Waste Characterization Study
Final Report

September 2025

The City of Worcester

DIVERSION DESIGNERS

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Executive Summary

The City of Worcester conducted a comprehensive waste characterization study in 2025 to provide baseline data for its Zero Waste Master Plan (ZWMP). As the second largest city in Massachusetts with approximately 206,000 residents, Worcester manages residential waste through its curbside collection programs for 1-6 unit dwellings (approximately 60,000 households), including Pay-As-You-Throw (PAYT), single-stream recycling and yard waste composting. The City operates a residential Drop-Off center servicing items such as bulk waste, hazardous waste, single-stream recyclables, textiles, and yard waste.

The study, conducted by the City's contractor Diversion Designers LLC., collected 111 samples weighing over 22,000 pounds total from 103 locations across six sectors: residential (1-6 units), residential multi-family (7+ units), Worcester Public Schools, commercial businesses, municipal buildings, and illegal dump sites. Materials were sorted into 50 categories using stratified random sampling to achieve 90% confidence level statistical significance.

Study Objectives

The study aimed to establish a baseline of Worcester's waste generation, collection, and disposal practices while identifying opportunities for improvement. Key objectives included:
- Measuring contamination rates in recycling streams.
- Quantifying recyclable materials currently disposed of as trash.
- Highlighting high-recovery materials to inform diversion efforts.
- Providing data to support cost-benefit analyses, grant applications, and future monitoring of waste stream changes.

Key Findings

This study revealed several opportunities to strengthen Worcester's waste reduction and diversion systems.

Organics
- Organics were high across samples, presenting significant diversion opportunities.
- Schools had the highest levels, with organics making up 69.7% of waste; of that, 79% were edible food scraps.

Yard Waste
- Residential (1-6 units serviced by the City's curbside collection) had very low levels (0.12%), while larger residential buildings (7+ units, not on curbside collection) showed significantly more yard debris (4.46%).

Recyclables
- Recyclable materials (paper, plastic, metal, and glass) were present throughout waste samples.

- In municipal trash, paper accounted for nearly 27%, including 19% from corrugated cardboard and mixed recyclable paper.
- Plastics made up 15% of municipal trash, with nearly one-fifth coming from PET (#1) containers.
- Multi-family recycling was dominated by paper (47.1%), primarily corrugated cardboard and mixed recyclable paper (44.6%).
- Glass and metal were consistently low across refuse and recycling streams.

Illegal Dumping
- Illegal dumpsites had the highest rates of glass (5.1%), construction & demolition debris (15.7%), and bulky items (23.3%), along with high levels of metal (5.5%) and electronics (14%).

Other Observations
- Diapers and sanitary products were most prevalent in multi-family (5.7%) and residential waste (10.3%).

Waste Characterization Study Results

Note: The results are presented as mean percentages to show the composition of the waste stream. Each value includes a margin of error, calculated at a 90% confidence interval, which indicates the level of uncertainty in the data. The associated high and low boundaries provide a range that helps illustrate the potential limits of each estimate.

Table 1: Sample Distribution

Sector	Refuse Samples	Recycling Samples	Locations
Residential (1-6 units)	25	-	5 routes over 5 days
Residential (7+ units)	15	3[1]	4 typologies
Commercial	40	5	10 typologies
Schools	9	-	3 elementary, 3 middle, 3 high
Municipal Buildings	8	-	7 facilities
Illegal Dump Sites	4[2]	-	4 locations
Total	**103**	**8**	**103 locations**

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[1] Intended to collect more recycling samples from multi-family buildings; however, random sampling revealed that many buildings did not have recycling dumpsters available
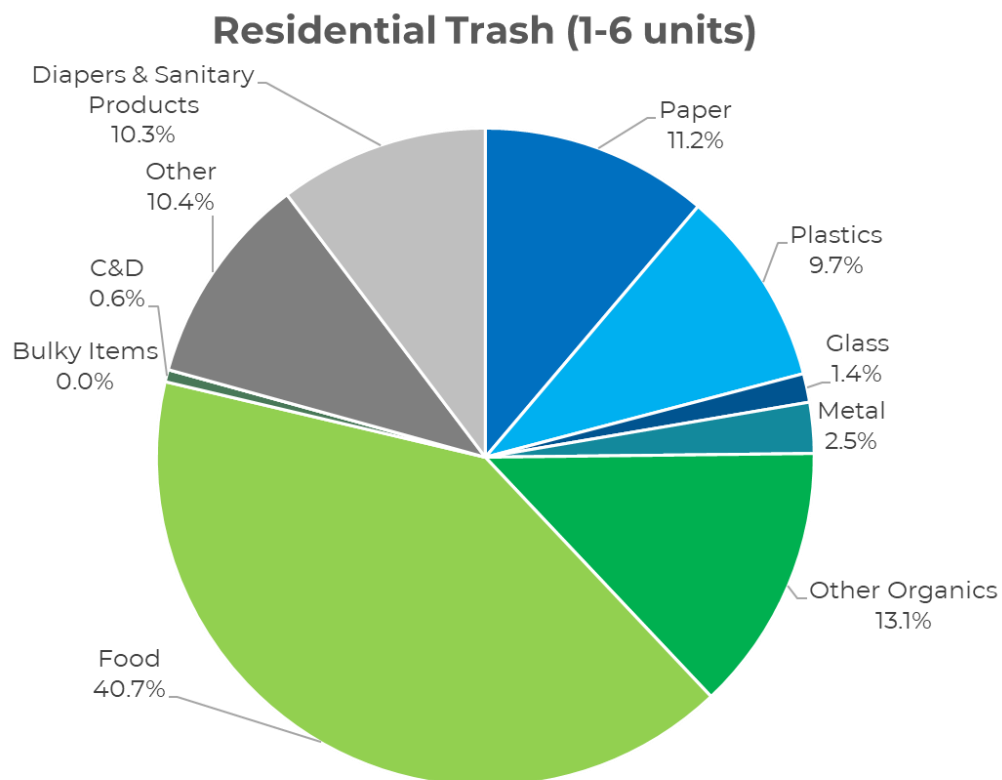
[2] Intended to sample five sites; however, one site was found to be clean at the time of sampling.

Study Results by Sector

Residential (PAYT) (1-6 dwellings)

Sample: Collected from all five collection routes over five weekdays during normal collection hours. Houses randomly selected using a random number generator to determine skip intervals. Multiple residences combined to produce 200+ pound samples.

Results: Sorting of residential refuse revealed missed opportunities in recycling, particularly Mixed Recyclable Paper (4.11%), suggesting challenges in consumer understanding of what qualifies as recyclable. The largest category was organics (53.87%), primarily composed of Edible Food Scraps (28.41%) and Non-Edible Food Scraps (12.32%).

Residential Trash (1-6 units)

- Diapers & Sanitary Products 10.3%
- Other 10.4%
- C&D 0.6%
- Bulky Items 0.0%
- Food 40.7%
- Paper 11.2%
- Plastics 9.7%
- Glass 1.4%
- Metal 2.5%
- Other Organics 13.1%

Multi-family Residential (7+ dwellings)

Sample: Four typologies sampled: mid-rise apartments (4-7 stories), garden-style apartments (1-3 stories), mixed-use buildings, and converted warehouses/lofts. Used quadrant-based mobile collection with random number generator determining sampling sequence.

Results: Samples from multi-family residential buildings—serviced by private haulers rather than the City's PAYT program—showed some presence of City-sponsored PAYT bags (0.05%). The largest portion of material was organics (31.76%), followed by Other (21.25%). Within organics, the majority was Edible Food Scraps (18.19%), Non-Edible Food Scraps (4.78%), and Yard Debris (4.46%). Notably, yard debris was far higher than in PAYT-serviced households, where it made up only 0.12%.

Residential Trash (7+ units)

Diapers & Sanitary Products 5.7%
Textiles 7.1%
Paper 12.6%
Other 8.5%
Plastics 10.5%
Glass 3.4%
Metal 5.7%
Bulky Items 10.7%
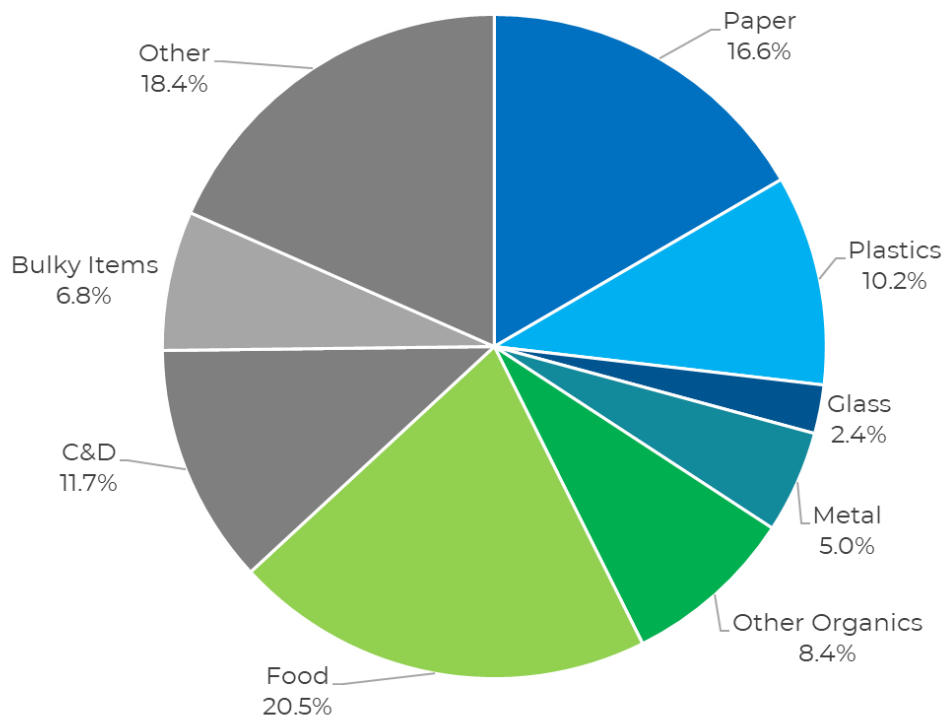Other Organics 8.8%
C&D 4.2%
Food 23.0%
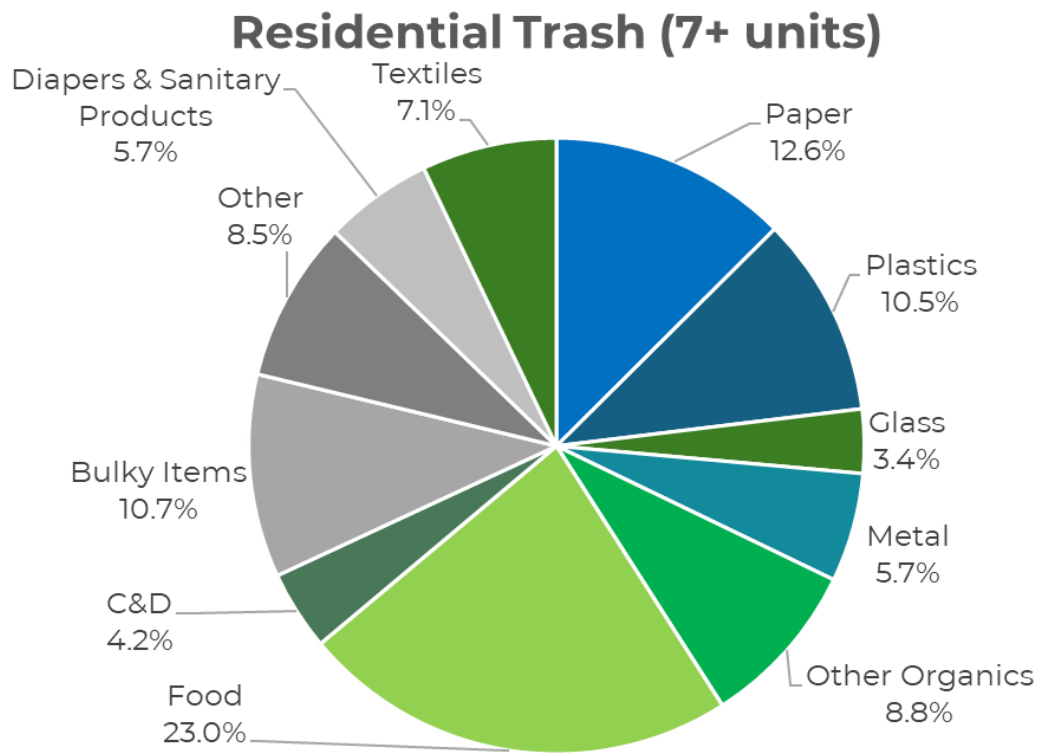
Commercial

Sample: 40 businesses across 10 typologies using post-stratification random sampling:
- Food Service & Hospitality
- Grocery & Supermarkets
- General Retail
- Healthcare Facilities
- Educational Institutions
- Office and Professional Services
- Manufacturing and Industrial
- Entertainment and Recreation
- Personal Services
- Freight and Logistics

Results: Commercial samples showed significant proportions of organics and paper, including Edible Food Scraps (14.68%), Non-Edible Food Scraps (5.81%), Corrugated Cardboard (6.41%), and Mixed Recyclable Paper (4.67%). These results highlight opportunities to expand both recycling and organics diversion. Interviews with 50 businesses revealed limited recycling and organics programs:
- *Recycling programs*: 25% had comprehensive programs, 37.5% limited programs, 2.5% planned to implement one, and 35% had none. With 34.2% of commercial refuse made up of recyclable paper, plastic, metal, or glass, there is a clear need to improve capture rates.
- *Organics programs*: Only 20% of businesses had some form of organics management. Among them, all had food donation programs, 10% used off-site composting, and one planned to start a compost program. The overall presence of organics (28.91%) in commercial refuse suggests that expanding organics programs would yield significant benefits.

Commercial Trash

- Other 18.4%
- Paper 16.6%
- Plastics 10.2%
- Glass 2.4%
- Metal 5.0%
- Other Organics 8.4%
- Food 20.5%
- C&D 11.7%
- Bulky Items 6.8%

Worcester Public Schools

Sample: Three schools per level (elementary, middle, high) selected for geographic and socioeconomic diversity. Sampling during the regular school year from aggregated cafeteria, classroom, and administrative waste.

Results: School refuse was overwhelmingly organics (69.7%), with the majority being Edible Food Scraps (55.4%). Other contributors included Non-Edible Food Scraps (3.4%), Food-Soiled Paper (5.2%), and Certified Compostable Food Service Ware (4.6%). Compostable food service ware was far more prevalent in schools than in any other sector (0.0–0.2%). Liquids (10.3%), primarily from partially consumed milk, juice, and water, were also notably high.

School Trash

Diapers & Sanitary Products 10.3%
C&D 0.0%
Bulky Items 0.0%
Other 2.1%
Food 58.8%
Paper 8.5%
Plastics 8.5%
Glass 0.0%
Metal 0.9%
Other Organics 10.9%
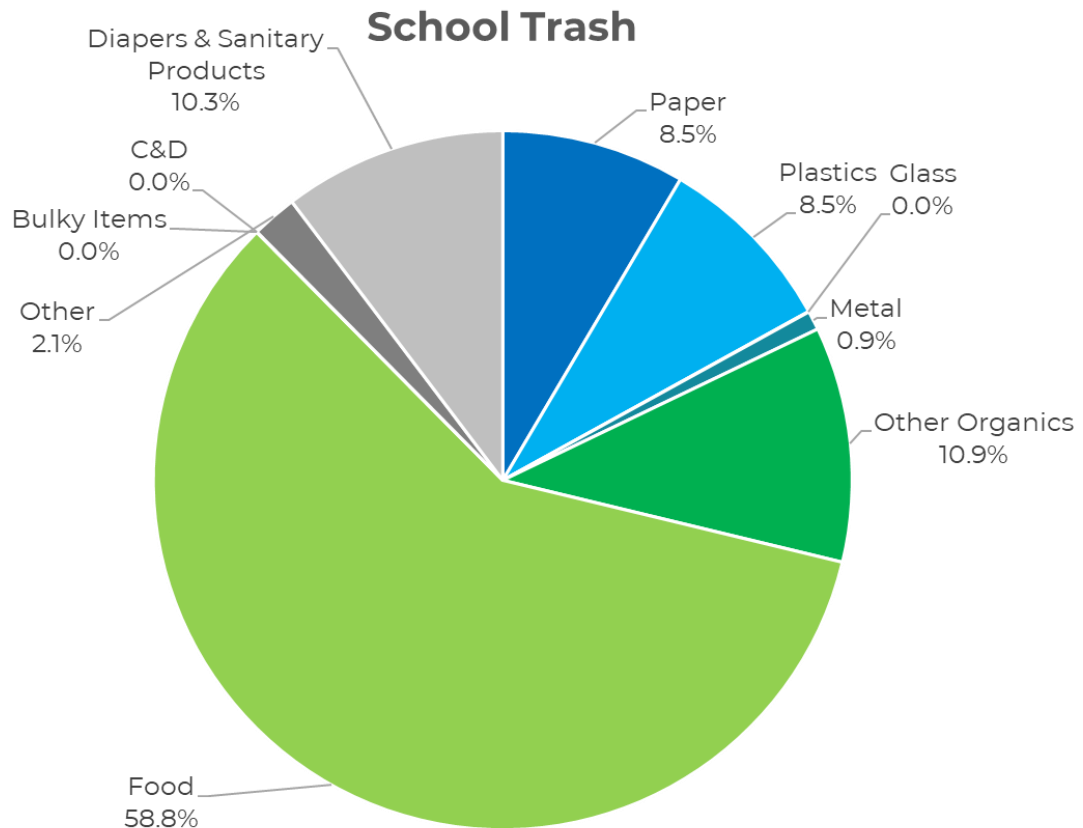
Municipal Buildings

Sample: Seven facilities including Inspectional Services, Worcester Public Library (main), City Hall, Emergency Management Headquarters, Worcester Senior Center, Fire Department Headquarters, and Police Headquarters. The DTM Admin Building and DPW Admin Building were intended sampling locations, however securing a sample of a relevant size was not possible during the sampling period. Therefore, Inspectional Services was sampled twice to increase the municipal sample size.

Results: Municipal refuse contained high levels of both organics (31.3%) and paper (26.8%). Organics were made up of Edible Food Scraps (11.0%), Non-Edible Food Scraps (4.3%), and Food-Soiled Paper (10.7%). Paper was largely Corrugated Cardboard (5.9%) and Mixed Recyclable Paper (13.0%), indicating strong potential for improved recycling capture. The Other (19.0%) category was also significant, primarily consisting of Liquids (4.8%), Diapers & Sanitary Products (2.9%), Textiles (5.9%), and Electronics (2.5%).

Municipal Trash

Diapers & Sanitary Products 2.9%
Other 16.2%
Bulky Items 1.9%
C&D 1.6%
Food 15.3%
Other Organics 16.0%
Metal 3.2%
Glass 1.7%
Plastics 14.6%
Paper 26.8%
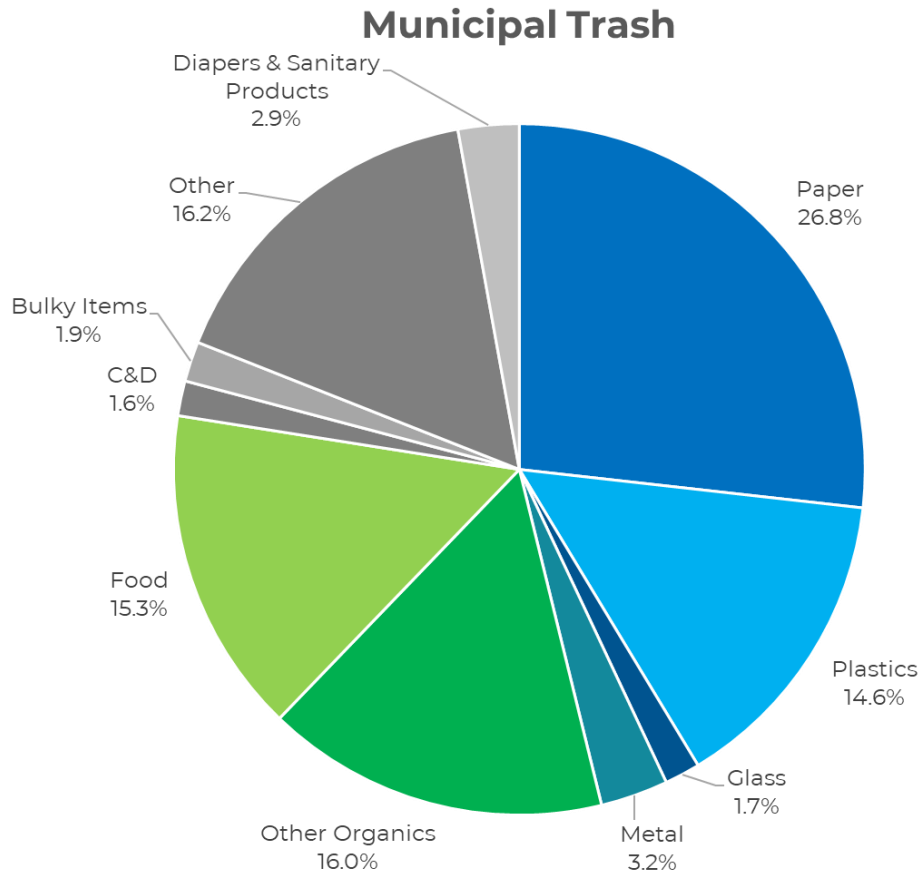
Illegal Dump Sites

Sample: Five locations were selected as sampling sites based on high-litter areas identified through Quality of Life Team coordination: Granite St., Bluff St., Walpole St., and Mayfield St. Eastern Ave. was also identified but contained no refuse at the time of sampling.

Results: Illegal dumpsites sampled contained a wide variety of materials. Key categories included Edible Food Scraps (8.6%), Clean Wood (6.1%), Treated Wood (5.0%), Whole Tires (11.9%), Furniture (11.4%), Textiles (6.4%), and Electronics (14.0%).

Illegal Dumping

Paper 2.9%
Plastics 4.3%
Glass 5.1%
Metal 5.5%
Other Organics 9.8%
Food 9.0%
C&D 15.7%
Whole Tires 11.9%
Furniture 11.4%
Textiles 6.4%
Electronics 14.0%
Other 2.5%
Diapers & Sanitary Products 1.8%
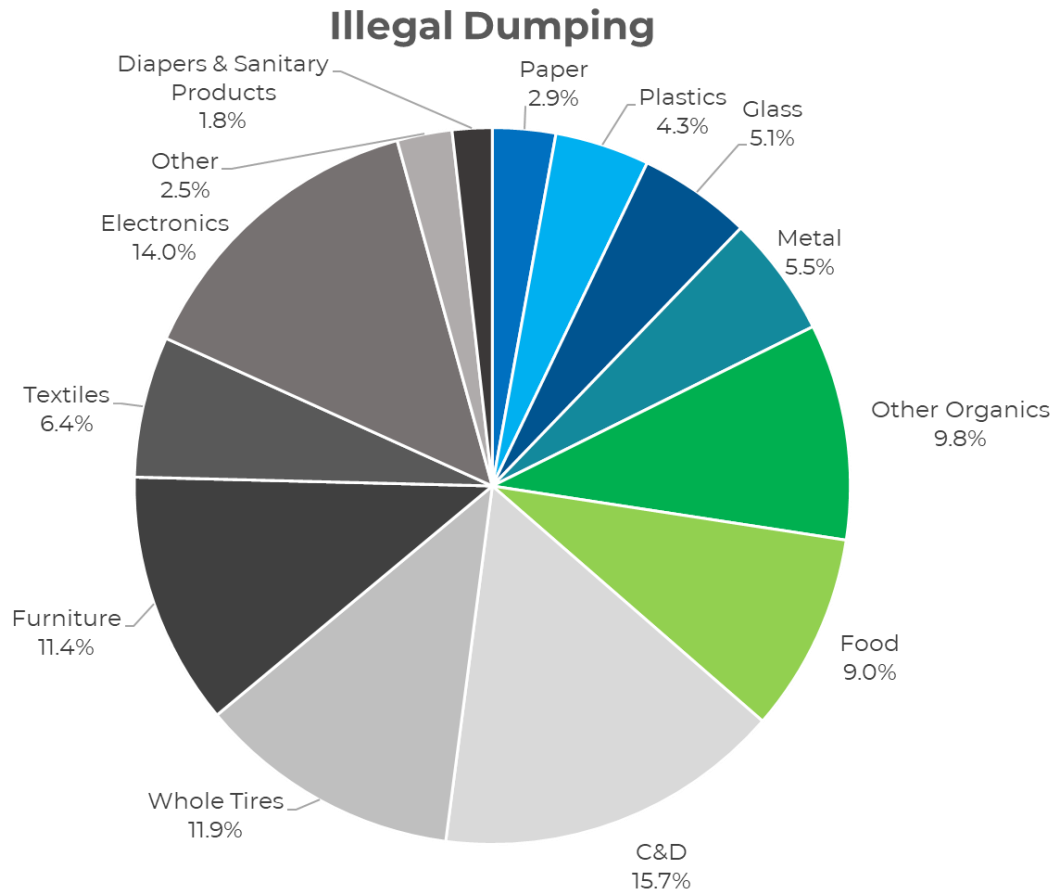
Study Results by Material Type

See Appendix A for full detailed descriptions of each material sampled.

Table 2: Material Composition by Sector

Residential (RES), Multi-Family (MTF), Commercial (COM), Schools (SCH), Municipal (MUN), Illegal Dumpsites (ILG), Recycling (REC), Refuse (REF)

	RES	MTF	COM	SCH	MUN	ILG	REC MTF	REC COM
Paper	11.20%	12.55%	16.61%	8.49%	26.78%	2.85%	47.10%	93.80%
Corregated Cardboard	0.28%	4.16%	6.41%	3.26%	5.88%	0.48%	26.18%	92.24%
Mixed Recyclable Paper	4.11%	3.44%	4.67%	1.48%	13.03%	1.50%	18.44%	0.67%

Aeseptic & Gable Top Cartons	0.43%	0.44%	0.37%	2.50%	0.72%	0.21%	1.27%	0.08%
Polycoated Paper	1.17%	0.80%	0.97%	0.60%	2.26%	0.42%	0.62%	0.00%

Non-Recyclable Paper	5.21%	3.70%	4.19%	0.65%	4.89%	0.25%	0.58%	0.81%
Plastics	9.71%	10.52%	10.24%	8.49%	14.58%	4.27%	12.18%	1.36%
PET (#1) Containers	1.28%	2.20%	1.43%	0.40%	2.52%	0.86%	4.31%	0.21%
HDPE (#2) Containers	0.48%	0.81%	0.82%	0.49%	0.99%	0.34%	1.98%	0.27%
PP (#5) Containers	0.54%	0.70%	0.39%	0.59%	0.79%	0.03%	0.64%	0.28%
Food Grade EPS (#6)	0.54%	0.36%	0.16%	0.03%	0.42%	0.02%	0.27%	0.00%
Non-Food Grade EPS (#6)	0.11%	0.20%	0.40%	0.00%	0.11%	0.12%	0.02%	0.08%
Recyclable Plastic Film	1.72%	1.57%	2.04%	1.78%	2.26%	0.24%	0.75%	0.17%
Non-Recyclable Plastic Film	1.62%	1.59%	2.13%	3.94%	3.19%	0.77%	0.89%	0.14%
City Sponsored Bags	0.88%	0.05%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Single-Use Grocery Bags	0.65%	0.63%	0.24%	0.04%	0.25%	0.21%	0.14%	0.10%
Single-Use Food Ware	0.37%	0.65%	0.69%	0.98%	2.31%	0.36%	0.40%	0.05%
Bulky Rigid Plastics	0.13%	0.62%	0.59%	0.00%	0.00%	0.75%	1.75%	0.00%
Other Rigid Plastics	1.39%	1.16%	1.34%	0.24%	1.73%	0.57%	1.03%	0.06%
Glass	1.41%	3.36%	2.37%	0.02%	1.66%	5.09%	3.81%	2.58%
Glass Bottles, Jars & Tubs	1.07%	3.03%	1.73%	0.02%	1.44%	2.15%	3.81%	2.36%
Other Glass	0.34%	0.33%	0.65%	0.00%	0.21%	2.94%	0.00%	0.21%
Metal	2.50%	5.72%	4.99%	0.88%	3.16%	5.45%	2.70%	0.67%
Aluminum Cans and Foil	0.74%	1.00%	0.79%	0.53%	1.39%	0.37%	1.53%	0.10%
Tin & Steel	0.75%	0.74%	0.69%	0.32%	0.79%	0.37%	0.91%	0.57%

Containers								
Other Non-Ferrous Metals	0.48%	0.32%	0.37%	0.00%	0.32%	1.36%	0.10%	0.00%
Other Ferrous Metals	0.52%	3.65%	3.14%	0.03%	0.67%	3.36%	0.16%	0.00%
Organics	53.87%	31.76%	28.91%	69.69%	31.32%	18.72%	5.62%	0.49%
Edible Food Scraps	28.41%	18.19%	14.68%	55.38%	11.00%	8.60%	2.86%	0.30%
Non-Edible Food Scraps	12.32%	4.78%	5.81%	3.42%	4.30%	0.37%	1.09%	0.00%
Food Soiled Paper	1.88%	1.52%	3.52%	5.20%	10.66%	0.47%	1.34%	0.19%
Certified Compostable Food Service Ware	0.07%	0.02%	0.10%	4.61%	0.19%	0.01%	0.02%	0.00%
Yard Debris	0.12%	4.46%	2.33%	0.96%	0.57%	6.71%	0.29%	0.00%
Other Organics	11.08%	2.79%	2.47%	0.11%	4.61%	2.55%	0.03%	0.00%
C&D	0.60%	4.18%	11.69%	0.02%	1.63%	15.69%	0.13%	0.00%
Clean Wood	0.01%	0.05%	2.01%	0.00%	0.00%	6.13%	0.00%	0.00%
Treated Wood	0.17%	2.26%	5.12%	0.01%	0.00%	4.98%	0.13%	0.00%
Drywall & Drywall Padding	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Carpet	0.23%	0.00%	0.19%	0.00%	0.00%	0.00%	0.00%	0.00%
Asphalt, Pavers, Brick, Concrete, and Rock	0.00%	0.00%	2.57%	0.00%	0.00%	4.58%	0.00%	0.00%
Remainder C&D	0.18%	1.87%	1.81%	0.00%	1.63%	0.00%	0.00%	0.00%
Bulky Items	0.00%	10.66%	6.79%	0.00%	1.87%	23.31%	16.91%	0.00%

Whole Tires	0.00%	0.00%	1.62%	0.00%	0.00%	11.88%	0.00%	0.00%
Furniture	0.00%	5.47%	4.47%	0.00%	1.87%	11.43%	6.55%	0.00%
Mattresses and Box Springs	0.00%	5.19%	0.70%	0.00%	0.00%	0.00%	10.36%	0.00%
White Goods: Large Appliances	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Other	20.71%	21.25%	18.40%	12.42%	19.01%	24.61%	11.53%	1.11%
Sharps & Medical	0.61%	0.05%	2.09%	0.00%	0.12%	0.10%	0.00%	0.00%

Waste								
Household Hazardous Waste	0.17%	0.46%	0.32%	0.00%	0.06%	0.03%	0.00%	0.00%
Liquids	1.30%	1.62%	3.29%	10.32%	4.76%	1.03%	0.45%	0.91%
Diapers & Sanitary Products	10.30%	5.68%	3.51%	0.44%	2.85%	1.80%	1.06%	0.00%
Textiles	3.69%	7.10%	2.52%	0.07%	5.94%	6.36%	1.89%	0.06%
Electronics	1.04%	1.41%	1.91%	0.22%	2.52%	13.96%	2.28%	0.00%
Non Lead-Acid Batteries	0.11%	0.25%	0.08%	0.00%	0.15%	0.11%	0.06%	0.00%
Lead Acid Batteries	0.00%	0.00%	0.43%	0.00%	0.00%	0.00%	0.00%	0.00%
Rubber	0.19%	0.72%	0.34%	0.00%	0.19%	0.45%	1.52%	0.11%
Fines/Residual	1.91%	1.54%	1.26%	0.94%	1.51%	0.04%	0.75%	0.03%
Other	1.38%	2.41%	2.64%	0.43%	0.91%	0.73%	3.53%	0.00%

Material-Specific Findings

Organics

Organics represented 18.7%–69.7% of samples overall, varying by sector. Edible Food Scraps consistently dominated, ranging from 8.6% at illegal dumpsites to 55.4% at schools, followed by Non-Edible Food Scraps. The consistently high proportion of organics across categories highlights a strong opportunity for diversion.

Bulky

Bulky materials included whole tires, furniture, mattresses, and box springs. These appeared only in multi-family residential, commercial, municipal, and illegal dumpsite samples. Although large appliances ("white goods") were considered as a category, none were observed during the sampling period.

Service Ware

Service ware (e.g., disposable cups, plates, utensils) was generally low, averaging 0.35–1.05% of samples, except in commercial recycling (0.05%) and municipal refuse (2.31%). Despite low weight percentages, these materials have a high volume-to-weight ratio, meaning small weight values can represent substantial space in the waste stream.

Yard waste

Yard debris was largely absent. In households served by the City's PAYT program, it accounted for only 0.12% of waste. Levels were higher in multi-family residential (4.46%) and illegal dumpsites (6.72%).

Other

The "Other" category included sharps and medical waste, household hazardous waste, liquids, diapers and sanitary products, textiles, electronics, batteries, rubber, fines/residuals, and mixed or uncategorized materials. This category ranged from 12.4%–24.6% of sample composition, typically around 20%. Across most sectors, diapers/sanitary products and textiles represented the largest share of this group.

Recycling Analysis/Material Misdirection

Across commercial and multi-family residential samples, most materials placed in recycling were correctly allocated. However, contamination rates varied significantly: residential (7+ units) recycling had 42.3% contamination, compared to only 3.7% in commercial recycling. The largest contaminants in residential recycling were organics (5.6%), other materials (11.5%),

and bulky items (16.9%).

Multi-family recycling data was limited due to availability; while more than 20 randomly selected sites were visited, many lacked recycling dumpsters, reducing the sample size. Commercial refuse also revealed that recyclable materials—though present in the recycling stream—remained heavily represented in the trash stream, indicating missed opportunities for recovery.

Study Methodology

The study employed rigorous stratified random sampling over 21 days in April 2025 for determining composition of unprocessed municipal solid waste. The methodology divides waste streams into distinct strata and samples randomly within each stratum to reduce variability and ensure adequate representation.

Sampling Methodology

The sampling strategy employed sector-specific methodologies tailored to each waste generator type to ensure representative data collection while accommodating operational constraints and access limitations across Worcester's diverse waste management systems. Samples were weighed out to accumulate over 200 pounds of material to be sorted. Where large quantities of a single material were to be included in the sample, they were weighed out and discarded on site at the sampling location.

Sorting Methodology

The sorting of the samples occurred on a table covered for rain and snow minimization. Sorters were assigned to categories to improve sort accuracy and efficiency. The samples would be sorted into the 50 material categories. Any items that sorters were unsure about were discussed and explained across the table. Once the entire sample was sorted, each category present in the sample was weighed out and recorded with the tare weight of the container it was in, noted and removed from the final weight.

Material Categories and Classification

The study utilized a comprehensive classification system designed to capture the full spectrum of materials present in Worcester's waste stream, with materials sorted into eight primary groups encompassing 50 total categories to enable precise identification of diversion opportunities and contamination sources. To see the full materials category list, refer to Appendix A.

Paper

Paper materials were categorized into five distinct types based on recyclability and composition. Corrugated cardboard included unwaxed and uncoated corrugated boxes with wavy layers, while mixed recyclable paper encompassed paperboard, kraft paper, cereal boxes, magazines, copy paper, and books. Aseptic and gable top cartons represented multi-layer packaging such as milk cartons and juice boxes, and polycoated paper included items with plastic coating for moisture resistance like coffee cups and frozen food containers. Non-recyclable paper captured materials that cannot be processed through recycling systems, including carbon copy paper, photographs, napkins, and shredded paper.

Plastics

The plastic category utilized resin identification codes and functional classifications to distinguish between different polymer types and end-of-life options. PET (#1) containers included bottles, jars, and thermoforms, while HDPE (#2) containers encompassed milk and juice bottles with necks and tubs. PP (#5) containers covered yogurt cups, margarine tubs, and medicine bottles, and expanded polystyrene was divided into food grade (#6) items like foam cups and clamshells versus non-food grade packaging materials. Plastic films were separated into recyclable clean, clear, single-layer films and non-recyclable multi-layered films with fused materials. City-sponsored yellow trash bags were tracked separately from single-use grocery bags, and single-use food ware included disposable clamshells, cups, utensils, and straws. Rigid plastics were categorized by size, with bulky items larger than a basketball distinguished from smaller miscellaneous plastic items.

Glass

Glass materials were separated into two primary categories based on their original function and recyclability potential. Glass bottles, jars, and tubs represented container glass designed for food and beverages, including wine bottles, pasta sauce jars, and baby food containers. Other glass included non-container materials such as window glass, mirrors, light bulbs, porcelain, and ceramics that require different handling and disposal methods.

Metal

Metal categories are distinguished between different alloy compositions and magnetic properties to support appropriate recycling streams. Aluminum cans and foil included food and beverage aluminum products such as beverage cans, foil wrap, and foil containers. Tin and steel containers encompassed food cans, empty aerosol cans, and empty paint cans made of tin-plated steel. Other non-ferrous metals included non-magnetic materials predominantly composed of copper, brass, stainless steel, lead, and zinc, while other ferrous metals captured iron-containing materials not in container form, such as steel scraps, tools,

and hardware.

Organics

Organic materials were categorized based on their composition and potential for recovery through composting or other organic waste processing methods. Edible food scraps included unused or partially used food that was fit for consumption prior to disposal, such as whole produce, prepared foods, and packaged foods. Non-edible food scraps captured food waste unsuitable for consumption, including peels, cores, and bones. Food-soiled paper encompassed paper products contaminated with food, such as soiled pizza boxes, unlined paper plates, and used napkins. Certified compostable food service ware included fiber or paper-based single-use items that were labeled and certified for commercial composting systems. Yard debris consisted of plant material from landscaping activities, including leaves, grass, branches, and plants, while other organics captured miscellaneous organic materials such as hair and natural fiber materials.

Construction & Demolition (C&D)

Construction and demolition materials were separated based on treatment status and material composition to support appropriate disposal and potential recovery options. Clean wood included any wood without adhesives, paint, stains, fire retardants, pesticides, or preservatives, such as dimensional lumber and pallets, with nails and screws considered acceptable. Treated wood encompassed pressure-treated materials or wood containing adhesives, paints, stains, or preservatives. Drywall and drywall padding included gypsum wallboard materials such as sheetrock and joint compound. Carpet consisted of textile floor covering and associated padding materials used in flooring applications. Asphalt, pavers, brick, concrete, and rock represented hard landscaping and construction materials including set or unset Portland cement mixtures and rock gravel larger than 2 inches in diameter. Remainder C&D captured mixed construction materials that could not be easily separated into other categories, including fiberglass insulation and miscellaneous construction debris.

Bulky Items

Bulky items represent large-scale materials requiring special handling and disposal considerations due to their size and composition. Whole tires included complete, un-shredded vehicle tires of all sizes with intact tire structure. Furniture encompassed household and office furniture such as chairs, tables, desks, and sofas, excluding mattresses and box springs which were tracked separately. Mattresses and box springs included all construction types and varieties of sleeping surfaces and supports. White goods represented large household appliances including refrigerators, washers, dryers, and stoves that typically contain valuable metals and require specialized processing.

Other

The remaining materials category captured specialized waste streams requiring particular handling attention due to safety, environmental, or regulatory considerations. Sharps and medical waste included all healthcare-related waste and devices intended to puncture or lacerate skin in medical capacities. Household hazardous waste encompassed items containing paints, thinners, solvents, vehicle fluids, cleaners, pesticides, fluorescent bulbs, and mercury-containing devices. Liquids included non-solid waste such as beverages and non-hazardous cleaning products, excluding household hazardous materials. Diapers and sanitary products covered adult and baby disposable diapers along with feminine hygiene products. Textiles included woven or knit fabric and cloth items such as clothing, linens, rugs, bags, curtains, and shoes, excluding carpet materials. Electronics encompassed devices with circuit boards, including computers, monitors, cell phones, stereos, and video equipment. Batteries were separated into non-lead-acid types such as alkaline, lithium, and rechargeable batteries versus lead-acid batteries used in vehicles and industrial equipment. Rubber materials included natural or synthetic rubber items such as shredded tires, bathmats, and garden hoses, excluding whole tires. Fines and residual materials consisted of particles smaller than 2 inches, including miscellaneous fragments of paper, plastic, glass, sand, and dirt. The final "other" category captured any waste materials that did not fit into existing categories, including cosmetics, shampoos, and lotions.

Team Structure & Organization

The study team was organized with specialized roles to ensure operational efficiency and data quality throughout the project. Amber Barbella served as Project Manager with overall responsibility for study execution, quality control, stakeholder communication, and final deliverables. Sophia Nielsen from Wegenerative functioned as Sort Lead, managing day-to-day sorting operations, team training and supervision, and ensuring sorting protocol consistency across all samples. Ally Blankenship served as Data Lead, responsible for data collection system design and maintenance, weight recording accuracy, and preliminary analysis during field operations. The sorting team consisted of four additional trained sorters who physically separated, categorized, and weighed waste materials according to established protocols, while the sampling team included two members responsible for representative sample collection and implementation of the mobile collection methodology at each designated location.

Quality Assurance & Quality Control (QAQC) & Data Processes

Upon the completion of the sort, the data was analyzed for quality control to ensure there were no errors or oversight in the data. From there the average (Mean %) was calculated and the Margin of Error (MOE) was used to calculate user and lower limits based on the 90% confidence interval. This data and its mean % was used to produce charts showing trends

overall for sections as well as highlighting specific categories to view trends.

Conclusion

The 2025 Waste Characterization Study identifies significant opportunities to improve waste diversion and resource recovery across the city of Worcester. Based on 111 samples totaling over 22,000 pounds, the study provides a robust baseline to guide implementation of the city's Zero Waste Master Plan. The study found that organics offer significant diversion potential, there are recycling gaps, and Worcester's PAYT program is working well. The study also reveals infrastructure and service delivery gaps that hinder full participation in diversion programs—especially in properties managed by private haulers. Addressing these gaps is critical to equitable progress

This study establishes a replicable methodology for future waste assessments. Regular follow-up studies every 5–10 years will enable Worcester to measure progress, adapt programs, and strengthen funding and compliance efforts.

With this data-driven roadmap, Worcester is well-positioned to lead the region in sustainable waste management—reducing disposal costs, improving environmental outcomes, and advancing its zero waste vision.

Appendix A

Table 3: Material Definitions

Material Group	Category	Definition
Paper	Corrugated Cardboard	Unwaxed/uncoated corrugated container boxes with wavy layer when torn
	Mixed Recyclable Paper	Single layer unlined paper material. Paperboard, kraft paper, cereal boxes, tissue boxes, paper towel rolls, junk mail, magazines, colored papers, mailing tubes, copy paper, books, envelopes
	Aeseptic & Gable Top Cartons	Multi-layer packaging made of bleached or unbleached paperboard coated with HDPE film and sometimes aluminum, typically used for beverage and food containers. Milk cartons, juice boxes, soup cartons.
	Polycoated Paper	Paper with plastic coating for moisture resistance. Materials: frozen food and ice cream containers, paper coffee cups, lined paper plates.
	Non-Recyclable Paper	Any paper products that cannot be recycled, not listed in the other paper categories. Carbon copy paper, label backing, photographs, napkins, paper towels, receipt paper, and shredded paper. Excludes: food soiled paper.

Plastics	PET (#1) Containers	#1 polyethylene terephthalate containers including bottles, jars and thermoforms.
	HDPE (#2) Containers	High-density polyethylene containers clear and translucent milk, juice, beverage, vinegar, distilled water bottles with necks and tubs.
	PP (#5) Containers	Polypropylene containers. yogurt cups, margarine tubes, medicine bottles. Excludes: single-use food containers i.e clamshells and plastic disposable soup cups.
	Food Grade EPS (#6)	Expanded polystyrene (styrofoam) items for food service. Foam cups, clamshell containers, foam plates
	Non-Food Grade EPS (#6)	Expanded polystyrene (styrofoam) items for packaging. Packaging peanuts, electronics packaging, trays that are used for packaging meat and groceries

	Recyclable Plastic Film	Clean, Clear, single-layer plastic film. Pallet wrap, bubble wrap, air pillows. Excludes: City sponsored bags, single-use grocery bags.
	Non-Recyclable Plastic Film	Multi-layered film that contains other materials that have been fused together. Aluminized film (chip bags), wrappers, Heavy-duty non-woven plastic bag designed and marketed to be reused, grain bags.
	City Sponsored Bags	Yellow plastic trash bags that are provided to Worcester residents
	Single-Use Grocery Bags	Thin plastic bags used for retail purposes. Single-use grocery bags and produce bags.
	Single-Use Food Ware	Rigid disposable food service items disposable food ware by type: straws and stirrers, clamshells, cups, utensils, (PET, HDPE, PP). Clamshells, cups, utensils, straws, stirrers. Excludes: Expanded Polystyrene (EPS) single-use service ware.
	Bulky Rigid Plastics	Large plastic items of various resin types. Must be larger than a basketball to be bulky. Milk crates, laundry baskets, storage bins, plastic furniture, large toys
	Other Rigid Plastics	Miscellaneous hard plastic items smaller than a basketball. Small toys, office supplies, toothbrushes, CD/DVDs, PVC hose.
Glass	Glass Bottles, Jars & Tubs	Container glass designed for food and beverages. Wine bottles, pasta sauce, baby food jars.
	Other Glass	Non-container and non-food container glass. Window glass, mirrors, light bulbs, porcelain, ceramics.
Metal	Aluminum Cans and Foil	Food and beverage aluminum products. Beverage cans, foil wrap, foil containers.
	Tin & Steel Containers	Food and product containers made of tin-plated steel. Food cans, empty aerosol cans, empty paint cans.
	Other Non-Ferrous Metals	Metals not containing iron. Non-magnetic, predominantly stainless steel. Copper, brass, aluminum non-container, lead, stainless steel, zinc. Excludes: bulky appliances and food containers.
	Other Ferrous Metals	Iron-containing metals not in container form. Non-container and magnetic. Steel scraps, tools, hardware.

Organics	Edible Food Scraps	Unused or partially used food fit for consumption prior to disposal. Whole produce, prepared foods, packaged foods.
	Non-Edible Food Scraps	Food waste unsuitable for consumption. Peels, cores, bones.
	Food Soiled Paper	Paper products contaminated with food. Soiled pizza boxes, unlined paper plates, used napkins.
	Certified Compostable Food Service Ware	Fiber or paper-based single-use foodware (such as clamshells, bowls, cups, utensils), labeled and certified. Unlined fiber containers, labelled certified compostable items. Identifiers: Compost certification labels.
	Yard Debris	Plant material from landscaping. Leaves, grass, branches, plants. Excludes: lumber.
	Other Organics	Miscellaneous organic materials. Hair, natural fiber materials, non-yard plant matter.
C&D	Clean Wood	Any wood which does not contain an adhesive, paint, stain, fire retardant, pesticide or preservative; includes such items as bulky wood waste or scraps from newly built wood products. The presences of nails or screws are acceptable. Dimensional Lumber, pallets. Excludes: Land debris or yard waste and trimmings. The presences of nails or screws are acceptable.
	Treated Wood	Wood that is pressure treated, or contains an adhesive, paint, stain, fire retardant, pesticide or preservative. Excludes furniture.
	Drywall & Drywall Padding	Gypsum wallboard and materials. Sheetrock, gypsum board, joint compound. Interior wall covering made of a sheet of gypsum sandwiched between paper layers. Examples include used or unused, broken or whole sheets of sheetrock, drywall, gypsum board, plasterboard, and wallboard.

	Carpet	Textile floor covering and padding. Flooring applications consisting of various natural or synthetic fibers bonded to some type of backing material. Carpet padding may include plastic, foam, felt, or other material used under the carpet to provide insulation and padding. Carpet, carpet padding, artificial turf. Excludes: Rugs (textiles).
	Asphalt, Pavers, Brick, Concrete, and Rock	Hard landscaping and construction materials. Includes asphalt paving materials, set or unset, and all types of fire-clay bricks. Includes Portland cement mixtures (set or unset), with or without aggregate materials (gravel, etc.). Includes rock gravel larger than 2"in diameter. Materials: Concrete blocks, bricks, rocks, pavers. Excludes: Soil and dirt
	Remainder C&D	Construction and demolition material that cannot be put in any other subtype. This type may include items from different types combined, which would be difficult to separate. Also includes fiberglass insulation and other miscellaneous C&D Materials not mentioned above.
Bulky Items	Whole Tires	Complete, unshredded tires. Vehicle tires of all sizes. Intact tire structure. Excludes: Shredded tire material
	Furniture	Household and office furniture. Chairs, tables, desks, sofas. Identifiers: Indoor/outdoor furniture items. Excludes: mattresses and box springs.
	Mattresses and Box Springs	Mattresses of all construction types including all-foam constructions (PE and Latex), and coil spring mattresses. Includes all varieties of box springs as well. Mattresses, box springs, futons, sleeping surfaces and supports. Excludes: appliances and bed frames (furniture).
	White Goods: Large Appliances	Large household appliances. Refrigerators, washers, dryers, stoves.
Other	Sharps & Medical Waste	Healthcare related waste. All forms of medical waste including "sharps" defined as any device or object intended to puncture or lacerate the skin in a medical capacity. Needles, bandages, medical equipment
	Household Hazardous Waste	Hazardous household items containing paints, thinners, solvents, vehicle equipment fluids, cleaners, pesticides/herbicides and fertilizers. Includes fluorescent bulbs, light ballasts, and mercury-containing devices.
	Liquids	Non-solid waste. Beverages, non-hazardous cleaning products, oils Excludes: Household hazardous waste (i.e paint)

	Diapers & Sanitary Products	Adult and baby disposable diapers, and feminine hygiene products
	Textiles	Woven or knit fabric and cloth items. Clothing, linens, rugs, bags, curtains, shoes. Excludes: Carpet.
	Electronics	Electronic devices and components. Includes all electronic items with a circuit board, including cathode ray tubes (CRTs) or other video displays, plasma and LCD monitors. cell phones, personal computers, laptop computers, notebook computers, processors, keyboards, etc. Includes stereos, VCRs, DVD players, etc.
	Non Lead-Acid Batteries	Common household batteries. Alkaline, lithium and rechargeable batteries.
	Lead Acid Batteries	Vehicle and industrial batteries. Car, truck, industrial equipment batteries.
	Rubber	Natural or synthetic rubber shredded tires, bathmats, inner tubes, rubber garden hoses. Excludes: entire tires.
	Fines/Residual	Small mixed particles. Materials: Dirt, dust, small fragments. Identifiers: Particles smaller than 2 inches. Small mixed fragments 2" and smaller, and includes miscellaneous fines (paper, plastic, glass, etc.), sand, and dirt.
	Other	Any other type of waste material not listed in any other sort category. Includes cosmetics, shampoos, lotions, etc.