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A NEW APPROACH TO CONDUCTING MSW COMPOSITION STUDIES

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ABSTRACT

Historically, municipal solid waste (MSW) composition studies have been conducted on waste streams using small samples (200-300 lbs.) for analysis. There has been considerable concern that a 200-300 lb. sample would not be representative of the daily waste flow from a typical municipal waste stream. Licata Energy & Environmental Consultants, Inc. was retained to conduct a waste composition analysis for a Town that generates approximately 800 tons of MSW per day. The analysis was used to optimize the design of a materials recovery facility for unsorted MSW (dirty MRF) and determine the quantity of recoverable material in the waste. The study was important to the project economics since the Town already had in place an effective curbside recycling program.

The authors designed and conducted a test program in which a 20 ton daily average sample was sorted into 23 components each day over a 10 day period. Both residential and commercial waste streams were analyzed using an existing MRF and an experienced sorting crew. The use of mechanical and manual sorting of the daily sample took an average of 10 hours per day and resulted in an analysis that had a high level of confidence in the detailed composition of the two streams.

BACKGROUND

In 1993, the Town of Brookhaven issued a request for proposals (RFP) for design, construction, operation, and ownership of a 900 T/D dirty MRF. A dirty MRF is a recycling process that receives raw waste without any source separation at the point of collection. The purpose of the proposed MRF was (1) to reduce the amount of waste going to the Town of Hempstead's waste-to-energy plant at a cost of over $112/ton and thereby reduce the Town's waste disposal cost, (2) to develop a compostable feed stock to comply with the permit condition to expand the Town's current landfill and comply with its Solid Waste Master Plan, and (3) to increase the amount of recycling in the Town to augment their existing curbside recycling program that collects metal and plastic containers, and newspapers (ONP).

The RFP stated that the Town would not take any responsibility for the waste composition or for changes in the composition during the proposed 20 year contract. The Town's RFP provided results of several independent waste composition studies conducted at their landfill. Four of the studies were done by the classical method of taking 200-300 lb. samples and conducting a hand sorting of the components into 12 to 16 categories. These studies were conducted in the late 1980's before the Town set up its curbside recycling program.

A fifth study, using an innovative technique, was conducted in September of 1992 after the Town had fully implemented its curbside recycling program. This survey relied upon a visual inspection supported by photographic backup to make estimates of the waste composition. In this program, the waste from an entire truck (about 8 tons) was spread out over a concrete pad and the engineers for the Town walked through the pile to make their visual estimates. The residential and commercial waste then was broken down into 32 categories. This test was conducted over a 5 day period and by using this method, the Town's engineers could survey 4 or 5 trucks per day.

The principals involved in the project did not believe that the available waste composition studies adequately answered the questions raised concerning the technical and economical viability of this project. In addition, previous survey methods did not reflect the newer technologies employed in today's MRFs for the sorting of recyclables. Star Recycling, Inc., the contractor selected to build, own, and operate the facility, wanted a greater level of confidence that there was still an economically recoverable amount of recyclable material(s) left in the waste after the curbside recycling program. In addition, they required data to optimize the staffing of the MRF. The design engineers needed data to optimize the design split between hand sorting and mechanical equipment and the financial community, which would support the project with revenue bonds, needed assurance that the project was economically viable. In addition, the New York State Department of Environmental Conservation (DEC) wanted to be assured of the viability of the project or they would not issue a permit to construct the facility.

Many concerns raised were based on the economic failure of the dirty MRF project in the nearby Town of Babylon that occurred during the RFP process for Brookhaven. The principals wanted to conduct a new waste composition study that reflected the components of Brookhaven's waste stream and determine to what extent they were recoverable. The visual method the Town's engineers had employed would not be acceptable to many of the principals involved, primarily because there was no historical base for this procedure.

The authors undertook a literature survey of the various methods used over the past 40 years. Most of the surveys conducted over this period were basically the same i.e., hand sorting 200-300 lb. samples. One survey conducted by Hollander and others in 1979 did sort 6.5 tons per day for 5 days. In his report, Hollander made a strong case for the sorting of larger samples and the need for waste characterization studies. The following is a summation of Hollander's perspective on waste characterization:

"Any system employed to process wastes must have the inherent flexibility to cope with the variability of its character. However endeavoring to characterize wastes, particularly municipal wastes, is akin to focusing on a target moving erratically in three dimensions. There are myriad influences and of fluctuating intensity, continually altering the quantity, composition and physical/chemical character of the material. The intensity of the influences can vary from Community to Community, from within the Community, from year to year, from season to season and even from day to day. Consequently 'defining' the specific nature of transitive municipal waste could become illusory.

"However, there must be a basis for economic analysis, design and subsequent operation with prescribed expectations accounting for the variability in the material as it may be encountered. Although particularly significant when embarking on a new program for processing wastes for recovery of the inherent material and/or fuel resources or thermal reduction with/without energy recovery, actual characterization of the wastes can also be very informative for continuing operations of existing facilities where optimization is an objective or monitoring is desired to avoid system malfunction....

"... Since there were no standard methods, procedures or programs, each investigator resorted to his own devices, ingenuity, resourcefulness and expediency in satisfying the current need for information and data. Consequently correlations of the data obtained by many investigators having employed an array of techniques and procedures for differing assortments of constituents still prompts misgivings regarding the confidence level in the information reported.

"The focus of uncertainty is considered to reside in the selection of samples for characterization which can be deemed representative of the large mass of material encountered each day and in part in the analysis technique(s).

"Some investigators endeavored to characterize 'their own household discards' with the expectation that they would be typical of the Community. Others had sorted and characterized crane bucket loads of material randomly drawn from an incinerator pit . . . or endeavored to obtain grab samples from newly dumped loads of material on a tipping floor or landfill. The size of each grab sample, the number of samples and the location taken from the mass of material were areas of uncertainty in establishing the credibility of the data generated with reproducibility of the data being the objective.

"Statistical analyses have been made and reported by several researchers regarding the efficacy of drawing upon many samples of small size (200-300 lbs.) for determining waste composition and subsequent chemical analysis. Although there is apparent recognition that these as-discarded, heterogeneous materials are coarse sized, fine sized, dense, compressible, loose, bagged or boxed, do not have granular characteristics, will not flow, will not blend, will segregate, the cone and quartering technique is nevertheless employed frequently to obtain 'the representative sample' for analysis. The sample selection technique is highly dependent on crew judgement and can easily become inadvertently biased."

Unfortunately, since this report was issued 15 years ago there have been no new initiatives towards resolving the uncertainty in waste composition studies.

The principals involved in the Brookhaven project established a criteria they wanted to utilized in establishing a program to characterize the Town's waste stream.

1. The size of the sample had to be statistically significant. A goal of a 20 ton sample per day for the duration of the test period was established. This represented 2.5% of the total waste stream.

2. A minimum of one week's data would be collected to determine the daily variation. A second week's data was desirable for redundancy.

3. A combination of hand sorting and mechanical separation was needed to simulate actual MRF operations. One principle of the

program was to use as much hand sorting as possible so that a comparison could be made with the data base from past studies. This eliminated using a totally mechanical system for sorting the waste.

4. A compostable fraction from the yard waste and mixed waste had to be obtained for pennit and economic reasons.

5. The differences between residential and commercial waste had to be determined. The criteria required that both fractions be analyzed separately and that estimates of the projected waste compositions could be made by taking various proportions of residential and commercial waste from different areas within the Town. This was significant to the Town and Star since there was concern that a significant portion of the commercial waste could increase or decrease depending on the outcome of various court rulings on flow control.

6. The study had to be conducted within a short period of time due to contract negotiations and the results had to be included in the Town's Contract with Star. This eliminated the possibility of determining seasonal variations. Seasonal variations would be done by primarily adjusting the yard waste component and by using past studies with seasonal variations as guidelines.

Therefore, a new approach was developed that took into consideration the objectives outlined above. The survey method developed to achieve these goals is described in the following sections.

INTRODUCTION

The waste composition study was conducted to provide a commercial scale testing program to validate the current composition of waste generated and collected within the Town of Brookhaven, N.Y., less the materials from the Town's mature curbside recycling program. The results of this study would be used to update inputs to augment and fine tune the project's economic analysis and assist in the design of a waste recycling and processing facility proposed by Star Recycling, Inc., Brooklyn, N.Y. Furthermore, the test program would serve to confirm the 1992 estimated composition of the Town's waste and would also provide valuable information on the day-to-day composition variations of the Brookhaven waste stream. Since test was conducted during a heavy yard waste collection period (grass clippings, leaves, and yard cleanings), it would also serve to determine if a composting program would be a viable option for the Town.

One of the major concerns when conducting any waste composition study is the ability to obtain a statistically large enough sample. For this program, approximately 20 tons per day of waste (which is about 2.5% of the Town's waste stream) would be provided by Brookhaven for testing and analysis. This size sample was taken daily over a period of 10 consecutive weekdays from October 25 to November 5, 1994. It was predicted that statistically, this procedure would result in a sample size that would achieve a precision of 10% with a 95% confidence level and would be representative of the total waste stream during the program including the day-to-day composition variations.

Upon delivery at the test site, the waste stream was sorted into eight major categories i.e., paper, plastic, glass, metal, yard waste, organics, other inerts, and remains. These categories were further subdivided into a total of 23 categories. The waste was sorted to reflect the composition of the current waste stream less the materials from the Town's mature curbside recycling program.

This study was unique in that a large sample was sorted, and a mechanical and hand-picking system was utilized to categorize the waste. In addition, the sorting technology used simulated the technology that would ultimately be utilized in the proposed full-scale Brookhaven facility.

STUDY METHODOLOGY

Town Collection Practices

The Town of Brookhaven is located in central Suffolk County, Long Island, New York. It is the largest town in Suffolk County with a population of 407,977 covering an area of some 326 square miles. The Town owns a landfill, a transfer station, and a Materials Recovery Facility (MRF) which receives and processes commingled source-separated recyclables. In addition, the Town operates two leaf composting facilities. Oversized bulky waste is disposed of at the Town's landfill and all other non-recyclable waste is transferred to the Town of Hempstead's waste-to-energy facility.

In 1988, the Town Board implemented a Town-wide Refuse Collection and Recycling Improvement Area for the collection of residential waste and recyclables, and this area was divided into 35 subdistricts. Private haulers collect and deliver residential waste to the transfer station four days a week (Monday, Tuesday, Thursday and Friday) while recyclables are collected only on Wednesday. The Town alternates recyclable Wednesday pickups with newspaper and cardboard picked up one week, and commingled containers collected on the alternate week. Commercial waste is collected by private haulers six days a week and is brought to the Town's transfer station.

The Town utilizes the services of approximately 35 different collection companies for its geographic area. Of these, 20 carters were selected to participate in the study by the Town's waste management consultant, Dvirka & Bartilucci, since they had dedicated residential or commercial routes that could be identified by truck number. Dvirka & Bartilucci designed a random number generator analysis based on 20 carters using a total of 80 trucks that normally deliver waste to the Town's transfer station. A different random numbering system was generated for each of the 10 days, thereby increasing the likelihood that the samples would cover the waste from different areas of the Town.

Since the capacity of the trucks used by the carters ranged from 3 to 10 tons, three to six selected trucks from this sample group were used to provide the needed quantity for the test. Waste from the selected trucks was dumped at an isolated section of the Town's transfer station. This material including oversized bulky waste (OBW) was then mixed by a front-end loader. The operator, based on his experience, selected approximately 20 tons from this mixed pile and loaded it onto a transfer trailer (100 yard capacity). The waste was delivered to the test site at Star's waste processing and recycling facility, BQE Services, Inc., in Brooklyn. The actual test sample loads averaged 21.49 tons with a range of 13.25 tons to 31.77 tons.

During the 10 day test period, the transfer trailer delivered residential waste to the test site on Monday, Tuesday, Thursday and Friday while the commercial waste was delivered only on Wednesday.

Historically, commercial waste makes up 20 percent of the waste delivered to the Town's transfer station. Therefore, it was reasonable to sample the commercial waste only one day a week which would be approximately 20 percent of the total. By proportioning the residential and commercial waste stream, a complete picture of the separate waste streams, as well as the total waste in the Town, could be obtained.

Waste Separation

In order to effectively sort and categorize approximately 20 tons per day of municipal solid waste, a special facility was required. Star's mixed waste and recycling processing facility, BQE Services, Inc., has the capability to sort and recycle mixed recyclables at the rate of 25 tons per hour. With modifications to the operating procedure of this facility, it was used as the test site to sort and categorize the daily 20 ton average sample.

Using this facility had an additional advantage in that it had certain features similar to the technology proposed for Star's Brookhaven facility. The sampling process is illustrated in Figure No. 1. Certain equipment at BQE such as the eddy current separator and glass separation equipment were not used. The use of this equipment would have limited the ability to recover some products due to limited conveyor capacity.

Since the object of this study was to determine the actual composition of the waste stream, the inclined and picking conveyors were run at a low speed in order to sort as many identifiable items as possible by category. When the pickers could not keep up with the feed rate, the belts were stopped to provide additional time for picking and sorting.

The transfer trailer containing the waste collected from the Town's transfer station was weighed upon entering the facility. The waste was dumped onto a designated cleaned area of the tipping floor in order to prevent commingling with other waste. The transfer trailer was again weighted upon existing the facility to determine the exact amount of waste used in the daily testing.

On the tipping floor, over sized bulky waste (OBW), bagged yard waste, wood and large pieces of corrugated cardboard (OCC) were sorted and weighed. Two sorters were assigned full time to the tipping floor for this portion of the operation. The remaining waste was then fed into a hopper by a mobile grapple and entered a trommel that was 18 feet long and 7 feet in diameter, with a 5° slope, and rotated at 14 RPM. This trommel was split into three 6 foot sections with 1", 1" and 2" holes to remove fines, glass, and organics and was equipped with spikes to serve as bag openers.

The unders fraction from the three sections of the trommel were dropped into Container 1 which was weighed on the truck scale at the completion of the day's testing. The contents of Container 1 were to be used as the basis for the compost feedstock determination for the full-scale project. Therefore, it was important to the study to determine the amount of compost feedstock and the composition of this stream that could be separated using a trommel.

Container 1 was then returned to a cleaned tipping floor and the contents dumped. The mobile grapple was used to thoroughly mix the pile of trommel unders material. Approximately 10 to 12 samples from various locations in the pile were collected using a quartering technique with a shovel. The samples were placed into 15 gallon cardboard containers lined with plastic garbage bags and sealed to prevent spillage and moisture loss. The unders sample containers were again mixed and divided into three samples using a quartering technique. One sample was sent to the on-site Star laboratory for analysis. The second sample was given to the Dvirka & Bartilucci representative. The third sample was retained as a spare. The sample was analyzed to determine the percent by weight of glass, organics, inerts, yard waste, and moisture.

The overs from the trommel were directed to the upper building level via an inclined conveyor and dropped onto a picking conveyor where the recyclables and other items were recovered by hand and sorted into hampers and/or chutes. Various sized hampers used to hold the sorted waste were numbered and tare weights were determined before the start of sorting and loading. As these hampers became full, they were weighed and removed from the test area so that no cross contamination could occur between testing days. The materials hand sorted into the chutes were baled and weighed at the end of each day. The residue and unsorted materials from the picking stations that remained on the conveyor belt were dropped into residue Container 3. This container was weighed at the end of the day on the truck scale.

As was the case for Container 1, Container 3 was returned to the cleaned tipping floor and the contents dumped. The mobile grapple was used to thoroughly mix the pile of residue material. Approximately 4 to 6 samples from various locations on the pile were collected using a quartering technique. This composite sample of 100-150 lbs. was placed into a large hamper and moved to the sorting area. This residue sample was placed on a table and thoroughly sorted by hand into the same 23 categories as the materials from the picking conveyor.

Some of the recovered components from the composite residue sample required a laboratory scale to insure accurate weighing. Other components i.e., contaminated paper were weighted on an industrial scale with a 0.1 lb. detection limit.

After the weight of each of the components in the residue sample was determined, a calculation was made to proportion the weight distribution based on the percentage of the entire Container 3 weight. The proportioned component weight from Container 3 was added to the component analysis of materials sorted on the tipping floor and picking stations.

Ferrous metals were removed from the picking conveyor using a magnetic separator. The ferrous metals were then dropped into a chute and directed into Container 2 where it was weighed at the end of the day on the truck scale. Heavy ferrous products i.e., tire rims were hand picked and added to Container 2. Other metals i.e., aluminum beverage cans, aluminum foil, and other non-ferrous metals were hand sorted into hampers and weighted.

The Fall season of 1994 in the New York area was unusually warm and it extended the yard waste collection season (grass clippings and leaves) well into November. Due to the warm weather, the study did not reflect the normal Fall yard waste collection season based on previous studies conducted on Long Island. This study indicated that up to 30% of the residential waste and an overall average of 22.85% was yard waste (see Table 1A). Prior studies for the month of November typically reported 10% yard waste collection. Since the yard waste component was identified, and studies from Brookhaven and other Long Island communities had previously identified yard waste on a seasonal basis, by proportioning the residential/commercial and yard waste components, an estimate of the annual compostable feedstock could be made.

Materials Sorted

The following items were sorted from the waste streams:

Paper
1. Corrugated cardboard
2. Newspaper
3. Mixed paper
4. Mixed soiled paper

Plastics
5. HDEP (#1)
6. PET (#2)
7. Mixed colored (other than HDEP and PET)
8. Plastic film
9. Other plastics

Glass
10. Recyclable (pieces larger than 6")
11. Unrecyclable (pieces less than 6")

Metal
12. Aluminum cans
13. Other aluminum (foil, etc.)
14. Ferrous metals
15. Other metals

Yard Waste
16. Leaves, grass, brush

Organics
17. Food waste, other organics
18. Wood waste
19. Textiles/leather/rubber

Other Inerts
20. Inert solids/rocks & dirt
21. Oversized Bulky Waste

Remains
22. Unidentified Residue
23. Diapers

Diapers were only considered as a separate category (No. 23) for one day's testing (November 2, 1994). This was due to the fact that the client added this category after the test had begun in order to determine if there was sufficient quantity to support a diaper recycling program. The November 2 commercial waste stream included collection of waste from a nursing home. The diapers from this collection were reported to represent 0.077 % of the total commercial waste stream. On all other days, the diapers were included in the mixed solid paper category.

Staffing

The project team anticipated testing an average of 20 tons per day, however, the actual test sample loads averaged 21.49 tons with a range of 13.25 tons to 31.77 tons. An average of 10 hours per day was needed to sort and process the waste stream with a range of 9 hours to 14 hours depending on the tonnage delivered.

The test used the services of part-time and full-time experienced heavy equipment operators, a full-time sorting crew, and two BQE Services, Inc. supervisors. Experienced personnel hand sorted the unders and residue, and maintained data entry records. Licata Energy and Environmental Consultants personnel supervised all operations with support from Dvirka & Bartilucci.

The sorting procedures used the services of the following personnel during this test:

Operations	Waste	Number of Personnel
Quality Control	All areas	2 supervisors - full time
	All areas	2 engineers - part time

Tipping Floor	OBW, wood, yard waste, OCC	1 front-end loader - part time 1 forklift operator - part time 2 sorters - full time 1 truck driver - part time
Mobile Grapple	Waste Separation and Loading of Trommel	1 operator - full time
Hand Pickers	Trommel Overs	10 sorters - full time
Hand Sorting	Unders and Residue	4 engineers - part time
Data Entry (Weighing, Categorizing)		1 engineer - full time 2 engineers - part time

Waste Sorting and Analysis

The composition of the Brookhaven waste was determined based on the processing of the waste delivered over 10 working days from October 25 to November 5, 1994. The determination was based on weighed quantities of components manually sorted on the tipping floor and the picking conveyor, and the material removed by the ferrous metals magnet. In addition, analysis of samples collected from the screenings from the trommel unders (Container 1), and the residue from the picking conveyor (Container 3), provided data from which a component analysis of the waste received could be constructed.

The analysis of the residue collected in Container 3 was added to the manually sorted weights and magnetically removed ferrous metals in order to obtain the mass balance summary of results presented in Table 1A, Table 1B, Table 2A and 2B.

The trommel unders were analyzed in order to provide additional details on the composition of the incoming waste. The breakdown of the analysis of this material, based on daily samples analyzed in the on-site Star Recycling Quality Control Laboratory, is presented in Table 3.

One portion of the samples of the trommel unders was analyzed for moisture content, organic matter by loss on ignition, and non-organic matter after ignition. The average moisture was approximately 40%, organic matter approximately 35%, and inert residue approximately 25% of the residential waste samples. Sieve analysis was then performed on another portion of these 10 samples. They were screened and hand sorted in order to determine glass content and yard waste, as well as any other organic and inert components. The test determined that glass represented about 6% of the trommel unders.

Identifiable yard waste averaged about 37% of the as-received trommel unders. Other organic materials which did not pass through the #10 mesh screen and could not be identified as yard waste were classified as "other organics" and averaged about 32% of the as-received trommel unders. The fine screenings (minus #10-mesh) that could not be identified as yard waste were classified as inerts based on a predominance of this type of material. They averaged approximately 25% of the as-received trommel unders.

To complete the material balance of the Brookhaven waste, the identifiable yard waste was added to the yard waste removed on the tipping floor and identifiable in the Container 3 residue. In addition, the glass content of the trommel unders was added to the glass picked and identified in Container 3 residue. The unidentifiable yard waste which did not pass through the #10 mesh screen was added to the other organic material identified in the Container 3 residue. Finally, the inert content of the trommel unders was added to the inert material identified in Container 3 residue.

Discussion: Precision at 95% Confidence Limit

The design of the test program was intended to achieve a precision of about 10% in the estimates of composition of the marketable components of the waste stream at a 95% confidence level. This can be translated into a statement that the average (or mean) percentage of a component will not be more than 10% greater than or less than the mean, 95% of the time, or in 95 out of 100 samples taken.

The procedure used by Hollander in his study found that newspaper was 8% of the residential waste stream, with a standard deviation of 0.73, or a coefficient of variation of 9%. For the 5 full-truck samples which were sorted, the student "t" would be 3.0. The calculation of precision is as follows:

Standard error = Sx x t $\sqrt{}$n-1 = 0.73 x 3.0/(2.645) = 0.828

Precision = (Standard error)/(mean) = 0.828/8-0 = 10.35 % of the mean.

The Star Recycling test found that newspaper averaged 4.973% of the waste with a standard deviation of 1.059. The number of samples of residential waste was seven days x three trucks per sample, or 21 trucks sampled: "t" is 2.09. The calculation is as follows:

Standard error = Sx x t $\sqrt{}$n-1 = 1.059 x 2.09/(4.472) = 0.4949

Precision = (Standard error)/(mean) 0.4949/4.973 = 9.95 % of the mean

The objective of achieving a precision of 10% has been achieved by both procedures, as illustrated above.

The procedure recommended by Britton in 1972, was to take samples of 90 to 130 kg, or about 240 lbs. Using Britton's data, a graph was developed by Hasselriis to determine the number of 200-300 lb. samples required to obtain a given precision given the percent of the component in the waste. Using this graph, a component of 5% would need about 200 samples (extrapolated) to attain a precision of 10%. This means that 200 samples totaling 25,000 lbs. of waste would have to be sorted using Britton's procedure to obtain the level of confidence required. The procedure used for this test sorted seven samples of about 40,000 lbs. each, achieving this precision, but having the benefit of simulating the dirty MRF which was planned.

STUDY RESULTS

Two of the goals of this study were to optimize the design and staffing of the proposed facility, and demonstrate the viability of using a dirty MRF to augment an integrated waste management plan that included a curbside collection program and a waste-to-energy facility.

Based on the study, the following changes were made to the MRF design:

1. The proposed design for the MRF had a trommel with 2" holes in the first section. To increase the compost feed fraction, the holes were enlarged to 3" in the final design.

2. Due to the unexpected amount of paper in the waste stream, 4 additional picking stations were added to the final design.

Based on the annual input of 200,000 tons of mixed residential waste (80%) and commercial waste (20%), the following materials were projected to be recovered from Brookhaven's waste stream:

Materials	Tons/Year
Corrugated Cardboard (OCC)	8,000 - 9,000
Newspaper (ONP)	5,000
Mixed Paper	800 - 1,000
Plastics (HDPE and PET)	3,000 - 4,000
Glass (for landfill cover)	2,500 - 3,000
Aluminum	1,100
Ferrous Metals	7,000
Wood	9,000 - 10,000
Mixed Waste Compost Fraction	50,000 - 70,000
Yard Waste for Compost	17,400

Table 4 presents a comparison of the results of this study and the 1992 visual study. This Table also presents a normalized waste composition adjusted for yard waste composition based on prior studies. This study plus an optimized design demonstrated to the project principals that the economics of this dirty MRF would be viable.

CONCLUSIONS

By using a combination of mechanical equipment and hand sorting by an experienced staff, the study provided a representative sample of the Town's waste stream that met the requirements of the owner and engineers to optimize the design of the proposed MRF.

The procedure employed for the testing of the Brookhaven waste stream at Star's BQE facility resulted in the determination of the composition of residential waste which provided a higher level of confidence than that from the previous testing procedures using visual inspections and 200 lb. samples. This is because the waste from three to six trucks was mixed to form the samples, combined with the total sorting of this mixed sample, and the use of a random sampling procedure to select the trucks, such that a representative portion of the entire waste stream had a good chance of being represented in each test sample.

In spite of the fact that fewer samples of commercial waste were obtained and analyzed, it must be considered that this smaller quantity can be averaged into the overall average by weight proportioning. It should also be noted that even though fewer samples were sorted, the high accuracy level calculated from the residential samples resulting from using the same full-load sorting procedure, should also apply to the commercial data.

The results of the study also indicate that both the waste composition and daily variations had changed somewhat since the completion of the 1992 Brookhaven waste composition study. However, the study did indicate that although the waste composition had changed, sufficient recyclable materials were present in the waste stream to justify the implementation of the waste recycling and processing facility proposed by Star for the Town of Brookhaven, as well as the viability of a yard waste/composting operation.

Unfortunately, at the time of the writing of this paper, the Brookhaven project has not proceeded due to various political changes in the Town, changes to the pricing structure at the Town of Hempstead's waste-to-energy plant, and uncertainty over flow control.

The waste composition analysis method described in this paper has subsequently been employed at two other MRF sites. In one case, it was used to resolve a contractual dispute between an owner and operator. In the second case, the test method was used to identify operational problems and to establish criteria to make changes to equipment and operational procedures.

ACKNOWLEDGEMENT

This study was undertaken with only a minimal amount of time to set up for an untried sampling methodology. The successful completion of the study was due to the efforts of the Town of Brookhaven; Dvirka & Bartilucci, Brookhaven's engineers; Star Recycling, Inc.; and Black & Veatch, Star's turnkey contractor.

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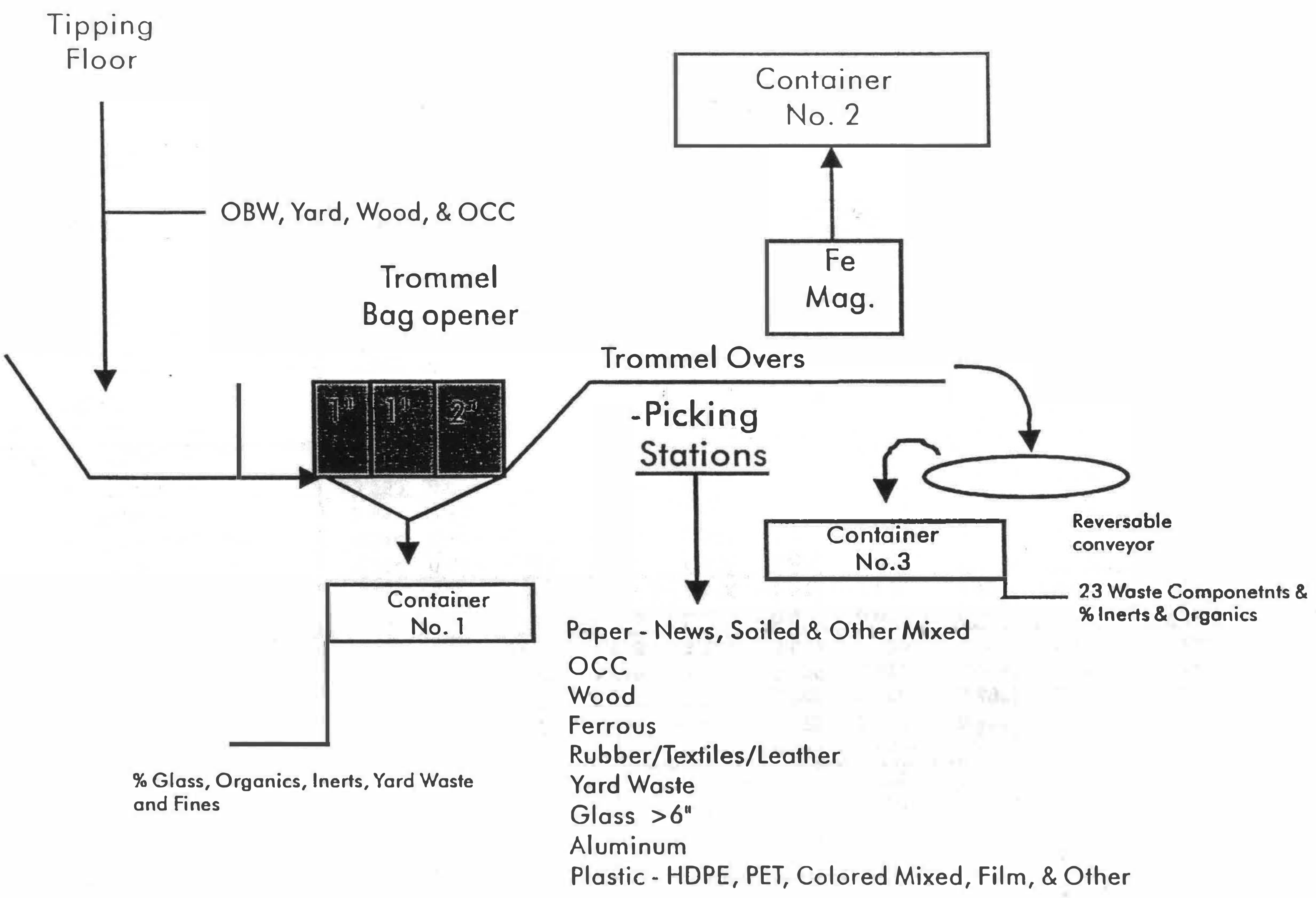

Fig. 1 BQE Recycling System

TABLE 1A
SUMMARY OF RESULTS - RESIDENTIAL WASTE

Type	Component	Test 1	Test 2	Test 5	Test 6	Test 7	Test 9	Test 10	Average	Std.Dev	Coef. of Variation	Sum of AVG
Paper	1. OCC	4.073	4.009	3.370	4.134	5.891	3.697	4.065	4.177	0.803	0.192	26.852
	2.ONP	5.267	4.068	4.223	5.655	4.442	4.203	6.953	4.973	1.059	0.213	
	3.Mixed paper	0.522	0.000	1.233	0.783	0.879	2.724	1.823	1.138	0.900	0.791	
	4. Mix soiled paper	21.969	15.153	18.109	17.979	18.521	13.501	10.718	16.564	3.719	0.225	
Plastics	5. HDPE	0.111	0.059	0.124	0.136	0.190	0.241	0.081	0.135	0.063	0.467	8.953
	6. PET	0.127	0.118	0.132	0.155	0.206	0.125	0.106	0.138	0.033	0.241	
	7.Mixed colored	0.395	2.123	0.119	0.140	0.309	0.080	0.282	0.493	0.728	1.478	
	8. Film	6.009	5.660	3.882	4.645	5.210	5.135	6.001	5.220	0.770	0.147	
	9. Other	0.822	1.356	3.660	4.978	3.809	3.014	3.132	2.967	1.441	0.486	
Glass	10. Recyclable	0.732	0.000	0.000	0.000	0.000	0.000	0.000	0.105	0.277	2.646	1.899
	11. Unrecyclable	1.987	1.568	1.540	2.364	1.758	1.688	1.654	1.794	0.292	0.162	
Metal	12. Aluminum Cans	0.274	0.649	0.175	0.068	0.166	0.080	0.063	0.211	0.208	0.985	4.711
	13. Other Aluminum	0.844	0.177	0.247	0.337	0.245	0.257	0.958	0.438	0.321	0.734	
	14. Ferrous	6.697	2.535	2.747	3.552	2.882	2.290	4.153	3.551	1.526	0.430	
	15. Other metals	3.280	0.059	0.239	0.000	0.000	0.000	0.000	0.511	1.224	2.395	
Yard Waste	16. Leaves, grass	16.011	30.389	20.102	19.015	20.429	23.370	30.644	22.851	5.668	0.248	22.851
Organics	17. Food waste -2"	9.085	11.120	11.885	15.773	15.647	11.259	8.507	11.897	2.872	0.241	21.193
	18. Wood	4.869	5.778	8.003	4.641	3.421	5.103	5.688	5.358	1.405	0.262	
	19. Textiles/leather/rubber	2.965	4.127	3.733	4.010	4.656	3.468	4.610	3.938	0.608	0.154	
Other	20. Inerts, rocks & dirt	8.454	8.809	12.632	7.974	6.430	8.085	7.072	8.494	1.998	0.235	12.930
	21. OBW	4.776	1.651	3.711	3.181	4.751	9.724	3.257	4.436	2.563	0.578	
Remains	22. Unidentified	0.732	0.590	0.132	0.480	0.158	1.957	0.232	0.612	0.635	1.039	0.612
	23. Diapers	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m			
	Total	100.001	99.998	99.998	100.000	100.000	100.001	99.999	100.000			

Note: Test 4 not included due to lost residue sample

TABLE 1B
SUMMARY OF RESULTS - RESIDENTIAL & COMMERCIAL WASTE

Type	Component	Test 1	Test 2	Test 3	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10	Average	Std.Dev	Coef. of Variation	Sum of AVG
		R	R	C	R	R	R	C	R	R	R+C			
Paper	1. OCC	4.073	4.009	10.685	3.370	4.134	5.891	9.239	3.697	4.065	5.463	2.669	0.489	30.663
	2.ONP	5.267	4.068	4.953	4.223	5.655	4.442	5.807	4.203	6.953	5.063	0.959	0.189	
	3.Mixed paper	0.522	0.000	0.690	1.233	0.783	0.879	1.478	2.724	1.823	1.126	0.804	0.715	
	4. Mix soiled paper	21.969	15.153	25.054	18.109	17.979	18.521	30.098	13.501	10.718	19.011	5.962	0.314	
Plastics	5. HDPE	0.111	0.059	0.306	0.124	0.136	0.190	0.192	0.241	0.081	0.160	0.079	0.497	9.128
	6. PET	0.127	0.118	0.111	0.132	0.155	0.206	0.153	0.125	0.106	0.137	0.031	0.225	
	7.Mixed colored	0.395	2.123	0.056	0.119	0.140	0.309	0.176	0.080	0.282	0.409	0.653	1.596	
	8. Film	6.009	5.660	5.593	3.882	4.645	5.210	6.412	5.135	6.001	5.394	0.778	0.144	
	9. Other	0.822	1.356	3.022	3.660	4.978	3.809	3.463	3.014	3.132	3.028	1.259	0.416	
Glass	10. Recyclable	0.732	0.000	0.000	0.000	0.000	0.000	0.245	0.000	0	0.109	0.247	2.279	1.912
	11. Unrecyclable	1.987	1.568	3.339	1.540	2.364	1.758	0.337	1.688	1.654	1.804	0.792	0.439	
Metal	12. Aluminum Cans	0.274	0.649	0.245	0.175	0.068	0.166	0.352	0.080	0.063	0.230	0.186	0.807	5.331
	13. Other Aluminum	0.844	0.177	1.085	0.247	0.337	0.245	0.406	0.257	0.958	0.506	0.353	0.698	
	14. Ferrous	6.697	2.535	8.069	2.747	3.552	2.882	4.734	2.290	4.153	4.184	2.006	0.479	
	15. Other metals	3.280	0.059	0.111	0.239	0.000	0.000	0.000	0.000	0	0.410	1.079	2.633	
Yard Waste	16. Leaves, grass	16.011	30.389	2.643	20.102	19.015	20.429	0.368	23.370	30.644	18.108	10.631	0.587	18.108
Organics	17. Food waste -2"	9.085	11.120	21.621	11.885	15.773	15.647	4.114	11.259	8.507	12.112	5.052	0.417	21.297
	18. Wood	4.869	5.778	5.309	8.003	4.641	3.421	8.243	5.103	5.688	5.673	1.553	0.274	
	19. Textiles/leather/rubber	2.965	4.127	1.575	3.733	4.010	4.656	2.467	3.468	4.61	3.512	1.021	0.291	
Other	20. Inerts, rocks & dirt	8.454	8.809	2.643	12.632	7.974	6.430	0.766	8.085	7.072	6.985	3.489	0.500	13.020
	21. OBW	4.776	1.651	2.504	3.711	3.181	4.751	20.760	9.724	3.257	6.035	5.986	0.992	
Remains	22. Unidentified	0.732	0.590	0.384	0.132	0.480	0.158	0.115	1.957	0.232	0.531	0.577	1.086	0.531
	23. Diapers	n/m	n/m	n/m	n/m	n/m	n/m	0.077	n/m	n/m	n/m			
	Total	100.001	99.998	99.998	99.998	100.000	100.000	100.002	100.001	99.999	100.000			

Note: Test 4 not included due to lost residue sample

TABLE 2A
MASS BALANCE SUMMARY - RESIDENTIAL WASTE

WASTE	TEST	WASTE TYPE	TONS Scale/Sort		% DISTRIBUTION TIPPING	PICKING*	CONTAINER 1	CONTAINER 2	CONTAINER 3	COMMENTS
10/24/94	1	Residential	31.77	31.40	11.15	22.94	28.65	.86	36.39	
10/25/94	2	Residential	16.88	16.98	18.22	23.64	27.89	1.89	28.33	
10/27/94	4	Residential	21.89	21.88	21.86	21.70	26.87	3.43	26.09	See Note 1
10/28/94	5	Residential	24.56	23.44	19.79	24.83	29.09	2.09	24.18	
10/31/94	6	Residential	27.05	26.43	14.37	24.46	30.29	2.08	28.78	
11/1/94	7	Residential	13.34	12.62	17.57	30.09	28.61	2.06	21.85	
11/3/94	9	Residential	24.59	24.89	14.18	27.42	31.90	1.04	25.39	
11/4/94	10	Residential	15.55	15.97	22.49	27.52	26.25	1.75	21.99	
TOTAL		Residential	175.63	173.61	139.63	202.60	229.55	15.20	213.00	
AVG.			21.95	21.70	17.45	25.33	28.69	1.90	26.63	
Std. Dev.			6.29	6.18	3.98	2.79	1.81	0.78	4.71	
Coef. of			0.29	0.29	0.23	0.10	0.07	0.41	0.17	
10/26/94	3	Commercial	17.88	17.96	9.86	32.21	24.65	6.23	27.04	
11/2/94	8	Commercial	13.25	13.05	27.04	39.71	1.76	3.29	28.19	See Note 2

*Includes recyclable and non-recyclable materials.
Note 1: Container #3 sample was not analyzed due to lost sample.
Note 2: Trommel was out of service for most of the day of the test.

TABLE 2B
MASS BALANCE SUMMARY - RESIDENTIAL & COMMERCIAL WASTE

WASTE	TEST	WASTE TYPE	TONS Scale/Sort		% DISTRIBUTION TIPPING	PICKING*	CONTAINER 1	CONTAINER 2	CONTAINER 3	COMMENTS
10/24/94	1	Residential	31.77	31.40	11.15	22.94	28.65	0.86	36.39	
10/25/94	2	Residential	16.88	16.96	18.22	23.64	27.89	1.89	28.33	
10/26/94	3	Commercial	17.80	17.96	9.86	32.21	24.65	6.23	27.04	
10/27/94	4	Residential	21.89	21.88	21.86	21.70	26.87	3.43	26.09	See Note 1
10/28/94	5	Residential	24.56	23.44	19.79	24.83	29.09	2.09	24.18	
10/31/94	6	Residential	27.05	26.43	14.37	24.46	30.29	2.08	28.78	
11/1/94	7	Residential	13.34	12.62	17.57	30.09	28.61	2.06	21.85	
11/3/94	9	Residential	24.58	24.88	14.18	27.42	31.90	1.04	25.39	
11/4/94	10	Residential	15.55	15.96	22.49	27.52	26.25	1.75	21.99	
TOTAL			193.42	191.53	149.49	234.81	254.20	21.43	240.04	
AVG.			21.49	21.28	16.61	26.09	28.24	2.38	26.67	
Std. Dev.			6.04	5.91	4.50	3.48	2.16	1.62	4.40	
Coef. of Variation			0.29	0.29	0.23	0.10	0.07	0.41	0.17	
11/2/94	8	Commercial	13.25	13.05	27.04	39.71	1.76	3.29	28.19	See Note 2

*Includes recyclable and non-recyclable materials.
Note 1: Container #3 sample was not analyzed due to lost sample.
Note 2: Trommel was out of service on the day of the test.

TABLE 3
CONTAINER 1 - TROMMEL UNDERS ANALYSIS

BROOKHAVEN WASTE COMPOSITION STUDY TROMMEL UNDERS ANALYSIS					SIEVE ANALYSIS (AS RECEIVED)			
DATE	TEST NO.	MOISTURE	ORGANIC	INERT	YARD	OTHER	INERTS	GLASS
RESIDENTIAL								
10/24/94	1	26.50	28.55	44.95	38.2	26.7	29.5	5.6
10/25/94	2	39.94	38.35	21.71	50.4	25.7	18.9	5.0
10/27/94	4	39.43	36.16	24.41	37.3	35.8	20.9	6.0
10/28/94	5	32.04	46.73	21.23	22.9	31.9	39.9	5.3
10/31/94	6	44.79	32.13	23.08	29.3	38.7	24.2	7.8
11/1/94	7	50.62	36.37	13.01	32.3	41.4	20.1	6.2
11/3/94	9	46.22	32.19	21.59	40.5	30.5	23.7	5.3
11/4/94	10	39.79	29.39	30.82	43.3	27.4	23.0	6.3
Average		39.92	34.98	25.10	36.78	32.26	25.03	5.94
Std Dev		7.25	5.49	8.78	8.01	5.46	6.39	0.83
COMMERCIAL								
10/26/94	3	45.03	35.37	19.60	0.60	86.80		12.60
11/2/94	8	48.16	24.55	17.29	0.40	94.30		5.30
Average		46.60	29.96	18.45	0.50	90.55		8.95
Std Dev		1.57	5.41	1.16	0.10	3.75		3.65

TABLE 4
COMPARISON OF 1994 STUDY RESULTS WITH 1992 STUDY

MATERIAL CATEGORY		STUDY RESULTS - 1994		STUDY RESULTS - 1992		1994 Residential Adjusted to 1992 Yard Waste	1994 R & C Adjusted to 1992 Yard Waste		RFP Design Base
		Residential	R & C	Residential	R & C				
PAPER	Corrugated	4.18	5.46	9.30	13.30	4.83	6.09	34.19	35.50
	Newspaper	4.97	5.06	5.40	5.10	5.75	5.64		
	Mixed Paper	1.14	1.13	9.00	8.30	1.32	1.26		
	Mixed Soiled	16.56	19.02	12.10*	11.10*	19.15	21.21		
	Subtotal	26.85	30.67	35.80	37.80	31.04	34.19		
PLASTICS	HDPE & PET	0.27	0.30	1.50	1.30	0.31	0.33	10.18	12.30
	Mixed Color	3.46	3.44	7.00	6.60	4.00	3.84		
	Plastic Film	5.20	5.39	4.50	4.20	6.01	6.01		
	Subtotal	8.93	9.13	13.00	12.10	10.32	10.18		
GLASS	Recyclable	0.11	0.11	1.50	1.30	0.13	0.12	2.13	1.50
	Non-Recyclable	1.79	1.80	0.10	0.20	2.07	2.01		
	Subtotal	1.90	1.91	1.60	1.50	2.20	2.13		
METALS	Aluminum Cans	0.21	0.23	0.40	0.40	0.24	0.26	5.94	3.30
	Other Aluminum	0.44	0.51	0.30	0.20	0.51	0.57		
	Ferrous	3.55	4.18	0.90	0.80	4.10	4.66		
	Other Metals	0.51	0.41	0.30	0.30	0.59	0.46		
	Subtotal	4.71	5.33	1.90	1.70	5.45	5.94		
YARD	Yard Waste	22.8585	18.11	10.80	8.70	10.80	8.70	8.70	10.30
ORGANICS	Food	11.9090	12.11	11.11	13.00	13.76	13.50	13.50	13.10
	Wood	5.36	5.67	10.20	10.60	6.20	6.32	6.32	8.00
	Textiles	3.94	3.51	9.60	8.50	4.56	3.91	3.91	8.50
OTHER	Inerts & Dirt	8.49	6.99	2.90	1.90	9.82	7.79	15.12	7.50
	OBW	4.44	6.04	1.50	1.50	5.13	6.73		
	Residue	0.61	0.53	1.60	2.70	0.71	0.59		
TOTAL		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* - Includes Diapers