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**PORTLAND PUBLIC SCHOOLS
WASTE STREAM ANALYSIS**

FY 94-95

by
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EXECUTIVE SUMMARY

- In 1989 fewer than ten schools were set up for recycling. By 1993 all 92 Portland Public Schools have some type of recycling program.
- Recycling programs vary from single-material programs like cardboard, to extensive multi-material programs including: foam trays, white paper, colored paper, mixed-waste paper, newspaper, magazines, cardboard, milk cartons and drink boxes, tin cans, and aluminum cans. In large part the success of individual school recycling programs is determined by the dedication of a few teachers, custodians, and parent volunteers.
- From the year 1989 to 1993 Portland Public Schools **reduced its waste 75 percent by weight and 50 percent by volume**. These results confirm the far-reaching successes of the District-wide recycling program.
- By volume, classroom waste accounts for most of the total school waste. One-third of the classroom waste is easily recyclable paper (see figure 1).
- With continued recycling education integrated into facilities management and a concomitant tracking system in place for individual school garbage generation, additional waste reductions are possible.
- An increase in the recycling rates for mixed-waste paper will result in an average reduction of one-half of a garbage dumpster per school per week.
- This works out to a direct savings to the District of \$12.44 per school per week. Given the size of the Portland Public School District this can translate into a \$1000 savings per week or **\$40,000 saved for the entire year**.
- Further reductions are possible by integrating meal selection with source reduction in mind. When planning meals, consideration should be given to serving only popular meals that are less likely to be thrown out.
- Food service should include options that promote source reduction; for example, a district-wide coordinated effort to implement a **light meal vs. heavy meal** program. Give the students a choice between big portions and small portions of food. Another example is an **offered vs. served** approach. In this option, the students are able to refuse any serving of food above an established minimum.

PURPOSE

The purpose of this study is twofold. The first part of the study is an analysis of the waste stream from a sample of seven Portland Public Schools. The second part of the study provides recommendations for waste reduction, recycling opportunities and potential cost savings for the district. In order to receive the greatest benefits from waste reduction, it will be important to tie in recycling education with facilities management.

METHODOLOGY

Sample:

A sample of seven schools was selected for the waste characterization study, five elementary schools and two middle schools. Schools selected were those that participated in the 1989 Recycling Report, prepared by University of Portland Consulting Team. These schools were selected so that a comparative analysis could be done between the two studies to determine the success of the recycling program that has subsequently been implemented in Portland Public Schools. Both high schools in the 1989 study were dropped from the 1993 study due to budget and time constraints.

Process:

A one day waste study for each school was conducted. For a specified day, each school was asked to set aside its waste and to not dispose of it until it had been studied by research staff. All of the day's waste was included. Information about student attendance, number of faculty and present recycling efforts were recorded. It was assumed that waste from each school was representative of a normal day's waste. Also, the menu of each meal was recorded. This was done because it is likely that different meals generate different levels of waste. (See appendix A for survey form and menu information).

Following the lunch period of the specified day, breakfast and lunch wastes were weighed, volumes of waste were estimated, and the average number of bags per day were recorded. Students sorted recyclables and placed them in their proper containers.

Classroom, kitchen, office, library and bathroom wastes were collected and set aside by custodial staff in the evening. The following morning all waste was weighed by research staff to determine its cumulative weight and volumes were recorded. Kitchen, bathroom and miscellaneous waste was then discarded leaving the classroom, library and office waste for further sorting.

The classroom, library and office waste was sorted by research staff to determine the amount of recyclable paper still being discarded. The waste was divided into three separate categories: 1) white paper, 2) mixed paper; consisting of colored paper, magazines, newspaper and other recyclable paper products, and 3) all other material. Weights and volumes of the categories were recorded. Due to time and resource constraints a sample of the total day's classroom, library and office waste was sorted for Lane Middle School and George Middle School.

Measurement:

To insure reliability and accuracy the same scale was used throughout the study. Weights were recorded and summed to the nearest pound. Volumes for paper, food and miscellaneous materials were calculated in the same manner as the 1989 study. Materials were placed in previously standardized 32 gallon garbage containers. No attempts were made to compress the materials other than periodic shaking to help the materials settle.

Products:

Information regarding total weight and volume of waste-per-student was calculated. Percentages of white paper and mixed paper as a portion of the total waste stream were also calculated.

Special note

To compare the 1989 and 1993 studies, kindergarten students were counted in the daily attendance records of each school. It should be noted that this portion of the population does not usually eat any meals while at school and only attends school for half of the day. Therefore, they should not be included in the food waste portion of the survey. However, they do contribute to the generation of other classroom materials being discarded, and as a result, should be taken into consideration when calculating classroom waste figures, but only as part-time students.

Another important note is that faculty in both the 1989 and 1993 studies were excluded from calculations of waste generation, even though they contribute to the school's waste stream. The reason they were excluded from the 1993 study was because they were not included in the 1989 study. This allowed for consistency in the comparative analysis of both studies. If future studies are to be conducted it is important to take into consideration the kindergarten population, and the faculty and support staff for each school.

RESULTS:

Data for each school are located in Appendix A. Included are weights and volumes for each category of waste, percent by weight and volume of each category, total pounds, and cubic feet and cubic yards of waste.

Figures 1 and 2 summarize the total pounds and volume of waste for each school on a per student basis for 1989 and 1993.

Data from 1989 presents a range of waste per student to be between 0.55 and 1.02 pounds and 0.10 and 0.26 cubic feet.

In 1993 the range of waste per student falls dramatically to between **0.35 and 0.61 pounds** and **0.07 and 0.11 cubic feet**.

This represents on average, a 75 percent reduction in waste by weight and a 50 percent reduction in waste by volume for the seven schools studied. The average is a good indicator of what is happening at other schools. These results confirm the far-reaching successes of the District-wide recycling program. A quick history reveals the magnitude of materials targeted for removal from the wastestream at Portland Public Schools:

- 1989-90 polystyrene targeted from the waste stream
- 1990-91 high grade paper recycling program initiated
- 1990-91 corrugated cardboard containers included
- 1991-92 milk cartons and milk targeted from the waste stream
- 1991-92 newspapers and magazines added to the program
- 1992-93 mixed-waste paper program started.

Figures 4 and 5 indicate the percent of total waste by weight and volume for an average of all schools that is generated by meal-related activities and all other activities. It must be noted that all other activities include classrooms, offices, lavatories, boiler rooms, hallways and library.

By weight, meal-related wastes accounted for 58 percent of the total waste, with "all other" waste making up the remaining 42 percent. By volume, meal-related wastes accounted for only 37 percent and "all other" waste 63 percent. It should be noted that the District uses a volume-based charge system to determine garbage costs, so in terms of potential waste reduction efforts greater attention should be paid to the classroom waste.

Figures 6 and 7 show the breakdown of "all other" waste by weight and volume for the following categories: white paper, mixed-waste paper, lavatory waste, and garbage. The data gathered indicates that approximately **40 percent** of the "all other" waste by weight or **50 percent** by volume, could be diverted through further recycling efforts and additional source reduction practices.

Careful examination of figure 7 shows the potential reductions that can be attained by recovering white and mixed paper from the classroom waste stream. One-third of all classroom waste is recyclable paper. Because classroom waste makes up most of the overall school waste by volume, significant reductions in waste are possible if continued education on the importance of waste reduction is stressed. Figure 1 on the next page depicts this.

To put this into better perspective consider the possible garbage reductions for an average elementary school with 500 students. If each student generated an average of 0.1 cubic feet of waste per day, then the total waste for that school would be 50 cubic feet or approximately two filled dumpsters a week. It has been determined that of that waste one-fifth is recyclable paper and could be easily diverted. **For one week this works out to be a reduction of one-half dumpster for a direct savings of \$12.44 per week.**

LIMITATIONS:

Given the timeline for this study it was impossible to sample each school on the respective date on which it was sampled in 1989. Although attempts were made to assure that the days selected for data collection were representative of typical school days, a limitation of this study remains that waste analysis was done for each school based on a single day of data collection.

TABLE 1
AVERAGE WEIGHT AND VOLUME OF WASTE
FOR EACH STUDENT PER SCHOOL FOR 1989 AND 1993

SCHOOL	POUNDS/ STUDENT '89	POUNDS/ STUDENT '93	CUBIC FEET/ STUDENT '89	CUBIC FEET/ STUDENT '93
ATKINSON	0.65	0.45	0.10	0.08
BRIDLE	0.82	0.35	0.26	0.07
EDWARDS	0.81	0.38	0.21	0.08
GEORGE	1.02	0.43	0.20	0.11
KING	0.93	0.52	0.20	0.09
LANE	0.83	0.42	0.25	0.09
STEPHENSON	0.55	0.38	0.13	0.10
RANGE:	0.55 - 1.02	0.38 - 0.52	0.10 - 0.26	0.07 - 0.11

SAMPLE: ELEMENTARY SCHOOL CLASSROOM WASTE AUDIT



One day's waste from classrooms, offices, and lavatories.

❶ White ledger and mixed-waste paper (consisting of colored paper, magazines, newspaper, construction paper, brown bags, junk mail and other recyclable paper products) separated from the classroom waste.



❷ Bags of actual garbage after recyclable paper was removed.

❸ Bags filled with recyclable paper that was still being discarded along with the regular trash.



FIGURE 2

AVERAGE WEIGHT OF TOTAL WASTE
FOR EACH STUDENT PER SCHOOL: 1989 AND 1993

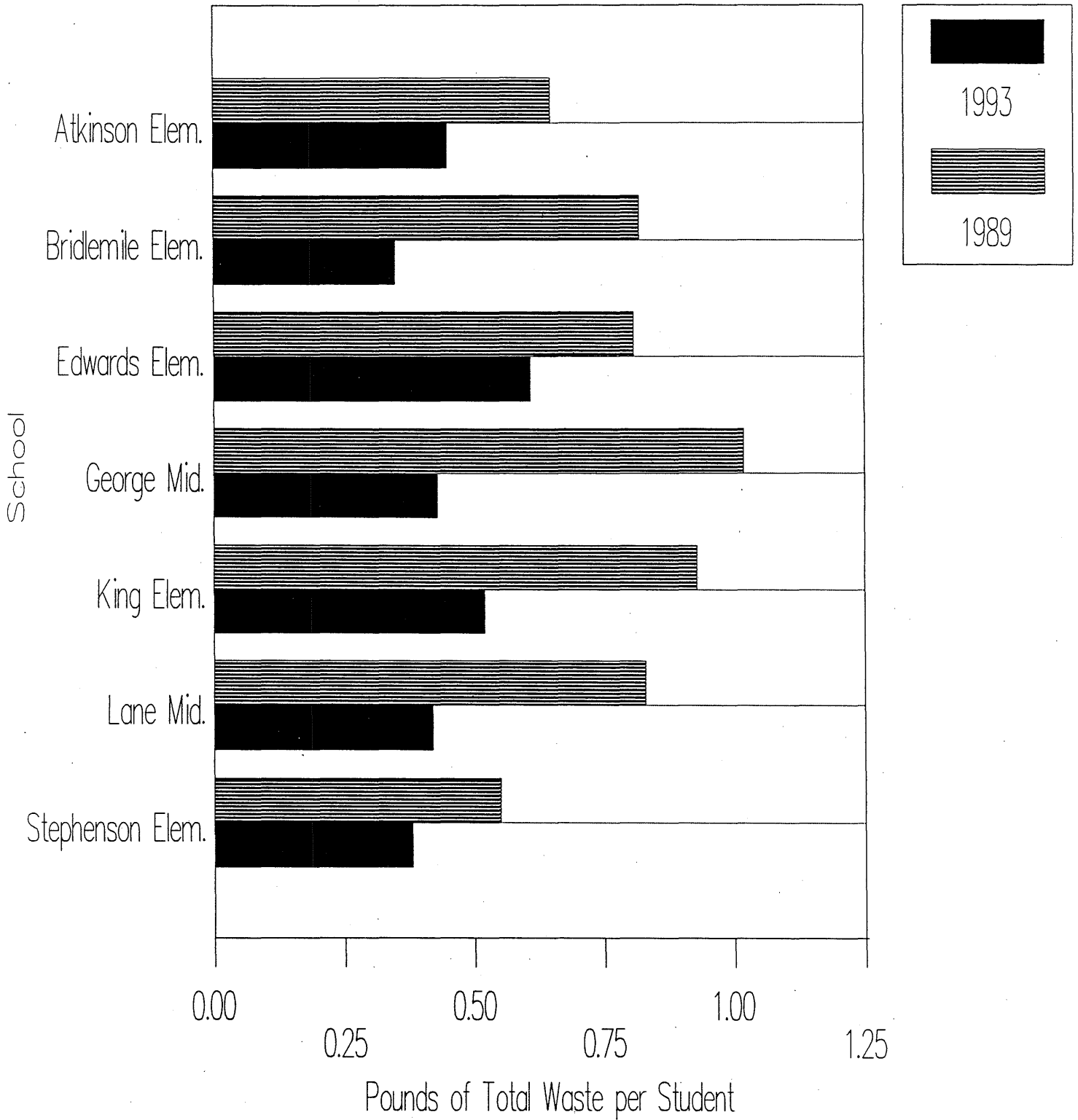


FIGURE 3

AVERAGE VOLUME OF TOTAL WASTE
FOR EACH STUDENT PER SCHOOL: 1989 AND 1993

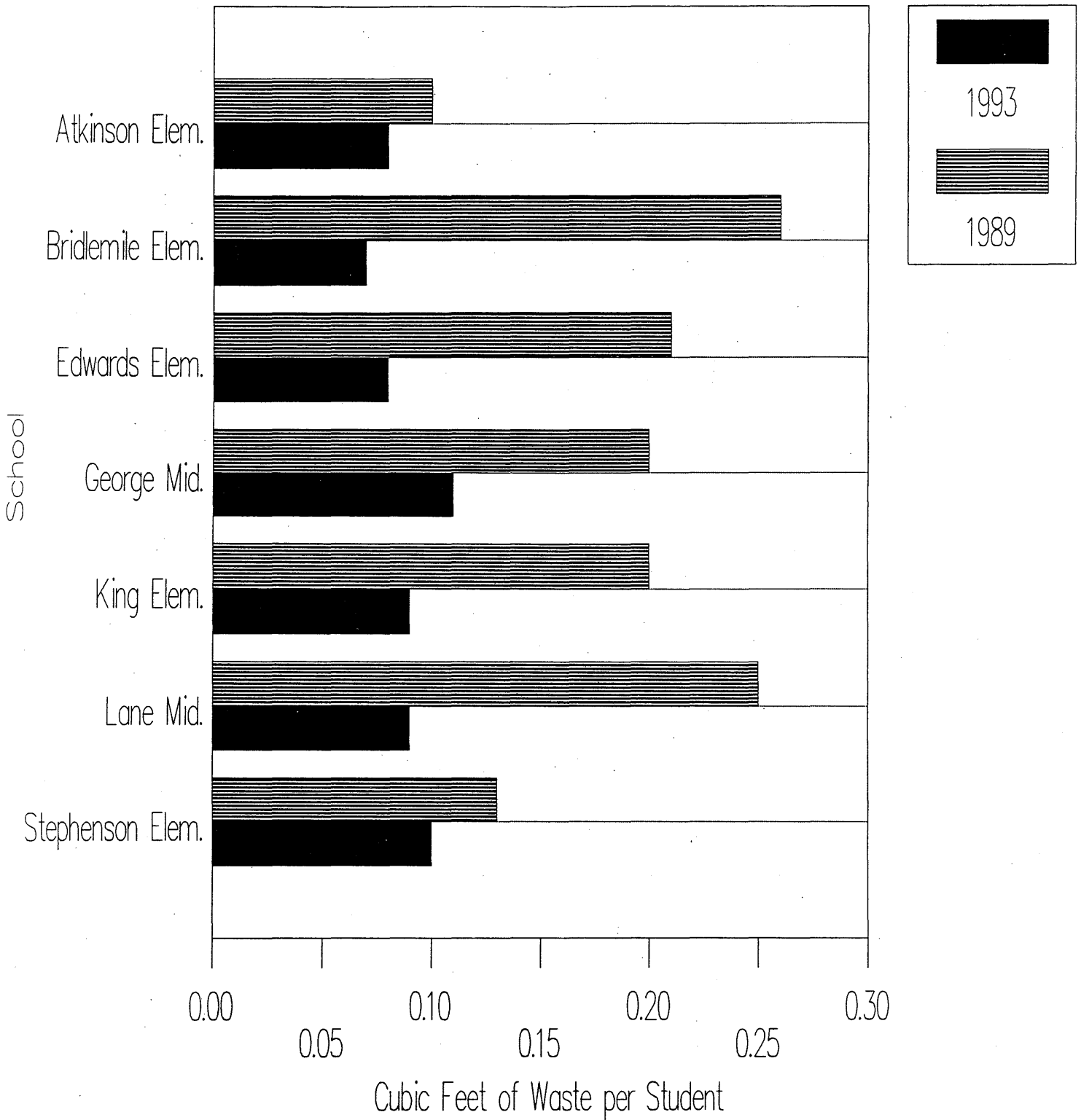


TABLE 2

COMPARISON OF "ALL OTHER" WASTE TO MEAL-RELATED
WASTE BY WEIGHT AND VOLUME (percent)

SCHOOL	% "ALL OTHER" BY WEIGHT	% MEAL BY WEIGHT	% "ALL OTHER" BY VOLUME	% MEAL BY VOLUME
ATKINSON	31	69	63	37
BRIDLE	40	63	57	43
EDWARDS	42	58	63	37
GEORGE	46	53	64	36
KING	35	65	55	44
LANE	52	48	67	33
STEPHENSON	45	55	67	33
AVERAGE %	42	58	63	37

"All other" activities include wastes from: classrooms, offices, lavatories, boiler rooms, hallways and libraries.

Meal-related activities include wastes from: breakfast, lunch, kitchen preparation, and faculty lunchrooms.

FIGURE 4

CLASSROOM AND MEAL WASTES AS A PERCENT
OF TOTAL WASTE BY WEIGHT
(average of all schools)

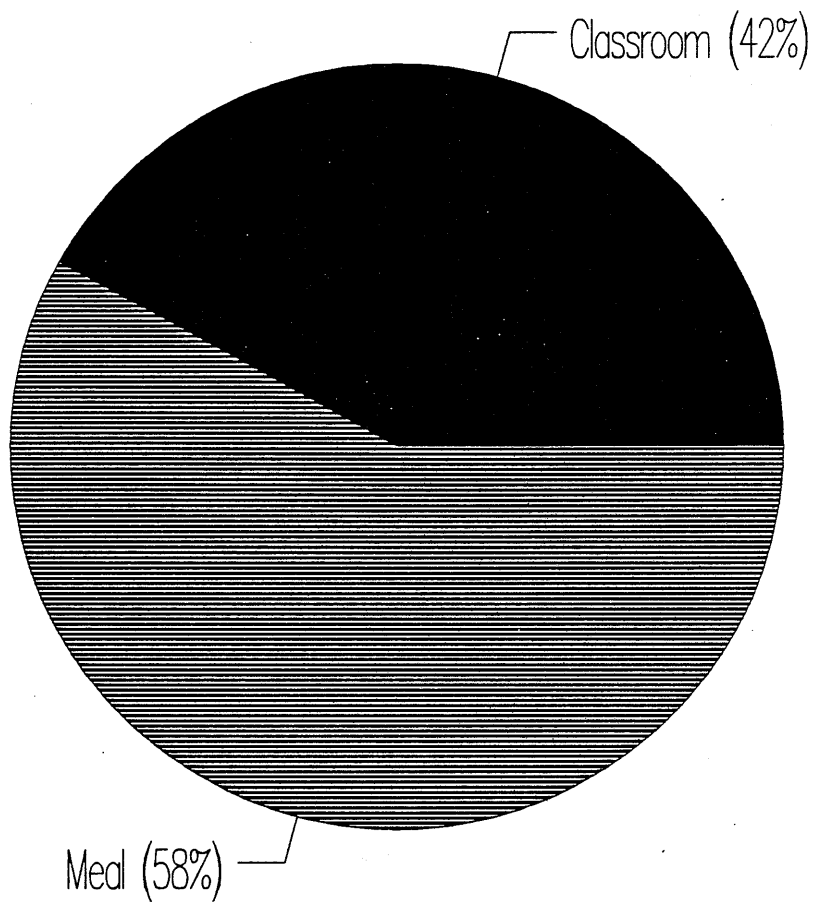


FIGURE 5

CLASSROOM AND MEAL WASTES AS A PERCENT
OF TOTAL WASTE BY VOLUME
(average of all schools)

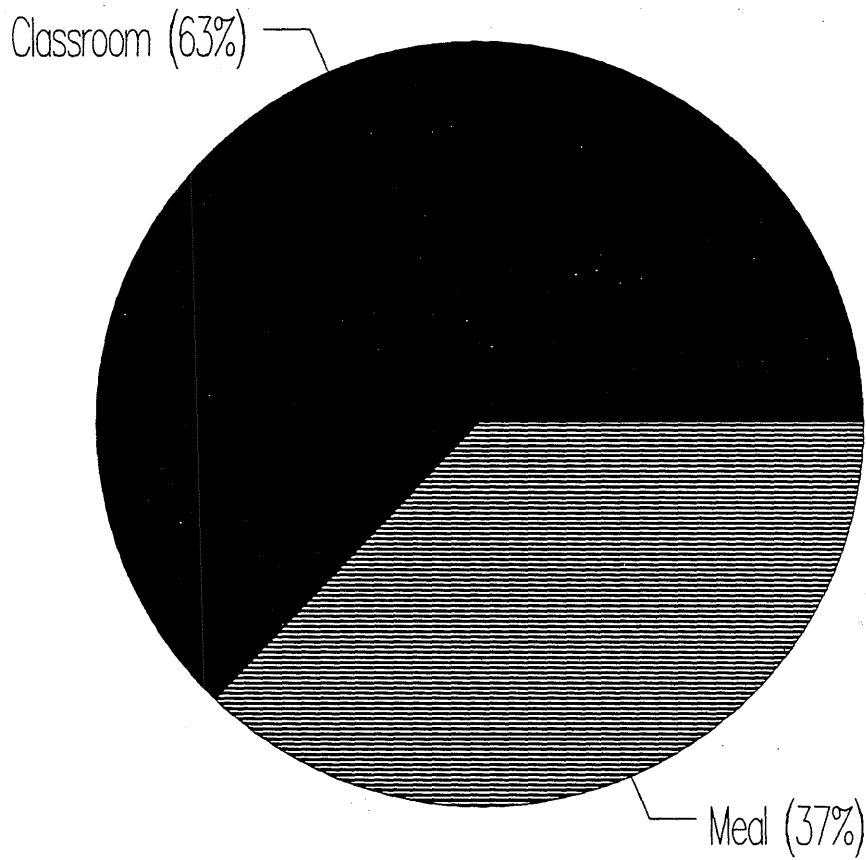


TABLE 4

SCHOOL CLASSROOM WASTES BY WEIGHT (pounds)

SCHOOL	TOTAL	WHITE	MIXED	GARBAGE	LAVATORY
ATKINSON	65	10	17	31	7
BRIDLEMILE	85	6	24	50	5
EDWARDS	38	4	10	20	4
GEORGE	107	5	15	75	4
KING	93	10	26	39	17
LANE	140	17	28	79	16
STEPHENSON	73	3	17	50	3
% OF TOTAL	-	9%	24%	57%	9%

TABLE 5

SCHOOL CLASSROOM WASTES BY VOLUME (gallons)

SCHOOL	TOTAL	WHITE	MIXED	GARBAGE	LAVATORY
ATKINSON	170	32	32	75	32
BRIDLEMILE	195	20	48	106	20
EDWARDS	96	7	15	58	16
GEORGE	268	20	60	160	20
KING	278	30	96	72	80
LANE	295	48	48	128	70
STEPHENSON	224	16	28	135	45
% OF TOTAL	-	11%	21%	50%	18%

FIGURE 6

SCHOOL CLASSROOM WASTES BY WEIGHT
(average of all schools)

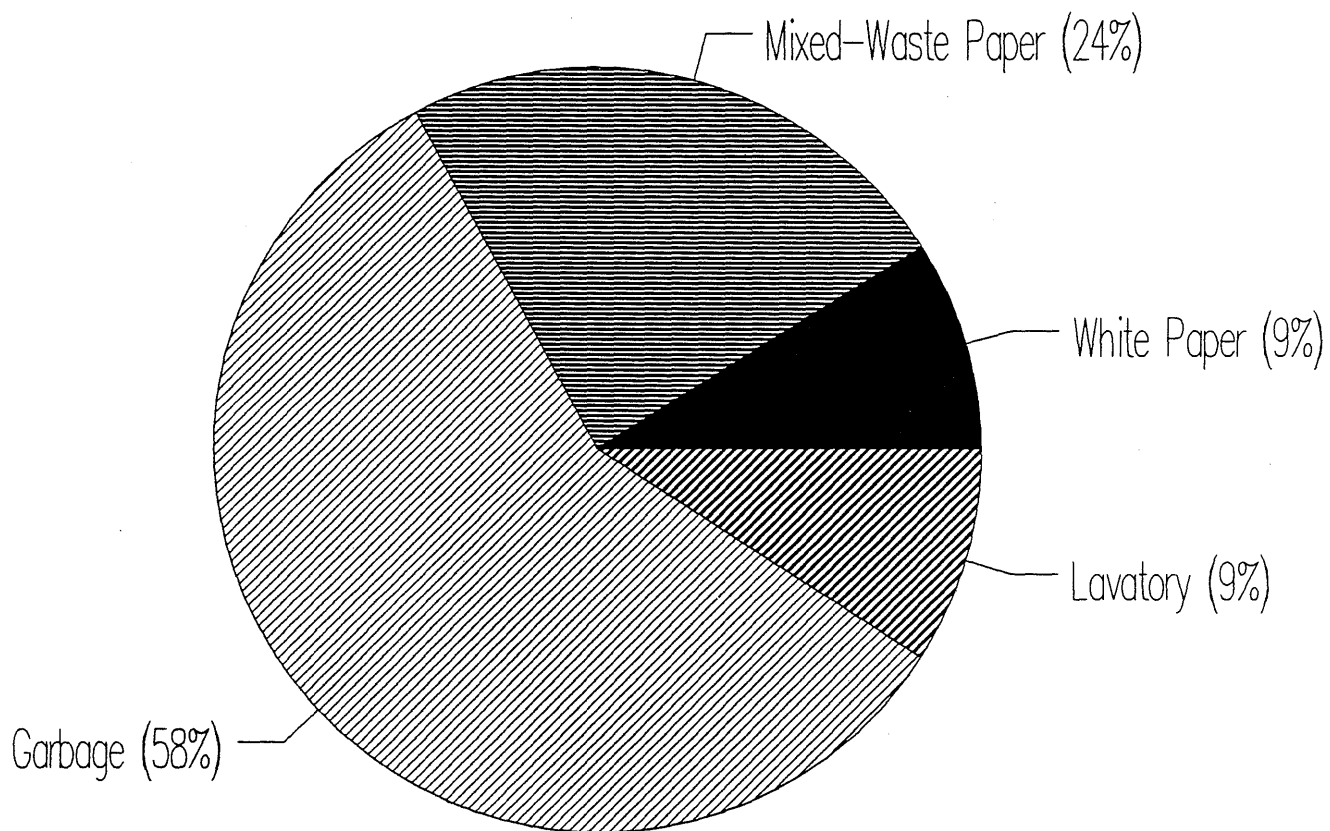
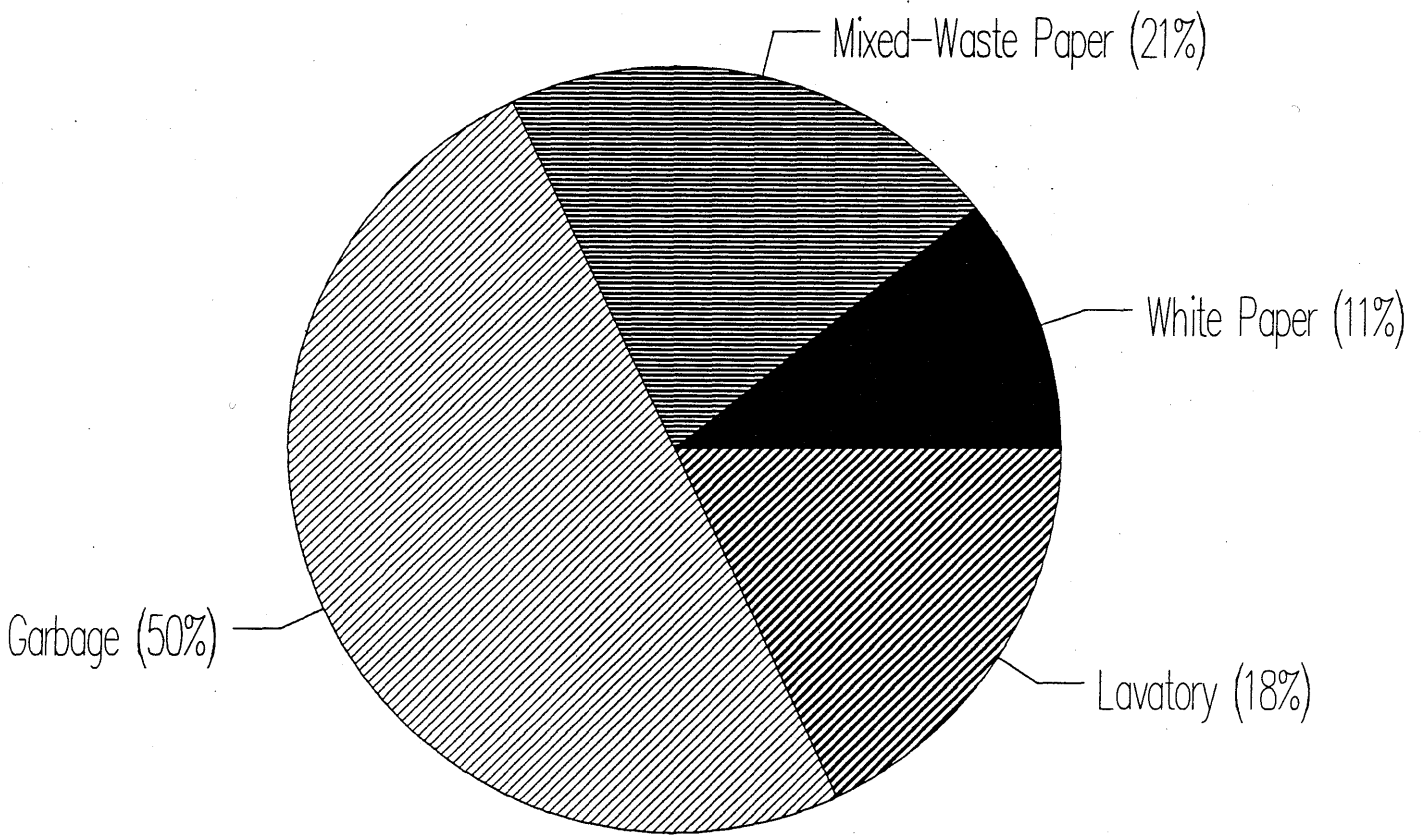


FIGURE 7

SCHOOL CLASSROOM WASTES BY VOLUME
(average of all schools)



PART TWO: WASTE REDUCTION OPTIONS FOR SCHOOLS

When applying the "Reduce-Reuse-Recycle" maxim to a given waste stream, the key is to be both conscientious and creative. Nearly every component in a waste stream has at least some potential for being reduced, reused, or recycled. As the hierarchy in the maxim indicates, the best overall option is to reduce any component of the waste stream. Reuse of the component is the next best alternative, with recycling as the option beyond that.

Taking the example of bond paper, the hierarchy can be illustrated. First, use of the paper should be reduced where possible. This means, for example, routing a single copy of a memo to a number of people instead of making several copies of that same memo and sending a copy to each person separately. It also means using both sides of the paper when copying. Second, attempts should be made to reuse the paper. Using the back of one-sided copies for memo paper or rough drafts is an option. Paper can also be reused in art projects. Third, any bond paper that is ready to be discarded should be sorted into containers for recycling.

These suggestions, of course, are not exhaustive. Within each category of reduction and reuse, especially, there are a myriad of possibilities. The point, as stated before, is to be both conscientious and creative with those possibilities.

The following list outlines some options for inclusion into the school's solid waste management plan. Some take more effort than others, but all should be considered.

PART A: FOOD WASTES:

1. **Composting** - some of the food wastes generated in the kitchen and cafeteria can be composted. The waste characterization study should be able to provide information about the quantity and quality of the material for composting. Considering only kitchen food wastes for composting is an option if most of the compostible material is confined to the kitchen waste. Using only kitchen waste for the composting effort is likely to provide the most consistent quality. Also, it is generally easier to train a small number of kitchen staff to source separate materials correctly than it is to train a large number of students. However, the educational value of teaching students how to compost should not be overlooked. The program can begin slowly and on a small scale to allow for time to educate and prepare the students to begin composting. The benefit to students as a learning experience can far outweigh the initial inconvenience of training them in proper procedures.

The actual composting can be done at a site on school grounds, or the composting material can be taken to a large composting facility. Obviously, the educational benefits to the students are greater when some amount of composting is done on-site.

The compost that is generated on-site can be used in the maintenance of the school grounds.

2. **Vermiculture** - Like composting, vermiculture can be a valuable educational experience for students. Vermiculture uses worms in bins to digest organic material and produce a soil amendment. Each square foot of the surface area of a worm bin will provide a digestion equivalent of one pound of organic material per week. As with composting, the educational value to the students can be substantial.

3. **Insinkerator** - Installing an industrial garbage disposal unit in the kitchen sink can divert some of the food waste from the solid waste stream. One must be mindful, however, that this is really only diverting the waste from one waste stream to another. It may be kept out of the garbage dumpster this way, but it still has to be treated in the sewage system as waste.

4. **Light Meals/Heavy Meals** - Give the students a choice between big portions and small portions of food. Some children, especially the younger ones, simply cannot eat the standard serving portions. Giving them a choice in portion sizes can reduce the amount of food thrown away because the child cannot eat as much as he/she is given.

5. **Offered versus Served** - In this option, the students are able to refuse any serving of food above an established minimum. For example, students may be required to choose at least three foods that meet minimum food group requirements, but are then allowed to refused any serving beyond that. This option may not be suitable for very young children. This reduces food waste that occurs when a child simply does not like a particular food and will not eat it even if it is served to him/her.

6. **Buffet-Style Programs** - Several food choices are given so that students can create a meal composed of the foods they will eat in the portions they can finish. This is probably most appropriate for older students. This option can reduce the amount of food that students discard. However, if the kitchen staff does not carefully plan the different amounts of each item in the buffet, it can lead to more food waste as uneaten food from the buffet is discarded. Of course, the kitchen staff should reuse any leftovers that they are able to.

7. **Change Menus** - Do not serve what it is obvious that the students do not eat. Instead, substitute similar foods that are more readily consumed. Be creative so that any applicable nutrition guidelines can be met, while dropping foods and preparation techniques in which the students are clearly not interested. Healthy food does nothing for a body if it ends up in the garbage can.

8. **Reuse Leftovers** - This option can be implemented to the extent that it is allowed by any health and nutrition standards under which the kitchen must operate.

9. **Variable Meal Costs**-Change from a flat-rate charge for meals to a variable rate. The variation in cost can pertain to a number of different meal variations. For example, a "light" meal can cost less than a "heavy" meal, and a charge per item can be implemented in the "offered versus served" approach.

10. **Use Permanent Ware**-Use permanent trays and utensils instead of disposable. A study conducted by the Portland Public Schools revealed that using polycarbonate permanent ware over polystyrene disposable ware is less environmentally damaging and, in the long run, could be cheaper. This is true even when recycling of the disposable ware was factored in.

11. **Sell Reusable Lunch Bags**-Nylon lunch bags can be ordered by the school and re-sold at cost to the students. Bags could come in school colors with the school logo, and a place for student identification. Students should be allowed to recycle their paper lunch bags, but remember that source reduction is best.

12. **Reusable Milk Bottles**-Instead of using milk cartons, consider contracting with a local dairy for milk in reusable containers. General Electric Co. has produced a plastic bottle that can be used about 100 times and then recycled.

13. **Provide for Recycling in the Teacher's Lounge**-Even when recycling is provided for students in the cafeteria, the teacher's lounge is often neglected. Make sure that all necessary recycling receptacles are provided in the teacher's lounge to reduce the amount of recyclables in that waste stream. This will probably include recycling bins for newspaper, paper, and magazines as well as for food containers.

PART B: OFFICE/CLASSROOM/LIBRARY SOLID WASTE

1. **Make Copies Double-Sided** - Invest in a double-sided copier if the school does not currently have one.

2. **Reuse Single-Sided Copies** - Paper that is only printed on one side can be cut into memo pads, or copied on the clean side for rough drafts.

3. **Use Half-Sheets of Paper** - Announcements, memos, and internal correspondence do not have to be printed on a full sheet of paper if half of a sheet will do.

4. **Buy Recycled** - Whenever possible, make sure that products containing recycled content are purchased for school use. It is now possible to buy everything from recycled paper to scissors with recycled plastic in the handles.

5. **Buy Reusable Versus Disposable Products** - Reduce waste generation by substituting disposable products, like disposable pens, with products that can be reused, like pens with replaceable cartridges.

6. **Remove Names From Unwanted Mailing Lists** - Instead of just recycling junk mail and unwanted magazines, ask the sender to remove the name from the sender's mailing list. To prevent future unwanted junk mail, contact the Mail Preference Service, Direct Marketing Association, 6 East 43rd St., New York, NY 10017. They can prevent specified names from being sold to most large mailing list companies.

PART C: LAVATORY WASTE

1. **Replace Paper Towels in Bathrooms** - Replace paper towels with either electric hand dryers or reusable linen towels. (See Appendix B)

PART D: OUTDOOR SOLID WASTE

1. **Use Grass Clippings as Mulch**-If grass is cut frequently, there will be no reason to remove the clippings from the grass. A mulching mower can also be used.

2. **Regulate Fertilizer Usage**-Use a formula with time-release nitrogen to regulate the rate at which grass grows. The faster it grows, the more potential waste it produces in the form of clippings, and the more energy it requires in frequency of cutting.

3. **Compost Leaves, Plant Trimmings, and Grass Clippings**-This can be done in conjunction with the food waste composting efforts.

Appendix A

School - Atkinson
Date - 1/27/93
Attendance - 465 *

Menu

Breakfast - Cinnamon roll.
Lunch - Ham and cheese on bun and carrots.

Waste Classification	Weight (lbs.)	Volume (cu. ft.)	Percent by Weight	Percent by Volume
Breakfast	24	15	11	5
Lunch	100	78	47	26
Class/Office/Library	58	139	27	47
Bathroom	7	32	3	11
Kitchen Prep.	22	32	10	11
Total	211	296	98	100

School - Bridlemile
Date - 2/9/93
Attendance - 617 *

Menu

Breakfast - Fruit and pumpkin bread.
Lunch - Tacos and green beans.

Waste Classification	Weight (lbs.)	Volume (cu. ft.)	Percent by Weight	Percent by Volume
Breakfast	5	12	2	3
Lunch	77	98	37	29
Class/Office/Library	80	174	39	52
Bathroom	5	20	2	6
Kitchen Prep.	40	32	19	10
Total	207	336	99	100

* Includes faculty and staff.

Appendix A

School - Edwards
Date - 1/26/93
Attendance - 249 *

Menu

Breakfast - Banana bread.
Lunch - Quesadilla and salad-green.

Waste Classification	Weight (lbs.)	Volume (cu. ft.)	Percent by Weight	Percent by Volume
Breakfast	0	0	0	0
Lunch	42	38	42	25
Class/Office/Library	34	80	34	53
Bathroom	4	16	4	11
Kitchen Prep.	20	16	20	11
Total	100	150	100	100

School - George
Date- 2/3/93
Attendance - 645 *

Menu

Breakfast - Cinnamon roll.
Lunch - Chicken sandwich and potatoes.

Waste Classification	Weight (lbs.)	Volume (cu. ft.)	Percent by Weight	Percent by Volume
Breakfast	14	16	6	4
Lunch	94	161	44	36
Class/Office/Library	103	248	48	56
Bathroom	4	20	2	4
Kitchen Prep.	0	0	0	0
Total	215	445	100	100

* Includes faculty and staff.

Appendix A

School - King
Date - 2/4/93
Attendance - 790 *

Menu

Breakfast - Sausage wrap.
Lunch - Wiener wrap and potato salad.

Waste Classification	Weight (lbs.)	Volume (cu. ft.)	Percent by Weight	Percent by Volume
Breakfast	22	28	7	6
Lunch	202	128	59	26
Class/Office/Library	75	198	22	40
Bathroom	17	80	5	16
Kitchen Prep.	24	55	7	11
Total	340	489	100	99

School - Lane Middle
Date - 2/8/93
Attendance - 691 *

Menu

Breakfast - Fruit choice and cinnamon roll.
Lunch - Lasagna and french roll.

Waste Classification	Weight (lbs.)	Volume (cu. ft.)	Percent by Weight	Percent by Volume
Breakfast	20	28	7	6
Lunch	85	72	32	17
Class/Office/Library	124	224	46	53
Bathroom	16	70	6	16
Kitchen Prep.	24	32	9	8
Total	269	426	100	100

* Includes faculty and staff.

Appendix A

School - Stephenson

Date - 2/10/93

Attendance - 376 *

Menu

Breakfast - No breakfast.

Lunch - Chicken nuggets and rice pilaf.

Waste Classification	Weight (lbs.)	Volume (cu. ft.)	Percent by Weight	Percent by Volume
Breakfast	0	0	0	0
Lunch	75	119	46	32
Class/Office/Library	70	179	43	48
Bathroom	3	45	2	12
Kitchen Prep.	14	30	9	8
Total	162	373	100	100

* Includes faculty and staff.

Appendix B

**COST ANALYSIS
PAPER TOWELS VS. CLOTH ROLL TOWELS VS. AIR DRYERS**

The District is committed to an effective waste management program. Central to this plan is source reduction. Opportunities may exist to reduce the amount of waste generated by the District. The tipping fee at the Arlington landfill nears \$80 per ton. At these high costs it makes good sense to divert material from the landfill. The following table shows possible hand-drying replacements for disposable paper towels.

The study is for the Blanchard Education Service Center (BESC), Portland Public Schools main administrative office. The building contains 20 bathrooms and 30 sinks or approximately 55 paper towel dispensers. Costs are based on a total usage of 4800 paper towels per day or 1920 hand-dries per day (4800 / 2.5, the average number of towels used per hand-dry).

	A	B	C
	PAPER TOWEL	CLOTH ROLL	AIR DRYER
(1) Materials for drying hands:	1.2 cases	19 rolls	37 kwhrs
(2) Cost of material:	\$12.00	\$28.50	\$2.20
(3) Amount disposed:	31 lbs	nil	nil
(4) Disposal Cost:	\$1.25	nil	nil
(5) # of liners used:	20	nil	nil
(6) Cost of liners:	\$1.00	nil	nil
(7) Capital investment for 55 units:	nil	nil	\$13,750.00
(8) Installation for 55 units:	nil	nil	\$13,750.00
(9) Maintenance:	nil	nil	\$1.35
(10) Custodial servicing costs:	\$6.00	\$2.80	nil
(11) Water used in manufacturing:	250 gal	n/a	nil
(12) Btu's of energy used:	225,000	n/a	nil
(13) Pollutants:	2.4 lbs	n/a	nil
(14) Recycled content:	40% post-consumer	nil	nil
(15) Pre-tax payback:	nil	nil	6.8 years
(16) TOTAL COST PER DAY:	\$20.25	\$31.30	\$3.55

EXPLANATIONS:

- 1a. 1.2 cases - based on average restocking of supplies. 290 cases ordered for BESC in fiscal year 1991-92
- 1b. 19 rolls - based on 4800 (# of paper towels used per day) / 2.5 (average # of towels used per hand-dry = 1920 (# of hand-drys per day) * 16 (average # of inches per hand-dry) / 1620 (# of inches per roll)
- 1c. 37 kWhrs = 1920 (# of hand-drys per day) * 30 (# of seconds to dry) / 3600 (seconds per hour) * 2.3 (KWHr)
- 2a. $\$12.00$ - based on 1991-92 bid; 1 case of paper towels costs $\$9.90$ * 1.2 (# of cases used per day at BESC)
- 2b. $\$28.50$ - based on 19 cloth towel rolls * $\$1.50$ (cost per roll)
- 2c. $\$2.20$ - 37 kWhrs * $\$.06$ (cost per kwhr)
- 3a. 31 lbs - 1 case of paper towels weighs 26 lbs
- 4a. $\$1.25$ = 31 lbs (weight for 1.2 cases) / 2000 (lbs per ton) * $\$80.00$ (cost to dispose of ton of waste)
- 5a. 20 - based on the number of restrooms serviced every day
- 6a. $\$1.00$ = 20 (# of restrooms) * $\$.05$ (cost per liner)
- 7c. $\$13,750$ is based on 55 units (# of paper towel dispensers at BESC) @ $\$250$ per unit (cost per unit)
- 8c. $\$13,750$ is based on 55 units (# of paper towel dispensers at BESC) @ $\$250$ per unit (8 hours labor, $\$30$ in materials)
- 9a. $\$1.35$ based on 1 hour of service per month or .05 hours per day @ $\$27$ per hour
- 10a. $\$6.00$ based on 1/2 hour per case to restock dispenser, empty trash, and bring trash to compactor
- 10b. $\$2.80$ based on 1 minutes to load cloth roll towel
- 11a. 250 gal - $24,000$ gal of water per ton of paper and $9,600$ gal per recycled ton of paper
- 12a. 225,000 - based on 28 million Btu's of energy per ton of paper and 7 million Btu's per recycled ton of paper
- 13a. 2.4 lbs - based on 300 lbs of pollutants per ton of paper and 75 lbs per recycled ton
- 14a. James River, Camas Mill
- 15c. 6.8 years - based on savings of $\$16.7$ per day from avoided paper costs

