City of Baltimore

RECYCLING AND SOLID WASTE MANAGEMENT MASTER PLAN

Second Report on Task 0

Results from Second Seasonal Waste Sort (Summer 2019)

26 September 2019

Prepared for:

Baltimore City Department of Public Works

Prepared by:

Geosyntec consultants

Columbia, Maryland

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receiving residential curbside recycling at the transfer station

20 June 2019

1. Introduction

Purpose

The goal of the waste sort is to provide reliable and up-to-date data on waste characteristics and quantities currently generated within Baltimore City. This data will be used to inform the ongoing Department of Public Works (DPW) planning effort for developing the City's Recycling and Solid Waste Management Master Plan, titled the "Less Waste, Better Baltimore" Plan.

Waste Streams Targeted for Sorting

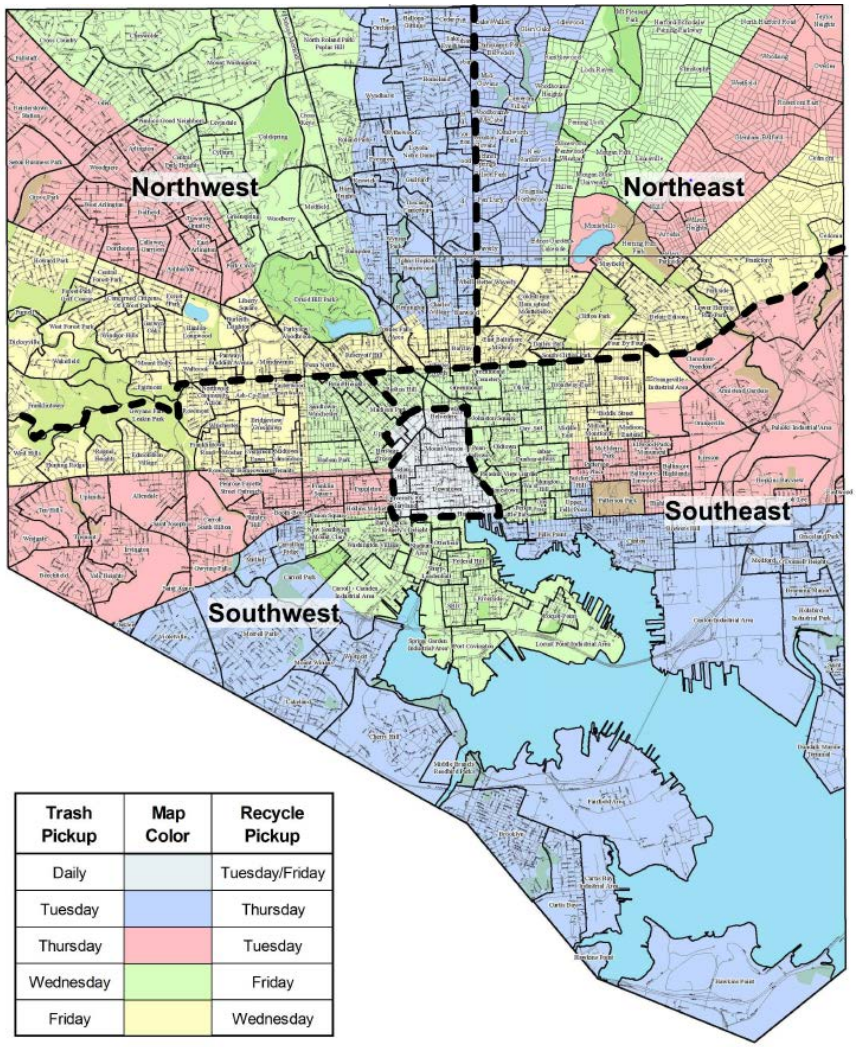
The Summer 2019 waste sort targeted the following components of the existing solid waste management system in Baltimore City.

Curbside Waste Collection

Collection services are provided weekly by DPW to single family households, City buildings, small businesses, and public schools. DPW provides services in four quadrants – Northwest (NW), Northeast (NE), Southwest (SW), and Southeast (SE) – plus the Central zone. Depending on collection routing, waste collected by DPW is delivered to Baltimore Refuse Energy Systems Co. (BRESCO) waste-to-energy (WTE) plant; DPW's Quarantine Road Landfill (QRL); or DPW's Northwest Transfer Station (NWTS), where it is consolidated into larger loads for transportation to BRESCO or QRL.

Commercial Waste Collection

Most commercial and industrial businesses in the City contract directly for waste collection with private haulers, who deliver waste to BRESCO, QRL, or to out-of-city transfer or disposal facilities.



Trash Pickup	Map Color	Recycle Pickup
Daily		Tuesday/Friday
Tuesday		Thursday
Thursday		Tuesday
Wednesday		Friday
Friday		Wednesday

Map of DPW's Collection Quadrants

Curbside Single-Stream Recycling

Curbside recyclable loads are directed to NWTS to be consolidated prior to being transferred to the Waste Management Recycle America (WMRA) materials recycling facility (MRF) on Kit Kat Road in Elkridge.

Residential Drop-Off Centers

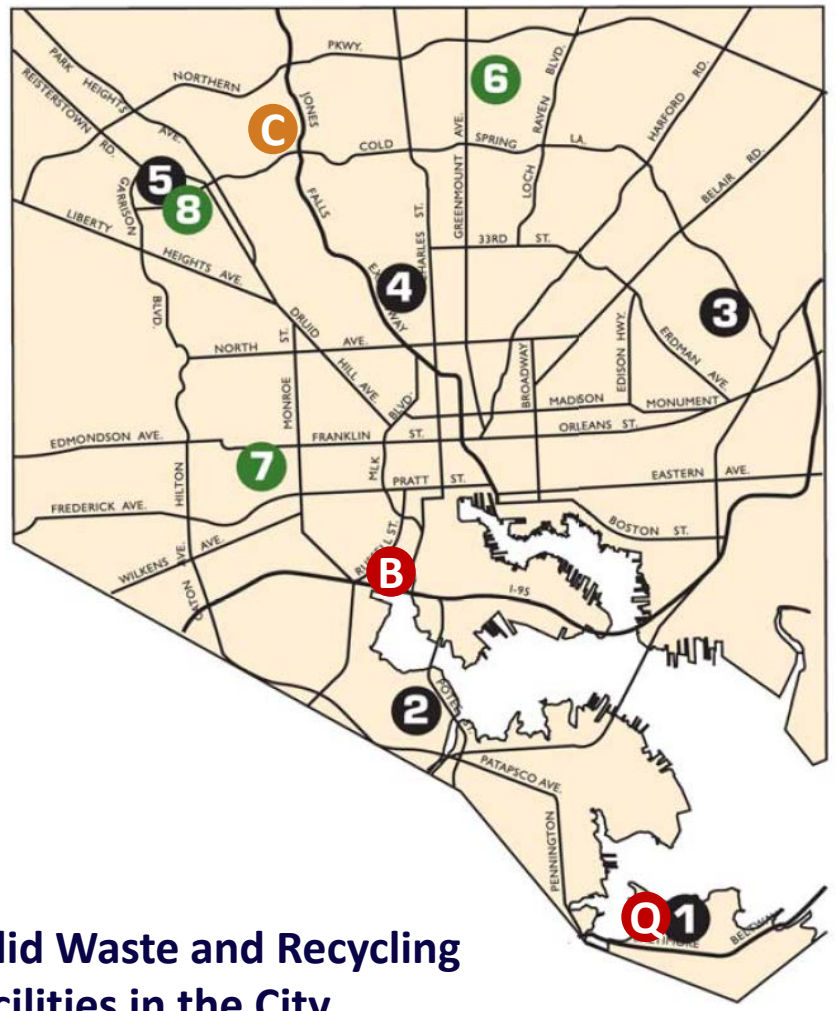
City residents may drop off household waste and recycling for free at QRL or NWTS as well as three other full-service residential drop-off centers, also known as convenience centers – Western Sanitation Yard (Reedbird Ave.), Eastern Sanitation Yard (Bowleys Lane), and NW Citizens Convenience Center (Sisson St.). In addition, DPW operates three drop-off centers that only accept recyclables – York Road Substation, Calverton Road Substation, and Lewin Substation. Waste and recyclables collected at these drop-off centers are consolidated and transferred as described previously.

NWTS, QRL, and Sisson St. are very active drop-off centers; therefore, these three centers were targeted for visual sorting during the Summer 2019 waste sort.

Small Haulers (Construction and Demolition Debris)

Construction and Demolition (C&D) debris generated in the City may be delivered to QRL; however, the bulk of C&D debris handled by large private haulers is delivered to private recycling or disposal facilities, many of which are outside the City.

Commercial small haulers collecting waste from within the City are permitted to deliver waste to QRL or, on a larger/more frequent basis, under the licensed small hauler programs at NWTS and QRL. Many small-hauler loads contain predominantly C&D debris. Small haulers at NWTS thus served as the C&D debris category targeted for visual sorting in the Summer 2019 waste sort.



Solid Waste and Recycling Facilities in the City

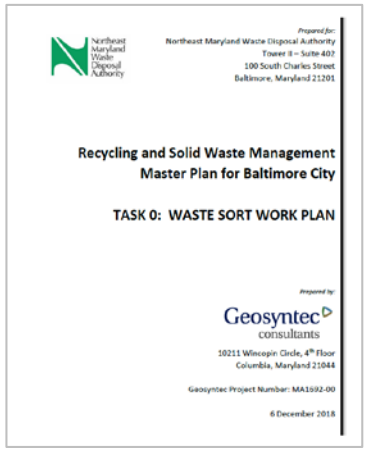
(Q)	Quarantine Road Landfill	(6)	York Road Substation*
(1)	QRL Convenience Center	(7)	Calverton Road Substation*
(2)	Reedbird Ave. Conv. Center	(8)	Lewin Ave. Substation*
(3)	Bowleys Lane Conv. Center	(B)	BRESCO
(4)	Sisson St. Conv. Center	(C)	Camp Small
(5)	Northwest Transfer Station	* Recyclable items only; operated by Dept. of General Services (DGS)	

2. Work Plan and Schedule for Sorting

Selection of Sorting Venues

All physical waste and recycling sorts were conducted at NWTS where trucks are unloaded, and thus loads could be sampled, indoors. This had significant advantages over QRL, which hosted the Winter 2019 sorting event. While workable, QRL was less than ideal as it required sorting in an open, unpaved area at the landfill which presented problems related to litter and run-on/run-off control, contamination of samples with mud or dirt, inclement weather delays, and daily trash removal and site cleanup.

Targeted visual sorting of loads brought to residential drop-off centers in the City was performed at the two largest and most active drop-off centers – QRL (item 1 on the map on p.5) and Sisson St. (item 4 on the map on p.5). In addition, a visual observation was conducted of loads delivered by small haulers to NWTS (item 5 on the map on p.5).


Northeast Maryland Waste Disposal Authority

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Recycling and Solid Waste Management Master Plan for Baltimore City

TASK 0: WASTE SORT WORK PLAN

Prepared by:
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Geosyntec Project Number: MA1692-00

6 December 2018

Details regarding the waste sampling and sorting methodologies and procedures are provided in Geosyntec's Work Plan (see attachment)

Schedule

The Summer 2019 waste sort took place between 5 and 28 June. In total, the waste sort included 11 full days of field work:

- Three days sorting 12 curbside residential trash loads;
- Three days sorting 14 commercial trash loads;
- Two days sorting 12 curbside residential recycling loads;
- One day of visual observation and targeted sorting of recyclables at the QRL and Sisson St. drop-off centers; and
- One day of visual observation of small-hauler loads at NWTS.

Calendar of Sorting Events

Mon	Tues	Weds	Thur	Fri
Jun 3	Jun 4	Jun 5 QRL Drop-Off	Jun 6 Sisson St. Drop-Off	Jun 7 NWTS Small Haulers
Jun 17 Com Trash 1 (5)	Jun 18 Com Trash 2 (4)	Jun 19 Com Trash 3 (5)	Jun 20 Recycling 1 (6)	Jun 21 Recycling 2 (6)
Jun 24	Jun 25	Jun 26 DPW Trash 1 (4)	Jun 27 DPW Trash 2 (4)	Jun 28 DPW Trash 3 (4)

sampling a load of curbside residential trash

26 June 2019

3. Results of Waste Sorting Activities

Curbside Residential Trash

Three days were assigned for sampling curbside residential trash, with a total target of 12 to 18 samples. Residential trash was sampled from DPW waste collection trucks (load packers) with at least two trucks per City Quadrant targeted in total. As NWTS was only actively handling recycling trucks and not trash trucks at the time of sampling, close communication between Geosyntec's crew manager, NWTS staff, DPW's Quadrant Managers, and truck drivers served to ensure that the appropriate number of trash trucks were directed to NWTS on each day for sorting. Difficulties in scheduling loads within the daily working window resulted in only four truck loads being sorted each day.

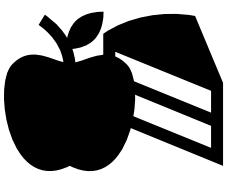
Waste Sampling and Sorting Procedures

Trucks assigned to deliver trash were directed to a separate area on the tipping floor inside the transfer station. Truck drivers were interviewed to record their load type and origin. Scale house records were used to obtain the total load tonnage. Once the entire truck load had been tipped, a sample of 200 to 300 lbs. was randomly selected by hand by Geosyntec's crew manager and wheeled in a tilt cart to the sorting area located just outside the transfer station building.

Each sample was pre-weighed and then tipped onto the sorting table for sorting into 11 classifications using toters and bins of known tare weight. Once sorting was completed, each toter/bin was reweighed to obtain the weight of material in each classification. After weighing, the toters were emptied back into the tilt cart and wheeled back to the tipping floor for disposal.

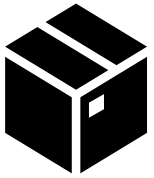
Sample Classifications

Samples were divided into 11 classification categories, consistent with the Winter 2019 waste sort.



Food Scraps

Mixed Paper



Cardboard

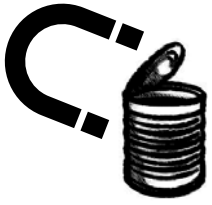
Glass

Aluminum

Mixed Plastics

Plastic No. 1

Plastic No. 2



Ferrous Metal

Yard Waste and Clean Wood

Unclassified (Other)

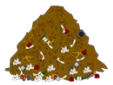
Unclassified materials are those that do not fit in one of the previous 10 categories, are made up of composite materials, or are unidentifiable. Diapers and cat litter are good examples.

Curbside Residential Trash

Number and Size of Samples

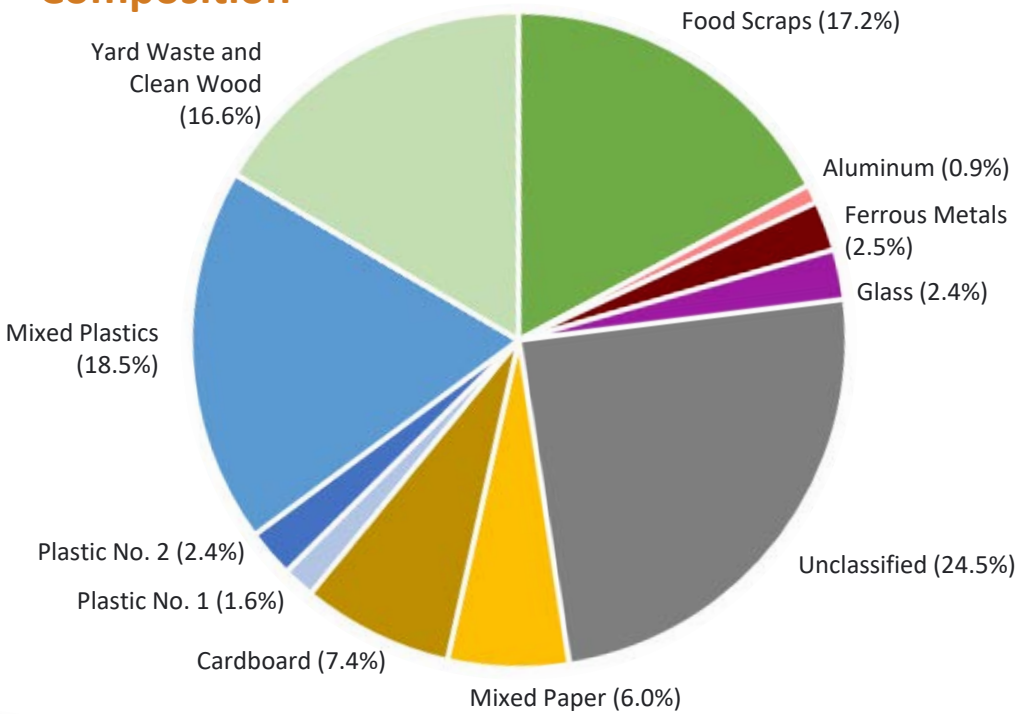
In total, 12 trash loads were sampled over three days. A combined total weight of 112 tons was delivered to the tipping floor, an average of about 9.4 tons per truck. From this, about 2,833 lbs. was selected for sorting, an average of about 236 lbs. per sample.

112 total tons delivered

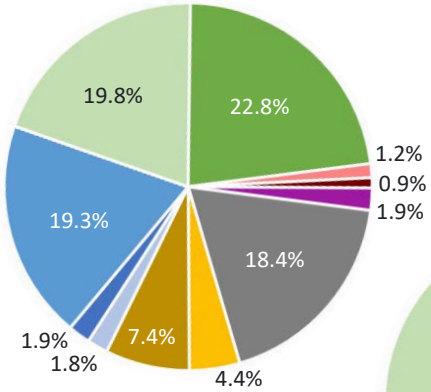


2,833 total lbs. sampled and sorted

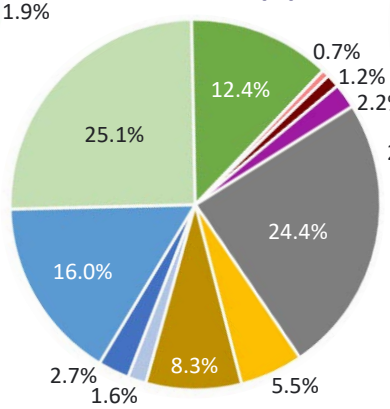
Composition



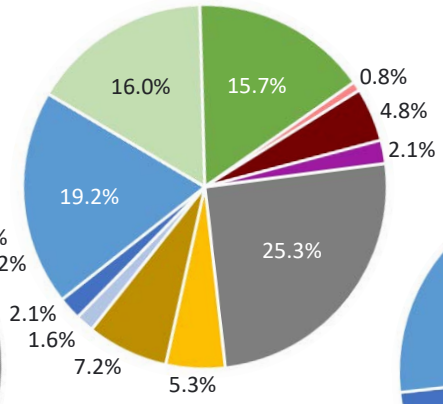
Breakdown by Quadrant



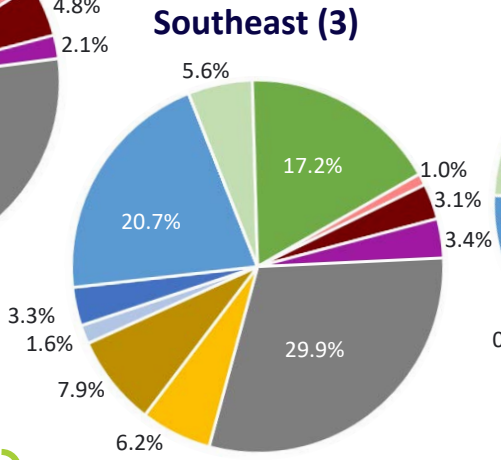
Northwest (3)



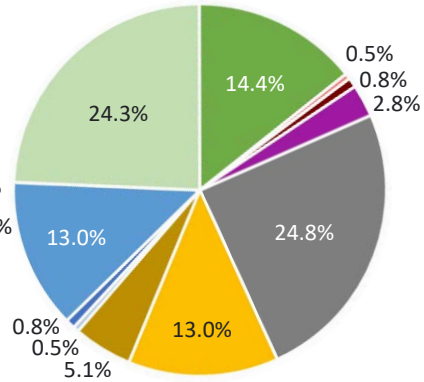
Southwest (2)



Northeast (3)



Southeast (3)

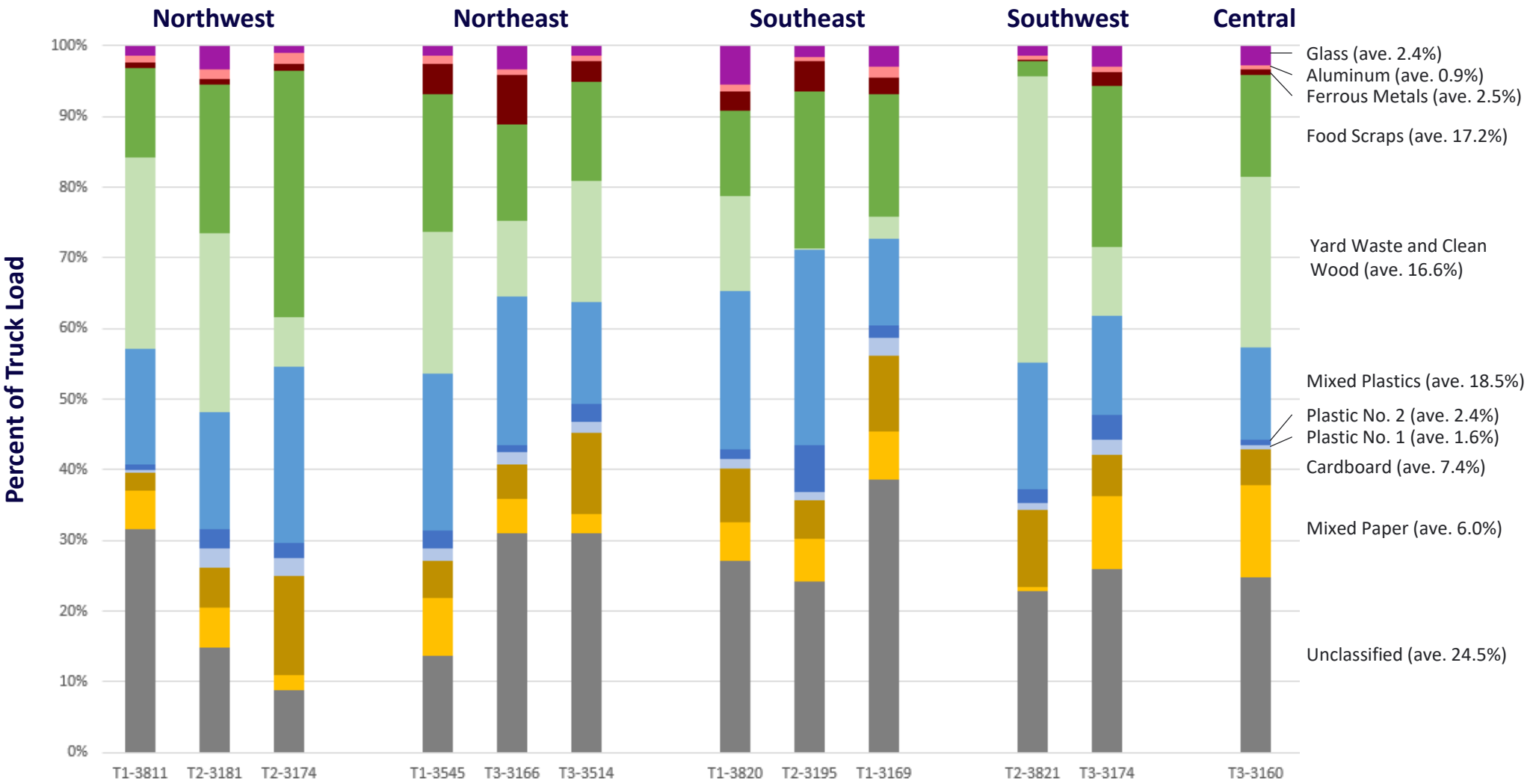


Central (1)

Number of loads per quadrant in parentheses. Variability was most evident in food scraps, yard waste, and unclassified content.

Curbside Residential Trash – Breakdown by Quadrant and Load

Each truck was assigned a unique load number based on the type of waste (trash, T), day of sorting (1 to 3), and vehicle tracking number (four digits) as shown in the chart below. Consolidated results and raw data for each load are provided in the appendix to this report.



sorting residential trash loads

26 to 28 June 2019

Commercial Trash

Commercial haulers play an important role in collection of waste from private customers in the City and account for a significant percentage of the total waste stream. Therefore, DPW requested participation from any large commercial hauler with a diverse customer base, extensive collection routes, and a wide range of collection vehicle types. The hauler was required to show licensure with the City Health Dept. and verify that all waste loads delivered to the waste sort would be collected within City limits and would not include C&D debris. After outreach via direct emails and social media, Republic Services, Inc. (RSI) was the only firm that volunteered to participate. Special dispensation was provided by DPW and MDE for selected RSI trucks to be diverted to NWTS as the transfer operation is typically reserved for handling DPW trucks only.

Waste Sampling and Sorting Procedures

Three days were assigned for sampling commercial trash delivered to NWTS by RSI, with a total target of 12 to 18 samples. RSI truck load types included open-topped "roll-on roll-off" (RORO) containers; closed compactor containers; front-end load packers (FELs); and rear-end load packers (RELs). Close communication between Geosyntec's crew manager, NWTS staff, RSI's Route Auditor, and truck drivers served to ensure that NWTS staff and Geosyntec's sorting crew were prepared to handle the appropriate number of trucks on each day for sorting. Difficulties handling the larger sizes of truck employed by RSI resulted in NWTS staff limiting the total number of trucks to five per day. One load was lost before sampling.

Once at NWTS, waste delivery and sampling protocols were the same as previously described for DPW curbside trash loads. Truck drivers were interviewed to confirm their load type and origin, with RSI's Route Auditor providing backup route maps and confirmation of collection details at the end of each day.

Sample Classifications

Samples were divided into 11 classification categories as previously described with reference to DPW curbside trash loads.

Types of Waste Collection Trucks

Four types of collection vehicle and load types were dispatched to NWTS by RSI for the waste sort.

Front-End Load Packers (FELs)

Their most common type of collection vehicle, RSI employ FELs to service any account that is not a specific point-source large waste producer or construction/demolition project. Customers can be anything from a small doctors' office to large apartment building to restaurants and office parks. FELs have the advantage that customers are served by one or more small dumpsters that can be automatically hoisted over the front of the truck and emptied into the onboard compactor section before the empty dumpster is replaced ready to use. This allows for quick and efficient collection.

Roll-On Roll-Off (RORO) Containers

RORO containers are generally used to service large-capacity customers or specific construction or other projects that generate bulk waste. Customers also include businesses, especially large office buildings, or special events such as outdoor carnivals and fairs.

Rear-End Load Packers (RELs)

RELs are the type of collection vehicle used by DPW for curbside services in the City, and are popular for residential services as they allow for flexible collection from a large number of small generators such as households. In RSI's operation in Baltimore City, this type of truck is only used to service customers that they have difficulty creating other service accounts for. This may be due to safety concerns or space limitations that preclude setting out FEL dumpsters or RORO containers, or requirements for physical labor. Typical customers include bars, restaurants, clubs, and small apartment buildings.

Compactor Containers

Compactor containers are designated for large-capacity customers that routinely generate more waste than can be handled efficiently using a non-compacting RORO container or FEL dumpsters. Typical customers include university and hospital buildings (especially cafeterias) as well as markets and grocery stores.

Commercial Trash

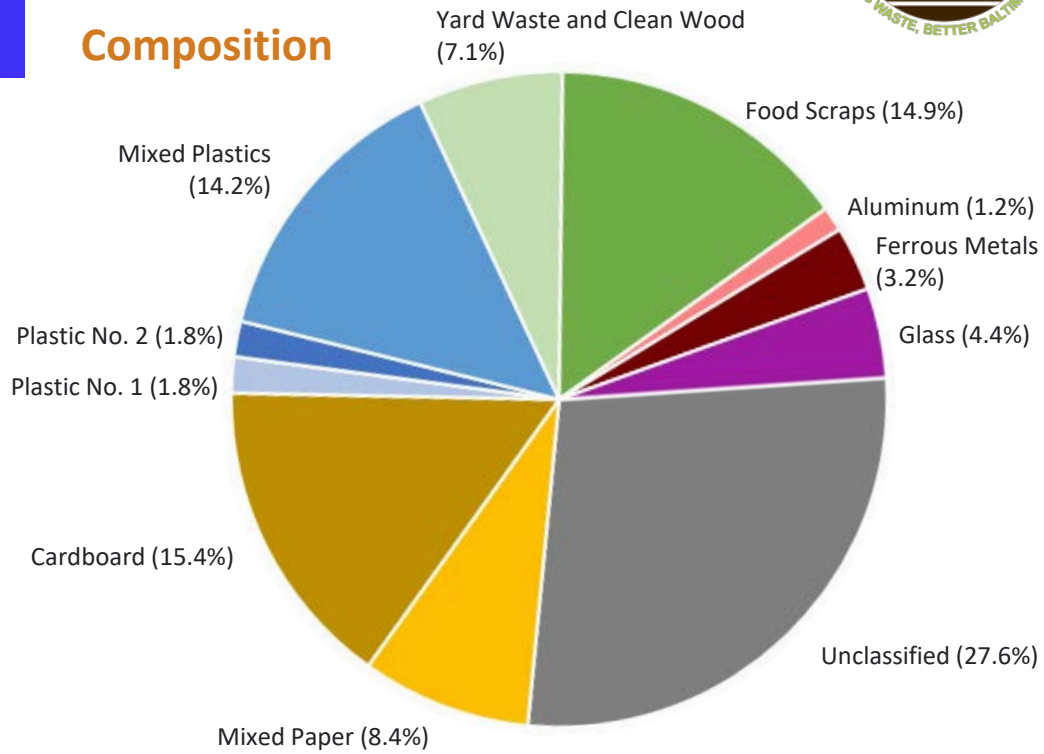
Number and Size of Samples

In total, 14 trash loads were sampled over three days. A combined total weight of 126 tons was delivered to the tipping floor, an average of about 9.0 tons per truck. From this, about 3,260 lbs. was selected for sorting, an average of about 233 lbs. per sample.

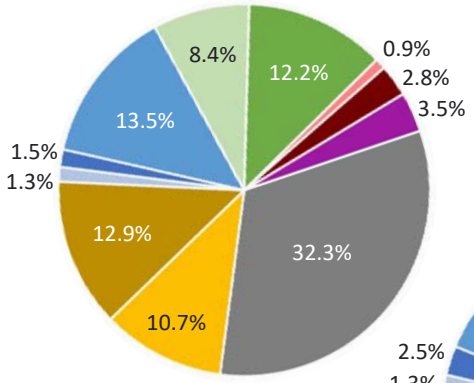
126 total tons delivered

3,260 total lbs. sampled and sorted

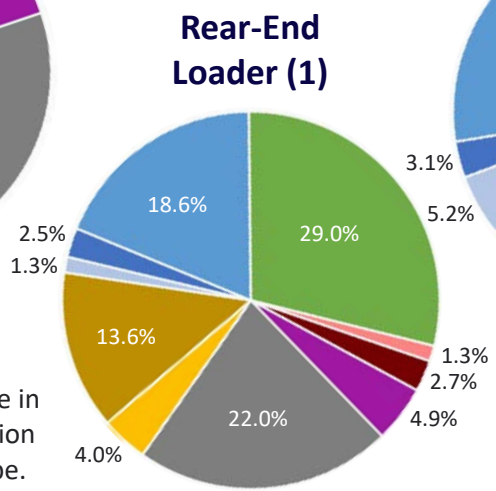
Composition

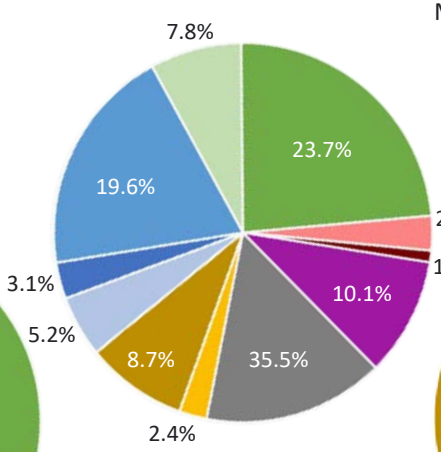


Breakdown by Truck Type

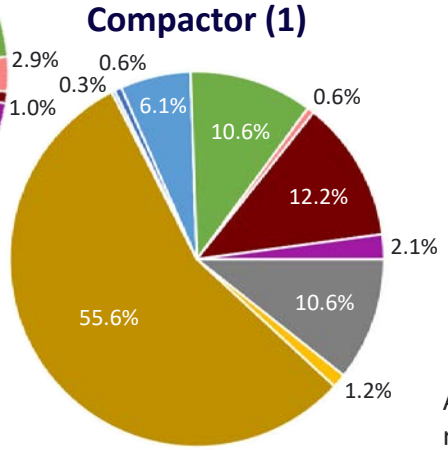


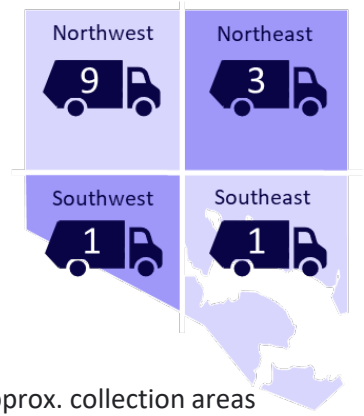
Front-End Loader (10)





RORO (2)



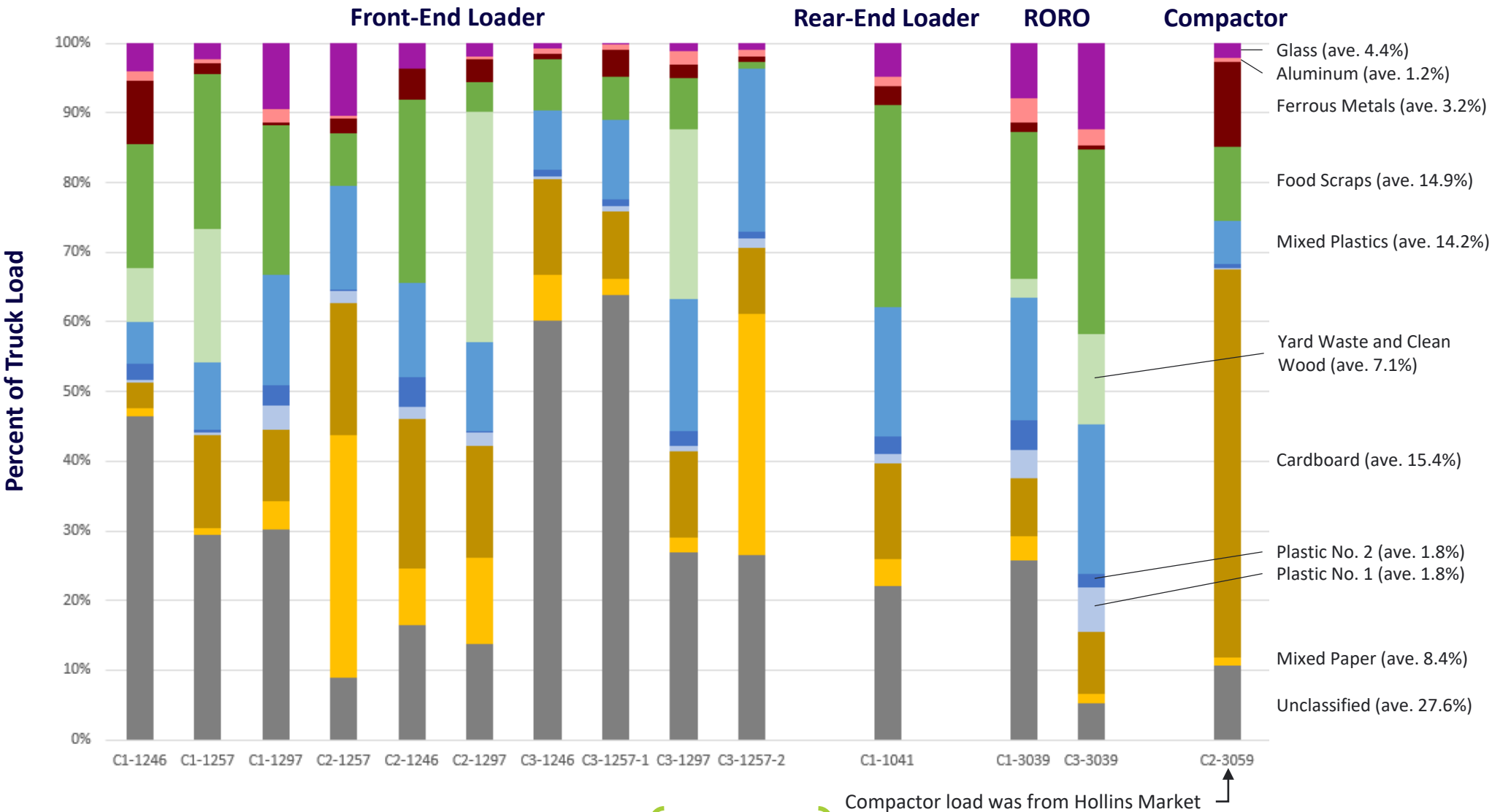


Number of loads per truck type in parentheses. Waste composition varies significantly by truck type.

Approx. collection areas relative to DPW's quadrants.

Commercial Trash – Breakdown by Truck Type and Load

Each truck was assigned a unique load number based on the type of waste (commercial trash, C), day of sorting (1 to 3), and vehicle tracking number (four digits) as shown in the chart below. Consolidated results and raw data for each load are provided in the appendix to this report.



Single-Stream Recycling

In the Winter 2019 waste sort, recycling loads were found to be much more homogeneous than trash; therefore, only two days were assigned for sampling curbside single-stream recycling, with a target of 10 to 15 samples. Recycling loads were sampled from DPW waste collection trucks (load packers) with a target of at least three trucks per City Quadrant. As DPW was already running nearly all recycling trucks to NWTS at the time of the Summer 2019 waste sort, preemptive communication between the sorting crew, NWTS staff, and DPW's Quadrant Managers was not necessary. Geosyntec's crew manager randomly selected trucks arriving at the scale, which were directed to a designated area of the tipping floor for sampling.

Waste Sampling and Sorting Procedures

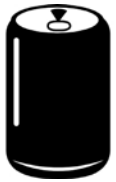
The methods for sampling, sorting, and disposing of single-stream recycling loads were the same as for trash loads.

In the Winter 2019 waste sort, recycling samples were divided into nine classification categories, with plastics classified as No. 1, No. 2, or mixed. For the Summer 2019 waste sort, mixed plastics were subdivided into hard plastics (i.e., all mixed rigid plastic items not classified as No. 1 or No. 2) and soft plastics (e.g., grocery bags, food film/wrap, chip packets, candy wrappers, or polystyrene clamshells).

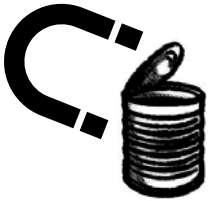
Materials that cannot be processed and recycled through a MRF and thus do not fit in any of the nine sort categories were classed as rejects (e.g., paper napkins, cups, plates, and tissues; garden hoses; textiles, rugs, and carpets; electric cords; electronics and appliances; scrap metal; wood; cat litter; and diapers). Recyclables that were heavily contaminated with food, liquids, dirt, or trash were also rejected. Common examples included greasy cardboard pizza boxes; unfinished soda cups; half-empty cans of food; plastic flower pots with soil and roots; and unwashed plastic yogurt pots.

Sample Classifications

Samples were divided into ten classification categories.



Aluminum



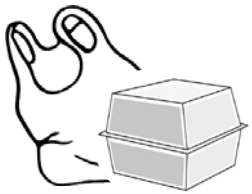
Ferrous Metals

Glass

Plastic No. 1

Plastic No. 2

Cardboard



Soft Plastics

Hard Plastics

Mixed Paper

Rejects

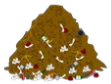
Rejects represent contaminants that must be removed at a sorting facility before the clean recyclables can be shipped to an end user. Strictly speaking, almost all of the mixed soft plastics, and much of the mixed hard plastics and mixed paper, may also represent contamination since these material classes generally do not have much or any value in the secondary materials markets. However, these were sorted separately to assess their overall contribution to recycling loads.

Single-Stream Recycling

Number and Size of Samples

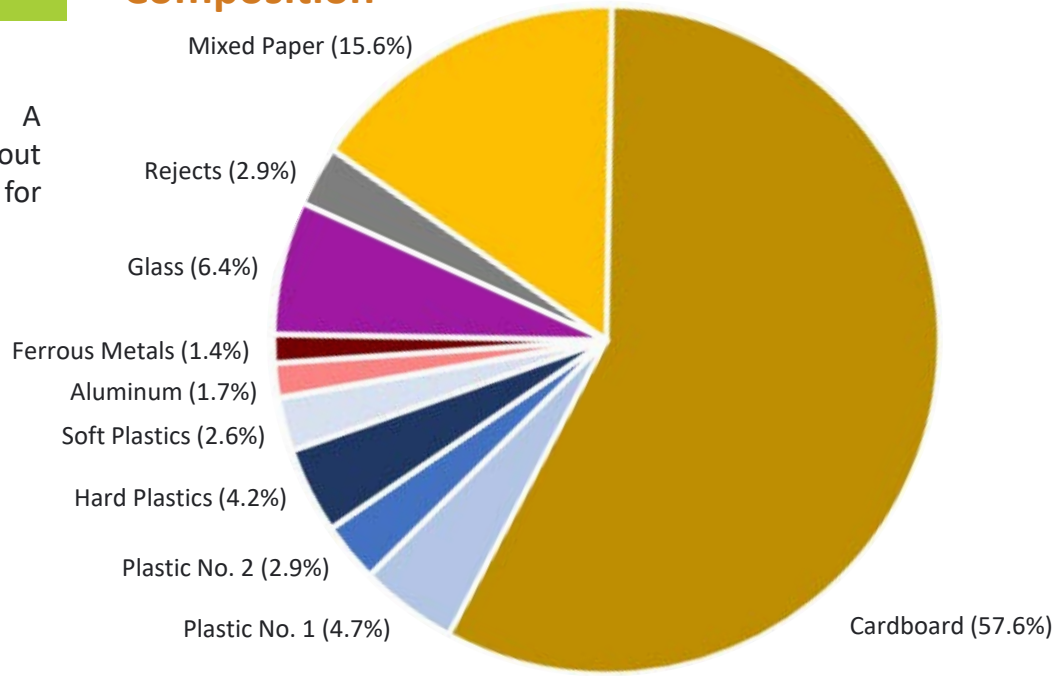
In total, 12 recycling loads were sampled over two days. A combined total weight of 52 tons was delivered, an average of about 4.3 tons per truck. From this, about 2,200 lbs. was selected for sorting, an average of about 183 lbs. per sample.

52 total tons delivered

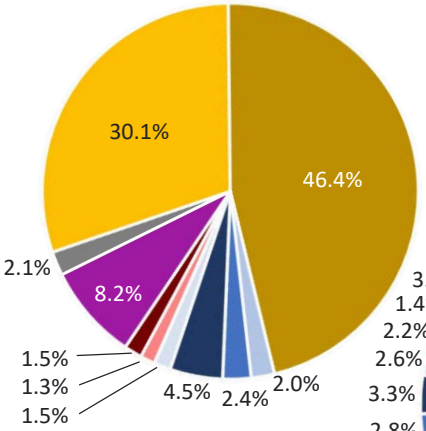


2,200 total lbs. sampled and sorted

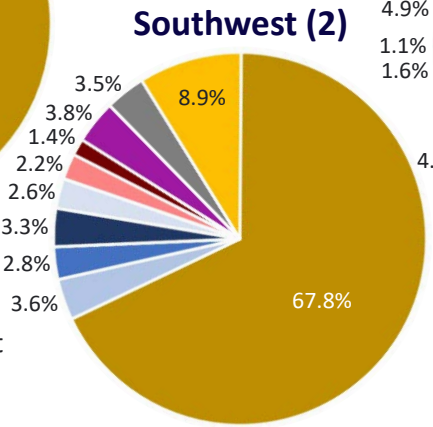
Composition



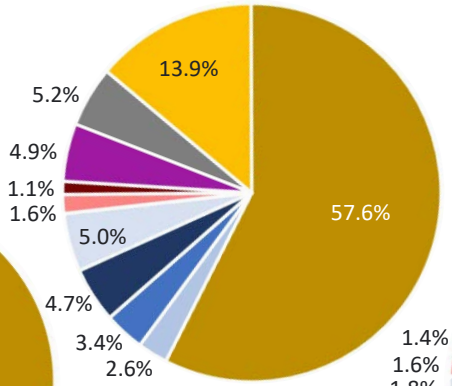
Breakdown by Quadrant



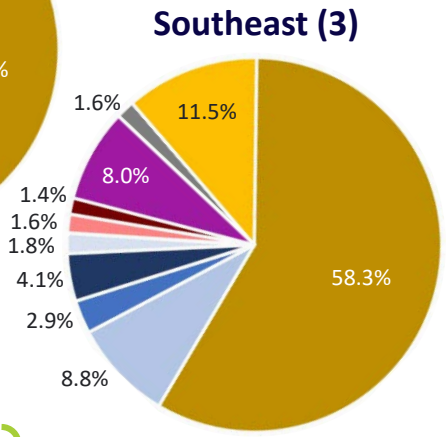
Northwest (2)



Southwest (2)



Northeast (2)



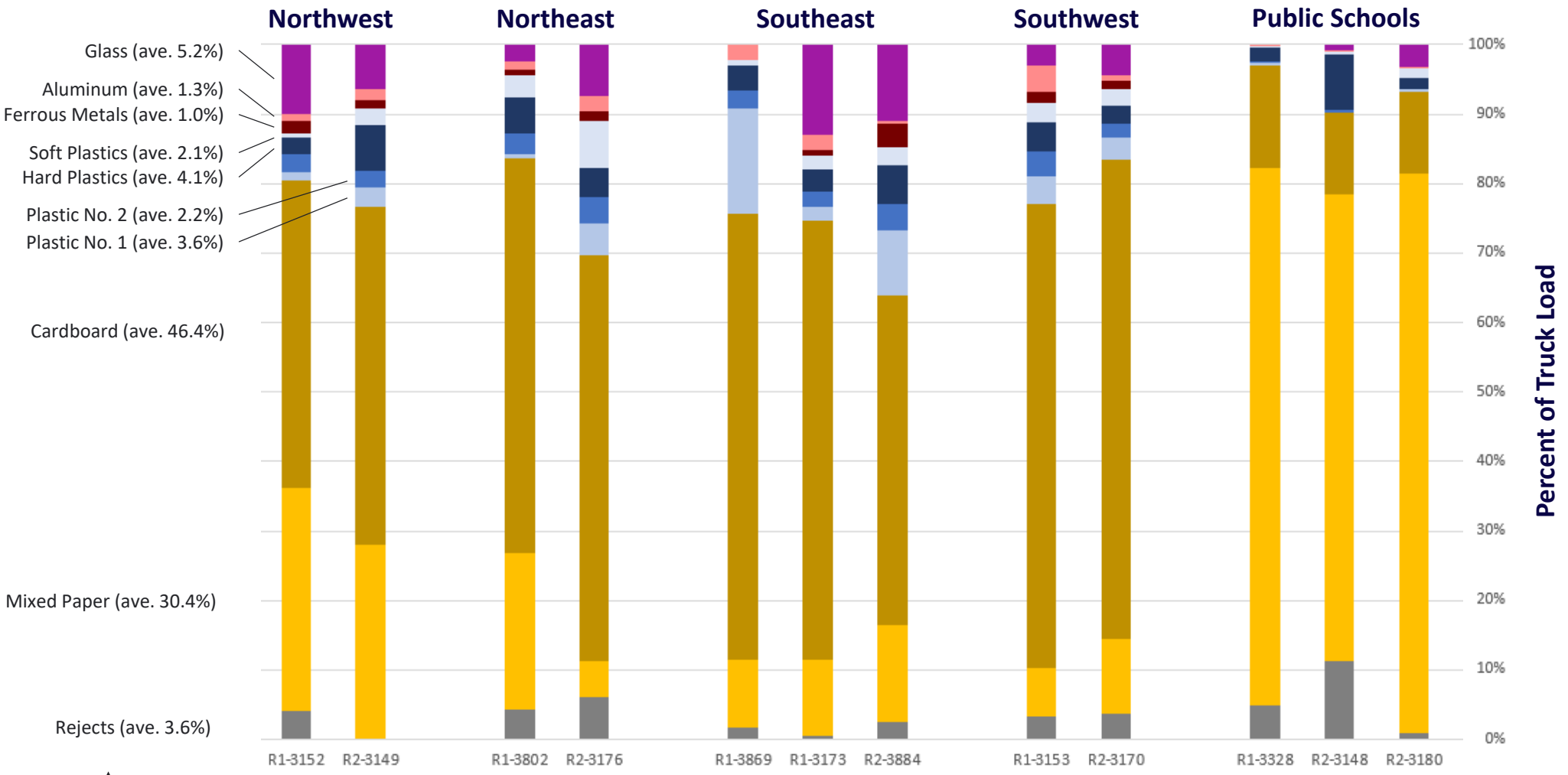
Southeast (3)

Variability was most significant in the mixed paper and cardboard categories.

Number of loads per quadrant shown in parentheses. An additional three trucks were sorted (one each from SW, NE, and NW); however, during sorting it was noticed the loads had been collected from end of year cleanouts at public schools and were dominated by paper. Therefore, these data are not included on this page.

Single-Stream Recycling – Breakdown by Quadrant and Load

Each of the 12 trucks was assigned a unique load number based on the type of waste (recycling, R), day of sorting (1 or 2), and vehicle tracking number (four digits) as shown in the chart below. Consolidated results and raw data for each load are provided in the appendix to this report.



Average values shown on this page are for all 12 loads, including public schools

sorting single-stream recycling loads

20 and 21 June 2019

Residential Drop-Off Centers

As shown on the map on p.5, DPW operates five residential drop-off centers (RDOCs) for waste and recycling as well as three RDOCs that only accept recyclables. For the Summer 2019 waste sorting event, targeted sorts of recycling loads were performed at two of the City's larger and more active RDOCs: QRL and Sisson St. The goals of the visual sorts were twofold:

- To gain an understanding of the types of materials brought in different vehicle classes through the course of an operating day; and
- To measure the quantities of traditional recyclables (i.e., ferrous metal and aluminum cans, paper and cardboard, no. 1 and 2 plastics, and glass) discarded at these two RDOCs.

The first goal was achieved by conducting a vehicle census, interviewing drivers, and visually assessing the composition of drop-off loads. The second goal was achieved by separating and weighing the targeted recyclables brought to the RDOCs.

Visual Observation and Sorting Procedures

The recycle sort areas at the RDOCs were the paved, raised drop-off platforms. Working in tandem, the sort crew approached vehicles entering the RDOC to inform drivers of the procedures. As vehicles were unloaded, targeted recyclables were transferred to 95-gal. toters set up in a demarcated work zone. In addition to sorting and weighing of recyclables, to the extent possible the sort crew also conducted a visual observation and recording of trash, C&D debris, and other materials. Drivers were also interviewed about the source and nature of the materials being dropped off. At regular intervals, the toters were weighed before being emptied into the drop-off trailers and reset for receiving fresh recyclables. The total mass of recovered recyclables was summed at the end of the day.

Sample Classifications

Fifteen visual classification categories were established. However, due to time and space constraints, recyclables were only sorted into four general classification categories.

Metal Cans | **Paper and Cardboard** | **No. 1 and 2 Plastics** | **Glass**

QRL Residential Drop-Off Center

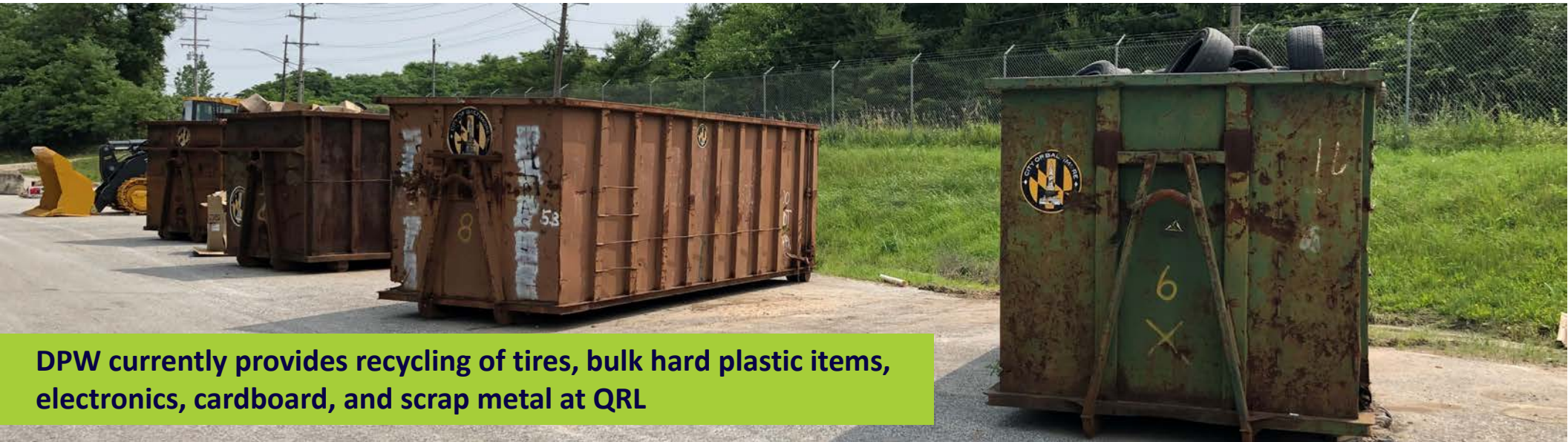
Number of Vehicles using the Center

Cars
Total = 6

SUVs/Minivans
Total = 17

Pickup Trucks
Total = 42

Time indicates number of vehicles using the center in succeeding 30-minute period.



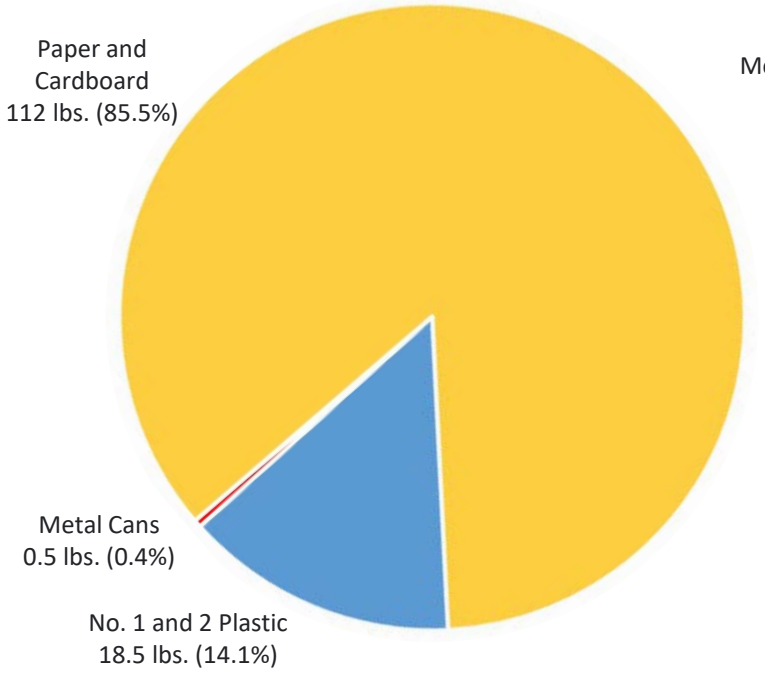
DPW currently provides recycling of tires, bulk hard plastic items, electronics, cardboard, and scrap metal at QRL

Composition of Loads at QRL Drop-Off Center

In total, 65 vehicles used the drop-off center at QRL in the 7½-hour period of observation between 9:00am and 4:30pm, an average of about 9 vehicles per hour. A combined total weight of 131 lbs. of targeted recyclables were recovered, equivalent to about 2 lbs. per vehicle. Used oil/antifreeze, tires, electronics, scrap metal, bulk hard plastics, and cardboard are currently collected separately but all other materials are comingled for disposal. Consolidated results and raw data are provided in the appendix to this report.

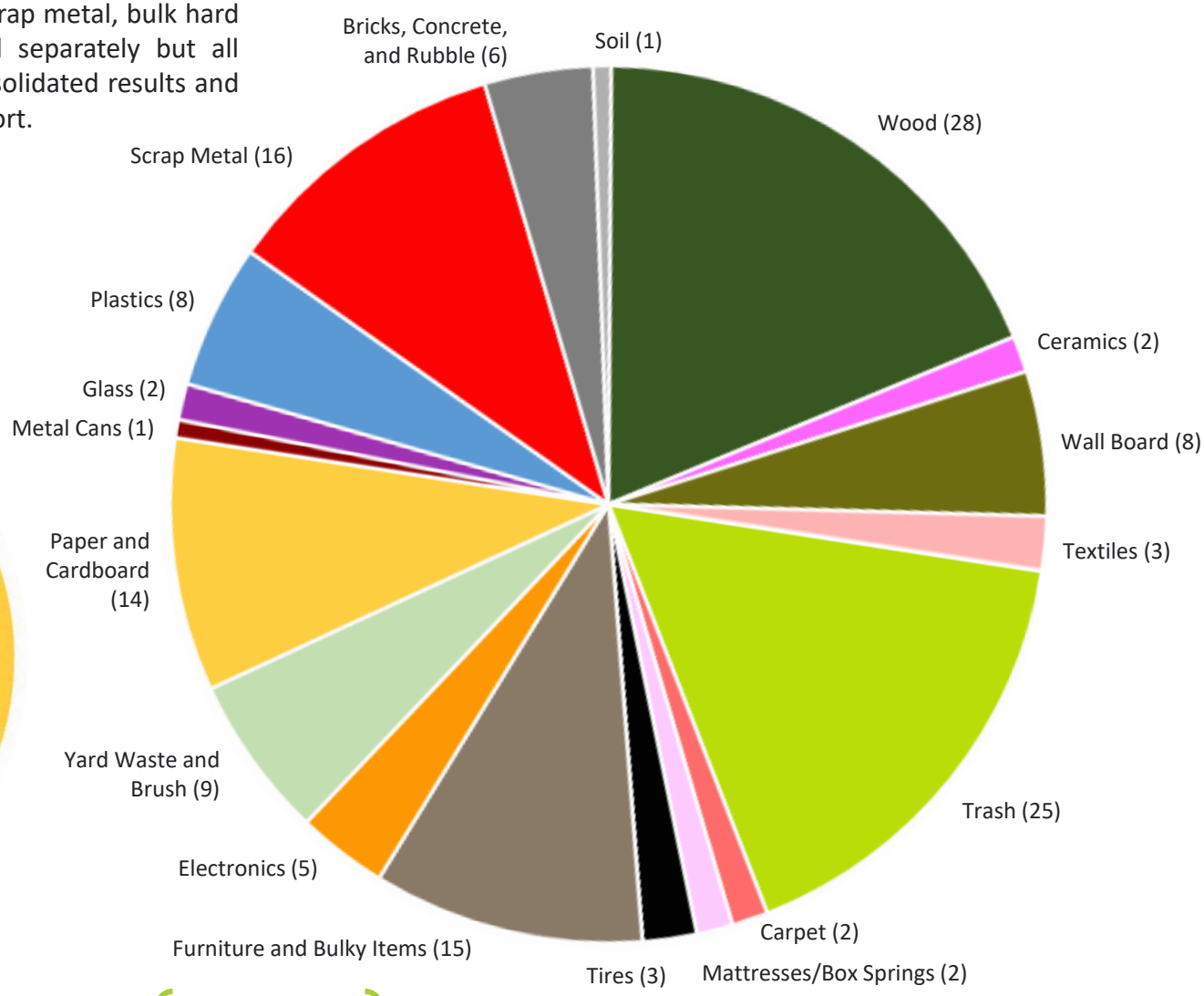
Breakdown of Recovered Recyclables by Weight

Chart shows percentage of total weight of recovered recyclables. No glass was recovered.



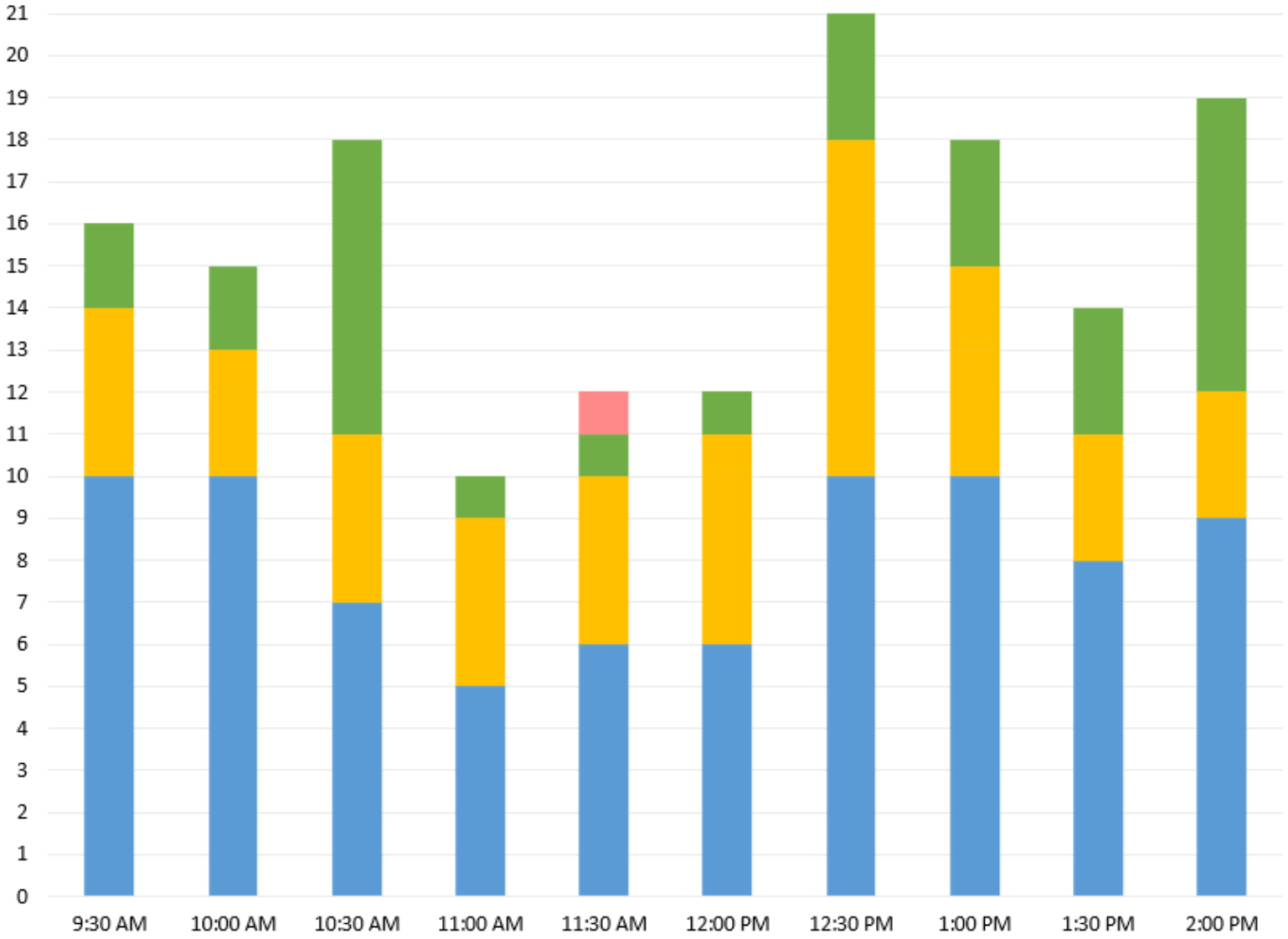
Breakdown of Vehicle Loads based on Visual Observation

Chart shows number of vehicles observed to drop off material class.



Sisson Street Residential Drop-Off Center

Number of Vehicles using the Center



Cars
Total = 30

SUVs/Minivans
Total = 43

Pickup Trucks
Total = 81

Work Vans
Total = 1

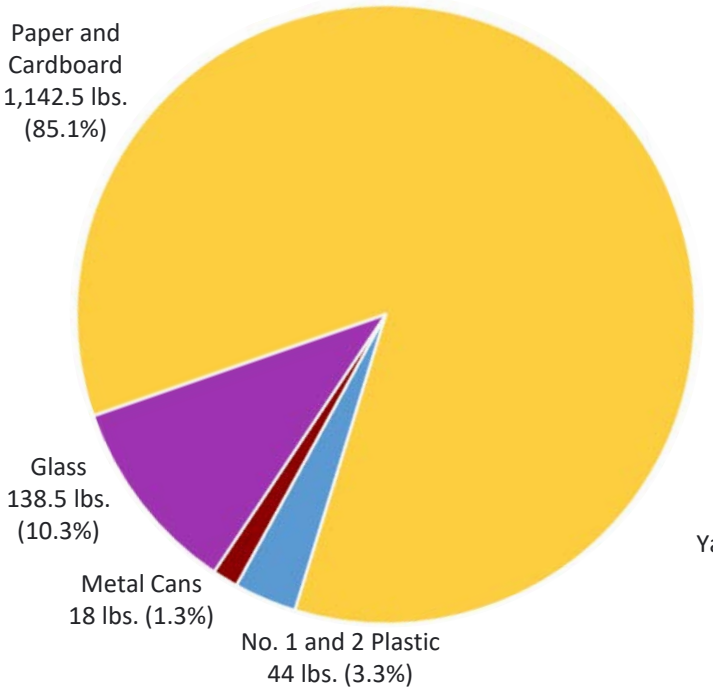
Time indicates number of vehicles using the center in succeeding 30-minute period.

Composition of Loads at Sisson St. Drop-Off Center

155 vehicles used Sisson St. over the five-hour period of observation between 9:30am and 2:30pm, an average of 31 vehicles per hour. A combined total weight of 1,343 lbs. of mixed recyclables were received, an average of about 9 lbs./vehicle. Separate collection of used oil/antifreeze, tires, household hazardous waste (HHW), electronics, scrap metal, hard plastic, and mixed recyclables is provided. C&D type wastes (except wood) are not accepted. Consolidated results and raw data are provided in the appendix.

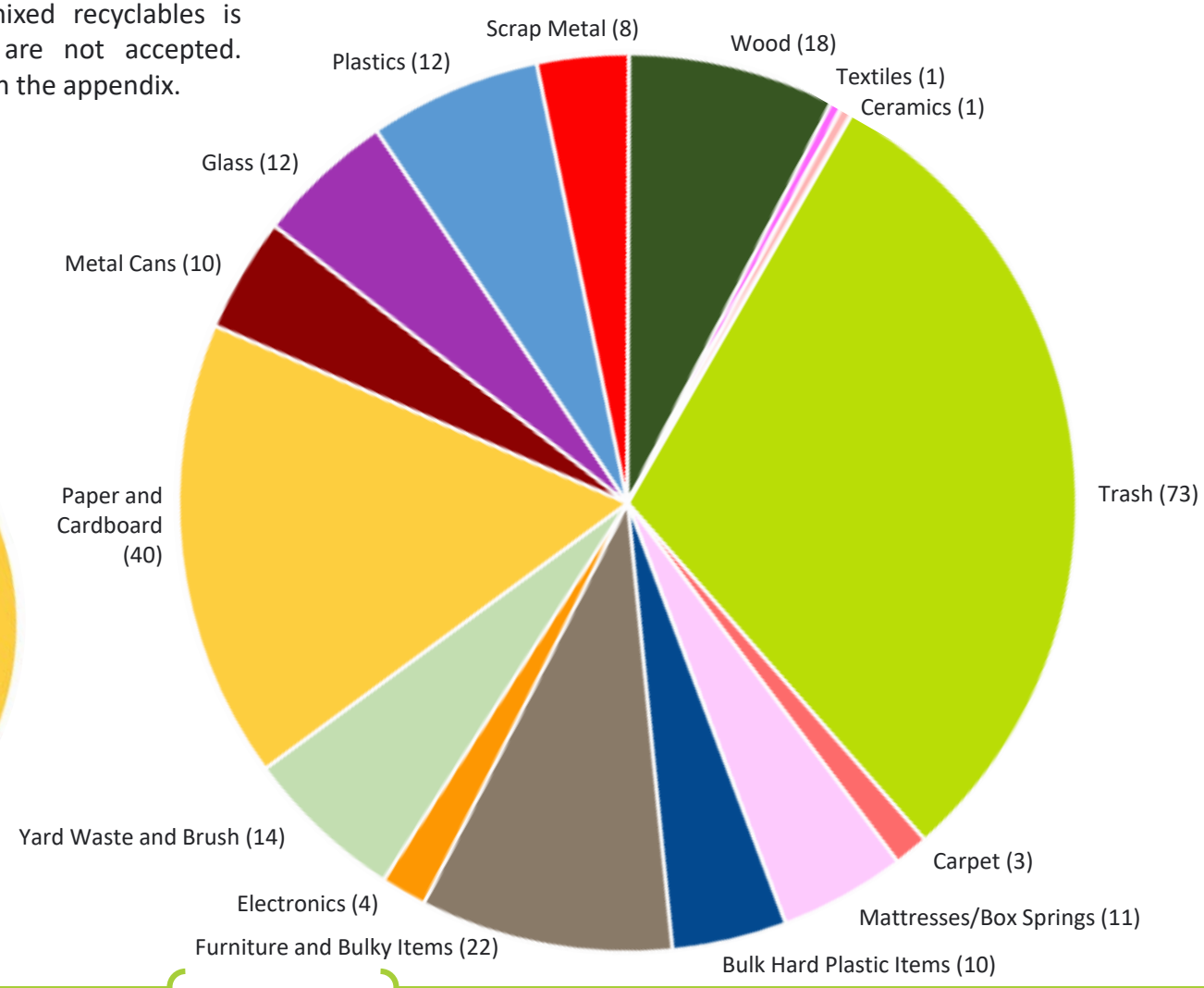
Breakdown of Recovered Recyclables by Weight

Chart shows percentage of total weight of mixed recyclables received.



Breakdown of Vehicle Loads based on Visual Observation

Chart shows number of vehicles observed to drop off material class.



metal can recovery at Sisson Street

6 June 2019

NWTS Small-Hauler Loads

The final component of the Summer 2019 sorting event was one day of visual observation and recording of the residential drop-off center (RDOC) at NWTS. The primary goal of the visual waste sort is to gain a quasi-quantitative measure of the materials delivered to the center by licensed small haulers, focusing on C&D debris.

Procedures for Visual Waste Sort

The RDOC at NWTS is a raised drop-off platform that allows six to eight vehicles to unload simultaneously into two trailers. Electronics, appliances, and scrap metal are collected separately, but otherwise no effort to separate waste is made. The RDOC is free for City residents under most circumstances; however, residents driving modified pick-up trucks, commercial vehicles, and/or with oversized loads, as well as licensed small haulers, must pay a fee to use the center. All vehicles entering the center must pass over the scale.

Working in tandem, the sort crew intercepted vehicles approaching the platform to inform drivers of the procedures. To the extent possible given the volume of traffic, the sort crew conducted a visual observation and recording of trash, C&D debris, and other materials being unloaded. Drivers were also interviewed about the source and nature of their loads. In general, small haulers were bringing waste from residential construction/refitting projects or from cleanouts of rental properties, basements, yards, garages, seized storage units, or empty buildings and lots.

Vehicle license tag numbers were noted to allow correlation with scale house records. A visual assessment of the composition of vehicle loads was made on a volumetric basis. Using published gross vehicle weights and volume-to-mass conversion factors, the proportional weight of materials per smaller hauler load was calculated, and then the total weight of the load estimated from comparison to scale house records.

Sample Classifications

No physical sorting of materials was conducted. Sixteen visual classification categories were established, of which five were focused on C&D debris (i.e., bricks/rubble/concrete/plaster, soil, wood, asphalt/shingles, and wall board).

Small hauler drop off activity

Cars
Total = 7

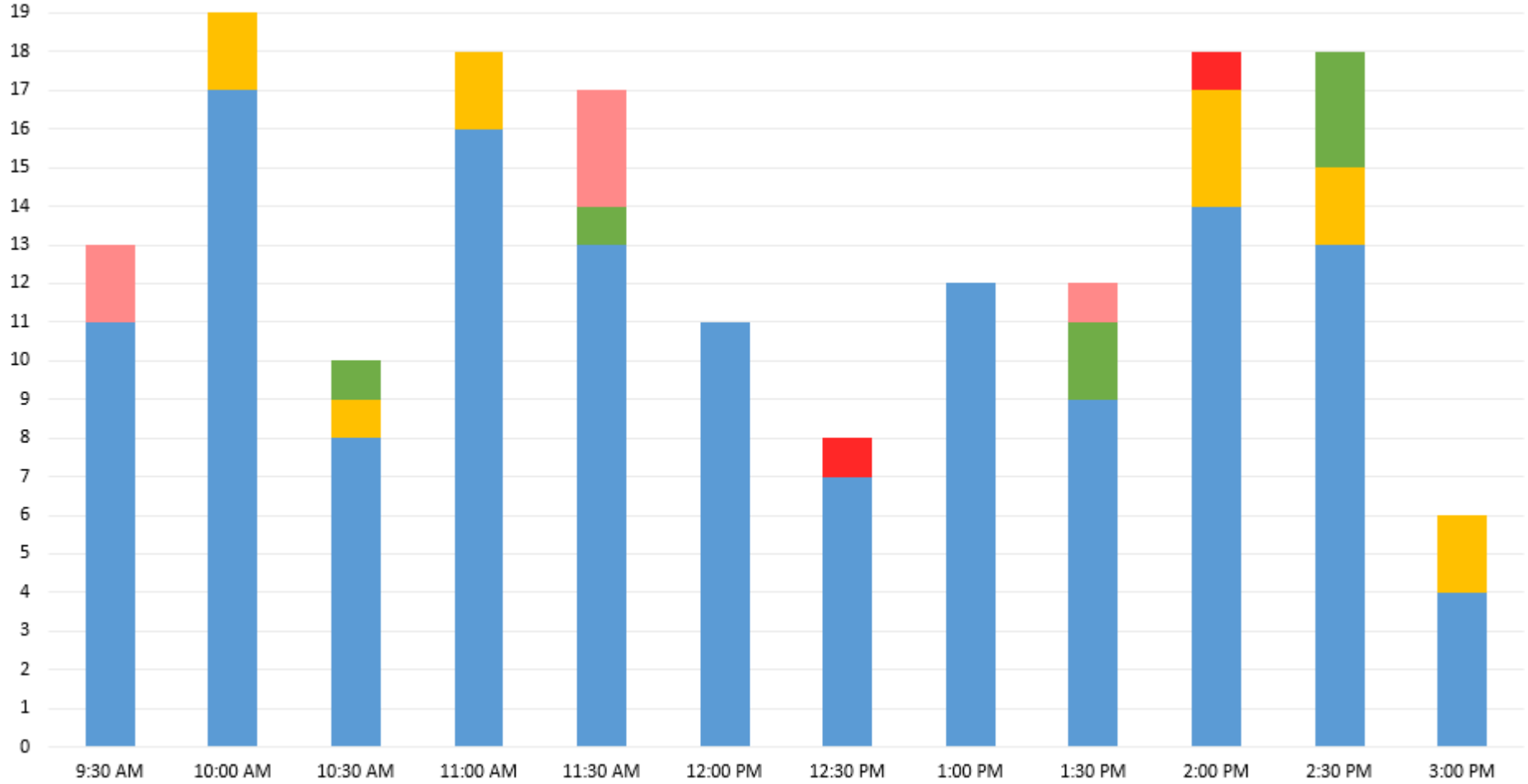
SUVs/Minivans
Total = 12

Pickup Trucks
Total = 135

Work Vans
Total = 6

Box Trucks
Total = 2

Time indicates number of vehicles using the center in succeeding 30-minute period.



Number of Vehicles using the Residential Drop-Off Center at NWTS

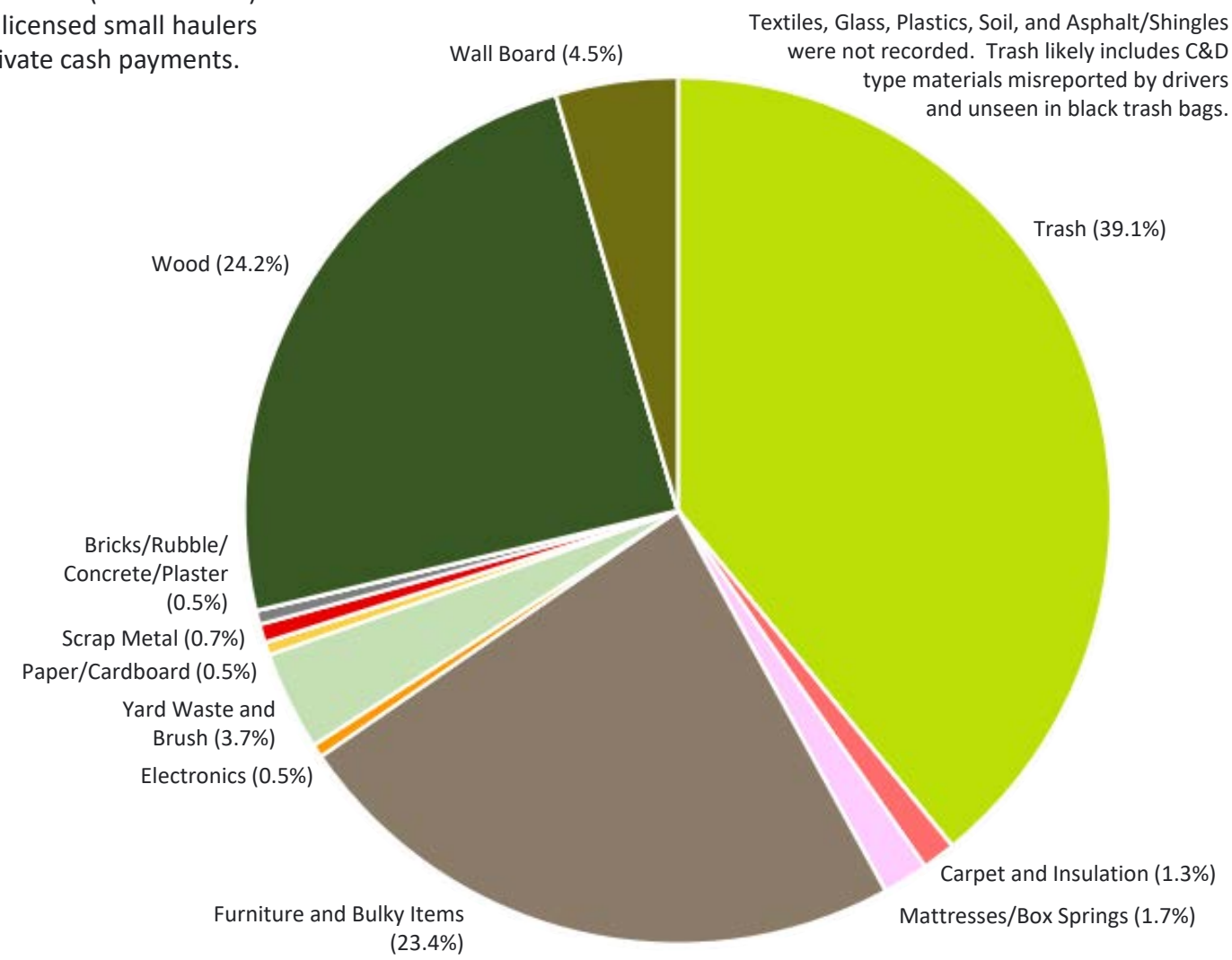
Composition of Loads Brought to NWTS Residential Drop-Off Facility

In total, 162 vehicles were observed using the RDOC at NWTS in the six-hour period of observation between 9:30am and 3:30pm, an average of 27 vehicles per hour. A visual sort of all vehicles was conducted by the sort crew. Of these, 91 vehicles (56% of total) were logged at the scale house as operated by licensed small haulers with an account and 22 vehicles (14%) were private cash payments.

The chart shows total average proportion by weight of drop-off materials in the 91 small hauler loads. Values are based on the sort crew's qualitative estimate of the volumetric composition of each load converted to mass using published conversion factors. Consolidated results and raw data are provided in the appendix.

Individual scale house tickets showing the gross vehicle weight were available for the 91 transactions by licensed small haulers during the period of observation. Net loads were estimated by subtracting the average empty vehicle weight for each class of vehicle based on published data for a common model. For example, pickups were represented by the lightest make of Ford F150 truck, while minivans were represented by the Dodge Grand Caravan. Based on this, the total tonnage received from these 91 transactions was estimated at about 119 tons, an average of about 1,990 lbs. per vehicle. Individual load size estimates were used to generate the overall percentage composition of all loads presented in the chart.

Breakdown of Total Vehicle Loads by Weight based on Visual Sort



small haulers unloading at the NWTS residential drop-off center

7 June 2019

4. Summary Discussion

Statistical Analysis

Sorting of residential trash and recycling was conducted in general accordance with the methods outlined in ASTM D5231-92 (2016), although aspects of the procedure were modified to meet the specific requirements and scope of the project. The methodology used to plan and analyze the statistical representability of the sample size is described in this section. Collection of 200 to 300 lbs. samples from each load was targeted for all waste streams.

Sample Sizes for Different Waste Streams

The total number of samples to be sorted can be estimated as a function of the expected waste components and the desired precision as applied to each component per the procedure outlined in ASTM D5231-92 (2016). In brief, mean and standard deviation (SD) values for one or more governing waste components are first approximated from representative data. For trash, waste composition data from the Winter 2019 waste sort were used, which showed food scraps as the governing component comprising an average 25.5% of residential trash loads with an SD of 7.2%. It was assumed that food scraps would remain the governing component of the unprocessed trash stream in Summer 2019. Using a confidence interval of 90% and precision of 10%, it was thus estimated that at least 24 samples would be required for the trash sort. Based on the field crew's experience during the Winter 2019 waste sort, four to six trucks can typically be sampled each day; therefore, six days of trash sorting should be planned.

A complicating factor was that sorting of both residential and commercial trash was planned for the Summer 2019 waste sort. While it would have been preferable to sort at least 24 trucks over six days from each trash stream, this was not logistically possible given operational restrictions in place at NWTS. Therefore, it was decided to split the trash sort equally between commercial and residential trash streams in the hope that the variability between the two would not be too significant. A target of 12-18 samples per waste stream was established with collection over three days.

Using the same procedure for the recycling sorts while assuming based on Winter 2019 data that cardboard would be the governing component (mean 53%, SD 9.1%), again with a confidence interval of 90% and precision of 10%, it was estimated that at least 10 samples were needed. A target of 10-15 samples was established.

Reviewing Statistical Representability

Following the waste sort, the mean and SD of each waste component was calculated to reassess the statistical representability of the sample sizes using the same parameters as before:

- Commercial trash: Actual governing component was cardboard (mean 15.4%, SD 12.4%); minimum samples needed = 188.
- Residential trash: Governing component was mixed plastics (mean 18.5%, SD 5.0%); minimum samples needed = 21.
- Recycling (excl. public schools loads): Governing component was cardboard (mean 57.9%, SD 9.0%); minimum samples needed = 8.

Calculation details are provided in the appendix. Based on these findings, data from the recycling sort are statistically representative as a standalone dataset. However, neither of the trash sorts collected sufficient samples to be statistically representative in their own right, although data from the residential trash sort are within

expectations set by the larger dataset collected in Winter 2019. As such, the Summer 2019 residential trash data should be reasonably representative if considered in conjunction with the Winter 2019 data. The high variability in commercial trash composition likely reflects the diversity of customers and vehicles, equipment, and routing used for waste collection services. In other words, trying to define the "average" commercial waste load was always going to be challenging. Understanding the commercial waste stream in the City may be better achieved by studying individual generators rather than mass collection. Results from the commercial waste sort should thus be used with caution and account for the highly variable nature of components such as mixed paper, cardboard, and yard waste.

It is noted that this analysis pertains to multi-day sorting events only. Results from one-day observations at the NWTS, QRL, and Sisson St. drop-off centers provide a "snapshot" of other waste disposal and recycling habits in the City but are not statistically representative.

Residential Trash

Ignoring unclassified material, the three largest components of residential trash were mixed plastics (18.5%), food scraps (17.2%), and yard waste/clean wood (16.6%), broadly in line with the Winter 2019 waste sort which understandably reported much less yard waste/clean wood (6.9%) but similar content of food scraps (25.5%) and mixed plastics (17.5%). Establishing a food and yard waste composting or anaerobic digestion program could thus reduce the size of the waste stream currently going to disposal by over 30% (assuming full participation and capture rates could be achieved). Finding recycling options for mixed plastics could reduce the total size of the current disposal stream by a further 20%; however, this would be challenging given current markets and technologies.

Notwithstanding the much smaller sample size in Summer 2019 (12 total, of which only nine were used in analysis due to domination of three loads by public school cleanouts) versus Winter 2019 (33 total), findings were broadly similar between the two seasons. Samples generally reflected limited variability between the different collection quadrants although there were some differences between individual loads in food waste, yard waste, and unclassified content.

The mixed paper and cardboard content was relatively low at 6.0% and 7.4%, respectively, very similar to their content in the Winter 2019 sort (6.1% and 8.6%, respectively). Similarly, the percentage of other recyclables (i.e., aluminum, no. 1 and 2 plastics, ferrous metals, and glass) in trash loads was low at less than 2.5% for each. Collectively, these materials comprise up to 23% of the waste stream, which suggests that there is room for additional recovery of traditional recyclables from households, City buildings, small businesses, and public schools served by DPW.

Commercial Trash

A limited sort was conducted of commercial trash collected by Republic Services, Inc. (RSI), a large private hauler with extensive contracts in the City. RSI provided four different types of collection vehicle – front end loaders (FELs), rear end loaders (RELs), roll-on roll-off (RORO) containers, and compactor containers – from which 14 samples were sorted. RSI's collection services are dominated by FELs, which similarly dominated the loads sorted (10 total). Most loads originated in northwestern areas of the City, representing in-City collection routes close to NWTS.

Ignoring unclassified material, the three largest components of commercial trash were cardboard (15.4%), food scraps (14.9%), and mixed plastics (14.2%). As discussed previously, however, commercial waste loads were highly variable, reflecting the broad diversity of customers served by different collection vehicle types. The compactor load, for example, was collected from Hollins Market and comprised 55.6% cardboard, mainly empty fruit and vegetable produce boxes. The next highest cardboard content measured was an FEL sample with 21.4%. Care needs to be taken when attempting

to assign average characteristics to commercial trash. Compactor and RORO containers are primarily used to service individual customers and special events and thus reflect the nature of those customers and events rather than typical materials collected.

Given that many commercial trash collection routes, especially by FELs, service large apartment buildings and other non-industrial waste generators, and these customers often have limited access to recycling, it is perhaps not surprising that the overall composition of commercial waste in FEL and REL loads appears to reflect residential trash without the recyclables removed. For example, the content of mixed paper, cardboard, glass, ferrous metals, and aluminum are all 1½ to 2 times higher in commercial trash than in residential trash. In particular, the average cardboard content (14%) in these 11 FEL and REL loads appears to represent significant opportunity for recycling.

Looking across all four different collection types, the average combined food scraps and yard waste content exceeds 22%. Establishing a food and yard waste composting or anaerobic digestion program could thus substantially reduce the size of the commercial waste stream going to disposal.

Single-Stream Recycling

Similar to the Winter 2019 results, recycle loads were dominated by cardboard (57.6%), reflecting the growing importance of online shopping for home delivery in many City households. Given the relatively low overall content of cardboard in curbside trash (7.4%), households appear to be doing a good job overall at separating cardboard for recycling.

Again similar to the Winter 2019 results, recycle loads exhibited relatively little variability between the four collection quadrants. Of the materials that did some show much variability, cardboard and mixed paper were most significant. Overall results were broadly aligned between the Summer and Winter 2019 waste sorts. In both cases, the three largest components were cardboard (57.6% vs. 53.0%, respectively), mixed paper (15.6% vs. 19.7%), and glass (6.4% vs. 7.5%). It is noted that the total sample size used in assessment of Summer 2019 data was limited to nine loads, although this was nonetheless calculated to be statistically significant.

The percentage of rejects in recycling loads was only 2.9%, lower than the 6.1% measured in Winter 2019 and significantly below industry reported average contamination rates of about 20%. However, mixed hard and soft plastics and mixed paper were sorted separately and found to comprise an average 4.2%, 2.6%, and 15.6% of loads, respectively. Many components of these three classes are not currently recyclable. If half of the mixed hard plastics and mixed paper content and all of the mixed soft plastics content were added to the rejects as a truer estimate of contamination levels, the overall contamination rate would rise to about 15%.

Drop-Off Centers & Small Haulers

Resident used the QRL and Sisson St. drop-off centers at a rate of about 9 and 31 vehicles/hour, respectively, discarding an average of 2 to 9 lbs. of traditional recyclables (over 85% of which was paper and cardboard). The most commonly discarded materials that are not currently recovered separately but could be were wood and furniture/bulky items. Small haulers brought an average of 1,990 lbs./load to NWTS at a rate of 27 vehicles/hour. As at the other drop-offs, wood and furniture/bulky items dominated disposal, with much less C&D debris observed than in the Winter 2019 study.

In summary of these observations, separating wood for recycling and furniture for refurbishment/reuse appears a practical consideration, which could make a positive impact on local job opportunities and the availability of affordable home furnishings while also reducing waste disposal.

single-stream curbside recyclables at the transfer station

28 June 2019

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