2. Summary of Methodology

The following section summarizes the three main tasks of the study methodology: Develop Plan, Collect Data, and Analyze Data.

Develop Plan

Step 1. Coordinate with City, Facility, and Hauler Staff

Prior to beginning fieldwork, Cascadia staff met with City of San Diego staff, Miramar Landfill staff, and hauler representatives to plan and coordinate study logistics such as space at the landfill, vehicle selection strategies, and assistance from fee booth staff. Route supervisors from the haulers helped to coordinate route selection and the delivery of selected loads. Facility managers from the landfill helped to coordinate sample delivery, identification, and other details involved with the field data collection effort.

Step 2. Define Waste Streams

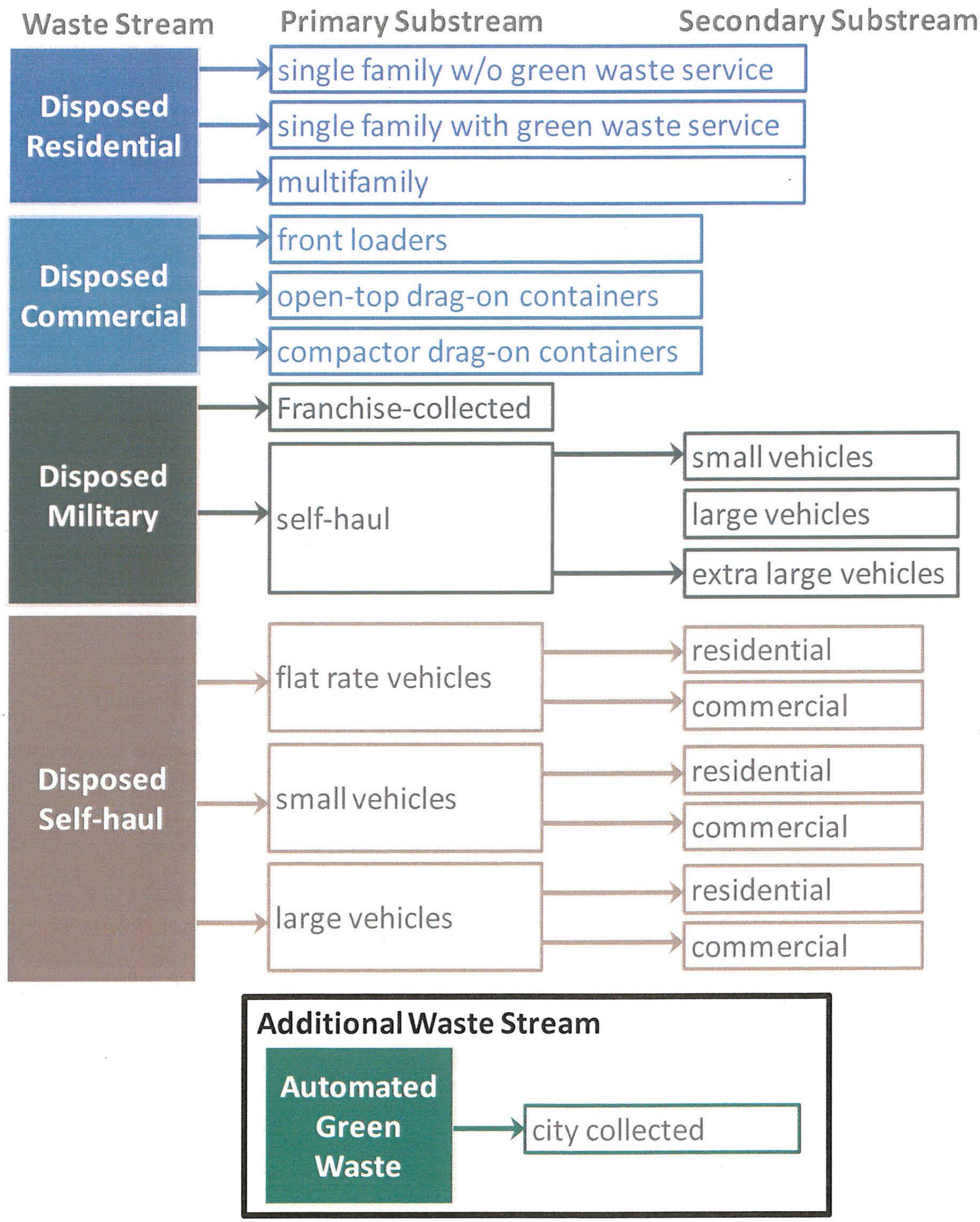
During the kickoff meeting, the project team defined the sampling universe: the four disposed waste streams, the green waste stream, and their associated substreams. The following characteristics define the waste streams, primary substreams, and secondary substreams:

- The **hauler** is the entity delivering the waste to the landfill. This study defined two hauler types: franchise/city-collected and self-haul. Franchise/city-collected includes entities that haul waste as their primary activity. Self-haul includes business and others for whom hauling is incidental – residents, contractors, landscapers, and junk collectors.
- The **generator** is the entity creating the waste. This study defined five generators: single family residential with green waste service, single family residential without green waste service, multifamily residential, commercial, and military.
- The **origin** designates whether the waste was generated inside or outside of San Diego city limits.
- The **vehicle type** designates the mode of transportation the hauler used to deliver the load to the landfill. This study defined seven vehicle types: front load packer trucks, open-top drag-on containers, compacted drag-on containers, flat rate vehicles, small vehicles, large vehicles, and extra large vehicles.
- Two **groups of materials** are included in the study – refuse and source separated green waste.

Some substreams are defined by fewer than the five possible characteristics. For example, the multifamily substream is defined by two characteristics – franchise-collected and generated at multifamily residences. Not every combination is used, for example the extra large vehicle type is only used in the military self-haul substream.

See Figure 1 for a summary of the included waste streams and substreams. The detailed definition for each substream can be found in Appendix G: Detailed Substream Descriptions and Tonnage Allocations.

Figure 1. Waste Streams and Substreams



Step 3. Define Materials

Cascadia worked with City staff to identify material types and definitions for this study. This list was based on CalRecycle's standard list of materials, with changes to reflect this project's objectives and local solid waste management practices. The field crew sorted the disposed samples into 90 unique material types which are divided among ten material classes: **Paper, Plastic, Glass, Metal, Electronics, Organic, Construction & Demolition, Household Hazardous Waste, Special Waste,** and **Mixed Residue.**

To identify additional diversion opportunities, the project team also organized material types into four recoverability groups:

- **Recyclable –** Materials for which recycling technologies, programs, and markets are well developed, readily available, and currently utilized.
- **Compostable/Potentially Compostable –** Organic materials typically accepted for use in commercial compost or digestion systems.
- **Potentially Recoverable –** Materials for which recycling technologies, programs, and markets exist, but are either not well developed or not currently utilized. Examples include *carpet & carpet padding*, and *paint*. These materials may also need source reduction, redesign, or producer responsibility programs to be recoverable.
- **Other Materials –** Materials that are not readily recyclable or face other market-related barriers. These materials may need source reduction, redesign, or producer responsibility programs to be recoverable.

Table 1 shows the organization of material types into recoverability groups. The recoverability groups are based on infrastructure at the time of the report, and the team expects that the interpretation of these groups will change as new technologies and programs become available. Additionally, each material type in the groups might have its own set of unique circumstances, so these groups should be used more as useful summaries than fixed data points. Please refer to Appendix B: Material Type Definitions for the division of material types into material classes, and for material type definitions.

Table 1. Potentially Recoverable Materials

Recyclable	Compostable/Potentially Compostable	Other Materials
Uncoated Corrugated Cardboard	Waxed Corrugated Cardboard	Remainder/Composite Paper
Paper Bags	Compostable/Soiled Paper	Flat Glass
Newspaper	Compostable Biodegradable Plastic Containers	Remainder/Composite Glass
White Ledger Paper	Food	Remainder/Composite Metal
Mixed Waste Paper	Palm, Succulent, Coral Tree	Dirty Film Plastic
Magazines	Leaves and Grass	Expanded Polystyrene
Phone Books and Directories	Prunings and Trimmings	Remainder/Composite Plastic
Aseptic/Milk Containers	Branches and Stumps	Diapers
CRV Clear Glass Bottles	Agricultural Crop Residues	Remainder/Composite Organics
Non-CRV Clear Glass Bottles and Containers	Grass Sod	Roofing Tar Paper/Felt
CRV Brown Glass Bottles	Manures	Roofing Mastic
Non-CRV Brown Glass Bottles and Containers	Clean Dimensional Lumber	Built-Up Roofing
CRV Other Colored Glass Bottles	Clean Pallets and Crates	Other Asphalt Roofing Material
Non-CRV other Colored Glass Bottles and Containers	**Potentially Recoverable**	Other Wood Waste
Tin/Steel Cans	Plastic Grocery and Merchandise Bags	Painted/Demolition Gypsum Board
Major Appliances	Clean Film Plastic	Contaminated Soil, Street Sweepings, Drain Cleaning
Other Ferrous Metal	Durable Plastic Items	Remainder/Composite C&D
CRV Aluminum & Tin Cans	Textiles	Sharps
Non-CRV Aluminum Cans	Asphalt Composition Shingles	Pharmaceuticals
Used Oil Filters	Clean Engineered Wood	Remainder/Composite Household Hazardous
Other Non-Ferrous Metal	Clean Gypsum Board	Ash
CRV HDPE Containers	Carpet & Carpet Padding	Sewage Solids
Non-CRV HDPE Containers	Rock, Soil and Fines	Industrial Sludge
CRV PETE Containers	Vehicle and Equipment Fluids	Treated Medical Waste
Non-CRV PETE Containers	Used Oil	Remainder/Composite Special Waste
Miscellaneous Plastic Containers	Lead-Acid Batteries	Mixed Residue
Concrete	Household Batteries	
Asphalt Paving	CFL, Fluorescent Tube and Other Mercury-Containing	
Oil-Based Paint	Bulky Items	
Water-Based Paint	Tire	
	Brown Goods	
	CRT	
	Computer-Related Electronics	
	Other Consumer Electronics	

Step 4. Schedule Field Work and Allocate Samples

The project team scheduled three seasons of field work: October 2012, January 2013, and June 2013. Each season spanned approximately 15 days, including one Saturday, with samples approximately evenly divided between seasons and days of the week. Sampling dates for each season were scheduled to avoid sampling near or on major holidays.

The project team developed the initial sample allocation plan to provide reliable data at the primary substream level. There were several factors that influenced the sample allocation, including the relative variability of waste from each of the streams and the availability of loads. For example, a greater number of samples were allocated to the more variable commercial and self-haul streams than to the less variable residential stream. Additionally, more samples were allocated to the self-haul, flat rate vehicle substream than to the self-haul, large vehicle substream because self-haul flat rate vehicles are more common than self-haul large vehicles. We did not set sample goals for secondary substreams because they were defined after the completion of sampling and were used for analysis only. Our sample allocation methodology follows the standard waste characterization protocol developed by CalRecycle, California's solid waste management governing body.

Table 2 summarizes the planned and actual number of samples collected for each season.

Table 2. Planned Vs. Actual Samples Collected 2012-2013

		October		January		June		Total	
Waste Stream	**Substream**	**Plan**	**Actual**	**Plan**	**Actual**	**Plan**	**Actual**	**Plan**	**Actual**
Residential	Single Family w/o Green Waste Service	30	30	30	31	30	30	90	91
Residential	Single Family with Green Waste Service	30	30	30	30	30	30	90	90
Residential	Multifamily	30	30	30	33	30	30	90	93
Commercial	Front Loader	40	43	40	43	40	40	120	126
Commercial	Open-top Drag-on Containers	40	40	40	40	40	40	120	120
Commercial	Compactor Drag-on Containers	40	40	40	40	40	40	120	120
Military	Franchise-collected	10	10	10	12	10	10	30	32
	Hand Sort Subtotal	*220*	*223*	*220*	*229*	*220*	*220*	*660*	*672*
Self-haul	Flat Rate Vehicle	125	122	119	124	119	128	363	374
Self-haul	Small Vehicles	90	92	85	92	85	74	260	258
Self-haul	Large Vehicles	52	54	49	51	49	63	150	168
Military	Self-haul	0	0	14	13	14	19	28	32
	Self-haul Visual Total	*267*	*268*	*267*	*280*	*267*	*284*	*801*	*832*
Green Waste		4	4	4	4	4	4	12	12
Total		**491**	**495**	**491**	**513**	**491**	**508**	**1,473**	**1,516**

Collect Data

Step 1. Select and Survey Loads

For this study, the load selection procedure varied by substream. Loads from substreams with regularly scheduled waste collection were pre-selected for sampling. Staff at the fee booth selected self-haul loads, military loads, and commercial drag-on containers on the day of sorting using a systematic selection procedure (selecting every n^{th} vehicle). A City staff person was on-site at the landfill each day to assist with the vehicle selection process. Their role included keeping track of progress towards the daily sampling goals, notifying the field crew when selected vehicles passed through the fee booth, and coordinating with haulers to ensure the timely arrival at the landfill of pre-selected vehicles.

For a full description of each sample selection procedure, refer to Appendix C: Study Design. Examples of all field forms our team used for data collection are included in Appendix E: Example Field Forms.

Pre-Selected Loads

The project team used route data from both the City of San Diego and major haulers to pre-select for sampling random single family, multifamily, and commercial front loader routes. We selected routes in each substream for each day using Microsoft Excel's random number generator. For routes that required multiple trips to the landfill to complete, the project team considered each load for each route as separately eligible for pre-selection.

Cascadia summarized selected loads on a separate *Vehicle Selection Sheet* for each sampling day. Before each sampling season, we distributed the *Vehicle Selection Sheets* and bright pink *Sample Placards* for each pre-selected load to hauler and City collections route supervisors. Each day, route supervisors distributed *Sample Placards* and any special collection instructions to the drivers of the pre-selected loads. Drivers placed the bright pink *Sample Placards* on their vehicle's dashboard so the field team could easily identify each pre-selected vehicle as it arrived at the landfill.

The study was designed to sample pure loads of multifamily and commercial waste. The haulers and City staff worked together to ensure delivery of pure loads on sampling days by modifying routes that were normally a mix of commercial and multifamily residential.

Systematically Selected Loads

Fee booth staff selected self-haul loads, commercial open-top containers, and military loads using a systematic selection process. The fee booth staff completed a brief interview with the driver of each vehicle arriving at the landfill to determine which substream the load belonged to. The staff kept track of the number of vehicles arriving from each substream on the *Vehicle Selection Sheet* and selected every n^{th} vehicle from each substream for sampling. The sampling interval *(n)* was determined for each substream by dividing each day's expected vehicle count in that substream by the number of samples needed in that substream on that day. The City provided expected vehicle numbers based on historical traffic data at the landfill.

Cascadia provided fee booth attendants with a *Vehicle Selection Sheet*, *Sample Placards*, and instructions for the systematic selection process. When a vehicle was selected for sampling, the attendant noted the vehicle type, generator type, and waste type on a *Sample Placard* and placed the *Sample Placard* on that vehicle's windshield or asked the driver to place it on the vehicle dashboard. The attendant directed selected loads to the designated sampling area.

Step 2. Collect and Sort Samples

Depending on the substream, Cascadia field staff either hand-sorted or visually characterized samples. Both of these methods are summarized below. For a full description of each method, refer to Appendix C: Study Design. For full list of material components and definitions used in the characterization field work, refer to Appendix B: Material Type Definitions.

Hand-sort Method

Field staff hand-sorted all loads of city-collected residential refuse, franchise-collected commercial and multifamily refuse, and military contract hauler refuse. When a selected vehicle arrived at the landfill face, the field crew manager collected the *Sample Placard*, verified the information noted on the *Sample Placard*, and instructed the selected vehicle to the proper tipping location. After the vehicle dumped its load, the field crew manager superimposed an imaginary 16-cell grid over the dumped material, identified a sample from a pre-selected random cell (noted on the *Sample Placard*), and used a small loader to extract this sample from the load. Field crew staff photographed each sample, sorted the material into 90 different material types, and recorded the weight for each sorted material type into the *Hand Sort Tally Sheet*. Each sample weighed at least 200 pounds and the average sample weighed 242 pounds.

Figure 2. Overview of Hand Sort Process

To characterize city-collected green waste loads, our field crew used a modified hand sort procedure and material list. Rather than extracting a 200 pound sample of material from the load for sorting, the field crew sorted entire green waste loads with the assistance of loader, removing and weighing only contaminant materials. The list of contaminant material types for green waste loads is included in Appendix B: Material Type Definitions.

Visual Characterization Method

A trained crewmember characterized all self-haul samples using volumetric-based visual estimations. When a selected vehicle arrived at the landfill face, the field crew manager collected the *Sample Placard* from the driver, verified the information noted on the *Sample Placard*, and instructed the selected vehicle to the proper tipping location. After the vehicle dumped its load, the crewmember photographed the load and measured the load volume with a measuring tape. A trained crewmember used a seven-step process to visually characterize self-haul loads as described in detail in Appendix C: Study Design.

The visual characterization method is most appropriate for samples where materials are bulky, layered, or distributed heterogeneously throughout the load. Under these circumstances, a 200 pound grab sample may not be representative of the entire load. Because self-haul samples are comprised primarily of bulky items, green waste, or construction materials, the visual characterization method is more appropriate, and more efficient, than hand sorting.

The visual characterization method uses industry standard density conversion factors to convert composition-by-volume estimates to composition-by-weight estimates. The conversion factors used are included in Appendix D: Waste Characterization Calculations.

Step 3. Determine Annual Waste Quantities

The project team used fee booth tonnage records and historical vehicle survey data to estimate the tonnage of incoming materials from each primary and secondary substream. The tonnage data is based on January 2012 to December 2012, the most recent full year of data available. For tables presented throughout the main body of the report, the residential and commercial waste stream tables only include refuse tonnages from within the City of San Diego. The military and self-haul samples include loads from both within San Diego and from other areas in San Diego County.

The sampling excluded residuals from the local recycling and C&D processing facilities. However, the overall residential and overall commercial composition tables, include the tonnages from these facilities as a line item to ensure that all disposed tons are accounted for when reconciling the composition data with the City's 2012 disposal tonnage records.

Table 3. Disposal by Primary Substream, 2012

Substream	Tons	Percent of Disposal
Single Family w/o Green Waste Service	107,310	8.3%
Single Family with Green Waste Service	199,291	15.4%
Multifamily	250,661	19.4%
Curbside Recycling Residue	10,422	0.8%
Residential Subtotal	*567,684*	*44.0%*
Front Loader	225,076	17.4%
Open-top Drag-on Containers	128,529	10.0%
Compactor Drag-on Containers	106,249	8.2%
C&D Processing Residue	14,993	1.2%
Commercial Subtotal	*474,847*	*36.8%*
Military Franchise-collected	21,480	1.7%
Military Self-haul	3,497	0.3%
Military Subtotal	*24,977*	*1.9%*
Flat Rate Vehicle	74,696	5.8%
Small Vehicles	39,615	3.1%
Large Vehicles	109,139	8.5%
Self-haul Subtotal	*223,450*	*17.3%*
Total Disposal	**1,290,958**	**100.0%**

Substream amounts may not sum to waste stream subtotals due to rounding.

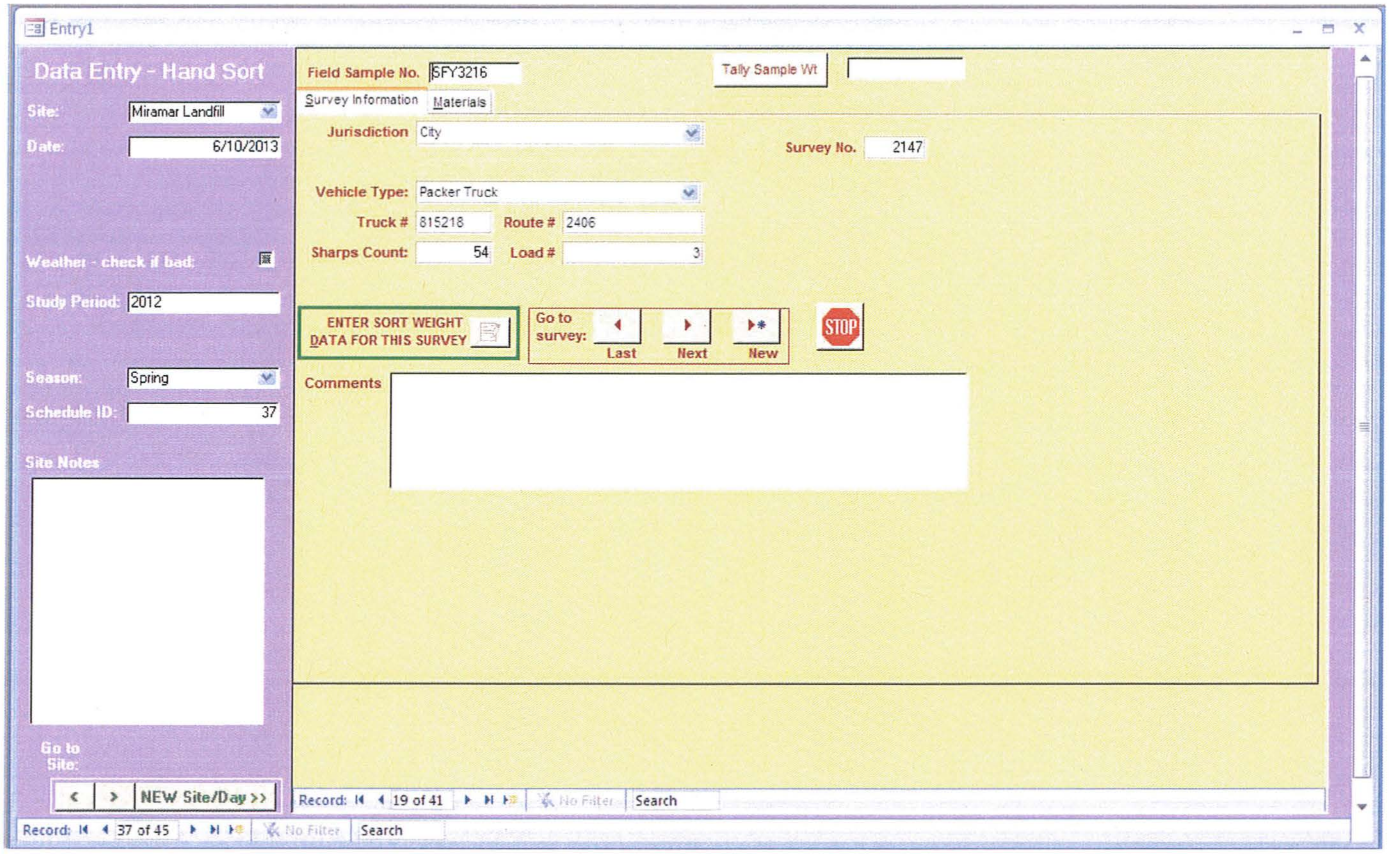
Appendix G: Detailed Substream Descriptions and Tonnage Allocations includes a detailed breakdown of the tonnage allocations, including the assumptions used to allocate tonnages. Tonnages for each primary substream and the residuals are summarized in Table 3.

Analyze Data

Cascadia field staff reviewed all field forms daily to identify any unusual or missing entries and resolve them immediately. After field work, Cascadia staff entered all collected data into a customized database twice to prevent data entry errors, and rectified any discrepancies between the two entries (see Figure 3 for a screenshot of the data entry database).

The project team developed detailed estimates of waste composition and quantities for each substream using the tonnage data the City provided and the methods described in Appendix D: Waste Characterization Calculations.

Figure 3. Screenshot of Data Entry Database



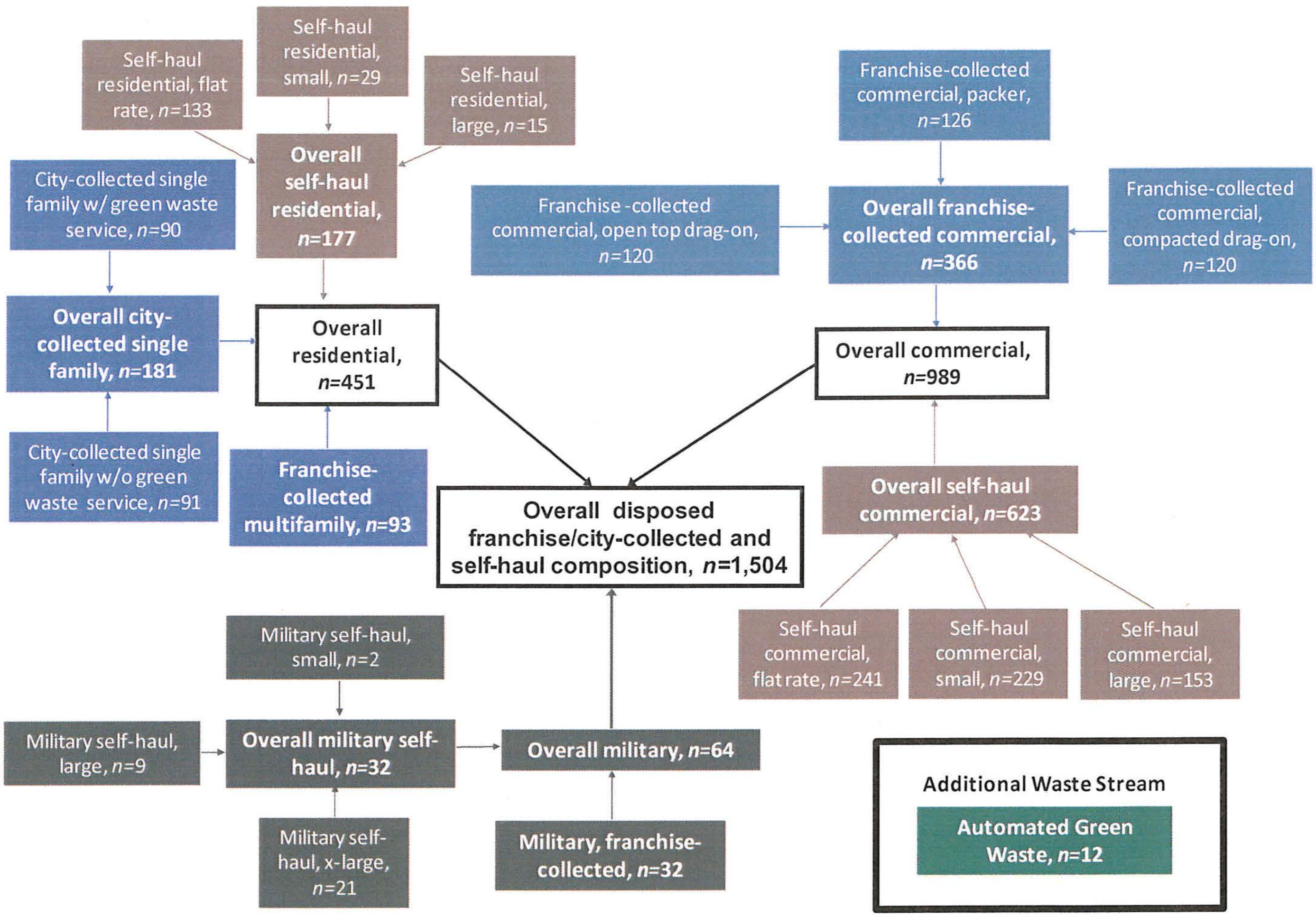
Changes from the Original Study Design

The project team made several small changes to the original study design over the course of the project. These changes were intended to ensure that the study met its objectives as outlined in the Introduction & Summary. The changes are summarized below.

- Military self-haul vehicles arrive infrequently at the landfill, but the composition of those loads is of interest to the project team to create a complete picture of military waste. Prior to beginning the second season, the project team redefined the substreams to create a military self-haul substream, and adjusted the sampling goals accordingly. Because the loads arrive infrequently, the field team selected for sampling every military self-haul load.
- The original green waste samples material list included ten contaminant types. However, during green waste sorting, the project team realized that the original list was insufficient to capture the variety of contaminants in green waste loads. The project team created and implemented a revised material list, and the field crew sorted all 12 green waste samples according to the revised green waste material list.
- The project was originally designed to provide composition data for four waste streams, their associated primary substreams, and the automated green waste (see Figure 1). During analysis, the project team also calculated composition results for an expanded set of secondary

substreams (primarily by further delineating the self-haul samples by generator type into residential self-haul and commercial self-haul). When selecting vehicles, the fee booth collected the information necessary to parse the samples into these more detailed secondary substreams. However, because the study was not designed to provide composition data at this level of detail, the study design did not set targets for the secondary substreams, and consequently some of the secondary substreams have very few samples. This affects the precision level of the results in the secondary substreams. The expanded sample stratification is illustrated in Figure 4. Composition data for substreams noted with bold text are included in the main body of the report. Composition data for the other substreams are included in Appendix F: Additional Composition Data.

Figure 4. Diagram of Expanded Sample Stratification



3. Study Results

Interpreting the Results

This report presents waste characterization results in three ways:

- First, two pie charts present an overview of waste composition by **Material Class** and by recoverability group. The Recyclable, Compostable/Potentially Compostable, and Potentially Recoverable groups are collectively referred to as recoverable.
- Next, the 10 most prevalent individual *material types*, by weight, are shown in a table.
- Finally, a detailed table lists the full composition and quantity results for the 90 *material types*. Please refer to Appendix B: Material Type Definitions for a list of definitions for *material types* used in the study.

A bar chart comparing the seasonal waste composition data by material class is also included for each of the overall waste streams and primary substreams.

Means and Error Ranges

The data from the characterization process were treated with a statistical procedure that provided two kinds of information for each of the *material types*:

- The percent-by-weight estimated composition of waste and
- The degree of precision of the composition estimates.

All estimates of precision were calculated at the 90% confidence level. An explanation of these calculations appears in Appendix D: Waste Characterization Calculations.

The example below illustrates how the results can be interpreted. In this example, the best estimate of the amount of *food* present in San Diego's waste is 15.0%. The plus or minus figure 0.8% reflects the precision of the estimate. When calculations are performed at the 90% confidence level, we are 90% certain that the true amount of *food* is between 15.0% plus 0.8% and 15.0% minus 0.8%. In other words, we are 90% certain that the true amount of *food* lies between 14.2% and 15.8%.

Material Type	Estimated Percent	+ / -
Food	15.0%	0.8%

Error Range (+/-)

The error range is a measure of the spread of values (variability) in a collection of data. For instance, if the quantities of *newspaper* were found to be nearly the same in each of the 1,504 refuse samples collected for this study, the result would be a very narrow error range. By contrast, if some samples were comprised of 75% *newspaper* and others were 0% *newspaper,* the results would show a much broader error range. In some cases the error range is larger than the estimated mean which leads to a negative number when the error range is subtracted from the mean. In these cases the true amount can be considered to be between 0.0% and

Rounding

When interpreting the results presented in the tables and figures in this report, it is important to consider the **effect of rounding**.

To keep the waste composition tables and figures readable, estimated tonnages are rounded to the nearest ton, and estimated percentages are rounded to the nearest tenth of a percent. Likewise, text references to the tables round the estimated percentages to the nearest percent. Due to this rounding, the **tonnages** presented in the report, when added together, may not exactly match the subtotals and totals shown in the tables. Similarly, the **percentages**, when added together, may not exactly match the subtotals or totals shown in the tables. Percentages less than 0.05% are shown as 0.0%.

It is important to recognize that the tons throughout the report were calculated using the non-rounded percentages. Therefore, using the rounded percentages from the tables to calculate tonnages may yield tonnages that are slightly different than those shown in the report.

For example, the rounded percentage for *food* in Table 5 is shown as 15.0%, while the more precise number, 14.99443313444%, was used in calculations. Similarly the total, non residuals disposed tonnage is shown as 1,265,543, slightly less than the actual value of 1,265,543.37. Using the more precise numbers, *food* is calculated to be 189,761 tons (as shown in Table 5) which is slightly less than the 189,831 tons we would get if we calculated using the rounded numbers (15.0%, 1,265,543 tons).