Section 3
METHODOLOGY

Introduction

The sampling plan for the State-wide Waste Composition Study was designed to achieve statistical representation by region, demographic area, and generating sector. A detailed sampling plan was included with the original scope of work for this study, which was subsequently refined prior to implementing the actual field data collection efforts. As a result of this sampling plan, a total of 1,185 samples were physically sorted, with another 449 samples visually characterized. The sections below describe significant elements of the sampling plan, as well as a summary of the sample breakdown.

Material Definitions

R. W. Beck worked with DEP to define a list of disposed MSW material types that are of greatest interest to the Commonwealth's solid waste and recycling planners. Ultimately, a list of 37 individual materials, categorized into six major material groups, were defined for the purposes of the study. The final list of materials that were analyzed in the study are shown below in Table 1. Detailed definitions are contained in Appendix A

Table 1 Targeted Materials in Disposed MSW

Paper	**Metals**
Newspaper	Steel Cans
Corrugated Cardboard	Aluminum Cans
Office/High Grade Paper	Other Ferrous Metals
Magazine/Glossy Paper	Other Aluminum
Polycoated/Aseptic Containers	Other Nonferrous Metals
Mixed Paper (Recyclable)	**Glass**
Other Paper (Non-recyclable)	Clear Glass Containers
Plastic	Green Glass Containers
#1 PET Bottles	Brown Glass Containers
#2 HDPE Bottles	Non-Recyclable Glass
#3 - #7 Bottles	**Organics**
Expanded Polystyrene	Yard Waste—Grass
Film Plastic	Yard Waste—Other
Other Rigid Plastic	Wood—Unpainted
Inorganics	Wood—Painted
Electronics	Food Waste
Carpet	Textiles
Drywall	Diapers
Other C&D	Fines
Household Hazardous Waste	Other Organics
Other Inorganics	

Seasonal Sample Distribution

Waste composition has been shown to vary by season. Certain components of the MSW stream—such as yard waste, construction and renovation debris, and selected packaging materials—are known to occur in the waste stream more frequently in one or more seasons. To assure that the study results accurately captured variability associated with seasonal changes in the waste stream, field data collection was performed across a full 12 month timeframe.

In total, four seasonal sampling and sorting events were performed, with each event featuring six weeks of field sorting. Field data collection was initiated in the summer of 2001, and concluded in the spring of 2002. Table 2 summarizes the dates of each of the four seasons of field sorting, as well as the number of samples obtained each season.

Table 2 Seasonal Field Data Collection Schedule

Season	Sort Dates	Number of Samples		
		Physical	Visual	Total
Summer	July 16- September 3, 2001	286	103	389
Fall	September 24- November 16, 2001	290	122	412
Winter	January 7- March 15, 2002	298	113	411
Spring	April 1- June 17, 2002	311	111	422
Totals		**1,185**	**449**	**1,634**

Host Facility and Regional Overview

Significant sampling was performed in all six regions of the Commonwealth. In order to obtain a range of samples from different demographic areas and generating sectors in each region, it was important to select host facilities that received representative waste from each region.

A total of 13 facilities ultimately hosted at least one week of field sampling and sorting. At most of the facilities, two weeks of sorting was performed, with the two weeks separated by six months to obtain seasonally opposite samples (e.g., sorting was either done in summer and winter, or in fall and spring). In general, we were successfully able to obtain the targeted distribution of samples at only two facilities in each region. However, due to the low occurrence of rural communities in the Southeast Region, a third facility was added to allow samples to be obtained from all targeted demographic areas.

Table 3 summarizes the facilities that hosted field sorting, as well as the targeted demographic areas surrounding each facility, the seasons in which sorting occurred, and the number of samples obtained from that facility.

Table 3 Host Facility Summary

Region	Facility	Seasons of Sorting				Targeted Demographic Area(s) [1]	Samples Taken [2]
		Sum	Fall	Win	Spr		
Northeast	Keystone Landfill	✓		✓		U, S, R	129
	Commonwealth Environmental Systems (CES) Landfill		✓		✓	S, R	125
Northcentral	Centre County Transfer Station	✓		✓	✓	U, S, R	195
	Bradford County Landfill		✓			R	57
Northwest	Superior Greentree Landfill	✓		✓		R	132
	Lake View Landfill		✓		✓	U, S, R	141
Southeast	Montgomery/Montenay RRF	✓				S	45
	TRC Transfer Station		✓		✓	U	104
	Chester County Landfill			✓	✓	S, R	123
Southcentral	Lancaster RRF	✓		✓		U, S, R	153
	Mountainview Landfill		✓		✓	S, R	153
Southwest	Laurel Highlands Landfill	✓		✓		U, S, R	139
	Imperial Landfill		✓		✓	U, S, R	138
Totals							**1,634**

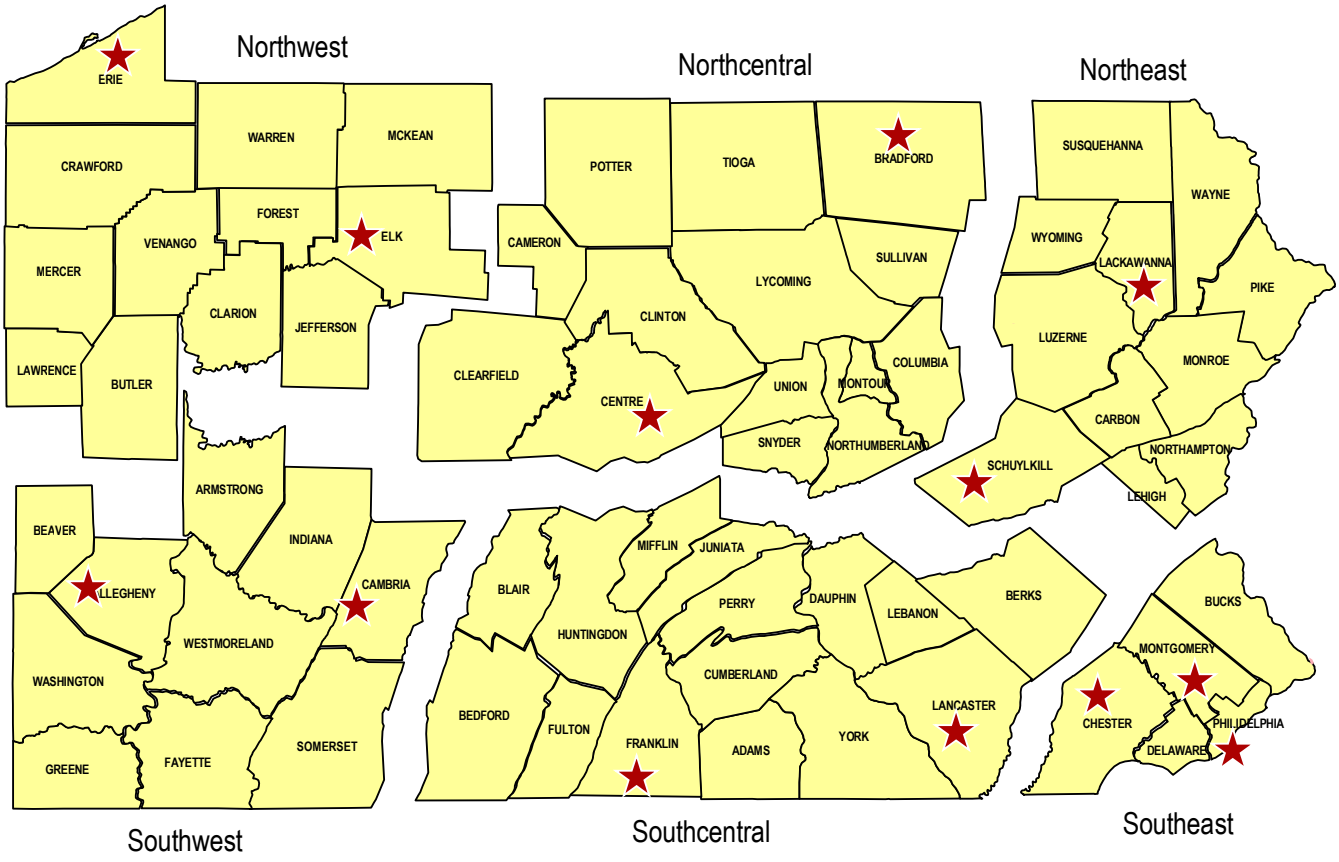
[1] Key: U=urban, S=suburban, R=rural
[2] Includes both physical and visual samples

As shown, at most facilities sorting was performed for one-week periods during each of two seasons. Note, however, that it was necessary to adjust the sorting schedule within several of the regions to assure that the targeted number of samples from specific demographic areas could be obtained. Specific adjustments are described below:

- **Northcentral Region**: Due to the lack of availability of urban and suburban samples at the Bradford County landfill, only one week of sorting was performed at this facility. The remaining three weeks of sorting were performed at the Centre County Transfer Station to capture suburban and urban (as well as some rural) samples from surrounding communities.
- **Southeast Region**: Because this region has very limited rural areas, as well as a large urban concentration around Philadelphia, it was necessary to sort at three facilities to obtain the targeted samples. During the final season of sorting (spring), data collection was divided between the TRC Transfer Station and the Chester County Landfill. Only one week of sorting was performed at the Montgomery/Montenay RRF.

Figure 1 presents a map of Pennsylvania showing the location of each of the host facilities within each region. As shown, these facilities were distributed across the Commonwealth's urban, suburban and rural areas, and allowed the project team to obtain a wide variety of sample material from many different local waste management systems.

Figure 1 Location of Host Facilities



Generating Sector Detail

In order to achieve statistically meaningful results, the overall sampling plan required that a minimum number of samples be obtained from each of the targeted regions, demographic areas, and generating sectors. To provide the greatest insight into the field sampling and sorting effort, the following types of incoming loads of MSW were differentiated in the study

- Single family residential waste;
- Multifamily residential waste;

- Commercial waste;
- Self-haul waste; and
- Bulky/Roll-off waste.

These are described more fully below.

Single-Family Residential Waste

Throughout the Commonwealth, single family waste makes up a majority of residential waste. In urban, suburban and many rural areas, single family waste is collected from the curb or alley on a regular basis and delivered to disposal facilities. Collection technologies include rearload or sideload manual, semi-automated, and automated collection performed on a weekly or twice per week basis. However, in some rural areas no mandatory curbside waste collection service exists. Residents in these areas may contract with a local hauler, self-haul their waste to a local disposal facility, or rely on rural convenience centers as drop-off points for residential waste.

Sampling and sorting single family waste was relatively straightforward at the host facilities included in the study. In some areas, both residential and commercial waste were commingled together in the same rearload vehicles. We were generally successful sampling from segregated single family truckloads at all of the host facilities.

Multi-family Residential Waste

In urban and suburban areas, multi-family waste is typically collected in dumpsters by front-end loading vehicles (although in rural areas it may be collected along with other residential waste in rearload compacting vehicles). Because most commercial waste is also collected via dumpsters, multi-family waste is often grouped in with commercial waste.

However, the multi-family residential waste stream is unique from both commercial waste and from single-family residential waste, and may represent an opportunity for increased diversion. The curbside recycling programs that target single-family households often cannot be offered to multi-family households. Additionally, different demographic and income characteristics of these households give rise to specific challenges that must be addressed to increase diversion from this generator segment.

Accordingly, throughout the field data collection, we attempted to obtain a fraction of residential samples from multi-family dwellings, especially in urban and suburban areas where multi-family dwellings are more common (or even prevalent over single family dwellings). Prior to conducting each of the weekly sorts, local haulers delivering waste to each facility were contacted to assess the fraction of multi-family waste. Although our sampling of residential waste was primarily focused on single-family waste, multi-family samples were targeted in proportion to the existence of multi-family dwellings in the waste shed of each host facility. For this reason, a greater percentage of multi-family samples were obtained in the urban and suburban areas of the Commonwealth (such as Philadelphia and Pittsburgh), while rural residential sampling targeted largely or entirely single family samples.

Because multi-family waste is often collected in the same vehicle with commercial waste, obtaining multi-family samples required closer coordination with local haulers to identify specific truckloads that contained entirely multi-family waste, or at least an identifiable fraction of multi-family waste within the collection truck body. While some multi-family waste samples may have contained trace amounts of commercial waste, the study was generally successful in obtaining multi-family samples at each host facility around which significant multi-family waste was collected.

Commercial Waste

Commercial waste in urban and suburban areas is often collected in dumpsters, although a significant amount of commercial waste is also collected manually or in carts. Collection techniques include front-end loading collection trucks, as well as rearloaders and compacting roll-off boxes at some larger commercial establishments. "Commercial" refers to all non-residential sources of waste, including retail establishments, offices, hotels, grocery stores, restaurants, and institutions like churches and hospitals. Note that commercial waste excludes industrial waste, which was outside the scope of this study.

Commercial waste tends to be collected by private haulers competing in the open market for refuse removal services. We were successfully able to identify incoming truckloads of commercial waste at the host facilities throughout this study.

Self-Haul Waste

At some of the facilities across the Commonwealth, at least a small fraction of residential and commercial self-haulers deliver material for disposal. Past studies have shown that the waste delivered by self-haulers is often different from normal residential and commercial waste generation. This material typically includes bulkier, less frequently disposed material such as construction, demolition and renovation debris; land clearing or yard cleaning debris; household/basement/garage clean-up waste; and other waste generated under special circumstances.

Often, no diversion programs have been implemented to capture this type of waste. As such, the sampling plan in each region allowed for some samples to be taken of self-haul waste, such that a separate analysis of self-haul waste could be performed to highlight the differences in this type of waste from the overall waste stream. During each weekly sort, self-haul loads were sampled and characterized based on the quantity of incoming waste delivered from self-haulers.

Bulky/Roll-off Waste

The majority of waste delivered to Pennsylvania's disposal facilities arrives in compacting trucks and some roll-off containers, and tends to be made up of items that are small enough to physically sort. However, at least some fraction of deliveries to any disposal facility consist of roll-off or self-haul trucks that contain bulky materials that are not conducive to physical sorting. Although physically sorting these loads is not feasible, they may make up a significant portion of the waste stream. These types

of loads often exhibit significant potential for improved diversion (although they generally originate from a diverse set of generators for which no consistent diversion programs can be implemented).

To accommodate the occurrence of randomly sampled truckloads that were found to contain bulky materials that are not conducive to physical sorting, we performed visual, volumetric samples of these loads throughout the sort. Visual sampling was intended to provide additional insight on the types of materials that are found in roll-off and possibly self-haul loads that were too bulky to physically sort, and to allow the composition of these loads to be captured in the State-wide analysis. Because there was no way to estimate the number of bulky loads that would be found at each host facility, we allowed for a floating number of bulky visual samples to be taken at each site.

Within each region, the final sampling plan sought to obtain the breakdown of physical and visual samples shown in Table 4.

Table 4 Regional Sampling Targets

Generating Sector	Demographic Area			
	Urban	Suburban	Rural	Total
Residential Samples [1]	30	30	30	90
Commercial Samples	30	30	30	90
Self-haul Samples	8	8	8	24
Total Physical Samples	**68**	**68**	**68**	**204**
Visual Samples				***Up to 60***

[1] Includes both single family and multi-family households
[2] No distribution of visually assessed bulky waste samples was set prior to the study; the actual number and distribution of visual samples was dependent on the distribution of incoming truckloads warranting visual analysis.

As shown, a total of 204 physical samples were targeted within each region, ideally distributed across the demographic areas and generating sectors as shown. Note that these targets represented an optimal distribution of samples. In some regions, it was not possible to obtain the precise distribution of samples targeted. Every effort was made to come as close as possible to these targets.

The majority of the samples were intended to be physically sorted samples. Physical sorting is appropriate for the majority of truckloads of waste that are delivered for disposal. The typical truckload of waste arrives in a compacting collection vehicle, with contents mixed together in the truck. However, sixty samples were allotted for taking visual samples of bulky waste loads in each region, although the actual number of visual samples was also dependent on the number of bulky loads that were found to enter each host facility during the sorts.

Sampling and Sorting

Field data collection includes three primary tasks:

(1) Identifying and taking samples from targeted truckloads from the specified generating sectors and demographic areas;

(2) Physically sorting or visually surveying each sample into the target material categories; and

(3) Recording the weight (physical) or volume (visual) of sorted materials.

These steps are described below

Sampling

Proper sampling requires that the origin and contents of each sampled truckload be verified prior to taking samples. Each week of sorting at a host facility, Field Supervisors were provided with a list of local haulers delivering waste, as well as information about the origin and type of waste collected by the haulers. Truckloads were selected using a stratified random sampling methodology.

When targeted trucks entered the facility, the Field Supervisor conducted a brief interview with the driver to verify certain information about the contents of the truckload. Questions included:

- Is the load residential, commercial, or mixed?
- Where did the material originate (specific geographic origin)?
- Were any out-of-the-ordinary items picked up on route?

The hauler, truck number, and truck type were recorded, as well as the scale ticket number (if applicable). We attempted to record all sampled truckloads should there be a need to verify the truck contents.

At each host facility, a designated area was established to conduct the physical sorting. Verified trucks were directed to tip in a designated area for "grab" sampling. Once the full load was tipped, a loader operator was directed to "grab" a 200- to 250-pound sample to be staged next to the sorting area. Industry literature specifies a minimum sample size of 200 pounds, which is consistent with the past sorting experience. However, in any field sort it is to be expected that some samples will weigh less than the 200-pound target. This discrepancy arises with less dense commercial loads that contain a significant fraction of corrugated boxes, foam packaging, or other light material. Conversely, some of the denser samples may be significantly heavier than 200 pounds. Despite these issues, samples were targeted at 200 to 225 pounds.

Specific grab samples were selected by dividing the load or an unbiased portion of the load into six to eight rectangular cells and then having the loader operator take a scoop from one of the cells. To minimize bias, the loader operator was directed to take a vertical slice from the pile at the selected quadrant of the load. As a precaution, the visible characteristics of the full waste load were observed by the Field Supervisor,

and any obviously non-representative material was noted and avoided in the sampling process.

Physical Sorting

Once samples are staged for sorting, each sample was manually loaded onto a specially designed sorting table. Bagged waste was carried to the table, while loose waste was loaded into a 40-gallon bucket to be moved to the table top. Certain large or bulky items were placed next to the scale for direct weighing.

From the sort table, which was covered by 1/2-inch screening, solid waste was manually sorted into labeled bins or baskets. Bagged material was broken open, and boxes were opened and all waste sorted. Sorting continued until the screen-top material was largely removed. Particles small enough to fall through the screen were characterized as Fines.

All samples were manually sorted into the 37 defined material categories[1].

Visual Surveying

To the extent incoming truckloads were found to contain bulky items, volumetric composition estimates were taken from the tipped load.

Visual estimation required the Field Supervisor to record the size of the incoming truckload, as well as the weight of the load, and then to systematically estimate the volumetric composition of the load. Standard visual estimation protocol requires the surveyor to first annotate all of the materials observed in the load, and then to estimate the volume percentage of each material from the largest to the smallest. Note that there is significantly greater error in visual volumetric estimation compared to physical sorting. For that reason, volumetric estimates for large materials are typically to the nearest five percent, with trace amounts of materials recorded as one percent.

Data Recording

On the first and last day of each weekly sort, tare weights were recorded for each of the containers used in the sort. Tare weights must be backed out from gross container weights to obtain accurate net material weight data.

After material from a given sample was sorted into the appropriate bins, the gross weight of each bin was systematically recorded on a custom designed data collection sheet. Bulky items too large to fit into a labeled container were weighed out separately and recorded as net weights. Especially large items were noted on the data collection sheet.

All weights were recorded to the nearest 0.1 pound. A blank data recording form is included in Appendix B.

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[1] During the winter season sort, wastes were further segregated between packaging and non-packaging waste. This resulted in the addition of 19 more material categories during this sort. Details about the packaging analysis are provided in Section 5 of this report.

Attainment of Sampling Targets

Overall, the original sampling plan targeted 1,224 physical samples and allowed up to 360 visual samples. Ultimately, the study obtained the targeted number of samples. However, after eliminating samples during the quality control process, 1,185 physical samples and 449 visual samples were ultimately retained for the analysis. This represents 97 percent of the targeted physical samples, and over 100 percent of the expected visual samples. As described below, these samples were distributed across the seasons, regions, generating sectors, and demographic areas targeted in the study.

Tables 5 and 6 compare the targeted number of samples with the actual number of samples obtained in the study. Table 5 compares the samples taken by region.

Table 5 Comparison of Targeted Vs Actual Samples by Region

Region	Physical Samples			Visual Samples		
	Targeted	Actual	Coverage	Allotted [1]	Actual	Coverage
Northeast	204	187	92%	60	67	112%
Northcentral	204	193	95%	60	59	98%
Northwest	204	198	97%	60	74	123%
Southeast	204	199	98%	60	73	122%
Southcentral	204	206	101%	60	101	168%
Southwest	204	202	99%	60	75	125%
Totals	**1,224**	**1,185**	**97%**	**360**	**449**	**125%**

[1] Note that visual samples were taken based on the availability of these incoming truckloads during each weekly sort. Bulky waste truckloads at some facilities were infrequent, resulting in fewer samples from these facilities.

As shown in Table 5, at least 92 percent of the targeted physical samples were obtained for each region, and at least 98 percent of the targeted visual samples were obtained for each region. Some of the sampling shortfalls were caused by operational obstacles beyond the project team's control, such as inclement weather, unforeseen staffing and operational obstacles and low availability of targeted truckloads. Additionally, some samples were eliminated from the analysis based on our quality control review. Samples were primarily excluded if they did not meet minimum size requirements, although some samples were omitted due to incomplete background information that allowed the samples to be properly classified by demographic origin and generator type. The shortfalls have not been found to have adversely impacted the results of the analysis.

Table 6 evaluates compares the samples taken by demographic area and by generating sector.

Table 6 Comparison of Targeted Vs Actual Samples by Demographic Area and Generating Sector

Region	Physically Sorted Samples			Visual Samples		
	Targeted	Actual	Coverage	Allotted [1]	Actual	Coverage
Urban	408	362	89%	120	136	113%
Suburban	408	386	95%	120	134	112%
Rural	408	437	107%	120	179	149%
Total	**1,224**	**1,185**	**97%**	**360**	**449**	**125%**
Residential	612	630	103%	180	131	73%
Commercial	612	555	91%	180	318	177%
Total	**1,224**	**1,185**	**97%**	**360**	**449**	**125%**

As shown, a minimum of 89 percent of the targeted number of physically sorted samples were obtained from each demographic area, with 107 percent of the targeted number obtained from rural areas of the Commonwealth. Not surprisingly, the greatest shortfall occurred with urban samples, due to the limited number of host facilities that receive direct-haul waste from urban areas. The number of samples by generating sector show that the targeted number of physically sorted residential samples was slightly exceeded, while a slight shortfall occurred in the number of physically sorted commercial samples. These shortfalls have not been found to have adversely impacted the results of the analysis.

Complete results of the analysis of all sample data are shown in the remaining sections of this report.