kitchen
REUSABLE - dishes stored on shelves around steam table. Glasses, cups and silver stored in dining area.

DISHWASHING:

MACHINE
PRE-WASH PREP. - scraped & sprayed
WASH SOLN. - Score
WASH TIME (TEMP.) - 160°F
RINSE TIME (TEMP.) - 180°F
DRY TIME (TEMP.) - air
COND. OF EQUIP. - good

MANUAL
WATER TEMP.
WASH -
RINSE -
SOAK TIME -
SOAP -
DRYING PROCEDURE -

GENERAL COMMENTS

Restaurant - good overall cleanliness

LOCATION: NE/Syracuse
TEST SITE: #6 (Family Style)
CATEGORY: dishes
DATE: 6/15/76

GENERAL:

FLOOR - kitchen - dirt, grease and food particles in corners
eating area - napkins, papers, dirt & cigarette butts on floor

WALLS - painted block, dirty, greasy in need of washing

CEILINGS - drop ceiling, grease & dirt coated

EQUIPMENT - kitchen stove thick with grease, grill, grease buildup

WINDOW (SCREENS) - back door in kitchen open with a fan pulling in outside air. Small screened window open.

LIGHTING - good

HANDWASHING FACILITIES & REST ROOM - dirty

PERSONAL CLEANLINESS - waitresses-good, dishwasher unkempt street clothes

RODENTS AND INSECTS - no evidence

AREA CLEANUP - paper towels

WASTE DISPOSAL - covered, lined container

STORAGE & HANDLING

DISPOSABLE - stacked uncovered behind serving counter

REUSABLE - stacked on top of or under counter on shelves

DISHWASHING:

MACHINE

PRE-WASH PREP. - wash/rinse

WASH SOLN. - Klean-All DeLux dishwashing compound

WASH TIME (TEMP.) - "10-12 min."

RINSE TIME (TEMP.) - 3 min @ 180°F

DRY TIME (TEMP.) - air

COND. OF EQUIP. - old - approx. 25 yrs. old

MANUAL

WATER TEMP.

WASH -

RINSE -

SOAK TIME -

SOAP -

DRYING PROCEDURE -

GENERAL COMMENTS

Old sugar/soup bowls greasy & dirty, stained coffee cups, food particles adhering to bread & butter plates. Overall - a dirty establishment.

LOCATION: NE/Syracuse
TEST SITE: #7 (Cafeteria)
CATEGORY: dishes
DATE: 6/28/76

GENERAL:

FLOOR - old broken-surfaced concrete - filthy

WALLS - painted masonite - old, dirty, pealing paint

CEILINGS - old and dirty

EQUIPMENT - old and dirty

WINDOW (SCREENS) - no opening windows
LIGHTING - very dim
HANDWASHING FACILITIES
& REST ROOM - generally dirty
PERSONAL CLEANLINESS - good
RODENTS AND INSECTS - no evidence
AREA CLEANUP - wet cloth
WASTE DISPOSAL - lined trash containers, uncovered

STORAGE & HANDLING

DISPOSABLE - stored in boxes in separate cover on floor. In use items stored in sleeves under service counter.
REUSABLE - stored on counters in service area.

DISHWASHING:

MACHINE
PRE-WASH PREP. - spray
WASH SOLN. - Impact, Lime-a-way rinse
WASH TIME (TEMP.) - } Unknown by employees. No gauges or controls.
RINSE TIME (TEMP.) - }
DRY TIME (TEMP.) - air
COND. OF EQUIP. - very old

MANUAL
WATER TEMP.
WASH -
RINSE -
SOAK TIME -
SOAP -
DRYING PROCEDURE -

GENERAL COMMENTS

Kitchen area similar to cellar. Unsealed cement floors, badly broken up. Serving area dirty. Eating area fairly clean.

LOCATION: NE/Syracuse
TEST SITE: #8 (Family Style)
CATEGORY: dishes
DATE: :/7/76

GENERAL:

FLOOR - tile (in need of washing)

WALLS - metal sheets in dishwashing room

CEILINGS - drop ceilings (clean)

EQUIPMENT - old, greasy gas range and grill

WINDOW (SCREENS) - no opening windows
LIGHTING - good
HANDWASHING FACILITIES - two handwashing sinks in working area - clean
& REST ROOM - clean
PERSONAL CLEANLINESS - good
RODENTS AND INSECTS - no evidence
AREA CLEANUP - wet cloth
WASTE DISPOSAL - plastic lined covered can

STORAGE & HANDLING

DISPOSABLE - stored in boxes and sleeves on metal rack in kitchen area

REUSABLE - stored exposed on counter top

DISHWASHING:

MACHINE - No
PRE-WASH PREP.-
WASH SOLN. -
WASH TIME (TEMP.) -
RINSE TIME (TEMP.) -
DRY TIME (TEMP.) -
COND. OF EQUIP. -

MANUAL
WATER TEMP. - not available - 150°F approximately
WASH - 1 wash
RINSE - 1 rinse and 1 sanitize rinse (1 tsp. Clorox to 1 gal. water)
SOAK TIME - No, only if there is time - no set time limit
SOAP - Amway Dish Drops
DRYING PROCEDURE - Air

GENERAL COMMENTS

Very small, very few dishes, working dirt present in kitchen area. Floors dirty, but no excessive dirt.

LOCATION: NE/Syracuse
TEST SITE: #9 (Fast Food)
CATEGORY: dishes
DATE: 6/10/76

GENERAL:

FLOOR - in need of cleaning, some dirt & dust buildup in corners & along the bottom of appliances

WALLS - clean but paint chipping in store room

CEILINGS - drop ceilings, stained

EQUIPMENT - stainless steel, all well cleaned

WINDOW (SCREENS) - no opening windows
LIGHTING - poor in washing area
HANDWASHING FACILITIES
& REST ROOM - stainless steel double sink in kitchen
PERSONAL CLEANLINESS - good
RODENTS AND INSECTS - no evidence
AREA CLEANUP - wet cloths (left to soak overnight in greasy water)
WASTE DISPOSAL - plastic wastecan, no liner

STORAGE & HANDLING

DISPOSABLE - stored in boxes in back room, clean & dry

REUSABLE - none

DISHWASHING:

MACHINE NO
PRE-WASH PREP. -
WASH SOLN. -
WASH TIME (TEMP.) -
RINSE TIME (TEMP.) -
DRY TIME (TEMP.) -
COND. OF EQUIP. -

MANUAL
WATER TEMP.
WASH - utensils, pots and pans in Tide, washed off and rinsed
RINSE -
SOAK TIME -
SOAP - Tide
DRYING PROCEDURE -

GENERAL COMMENTS

The eating area and work area of this establishment were kept very clean - floors, walls, countertops & equipment. The backroom storage area was in need of cleaning.

LOCATION: NE/Syracuse
TEST SITE: #10 (Family Style)
CATEGORY: dishes
DATE: ·/9/76

GENERAL:

FLOOR - kitchen floor old cracked tile

WALLS - old, not well cleaned

CEILINGS - painted, clean

EQUIPMENT - stainless steel kept clean, wood surfaces & cast iron areas in need of cleaning.
WINDOW (SCREENS) - no opening windows, screened front door
LIGHTING - poor in kitchen, good in eating/serving area and around counter
HANDWASHING FACILITIES & REST ROOM - good
PERSONAL CLEANLINESS - good
RODENTS AND INSECTS - no evidence
AREA CLEANUP - sponge and wet rag
WASTE DISPOSAL - covered, lined trash can

STORAGE & HANDLING

DISPOSABLE - stored in basement on shelves and under counter in sleeves. plastic knives, forks & spoons reused
REUSABLE - stored under counter, stacked

DISHWASHING:

MACHINE
PRE-WASH PREP. - no pre-wash prep.
WASH SOLN. - Impact
WASH TIME (TEMP.) - 3 min @ 160-165°F
RINSE TIME (TEMP.) - 2 min 160-165°F
DRY TIME (TEMP.) - heat from dishwasher (160-165) then dried with paper towels
COND. OF EQUIP. - moderate, dishwasher not new

MANUAL
WATER TEMP.
WASH -
RINSE -
SOAK TIME -
SOAP -
DRYING PROCEDURE -

GENERAL COMMENTS

The establishment was generally clean.

LOCATION: NE/Syracuse
TEST SITE: #11 (Fast Food)
CATEGORY: dishes
DATE: 6/18/76

GENERAL:

FLOOR - dirty

WALLS - dirty

CEILINGS - dirty

EQUIPMENT - ovens clean, work area clean

WINDOW (SCREENS) - no opening windows, front door open, no screen
LIGHTING - poor
HANDWASHING FACILITIES
& REST ROOM - dirty floors
PERSONAL CLEANLINESS - aprons of cooks dirty
RODENTS AND INSECTS - no evidence
AREA CLEANUP - damp cloth
WASTE DISPOSAL - covered, lined containers

STORAGE & HANDLING

DISPOSABLE - stored in cases in back room on floor and on shelves, some items removed from cases and stored exposed on shelves & counter tops
REUSABLE - None

DISHWASHING:

MACHINE - No
PRE-WASH PREP. -
WASH SOLN. -
WASH TIME (TEMP.) -
RINSE TIME (TEMP.) -
DRY TIME (TEMP.) -
COND. OF EQUIP. -

MANUAL - No
WATER TEMP.
WASH -
RINSE -
SOAK TIME -
SOAP -
DRYING PROCEDURE -

GENERAL COMMENTS

Two floor fans were in operation in the eating area. The kitchen working area was kept well cleaned.

LOCATION: NE/Syracuse
TEST SITE: #12 (Hospital)
CATEGORY: dishes
DATE: 6/22/76

GENERAL:

FLOOR - tile - clean

WALLS - tile - clean

CEILINGS - aluminum - clean

EQUIPMENT - cafeteria had buildup in corners, kitchen - clean

WINDOW (SCREENS) - all windows screened
LIGHTING - good
HANDWASHING FACILITIES
& REST ROOM - clean and readily available
PERSONAL CLEANLINESS - very good
RODENTS AND INSECTS - no evidence
AREA CLEANUP - wet rag
WASTE DISPOSAL - covered, lined trash containers

STORAGE & HANDLING

DISPOSABLE - in sleeves and boxes on shelves. Clean storage room off kitchen.
REUSABLE - no storage - used immediately after washing

DISHWASHING:

MACHINE
PRE-WASH PREP. - scrape and spray
WASH SOLN. - Impact
WASH TIME (TEMP.) - } 5 min. 200°F
RINSE TIME (TEMP.) - }
DRY TIME (TEMP.) - air
COND. OF EQUIP. - stainless steel, very clean

MANUAL
WATER TEMP.
WASH -
RINSE -
SOAK TIME -
SOAP -
DRYING PROCEDURE -

GENERAL COMMENTS

There were 2 kitchen areas, one for hospital meals and one a general service cafeteria. The hospital kitchen was very clean. The cafeteria kitchen had some food and dirt buildup in hard to clean areas of equipment and floors.

LOCATION: NE/Syracuse
TEST SITE: #13 (Hospital)
CATEGORY: dishes
DATE: 6/21/76

GENERAL:

FLOOR - clean

WALLS - clean

CEILINGS - clean

EQUIPMENT - stainless steel, clean

WINDOW (SCREENS) - no windows
LIGHTING - good
HANDWASHING FACILITIES
& REST ROOM - clean & readily available
PERSONAL CLEANLINESS - good
RODENTS AND INSECTS - no evidence
AREA CLEANUP - wet rag
WASTE DISPOSAL - covered, lined containers

STORAGE & HANDLING

DISPOSABLE - stored in boxes and sleeves off the floor, in special room off kitchen
REUSABLE - no storage - used immediately after washing

DISHWASHING:

MACHINE
PRE-WASH PREP.- scraped
WASH SOLN. - Soil-A-Way
WASH TIME (TEMP.) - 5 min. 160°F
RINSE TIME (TEMP.) - 180°F
DRY TIME (TEMP.) - air
COND. OF EQUIP. - very good

MANUAL
WATER TEMP.
WASH -
RINSE -
SOAK TIME -
SOAP -
DRYING PROCEDURE -

GENERAL COMMENTS

Flatware was washed twice. Both the hospital kitchen and cafeteria were very clean.

LOCATION: NE/Syracuse
TEST SITE: #14 (School)
CATEGORY: dishes
DATE: 6/11/76

GENERAL:

FLOOR - Painted and clean

WALLS - Painted and clean

CEILINGS - Painted and clean

EQUIPMENT - Stainless steel - very clean

WINDOW (SCREENS) - in place
LIGHTING - good
HANDWASHING FACILITIES
& REST ROOM - clean, neat, well stocked
PERSONAL CLEANLINESS - excellent
RODENTS AND INSECTS - no evidence
AREA CLEANUP - wet cloth (tables)
WASTE DISPOSAL - covered lined cans

STORAGE & HANDLING

DISPOSABLE - Not used often except for non-student functions. A few left-overs were in a kitchen drawer and storage closet.

REUSABLE - Plastic utensils were reused. Other reusables stored under service counter or on a cart covered with a cloth.

DISHWASHING:

MACHINE
PRE-WASH PREP.- pre-rinsed and scraped
WASH SOLN. - "Salute"
WASH TIME (TEMP.) - 170°F
RINSE TIME (TEMP.) - 180°F
DRY TIME (TEMP.) - air
COND. OF EQUIP. - very clean

MANUAL
WATER TEMP.
WASH -
RINSE -
SOAK TIME -
SOAP -
DRYING PROCEDURE -

GENERAL COMMENTS

The kitchen area and cafeteria were kept exceptionally clean although the lunch tables had not been cleaned from a social function the night before.

LOCATION: NE/Syracuse
TEST SITE: #15 (School)
CATEGORY: dishes
DATE: 6/14/76

GENERAL:

FLOOR - clean

WALLS - clean

CEILINGS - clean

EQUIPMENT - stainless, clean

WINDOW (SCREENS) - no windows
LIGHTING - good
HANDWASHING FACILITIES
& REST ROOM - clean
PERSONAL CLEANLINESS - very good
RODENTS AND INSECTS - no evidence
AREA CLEANUP - wet cloth, very thorough
WASTE DISPOSAL - lined, covered containers

STORAGE & HANDLING

DISPOSABLE - not used except for emergency. A few sleeves of cups for juice were stored under the counter.
REUSABLE - stored in portable stainless steel cabinet

DISHWASHING:

MACHINE
PRE-WASH PREP. - presoak and double rinse
WASH SOLN. - "Salute"
WASH TIME (TEMP.) - 160°F
RINSE TIME (TEMP.) - 170°F (susally 180° but not working properly)
DRY TIME (TEMP.) - air
COND. OF EQUIP. - very good

MANUAL
WATER TEMP.
WASH -
RINSE -
SOAK TIME -
SOAP -
DRYING PROCEDURE -

GENERAL COMMENTS

No glasses used, milk from cartons with straws. Overall - very clean.

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APPENDIX K

The Society of the
Plastics Industry, Inc.

355 Lexington Avenue
New York, New York 10017
(212) 573 9400

June 27, 1977

Mr. Charles Peterson, Project Officer
Resource Recovery Division
Office of Solid Waste Management Projects
U.S. Environmental Protection Agency
Washington, D.C.

Dear Mr. Peterson:

Subject: Draft Report, Contracts No. AW-463,
Midwest Research Institute Project 4010-D,
Study of Environmental Impact of Disposables
versus Reusables

Referring to your interest in receiving comments on the subject Draft Report, we wish to submit comments on behalf of the SPI's Foam Cup and Container Division, representing essentially all of U.S. producers of one of the products evaluated in your Report, as well as the suppliers of the resin material used to manufacture foam cups.

We have thoroughly reviewed the draft report and find that there are a number of areas where the lack of appropriate research data, or the use of inconsistent or illogical approaches to evaluating the data, have led to misleading or inaccurate conclusions that could do unnecessary damage to the public's true perception of the benefits of foam cups and other disposable products.

We are aware of the comments of the Single Service Institute to you on the subject Draft Report, and have reviewed the analysis and suggestions prepared for SSI by Arthur D. Little, Inc., and the SSI Public Health Advisory Council. We find that we agree fully with the determinations of SSI as to the contents of the Draft Report, and with their suggestions on necessary changes in order to obtain a complete and factual document.

We also urge that the suggested additional work and modifications be completed, rather than release, publish or file the report in its present form. We feel this may lead to public knowledge of Draft Report material that is an inaccurate portrayal of the comparative benefits of foam cups and other disposable products.

We appreciate your consideration of our comments.

Sincerely,

Ralph L. Harding, Jr.
President

RLH:alc

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