ATTACHMENT III

WASTE CHARACTERIZATION ACTIVITIES

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1.0 INTRODUCTION

Section 27-0107 of the New York State Conservation Law requires New York State planning units (counties and municipalities) to draft, and update at least decenially, a local Solid Waste Management Plan. Among the requirements of such local Solid Waste Management Plans are to "characterize the solid waste stream to be managed in the planning period." (New York State Environmental Conservation Law, Section 27-0107, Subsection 1.b.i.) In April of 2004, the Bureau of Waste Prevention, Reuse and Recycling (BWPRR) of the New York City Department of Sanitation (DSNY) contracted with a consulting firm to conduct a Citywide Waste Characterization Study (WCS). The preliminary phase of the WCS has been completed, fulfilling the State's requirement for the current New York City Solid Waste Management Plan. Follow-up phases to the WCS will provide more in-depth information on the DSNY-managed Waste stream.

The last Citywide waste characterization study was conducted in the City in 1989-1990. Over the past 12 years, the DSNY has conducted four smaller-scale waste composition studies of DSNY-managed refuse and recycling.[1] The results of these studies varied considerably because they examine different groups of waste generators served by DSNY. The results of the 1989-1990 study have been utilized in the preparation of the New SWMP, while the future results of the new Waste Characterization Study currently underway and outlined below will further inform the DSNY's solid waste management planning over the proposed planning period.

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1. For the DSNY's 1990 Waste Composition Study, see City Department of Sanitation, A Comprehensive Solid Waste Management Plan for New York City and Final Generic Environmental Impact Statement, Appendix Volume 1.1, Waste Stream Data, August 1992; and City Department of Sanitation Operations Planning Evaluation and Control, New York City Waste Composition Study 1989-1990 (four volumes). For the DSNY's Staten Island Waste Composition Study, see HDR Engineering, Inc., Report on Staten Island District 3 Waste Composition Analysis (June 1997). For the DSNY's Low-Diversion Districts Waste Composition Study, see City Department of Sanitation, Mixed Waste Processing in New York City: A Pilot Test Evaluation (October 1999). And for the DSNY's "suburban" neighborhood study, conducted for a backyard composting evaluation , see City Department of Sanitation, Backyard Composting in New York City: A Comprehensive Program Evaluation (June 1999).

In May and June of 2004, DSNY conducted a preliminary waste characterization study (PWCS) in which the curbside refuse and recyclables stream was characterized for the City as a whole. The results, summarized in Section 2.3.2 and detailed in the PWCS Final Report in Appendix D, describe the curbside waste stream in terms of its material composition and the breakdown of refuse vs. recycling streams. It is important to note that while this study was considered preliminary, the sampling procedures used ensure that its results are accurately characterize the curbside waste stream. In other words, enough samples of waste were taken to be confident – based on generally agreed upon statistical principles – that the results reflect what was in the refuse and recycling in May and June of 2004. The methods used to analyze the data conform to rigorous analytic standards, and the results have been calculated so as to objectively convey what was observed.

Phase I, scheduled for Summer 2004 through 2005, will re-examine residential waste to better understand how it varies by season and by housing density and income. It will also assess street-basket waste, and will include a special focus on the relationship between structural and service characteristics of multi-unit buildings and refuse and recyclables generation and composition. Phase II will cover the characterization of waste from public institutions served by DSNY. It will also include an examination of construction and demolition debris, lot cleaning, and inter agency fill streams managed by the DSNY. The scheduling of Phase II has not yet been finalized.

The WCS will be coordinated through the Bureau of Waste Prevention, Reuse and Recycling (BWPRR), and will involve the participation of several other bureaus within DSNY, including the Bureau of Cleaning and Collections, the Bureau of Waste Disposal, and the Bureau of Planning and Budget's Operations Management Division. The outcome of the WCS will enable the DSNY to (1) determine whether additional materials may be appropriate for recycling or other methods of handling and/or reducing wastes in the future; (2) improve the DSNY's waste prevention, reuse, recycling, and other sanitation-related public education efforts, especially to aid targeting of groups of waste generators for outreach and publicity; (3) improve the DSNY's enforcement of existing recycling and other sanitation laws and codes; (4) inform DSNY operations, including equipment procurement, facility construction, and collection route structure; (5) generate information relevant to recycling processors and other entities engaged in market development for the City's recyclable materials; and (6) provide, where feasible, an understanding of how MSW in the City has changed over the past decade, through comparison of study results with results from prior City waste characterization studies

The level of detail and range of waste streams examined under the WCS is unprecedented among municipal waste characterization studies for cities throughout the U.S. No other city has examined the variation in waste composition by housing density and income. No other city has attempted to link, through direct observation (rather than surveys), structural characteristics of multi-unit buildings and their recyclables composition. Among major cities, only Seattle has undertaken a concurrent characterization of the recyclables stream; most cities characterize refuse only. Only Seattle has also analyzed the composition of street basket waste. Moreover, the number of material categories that will be assessed in the WCS far exceeds those used by other jurisdictions. The ambitious scope of the WCS is appropriate to the City's massive waste stream and particular demographic characteristics, and will set a new standard in municipal waste characterization in the United States.

2.0 METHODOLOGIES FOR PHASE I

2.1 Phase I Residential Waste Characterization Methodology

Using random selection methods, and taking into account Citywide variation in housing and density, refuse and recycling routes will be randomly selected for sampling each working day of a three-week period each season. DSNY Borough superintendents will be informed of the selected sample routes one week before collection. They will coordinate a protocol in which sample trucks have identifying posters affixed and trucks collect waste on normal routes and return to district garages to await relay to pre-assigned waste transfer stations (for refuse) and recycling vendors (for recycling). DSNY consultants and BWPRR staff will be on hand at transfer stations to take grab samples from each sample truck using a front-end loader. Each sample will placed into a series of 90-gallon containers and coded for identification.

DSNY consultants will transport samples to one of two sort sites, where contents will be sorted into material categories corresponding to a pre-established list. Sorted contents will be weighed and, in some cases, counted. Data will be recorded and checked using a standard Quality Control/Assurance protocol. Recorded data will be compiled in a database off site. Bulk refuse and recycling (defined as items that do not fit into a 90-gallon container) in grab samples will be weighed and described, but not included in the material sorts.

2.1.1 Definition of Housing Density and Income Strata

There is considerable variation in median household income and numbers of residential structures and number of units per structure throughout the neighborhoods of the City. Prior research both by DSNY and in other jurisdictions suggests that waste composition may vary with one or both of these demographic characteristics. In order to capture this variation, sampling will be carried out such that results will be statistically significant for each of eight income/density combinations (strata) in the City.

To accomplish this, we begin by dividing the City's 2,217 Census Tracts into a set of income/housing density strata so that we can select collection routes in tracts that are representative of each stratum. Definitions of income and housing density are as follows.

2.1.1.1 Income

Using data from the 2000 Census, median household income for each of the City's 2,217 census tracts was divided evenly into three groups. The High Income Group includes all census tracts with an average median household income over $46,193. The Medium Income Group includes all census tracts with an average median household income less than $46,193 and greater than $30,763. The Low Income Group includes all census tracts with an average median household below $30,763. This results in three equal income groups. These same groupings are currently used by DSNY to categorize Sanitation Districts and are used by the Department of City Planning to characterize CDs in the City.

High Income > $46,193

Med. Income $46,193=<INC>= $30,763

Low Income < $30,763

2.1.1.2 Housing Density

Using 2000 Census data, the number of residential structures and the number of units per structures is used as a basis for determining housing density. The High Density Group includes those census tracts in which 67% or more of the residential housing structures contain 10 or more units. The Low Density Group includes those census tracts in which 67% of the residential structures contain two or fewer units. The Medium Density Group includes all those census tracts that are not in either the High Density Group or the Low Density Group.

High Density 67% - more than 10 Units

Medium Density Areas under 67% criteria = 3 to 9 units

Low Density 67% - 2 or fewer Units

2.1.2 Stratifying Census Tracts

Based on the methodology described above, all census tracts are assigned to one of the nine strata, as outlined in Table 2.1.2-1.

Table 2.1.2-1
Distribution of Census Tracts by Income and Density Strata

	High Income	**Medium Income**	**Low Income**	**Total**
High Density	167	127	342	636
Medium Density	162	435	392	989
Low Density	410	177	5	592
TOTAL	**739**	**739**	**739**	**2,217**

Note that there are only 5 out of over 2,000 census tracts that qualify as “low income/low density.” Closer examination of the characteristics of these tracts show that all but two of them consist mainly of non-residential property. For this reason, “low income - low density” will not be included as a stratum for sampling, reducing the total housing/density strata to eight.

Because census tracts are the smallest unit in which census data is reported, they provide the greatest level of demographic detail achievable at a Citywide level. As the tables above show, there are 2,217 Census Tracts in the City and 59 Sanitation Districts. For this reason, the results of the Phase I residential components will be able to be applied to strata on either the Census Tract-level or the Sanitation District-level.

2.1.3 Number of Samples

In a waste characterization study, the number of samples that are sorted affects the accuracy of the estimate. For example, if only one 200-pound sample of the City's refuse were sorted, it is very unlikely that the estimate resulting from sorting that single sample would match the composition of the City's entire curbside refuse. On the other hand, if hundreds of thousands of 200-pound samples were sorted - enough samples so that every ounce of the City refuse and recyclables were sorted - the resulting estimate would be very accurate.

If the material we were sorting were consistently and homogeneously discarded by households, it would be relatively easy to arrive at an estimate of how many samples to take. It would take very few samples to develop an estimate if there were only two materials in the waste stream and they were always found in the same proportion in every sample. However, refuse, and to a lesser degree, recyclables, are extremely variable, and the percentage of each type of waste can vary considerably between samples. Even from the same household, the type of waste can vary depending on when the sample is collected. For example, during the autumn, one would expect to find a great deal of leaves, but in the winter there will be few leaves or none. On the other hand, one would be likely to find food waste throughout the year. Because of the potential for variability between samples, a different number of samples may be required to obtain an accurate estimate for different types of waste. Continuing the example, since food waste is likely to be found more consistently than leaves, fewer samples would be required to obtain an accurate estimate of the food waste percentage.

Typically, an estimate of the composition of waste is presented as three numbers: (1) the Sample Mean; (2) the Confidence Level; and (2) the Confidence Interval. The Sample Mean is the average percentage of a given material found in the samples sorted. For example, after sorting thirty samples of refuse, there will be a list of 30 percentages of paper waste. If the average of the 30 percentages of paper is 35%, then the Sample Mean of paper is 35%.

The Confidence Level and the Confidence Interval are intertwined concepts. Together, they allow statements to be made about the entire population from the sample taken. The Sample Mean is simply the average value of the samples; it is unlikely that the percentage of a given type of waste for the entire population matches the Sample Mean exactly. The Confidence Level and the Confidence Interval provide a way to convey how much the samples tell us about the entire population.

The Confidence Level indicates the degree of certainty that the Confidence Interval contains the population mean value. For example, if the Confidence Interval - 33% to 37% for paper - is based on a Confidence Level of 90%, we can be 90% confident that the population's percentage of paper waste is contained in that interval. In waste characterization studies, a 90% Confidence Level is a widely accepted standard.

The third number used in describing the composition of the refuse is the Confidence Interval. This is an expression of the uncertainty regarding the population Mean. For example, our Sample Mean of 35% for paper waste may have a Confidence Interval of ±7%, at a 90% Confidence Level. That is, based on our number of samples and results obtained, we would expect that 90% of the time, the amount of paper waste in the refuse of the entire population would be between 28% and 42%.

In recommending the number of samples of refuse and recyclables to sort for the Phase I residential WCS, not only was the level of accuracy of the estimate considered, but also the degree of variability for various material categories found in the PWCS, as well as the cost of providing this estimate and the variability of materials being sorted. As noted above, the variability of some material in the refuse is greater than other materials. Yard waste is much more variable than food waste. Therefore, for a given number of samples, the estimate of some materials will be more accurate than the estimate for others. Sorting a few hundred samples of refuse may provide a Confidence Interval of ±8% for paper, but a ±30% for yard waste. To achieve a ±8% for yard waste would require significantly more samples and be prohibitively expensive.

In practical terms, "variability" simply means the variation we are likely to find between samples. If 10 samples are sorted, and each sample has between 28% to 32% of a given waste type, we can be pretty certain that the percentage of this waste type for the population as a whole lies in this general range. But if these same 10 samples are sorted, and find results of 1%, 80%, 20%, 65%, and so forth, there is much less certainty about the percentage of this waste type in the entire population. There is a point of diminishing returns for waste sampling. After that point, the cost of achieving small increases in accuracy is high. Below that point, significant increases in accuracy can be achieved with relatively little cost.

Weighing all of these factors it was determined that at least 200 samples of refuse per stratum be sorted. Additional samples might be slightly helpful in improving accuracy, but the amount of improvement diminishes as more samples are taken. The value of 200 samples reflects an appropriate number of samples to achieve useful accuracy at a reasonable cost.

The results of PWCS showed relatively little variability in the City's paper recycling stream. Paper had a relative uncertainty of 0.52% at a 90 percent confidence level which is substantially below the goal of + 7.5% relative uncertainty at a 90% confidence level. It is estimated that by sorting 40 samples per strata, the goal of + 7.5% can be achieved for paper. On the other hand, the PWCS results show that the MGP stream was substantially more variable than was paper. Using results from this study, we estimate that by sorting 160 MGP samples per strata, the goal of + 7.5% relative uncertainty could be achieved for the MGP.

To define the universe (or population) that is to be sampled, DSNY's Bureau of Cleaning and Collection (BCC) will provide a list of refuse and recycling collection routes currently active citywide for each season. Using standard random selection methods, sample routes will be selected that fall within census tracts corresponding to the eight income/density strata. Samples will also be weighted to account for variations in setout size of early versus late week refuse collections. The following table summarizes the total number of residential samples to be taken over the four seasons.

Table 2.1.3-1
Samples for Phase I - Four Seasons

Waste Stream Component	Total Samples	Samples per Strata
Residential Refuse	1,600	200
Residential Paper Recycling	320	40
Residential MGP Recycling	1,280	160
Total Residential Samples	**3,200**	**400**

2.1.4 Size of Samples

Samples weighing 200 pounds (lbs) for refuse and 125 lbs for MGP and paper recycling will be collected from each sample load. As with the number of samples, past research on our own and other jurisdictions' waste streams confirms that this sample weight is adequate to ensure statistically significant results.

Studies by the USEPA and academic sources (e.g., Klee, Design and Management for Resource Resource Recovery: Quantitative Decision- Making, Ann Arbor Science, 1980) suggest that as the size of the refuse samples increases beyond 200 to 300 pounds, the statistical benefits associated with the larger sample size are outweighed by the incremental increase in the cost of analysis. As a result, the minimum refuse sample weight of 200 pounds has been the industry standard for MSW composition studies in the United States for the past 15 years (including statutory requirements where such studies are mandated by state or local law).

The considerations in selecting a minimum sample size for recyclables are significantly different. Unfortunately, there is little literature, or scientific study, or established industry practice upon which to draw in order to defend a minimum sample size for mixed recyclables. This may be, in part, due to the relative immaturity of this particular field of study. However, based upon the consultants' collective experience with waste characterization studies, a minimum of 125 pounds per sample was chosen. An explanation of the basis for this value is summarized below.

Appropriate minimum sort sample size, regardless of the materials being sorted, is a function of the mass and variability of the individual components within the material being analyzed. If, for example, the study were to examine the weight of individual grains of sand within a sample, the minimum sample size would be smaller, given that grains of sand have a relatively low mass, and variability in mass between individual grains is also relatively low. In this example, it is intuitive to suppose that a reasonable minimum size for a sort sample would be a few ounces of sand. The accepted minimum sample size for refuse (200 pounds) takes into account the average mass and volume of individual refuse components and the variability between the largest and smallest of these items (from a cigarette butt to a TV, for example). Components making up the recyclables stream are significantly more homogeneous (in terms of mass and volume) than those found in refuse. Not only are there significantly fewer components in recyclable samples, the variability between the largest and the smallest of these items is similarly low, in a relative sense.

2.2 Phase I Street Basket Waste Characterization Methodology

The methodology for characterizing street basket waste will be similar to that for residential waste, but will not differentiate among housing density and income strata. Instead, we will randomly select 200 routes from among the 647 dedicated street basket routes throughout the City each season. Grab samples weighing 200 lbs will be taken from these sample trucks at specified transfer stations, for sorting into the same material categories used for residential waste characterization. Additional observations and classifications will be made to assess the misuse of street baskets by residents and businesses for curbside waste disposal. The methodology for the street basket portion of Phase I will also be informed by prior research on this topic in Seattle.

2.3 Phase I Multi-Unit Waste Characterization Methodology

Due to the complexity of Phase I and the multi-unit component in particular, this aspect of the study will not be undertaken until the winter sampling season. Out of over 180,000 multi-unit apartment buildings in the City, 125 will be randomly selected in a stratified sample reflecting variation in income and housing density of their census tract, size and other characteristics. Waste will be collected from these buildings in dedicated trucks and sorted using a similar methodology to the residential component of the WCS. During the sampling period, each sample building will undergo site visits by BWPRR outreach staff to record structural information and to interview superintendents and residents about recycling arrangements. These data will be supplemented by structural data from databases maintained by City housing agencies. We will apply various multivariate statistical techniques, including multiple regression, to examine the correlation between building characteristics and waste composition.

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