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Excess Food Opportunities Map – Technical Methodology

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Excess Food Opportunities Map – Technical Methodology

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Abstract

This report presents the methodology behind development of the US EPA Excess Food Opportunities Map (Map) which supports diversion of excess food from landfills. The information presented by the Map can be used to inform waste management at the local level, and identify potential sources of organic feedstocks, infrastructure gaps, and disposal alternatives to landfill.

This report describes the identification of select industrial, commercial and institutional sources in the United States that potentially generate excess food at the establishment level, and identification of potential recipients of these materials. Based on the North American Industry Classification System (NAICS), 89 categories of industries representing approximately 1.3 million establishments in the US were identified as potential sources of excess food. These 89 industries were grouped into the following categories: food manufacturers and processors (54), food wholesalers and distributors (22), educational institutions (2), the hospitality industry (3), correctional facilities (1), healthcare facilities (1), and the food services sector (6). Several publicly and commercially available datasets containing common business statistics for the selected industries were then compiled as a precursor to generating establishment-level excess food estimates. Data for food services sector establishments (e.g., restaurants, caterers, etc.) was not compiled for this version of the map due to resource constraints. Methodologies developed by various states and non-profit organizations were then reviewed to identify approaches to estimating excess food generation rates by industry. Combining select methodologies with establishment-level data resulted in a dataset that supports the Map and includes more than 500,000 potential excess food generators. The map also identifies more than 4,000 potential excess food recipients, described as composters, anaerobic digestion facilities, and food banks.

Executive Summary

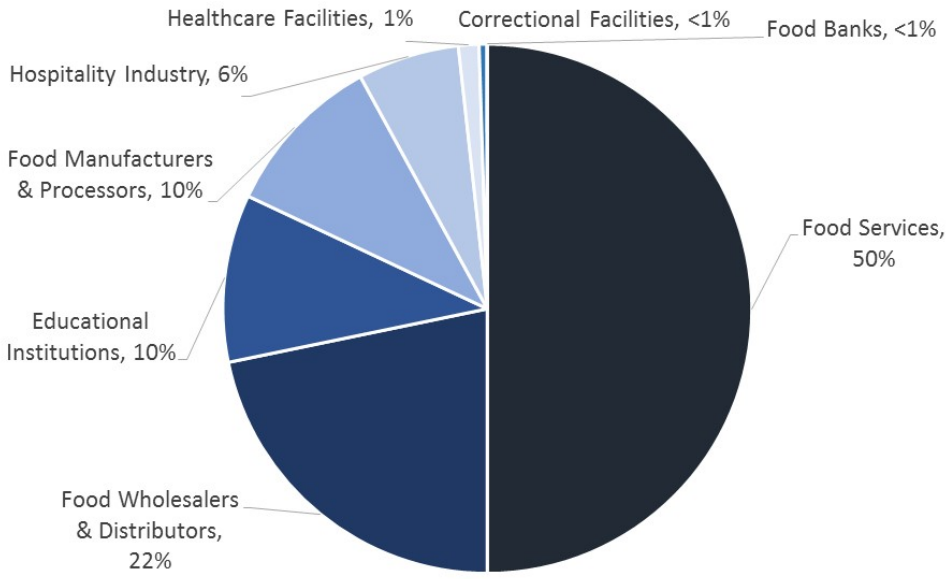
This report describes the effort to create estimates for the US EPA Excess Food Opportunities Map (Map). This interactive map supports nationwide diversion of food from landfills through the display of more than 500,000 potential industrial, commercial, and institutional waste generator locations, estimates of their excess food generation rates, and the display of more than 4,000 potential recipient locations. This map can be used to:

- Inform waste management decisions at the local level;
- Identify potential sources of food for rescue and reuse;
- Connect potential feedstocks to compost, anaerobic digestion, or other excess food processors;
- Identify potential infrastructure gaps for managing excess food.

For the purposes of this report, "excess food" refers broadly to post-harvest food that is produced for human consumption but not consumed by humans. Note that EPA's "Advancing Sustainable Materials Management: 2014 Fact Sheet" report characterizes food in the municipal waste stream as post-consumer rather than post-harvest (US EPA (2016b)). Because EPA intends to maximize recovery and beneficial use of all discarded organics, some inedible parts (e.g., pits, rinds, bones) were included in the excess food estimates, to the extent that they were included in the set of referenced studies. This report does not include discarded vegetable oil in the excess food estimate, if exclusively provided by the studies used to develop the methodologies, since a large percentage of used cooking oil is purchased as feedstock for biofuel or animal feed production and therefore is not waste. Further, this report does not include on-farm losses, including unharvested crops or processing by-products.

Based on the North American Industry Classification System (NAICS), 89 categories of industries representing approximately 1.3 million establishments in the US were identified as potential sources of excess food. These 89 industries were grouped into the following sectors: food manufacturers and processors (54), food wholesalers and distributors (22), educational institutions (2), the hospitality industry (3), correctional facilities (1), healthcare facilities (1), and the food services facilities (6). Figure E-1 shows that food services establishments (e.g., restaurants, caterers, etc.) and food wholesalers and distributors (e.g., supermarkets and grocery stores) make up the majority of potential sources of excess food. Commercially and publicly available data were compiled to create a Dataset of all identified industry establishments. Data on food services facilities (e.g., restaurants, caterers, etc.) was not included due to resource constraints. The Dataset includes each establishment's name, location, and a calculated estimated excess food generation rate. The Dataset also includes potential recipients of excess food, including establishment name and location for composting operations, anaerobic digestion facilities, and food banks.

Figure E-1. Non-Residential Excess Food Generating Sectors



Sector-specific methodologies for estimating excess food generation rates were adopted from existing studies conducted by several state environmental agencies (i.e., Connecticut, Massachusetts, Vermont, and South Carolina), as well as other sources, such as the Food Waste Reduction Alliance (FWRA). All adopted studies used methodologies based on commonly tracked business statistics to estimate excess food generation rates for several or all of the targeted sectors. These business statistics include number of employees (for food manufacturers and processors), annual revenue (for food wholesalers and distributors, and manufacturers and processors), number of rooms (for hotels), number of students (for schools, colleges, and universities), number of inmates (for correctional facilities) and number of beds (for healthcare facilities).

Using establishment-specific statistics collected in the Dataset, the methodologies were used to estimate the amount of excess food from each establishment in each of the targeted sectors. In cases where more than one methodology was available, a range of excess food estimates was calculated. This was done for educational institutions (public schools), the hospitality industry, correctional facilities, and healthcare facilities. In some case, like for grocery stores and supermarkets, methodologies were available to also generate an estimate of the edible fraction of excess food (i.e., food suitable for human consumption). The plate excess food fraction (i.e., postconsumer leftover food) could also be estimated for colleges and universities.

The Map and methodologies are not intended to provide accurate nation-wide estimates of excess food generation, nor do they reflect establishment-specific recovery or recycling efforts. Rather, they are intended to show estimated generation amounts, potential sources and possible recipients of excess food. This information may be used to help the public and private sectors divert excess food from landfill and toward more preferred uses as reflected in the Food Recovery Hierarchy

(i.e., human consumption, animal feed, industrial use, anaerobic digestion, compost). Limitations of the Map and technical methodology include the following:

- Methodologies are based on very limited measured data, some of which is nearly 20 years old. More recent measured data and a representative sample size are always preferred.
- Estimation of the edible fraction of excess food was not available for most sectors and is important because the edible fraction may be used to feed people, which represents the most preferred use of wholesome food that would otherwise be excess.
- Food services establishments are currently missing from the Map and Dataset due to resource constraints, and represent roughly 50% of the universe of establishments potentially generating excess food.
- Animal, milk, and egg producer establishments are currently missing from the Map and Dataset, and represent roughly 6% of the universe of establishments potentially generating excess food.
- On-farm loss is not captured in the current Map and Dataset and represents a relatively significant proportion of excess food.
- Due to data constraints, an estimated excess food generation rate was calculable for roughly 86% of mapped establishments.

The following are recommendations for future Map and technical methodology improvement:

- Additional studies are needed to update generation rates for all sectors.
- Include food services establishments, and animal, milk, and egg producer data in the Dataset to provide a more complete and useful Map.
- Expand map content to include other potential recipients and sources of excess food, potentially including on-farm loss, including unharvested crops, processing materials, or unmarketable crops.
- Research additional sources of publicly and commercially available data to increase the percentage of establishments for which excess food generation rates can be estimated.

This report was the result of a joint Regional Sustainability project between ORD and Region 9 that was initiated in 2014. At the time the project was funded there was no indication that the work would eventually become a component of an EPA-curated public website. Therefore, following ORD peer review guidance, the level of peer review was internal to EPA.

Acknowledgements

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List of Abbreviations, Acronyms, and Initialisms

AHD	American Hospital Directory
BJS	Bureau of Justice Statistics
BOP	Bureau of Prisons
CT	Connecticut
CTDEP	Connecticut Department of Environmental Protection
DOC	Department of Corrections
EPA	Environmental Protection Agency
FWRA	Food Waste Reduction Alliance
ICI	Industrial, Commercial, and Institutional
lb	Pounds
MA	Massachusetts
MSW	Municipal Solid Waste
NAICS	North American Industry Classification System
NCES	National Center for Education Statistics
RWMA	Recycling Works Massachusetts
SC	South Carolina
SCDOC	South Carolina Department of Commerce
SIC	Standard Industrial Classification
ton	Short Ton
UNEP	United Nations Environment Program
US	United States
US EPA	United States Environmental Protection Agency
USCB	United States Census Bureau
USDA	United States Department of Agriculture
VT	Vermont

1. Introduction

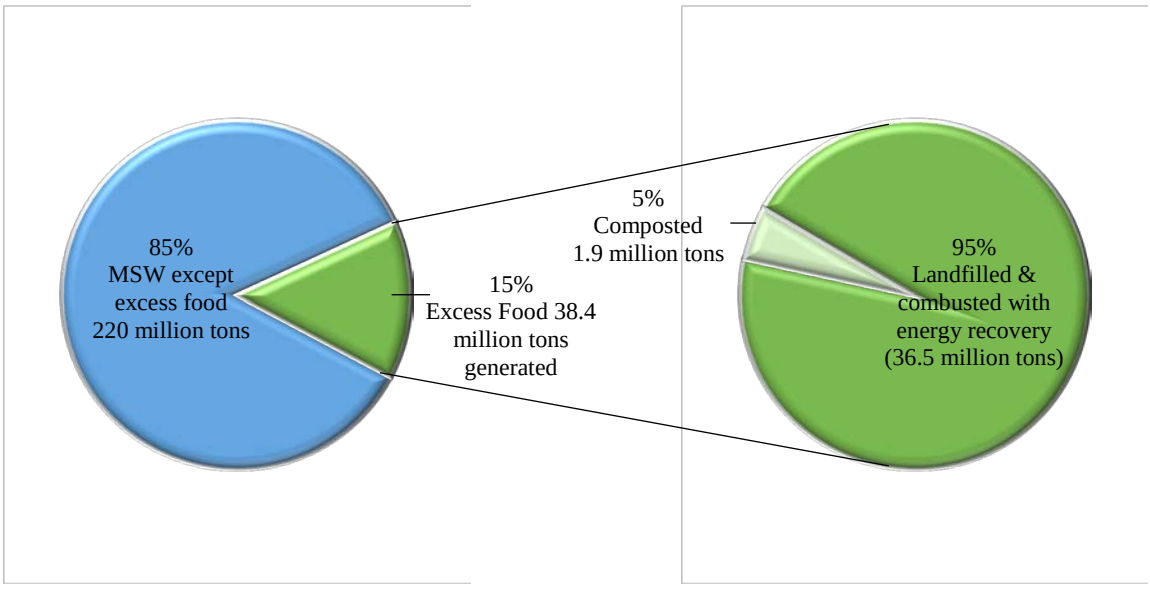
1.1. Background

On September 16, 2015, in alignment with Target 12.3 of the United Nations Sustainable Development Goals, the United States Department of Agriculture (USDA) and United States Environmental Protection Agency announced the first ever domestic goal to reduce food loss and waste by half by the year 2030. The EPA Excess Food Opportunities Map (Map) is a tool intended to support achievement of this goal.

The United Nations Environment Program (UNEP) estimates that approximately one third of food produced for human consumption is excess (UNEP, n.d.). The USDA estimated that in 2010, approximately 66.5 million tons of food (i.e., 31% of the 430 billion pounds produced) was lost at the retail and consumer level in the US (USDA, 2014). Production of this excess food requires significant water, land, and additional resources.

As reflected in Figure 1-1, the EPA estimated that post-consumer excess food represents approximately 15% (i.e., 38.4 million tons) of all Municipal Solid Waste (MSW) generated in 2014 (US EPA, 2016b). Approximately 95% of food included in the municipal solid waste stream was either landfilled or combusted, and just 5% composted (US EPA, 2016b). Landfills are the third largest anthropogenic source of methane emissions in the United States, and accounted for 17.6% of total methane emissions in 2015 (US EPA 2017a). Therefore, diverting excess food from landfills where it might degrade before gas collection is implemented could significantly reduce the production of greenhouse gas emissions.

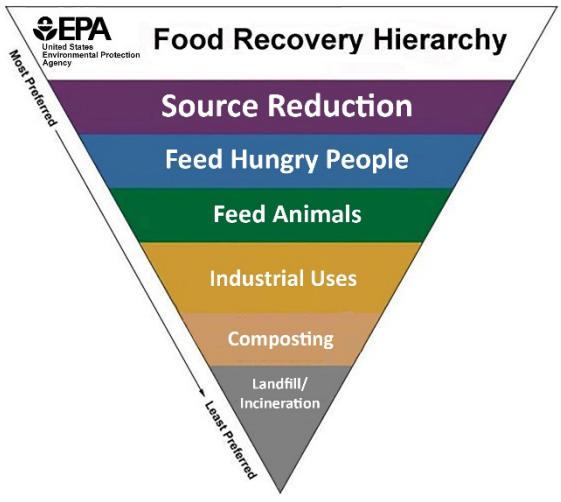
Figure 1-1. US EPA Estimation of U.S. Excess Food Disposition in 2014



The definition of excess food varies across studies and among organizations, resulting in different estimates of excess food. For example, while the USDA considers only the edible fraction in its accounting of food losses as its focus is on improving human nutrition (USDA 2014), the US Department of Energy's estimates include used vegetable oil because this is a valuable energy resource. For the purposes of this report, "excess food" refers to post-harvest food that is intended for human consumption but removed from the supply chain to be recovered, recycled, or disposed. EPA's goal is to maximize recovery and beneficial use of all discarded organics, so some organic materials are included in this definition that are not intended for human consumption, such as inedible parts (e.g., pits, rinds, bones) discarded in kitchens or during processing, some green organic material (e.g., flower trimmings), pet food, and yard waste collected by municipal services. This definition does not include unharvested crops or on-farm processing excess; used cooking oil (recycled as animal feed or biofuel); and excess food or other organic material disposed of by the residential sector. Note that for EPA's "Advancing Sustainable Materials Management: 2014 Fact Sheet" report characterizes food in the municipal waste stream as post-consumer rather than post-harvest (US EPA 2016b).

To prioritize efforts to divert excess food, EPA created the Food Recovery Hierarchy (Figure 1-2) (US EPA, 2015). Source reduction is the most preferred option as it not only mitigates the environmental impacts associated with management of excess food, but also minimizes the impacts associated with food production, processing, and delivery to the end-user. Any other management option chosen in a particular situation is dependent on the characteristics and the source of the excess food. For example, some food preparation residuals and/or post-consumer food discards may not be suitable for human consumption, so the next most preferred use is for animal feed. Feeding people and landfill/incineration are the most and least preferred options, respectively, for managing the edible fraction of excess food.

Figure 1-2. Food Recovery Hierarchy for Sustainable Management of Food (US EPA 2015)



Several states have already passed legislation requiring diversion of excess food and other organics from landfills, supporting the domestic goal of reducing excess food by 50% by 2030. These include Massachusetts (310 CMR 19.000), California (AB 1826), Connecticut (CGS Sec. 22a-226e), and Vermont (Vermont Act 148), all of which set limits on the quantity of food certain generators can send to landfill. Furthermore, several of these states (e.g., Connecticut and Vermont) have developed interactive tools for mapping state-specific excess food sources, sometimes including potential excess food recipients, such as composting facilities, in their tools. Beyond these regulatory efforts, there are also a number of voluntary regional-scale excess food generation and disposal efforts (USDA, 2014; US EPA, 2016; FWRA, 2014).

At the national level, US EPA has developed tools and resources for measuring, tracking, and reducing excess food, as well as assessed the cost and environmental impact of excess food management (US EPA 2014, US EPA 2016a). The Agency also estimates a nation-wide excess food generation rate from residential, institutional and commercial sources

on an annual basis (US EPA 2016b). The US EPA recognizes the need for tools to support a broader understanding of potential excess food generation, and to foster collaboration and partnership among stakeholders interested in promoting and achieving sustainable management of food.

1.2. Objectives and Approach

The primary objective of this report is to present the methodology used to develop the Map, including establishment-specific estimates of excess food generation. This national-scale, interactive map is intended to help inform waste management decisions at the local level, and identify potential sources of organic feedstocks, infrastructure gaps, and disposal alternatives to landfill. The approach taken is as follows:

- Using the North American Industry Classification System (NAICS), 89 industry classes were identified as industrial, commercial, or institutional (ICI) generators of excess food and were grouped into the following sectors: food manufacturers and processors (54), food wholesalers and distributors (22), educational institutions (2), the hospitality industry (3), correctional facilities (1), healthcare facilities (1), and the food services sector (6). A full list of industry NAICS codes and descriptions is provided in Appendix C. Agricultural sources of excess food were not included in this study.
- An extensive literature review informed development of methodologies used to estimate excess food generation factors for each industry class (further detail provided in Appendix A).
- Publicly and commercially available data sources were mined for supplementary data to estimate establishment-level excess food generation rates using the identified methodologies. The resulting Dataset was used to support the online Map.
- Information about potential recipients of excess food was also collected and mapped, and includes food banks, composters, and anaerobic digestion facilities.
- Information about communities with source separated organics programs was also collected and mapped.

The resulting map provides establishment-level information such as name, geographic location, and physical address, and where possible, estimates of waste food generation. The Map also includes similar establishment-level information about potential recipients of excess food that also comes from publicly and commercially available datasets, as well as state websites.

1.3. Report Organization

This report is organized as follows:

Chapter 1: Introduction

Chapter 2: Sector-specific data sources and excess food estimation methodologies for generators

Chapter 3: Macro analysis of sector-specific excess food generation rates

Chapter 4: Data sources for recipients

Chapter 5: Data sources for communities with residential source separated organics programs

Chapter 6: Limitations and future research needs

References

Appendix A: A Review of Excess Food Estimation Methods

Appendix B: Excess Food Characteristics

Appendix C: Glossary

2. Sector-Specific Data Sources and Excess Food Estimation Methodologies for Generators

2.1. Overview

This chapter describes the methods and data sources used to estimate the excess food generation rates for individual establishments in the 89 identified ICI industries. For the purposes of this report, "excess food" refers broadly to post-harvest food that is produced for human consumption but removed from the supply chain to be recovered, recycled, or disposed (refer to Appendix C for full definition). The definition does not include unharvested crops or on-farm processing excess; used cooking oil (recycled as animal feed or biofuel); and excess food or other organic material disposed of by the residential sector.

The 89 ICI industries were grouped into the following major sectors: food manufacturers and processors (54), food wholesalers and distributors (22), educational institutions (2), the hospitality industry (3), correctional facilities (1), healthcare facilities (1), and food services (6). Because EPA's goal is to maximize recovery and beneficial use of all discarded organics, some industries were included that generate other kinds of organics that are not food for human consumption, such as 311111 (Dog and Cat Food Manufacturing) and 424930 (Flower, Nursery Stock, and Florists' Supplies Merchant Wholesalers). The full list of industries, and associated excess food characteristics, is provided in Appendix B.

Table 2-1 summarizes the methods used in this study to estimate annual establishment-specific excess food generation rates, as well as data sources. Establishment-level data for most industries came from Hoover's, Inc. and included contact information, location details (geo-coordinates and physical addresses), establishment type (headquarters, branch, or single location), revenue ($USD), and number of employees. Similar establishment-level data for educational institutions was obtained from the National Center for Education Statistics (NCES 2017a, 2017b, 2017c).

In general, methodologies to estimate the annual excess food generation rates for the majority of targeted sectors were available in four state studies, which themselves were based on literature reviews: CTDEP (2001) ("CT Study"), MassDEP (2002) ("MA Study"), SCDOC (2015a) ("SC Study"), and VTDEC (2014a, 2014b) ("VT Study") (Appendix A). Where these studies did not provide a methodology for a sector, or if sufficient data were not available to use the methodology, methodologies from other studies were employed. These additional sources include RWMA, FWRA (2014), and CCG (2006). An excess food generation factor range was estimated for sectors if more than one methodology and the associated input data were available (i.e., colleges and universities, public elementary and secondary schools, hospitality industry, correctional facilities, healthcare facilities). The excess food estimate includes edible as well as inedible food to the extent accounted for by the studies used by each state to develop their own methodologies. The edible and/or plate excess food generation rate was also estimated for the industries and establishments for which such data were available and relevant (i.e., supermarkets and grocery stores, and colleges and universities). The absence of edible and/or plate excess food data for an industry in this report does not necessarily mean that no edible excess food is produced by that industry. If data were not available to generate an estimate, the establishment was still mapped, but no estimate was provided.

Note: *The generation factors used for excess food, edible excess food, and plate excess food generation estimates are based on studies conducted in a particular time and place. Therefore, these estimates may not be representative of current excess food generation. In addition, these estimates do not account for an establishment's current handling of excess food (e.g., the establishment might already be donating, feeding to animals, or composting its excess food). Local education, infrastructure, motivation, and technology contribute to different practices and results, geographically.*

Table 2-1. Excess Food Estimation Methodologies for Identified Sectors

Excess Food Generator Sector	Variable Parameters	Generation Factor	Excess Food Calculation Algorithm (tons per year)	Comments	Data Source	Adopted from
Food Manufacturers and Processors	$ Revenue	0.053 lbs per $ revenue	($ Annual Revenue) × (0.053 lbs per $ Annual Revenue) ÷ (2,000 lbs per ton)		Hoover's, Inc.	FWRA (2014)
Food Wholesalers and Distributors						
Supermarkets and other Grocery (except Convenience) Stores	# of employees	3,000 lbs per employee per year	(# of employees) × (3,000 lbs per employee per year) ÷ (2,000 lbs per ton)		Hoover's, Inc.	CT/MA/SC Studies
Other Wholesalers and Distributors	$ Revenue	0.01 lbs per $ revenue	($ Annual Revenue) × (0.01 lbs per $ Annual Revenue) ÷ (2,000 lbs per ton)		Hoover's, Inc.	FWRA (2014)
Educational Institutions						
Elementary and Secondary Private Schools	# of students # of days school open per year	0.35 lbs per meal	(# of students) × (0.35 lbs per meal) × (1 meal per day) × (number of days school opens per year) ÷ (2,000 lbs per ton)		NCES, 2017b	CT/MA/SC Studies
Elementary, Middle, High School, K-12 Public Schools	# of students	Elementary: 1.13 lbs per student per week Middle: 0.73 lbs per student per week High School: 0.35 lbs per student per week K-12: 0.72 lbs per student per week	(# of students) × ('x' lbs per student per week) × (40 week per year) ÷ (2,000 lbs per ton)	Assumes school opens for 40 weeks in a year	NCES, 2017a	VT Study
	# of students	0.5 lbs per student per week	(# of students) × (0.5 lbs per student per week) × (40 week per year) ÷ (2,000 lbs per ton)	Assume school opens for 40 weeks in a year	NCES, 2017a	RWMA
Colleges and Universities	# of students	For residential students: 0.35 lbs per meal, 405 meals per student per year For non-residential students: 0.35 lbs per meal, 108 meals per student per year	$\left(\text{\# of residential students} \times 405\frac{\text{meals}}{\text{student}}{\text{year}} + \text{\# of non-residential students} \times 108\frac{\text{meals}}{\text{student}}{\text{year}}\right) \times 0.35\frac{\text{lbs}}{\text{meal}} \div 2{,}000\frac{\text{lbs}}{\text{ton}}$	Dormitory capacity was used for number of residential students. Number of non-residential students was calculated by subtracting dormitory capacity from total enrollment.	NCES, 2017a	CT Study
	# of students	1.13 lbs per student per week	$(\text{\# of students}) \times 1.13\frac{\text{lbs}}{\text{student}}{\text{week}} \times 31\frac{\text{weeks}}{\text{year}} \div 2{,}000\frac{\text{lbs}}{\text{ton}}$		NCES, 2017a	VT study
Hospitality Industry	# of employees	345.64 lbs per room per year 3.38 rooms per employee	(# of employees) × (3.38 rooms per employee) × (345.64 lbs per room per year) ÷ (2,000 lbs per ton)	Number of rooms was estimated using an average of 3.38 rooms per employee (Mount and Frye, 2006)	Hoover's, Inc.	RWMA
	# of employees	1,984 lbs per employee per year	(# of employees) × (1,984 lbs per employee per year) ÷ (2,000 lbs per ton)		Hoover's, Inc.	CCG (2006)
Correctional Facilities	# of employees	1.0 lbs per inmate per day 5.28 inmates per employee	(# of employees) × (5.28 inmates per employee) × (1.0 lbs per inmate per day) × (365 days per year) ÷ (2,000 lbs per ton)	CT, MA, and SC Studies estimated excess food using number of inmates; however, Hoover's, Inc. provided data for number of employees. Average number of inmates per employee was generated from the Department of Corrections website of Florida, Georgia, and Alabama, Federal Bureau of Prisons (5.28 inmates per employee), and US Bureau of Justice Statistics (3.75 inmates per employee).	Hoover's, Inc.	CT/MA/SC Studies
	# of employees	1.0 lbs per inmate per day 3.75 inmates per employee	(# of employees) × (3.75 inmates per employee) × (1.0 lbs per inmate per day) × (365 days per year) ÷ (2,000 lbs per ton)			
Healthcare Facilities	Revenue ($ million)	3.42 lbs per bed per day 0.269 beds per Revenue ($ million)	(Revenue ($ million)) × (0.269 beds per Revenue ($ million)) × (3.42 lbs per bed per day) × (365 days per year) ÷ (2,000lbs per ton)	CT, MA, and SC Studies estimated excess food using number of beds; however, Hoover's, Inc. provided data for revenue of each establishment. A relationship (0.269 beds per Revenue ($ million)) between number of beds and establishment's revenue was generated using data obtained from the AHD, which summarizes data for all US hospitals by state.	Hoover's, Inc.	CT Study
	Revenue ($ million)	1.5 lbs per bed per day 0.269 beds per Revenue ($ million)	(Revenue ($ million)) × (0.269 beds per Revenue ($ million)) × (1.5 lbs per bed per day) × (365 days per year) ÷ (2,000lbs per ton)		Hoover's, Inc.	VT Study
Food Services Sector	# of employees	260 to 3,392 lbs per employee per year	(# of employees) × (260 to 3,392 lbs per employee per year) ÷ (2,000 lbs per ton)			See Appendix A
	$ Revenue	0.033 lbs per $ revenue	($ Revenue) × (0.033 lbs per $ Revenue) ÷ (2,000 lbs per ton)			FWRA (2014)

2.2. Food Manufacturers and Processors

2.2.1. Overview

Fifty-four industries were classified as food manufacturers and processors (Table 2-2). These industries are grouped as follows: animal production and aquaculture (NAICS Code 112), food manufacturing (NAICS Code 311), beverage and tobacco product manufacturing (NAICS Code 312), and ethyl alcohol manufacturing (NAICS Code 325193). A subset of this group, identified as establishments classified under NAICS codes 112111 through 112420, is termed "animal, milk, and egg producers". This subset does not appear in the Map.

Table 2-2. NAICS Codes for Food Manufacturers and Processors

No.	NAICS Code	NAICS Code Description
1	112111	Beef Cattle Ranching and Farming
2	112112	Cattle Feedlots
3	112120	Dairy Cattle and Milk Production
4	112210	Hog and Pig Farming
5	112310	Chicken Egg Production
6	112320	Broilers and Other Meat Type Chicken Production
7	112330	Turkey Production
8	112340	Poultry Hatcheries
9	112390	Other Poultry Production
10	112420	Goat Farming
11	112930	Fur-Bearing Animal and Rabbit Production
12	311111	Dog and Cat Food Manufacturing
13	311119	Other Animal Food Manufacturing
14	311221	Wet Corn Milling
15	311224	Soybean and Other Oilseed Processing
16	311225	Fats and Oils Refining and Blending
17	311230	Breakfast Cereal Manufacturing
18	311313	Beet Sugar Manufacturing
19	311314	Cane Sugar Manufacturing
20	311340	Non-chocolate Confectionery Manufacturing
21	311351	Chocolate and Confectionery Manufacturing from Cacao Beans
22	311352	Confectionery Manufacturing from Purchased Chocolate
23	311411	Frozen Fruit, Juice, and Vegetable Manufacturing
24	311412	Frozen Specialty Food Manufacturing
25	311421	Fruit and Vegetable Canning
26	311422	Specialty Canning
27	311423	Dried and Dehydrated Food Manufacturing
28	311511	Fluid Milk Manufacturing
29	311512	Creamery Butter Manufacturing
30	311513	Cheese Manufacturing

No.	NAICS Code	NAICS Code Description
31	311514	Dry, Condensed, and Evaporated Dairy Product Manufacturing
32	311520	Ice Cream and Frozen Dessert Manufacturing
33	311611	Animal (except Poultry) Slaughtering
34	311612	Meat Processed from Carcasses
35	311613	Rendering and Meat Byproduct Processing
36	311615	Poultry Processing
37	311710	Seafood Product Preparation and Packaging
38	311811	Retail Bakeries
39	311812	Commercial Bakeries
40	311813	Frozen Cakes, Pies, and Other Pastries Manufacturing
41	311821	Cookie and Cracker Manufacturing
42	311824	Dry Pasta, Dough, and Flour Mixes Manufacturing from Purchased Flour
43	311830	Tortilla Manufacturing
44	311911	Roasted Nuts and Peanut Butter Manufacturing
45	311919	Other Snack Food Manufacturing
46	311920	Coffee and Tea Manufacturing
47	311930	Flavoring Syrup and Concentrate Manufacturing
48	311941	Mayonnaise, Dressing, and Other Prepared Sauce Manufacturing
49	311942	Spice and Extract Manufacturing
50	311991	Perishable Prepared Food Manufacturing
51	311999	All Other Miscellaneous Food Manufacturing
52	312120	Breweries
53	312130	Wineries
54	325193	Ethyl Alcohol Manufacturing

2.2.2. Food Manufacturers and Processors (except animal, milk, and egg producers)

The CT, MA, and VT Studies reported a large variation in excess food generation factors from food manufacturers and processors. *No generalized relationship was observed between excess food generation and sector-specific parameters due to variations in operational and handling approaches*. The CT Study reported that sales data may be an indicator of excess food generation for the food manufacturers and processors sector, if other variables are constant.

A study of food manufacturers and processors, conducted by the Food Waste Reduction Alliance (FWRA) and representing 17% of total projected US sales for 2011, estimated approximately 0.053 pounds of excess food generated per dollar of company revenue (FWRA, 2014). The FWRA generation factor was used in conjunction with annual revenue data obtained from Hoover's, Inc. to estimate the annual amount of excess food generated by food manufacturing and processing facilities. This is reflected in the following equation:

$$\text{Food Manufacturers and Processors Excess Food } \frac{\text{tons}}{\text{year}} =$$

$$\text{Facility's Annual Revenue (\$)} \times 0.053 \frac{\text{lb}}{\text{Annual Revenue (\$)}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

It should be noted that the CT Study did not develop a methodology for this sector based on diversity of operations and handling of discarded organics, which may significantly impact the excess food generation rate among the entities within a single NAICS code. For example, some meat packers may procure and process entire carcasses and discard a large fraction as waste, whereas some may purchase partially processed cuts of meat and discard only a small fraction (CTDEP, 2001). This example illustrates the nature of variation in operation among the facilities within a single NAICS code that can have a significant impact on excess food generation rates. In addition, some of the manufacturers, such as hog farmers, may recover and reuse excess food on-site and may not have excess excess food for off-site management. Therefore, due to the absence of NAICS-code specific excess food generation factors, a constant generation factor based on revenue was applied to estimate an excess food generation rate for all facilities belonging to these 54 NAICS codes.

Finally, note that although the VT Study published a method for estimating excess food for bakeries, which fall in this sector, Hoover's Inc. did not provide seat data for bakeries which was required for the calculation. The excess food generation rate from bakeries was therefore estimated using the equation presented above.

2.2.3. Animal, Milk, and Egg Producers

Animal, milk, and egg producers (NAICS codes 112111 through 112420) are treated as a subset of manufacturers and processors and are considered potential generators as well as potential recipients of excess food. This is because it is possible for animal feeding operations to use excess food, such as in feed preparation, as well as create waste products. While this group does not appear in the Map, it would rely on the same equation as that used for Food Manufacturers and Processors to estimate excess food generation.

2.3. Food Wholesalers and Distributors

2.3.1. Overview

Twenty-two industries were classified as food wholesalers and distributors, including supermarkets and grocery stores (Table 2-3). Establishment-level data for this sector was obtained from Hoover's, Inc.

Table 2-3. NAICS Codes for Food Wholesalers and Distributors

No.	NAICS Code	NAICS Code Description
1	424410	General Line Grocery Merchant Wholesalers
2	424420	Packaged Frozen Food Merchant Wholesalers
3	424430	Dairy Product (except Dried or Canned) Merchant Wholesalers
4	424440	Poultry and Poultry Product Merchant Wholesalers
5	424450	Confectionery Merchant Wholesalers
6	424460	Fish and Seafood Merchant Wholesalers
7	424470	Meat and Meat Product Merchant Wholesalers
8	424480	Fresh Fruit and Vegetable Merchant Wholesalers
9	424490	Other Grocery and Related Products Merchant Wholesalers
10	424510	Grain and Field Bean Merchant Wholesalers
11	424520	Livestock Merchant Wholesalers
12	424810	Beer and Ale Merchant Wholesalers
13	424820	Wine and Distilled Alcoholic Beverage Merchant Wholesalers
14	424910	Farm Supplies Merchant Wholesalers (Animal feeds (except pet food))
15	424930	Flower, Nursery Stock, and Florists' Supplies Merchant Wholesalers
16	445110	Supermarkets and Other Grocery (except Convenience) Stores
17	445210	Meat Markets
18	445220	Fish and Seafood Markets
19	445230	Fruit and Vegetable Markets
20	445291	Baked Goods Stores
21	445292	Confectionery and Nut Stores
22	445299	All Other Specialty Food Stores

2.3.2. Food Wholesalers and Distributors (except supermarkets and grocery stores)

The CT, MA, and VT Studies did not report a correlation between excess food and parameters such as number of employees, sales, or facility area due to variations in food handling practices among food wholesalers and distributors, except supermarkets and grocery stores. The CT Study reported that, similar to food manufacturers and processors, sales data can serve as a predictor for excess food generation. The FWRA conducted a survey of food wholesalers and distributors (including grocery retailers) and reported that approximately 10 lbs of excess food were generated per 1,000 dollars of revenue (FWRA, 2014). The FWRA survey collected data from establishments generating approximately 32% of the total projected sales of US wholesalers and distributors.

EPA evaluated the amount of excess food generated by each food wholesaler and distributor (except supermarkets and grocery stores) using revenue data obtained from Hoover's, Inc. and a generation factor of 0.01 lb of excess food per dollar revenue based on the data reported by FWRA

(2014). The following equation was used to estimate the annual amount of excess food produced by food wholesalers and distributors, except supermarkets and grocery stores:

$$\text{Food Wholesalers and Distributors Excess Food } \frac{\text{tons}}{\text{year}} =$$

$$\text{Establishment's Annual Revenue \$} \times 0.01 \frac{\text{lb}}{\text{Annual Revenue (\$)}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

2.3.3. Supermarkets and Grocery Stores

Excess food generation in supermarkets and grocery stores was estimated using the approach of the CT, MA, and SC Studies, where the number of employees was used to quantify excess food (the methodology was first used by CT Study and later adopted by MA and SC Studies). Establishment-level data for this sector was obtained from Hoover's, Inc., which included employee data. The following equation was used to estimate the amount of excess food from supermarkets and grocery stores:

$$\text{Supermarkets and Grocery Stores Excess Food } \frac{\text{tons}}{\text{year}} =$$

$$\text{Number of employees} \times \frac{3{,}000 \frac{\text{lb}}{\text{employee}}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

The edible portion of excess food generated by supermarkets and grocery stores was also estimated. Jacob (1993) conducted a survey of eight supermarkets and observed that approximately 95% of excess food generated by the bakeries, and 15% of excess food generated by produce departments, would be acceptable to food banks. Based on Jacob (1993), it was estimated that approximately 600 lbs of edible excess food is annually generated per employee from supermarkets and grocery stores. This value was used to estimate edible excess food generation from supermarkets and grocery stores, per the following equation:

$$\text{Supermarkets and Grocery Stores Edible Excess Food } \frac{\text{tons}}{\text{year}} =$$

$$\text{Number of employees} \times \frac{600 \frac{\text{lb}}{\text{employee}}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

2.4. Educational Institutions

2.4.1. Overview

The educational institutions sector consists of colleges, universities, and professional schools, and elementary and secondary schools (Table 2-4). The CT, MA, SC, and VT Studies used number of students as a parameter to quantify the amount of excess food generated. Different approaches were used to estimate excess food for colleges and universities, and primary and secondary schools, as described in the following sections.

Table 2-4. NAICS Codes for Educational Institutions

No.	NAICS Code	NAICS Code Description
1	611110	Elementary and Secondary Schools
2	611310	Colleges, Universities, and Professional Schools

2.4.2. Colleges and Universities

Data for colleges and universities were collected from the Integrated Postsecondary Education Data System of the National Center for Education Statistics (NCES) for the 2013/2014 school year. This data includes the name, address, geo-coordinates, total enrollment, and total dormitory capacity of each institution. Excess food generation was estimated using two different methods developed in the CT and VT Studies, resulting in a range of values for each institution. *Note that the data used to develop excess food generation factors are based on studies conducted in the late 1990s and may not represent current college and university excess food generation and management practices. Future research is needed to develop generation factors reflective of current practices.*

The CT Study identified colleges and universities as residential and non-residential institutions and provided a separate equation for each type. The NCES database did not specifically provide the number of students at residential and non-residential institutions, however, dormitory capacity data at each school were available and used as a surrogate for the number of students living on a given campus. The CT Study equations for residential and non-residential institutions were thus combined, and dormitory capacity was used as a proxy for number of residential students, while the remaining number of students were assumed to be non-residential. The following equation (which modifies the equation used in the CT Study based on available total enrollment and dormitory capacity for each institution) was used to estimate the amount of excess food from colleges and universities:

$$\text{Colleges and Universities Excess Food } \frac{\text{tons}}{\text{year}} = \left(\begin{array}{l} \text{Dormitory Capacity} \times \frac{405 \frac{\text{meals}}{\text{student}}}{\text{year}} + \\ (\text{Total Enrollment-Dormitory Capacity}) \times \frac{108 \frac{\text{meals}}{\text{student}}}{\text{year}} \end{array} \right) \times 0.35 \frac{\text{lb}}{\text{meal}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

The VT Study estimated an average of 1.13 lbs of excess food per student per week assuming institutions are open for 31 weeks per year. The following additional equation from the VT Study was used to estimate the excess food generated from colleges and universities:

$$\text{Colleges and Universities Excess Food } \frac{\text{tons}}{\text{year}} =$$

$$\text{Number of students} \times \frac{1.13 \frac{\text{lbs}}{\text{student}}}{\text{week}} \times 31 \frac{\text{weeks}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

Regarding edible excess food, Whitehair et al. (2013) conducted a 6-week study at a university dining facility serving 540 university students living in residence halls and observed that more than 0.13 lb of edible food was disposed of per plate. A plate excess food generation rate range for colleges and universities was estimated using the CT and VT Study formulas and applying the Whitehair et al. (2013) rate, and assuming that 5 meals are served per student per week (from VT Study methodology):

$$\text{Colleges and Universities Plate Excess Food } \frac{\text{tons}}{\text{year}} =$$

$$\left(\begin{array}{l} \text{\# of residential students} \times \dfrac{405 \dfrac{\text{meals}}{\text{student}}}{\text{year}} + \\ \\ \text{\# of non-residential students} \times \dfrac{108 \dfrac{\text{meals}}{\text{student}}}{\text{year}} \end{array} \right) \times 0.13 \frac{\text{lbs}}{\text{meal}} \times \frac{\text{tons}}{2{,}000 \text{ lbs}}$$

$$\text{Colleges and Universities Plate Excess Food } \frac{\text{tons}}{\text{year}} =$$

$$\text{Number of students} \times 0.13 \frac{\text{lbs}}{\text{meal}} \times \frac{5 \frac{\text{meals}}{\text{student}}}{\text{week}} \times 31 \frac{\text{weeks}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lbs}}$$

2.4.3. Elementary and Secondary Schools

The CT, MA, and SC Studies estimated the amount of excess food generated from private schools, whereas RWMA and the VT Study estimated the amount of excess food produced from public schools. The VT Study also identified the amount of excess food generated by students of various grade levels.

Information for elementary and secondary schools was collected from open-access databases. The NCES Private Schools Universe Survey provided information for 26,983 private schools for the 2011-2012 school year. The information includes institution name, address and geo-coordinates, number of students, and number of school days. The excess food generated annually by each private school was estimated based on the number of students and the number of school days considering a generation factor of 0.35 lb of excess food per student per meal (as suggested by the CT Study) and assuming one meal per student per day. The NCES database provided the number of days schools are open per year for each school. The excess food generation for private schools was estimated using the school-specific number of days in the following equation (using the excess food generation factor suggested by the CT Study):

$$\text{Private Elementary and Secondary Schools Excess Food } \frac{\text{tons}}{\text{year}} =$$

$$\text{Number of students} \times 0.35 \frac{\text{lb}}{\text{meal}} \times 1.0 \frac{\text{meal}}{\text{day}} \times \frac{\text{number of days school is open}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

Public school data were obtained from the NCES Public Elementary/Secondary School Universe Survey for the 2012-2013 school year and included institution name, address, geo-coordinates, school level (elementary, middle, high school, and others), and the total number of students for 102,890 public schools.

The excess food generated by each public school was estimated based on the number of students using methods suggested by RWMA and the VT Study. RWMA suggests using an excess food generation factor of 0.5 lb per student per week regardless of the grade level of the student. The VT Study provides the generation factor by grades: elementary, middle, high school, and other (K-12) students generate an average of 1.13, 0.73, 0.35, and 0.72 lb of excess food per student per week, respectively. RWMA and the VT Study obtained the excess food generation factor after conducting surveys of public schools. Both methods were used to estimate the amount of excess food generated by each school, and the resulting range of values included in the Dataset. The VT Study assumed 40 school weeks per year which was carried through the estimates given that NCES did not provide this statistic.

$$\text{Public Elementary and Secondary Schools Excess Food } \frac{\text{tons}}{\text{year}} =$$

$$\text{Number of students} \times \frac{0.5 \frac{\text{lb}}{\text{student}}}{\text{week}} \times 40 \frac{\text{weeks}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

$$\text{Public Elementary and Secondary Schools Excess Food } \frac{\text{tons}}{\text{year}} =$$

$$\text{Number of students} \times \frac{x \frac{\text{lb}}{\text{student}}}{\text{week}} \times 40 \frac{\text{weeks}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

Note: x= 1.13 for elementary school students, 0.73 for the middle school students, 0.35 for the high school students, and 0.72 for other school (K-12) students.

Table 2-5 summarizes the variables and generation factors used in the excess food estimate methodologies for the different educational institutions.

Table 2-5. Parameters Used to Estimate Excess Food Generation Rates for Educational Institutions

Educational Institution Type	Variable	Excess Food Generation Factors
Colleges and Universities		
Residential Institution	Number of Students	0.35 lbs/meal 405 meals/student/year
Non-Residential Institution	Number of Students	0.35 lbs/meal 108 meals/student/year
All Colleges and Universities	Number of Students	1.13 lbs/student/week 31 weeks/year
Private Elementary and Secondary Schools		
Elementary/Secondary	Number of Students, Number of Days School Open per Year	0.35 lbs/meal
Public Elementary and Secondary Schools		
Elementary/Secondary	Number of Students	0.5 lbs/student/week 40 weeks/year
Elementary School	Number of Students	1.13 lbs/student/week 40 weeks/year
Middle School	Number of Students	0.73 lbs/student/week 40 weeks/year
High School	Number of Students	0.35 lbs/student/week 40 weeks/year
K-12	Number of Students	0.72 lbs/student/week 40 weeks/year

2.5. Hospitality Industry

As listed in Table 2-6, establishments belonging to three NAICS codes were grouped as the hospitality industry.

Table 2-6. NAICS Codes for the Hospitality Industry

No.	NAICS Code	NAICS Code Description
1	713210	Casinos (except Casino Hotels)
2	721110	Hotels and Motels
3	721120	Casino Hotels

Since the majority of establishments in this sector are classified as "hotels and motels", excess food estimates were based on two studies focused on this sector resulting in a range of estimates. Note that the state studies did not provide specific methodologies for this sector.

RWMA provides a method for estimating excess food from "lodging and hotels" and provides an estimate of 345.64 lbs/room/year excess food.

Based on data reported by Mount and Frye (2006), extended-stay and limited-service hotels in the US were estimated to have an average of one employee per 3.38 rooms. Data on number of employees was available from Hoover's, Inc. Therefore, the equation for excess food for this sector reads as follow:

$$\text{Hospitality Industry Excess Food } \frac{\text{tons}}{\text{year}} =$$

$$\text{Number of employees} \times 3.38 \frac{\text{rooms}}{\text{employee}} \times \frac{345.64 \frac{\text{lbs}}{\text{room}}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lbs}}$$

Additionally, CCG (2006) conducted a survey of large hotels belonging to SIC code 70 (defined as including hotels, rooming houses, camps, and other lodging places) to estimate the waste generation and disposal practices of large hotels in California. The data generated from 30 hotels showed an average of 5,049 lbs per employee per year of total waste generation, of which approximately 39% (1,984 lbs per employee per year) was excess food. Based on the data reported by CCG (2006), the following equation was also used to estimate excess food generation from hotels:

$$\text{Hospitality Industry Excess Food } \frac{\text{tons}}{\text{year}} =$$

$$\text{Number of employees} \times \frac{1{,}984 \frac{\text{lb}}{\text{employee}}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

Table 2-7 summarizes the variables and generation factors used by different methodologies of excess food estimation for the hospitality industry.

Table 2-7. Parameters Used to Estimate Excess Food Generation Rates for Hospitality Industry

Hospitality Industry Type	Variable	Excess Food Generation Factors
Hotels and Motels, Casino Hotels, Casinos	Number of employees	3.38 rooms/employee 345.64 lb/room/year
	Number of employees	1,984 lb/employee/year

2.6. Correctional Facilities

To estimate the amount of excess food generated by correctional facilities, facility-level data for NAICS code 922140 were collected from Hoover's, Inc.

The excess food estimation methodologies for correctional facilities used by the CT, MA, SC, and VT Studies were based on parameters such as number of inmates, number of beds, or number and volume of dumpster pickups per week. While Hoover's, Inc. did not provide any of this data, the Department of Corrections (DOC) for various states, the Federal Bureau of Prisons (BOP), and the Bureau of Justice Statistics (BJS) do publish information on the number of inmates and employees for state and/or federal prisons. Using these sources, the following average numbers of inmates per employee were estimated:

1. 5.28 inmates per employee, estimated using data for all federal prisons and prisons in Florida, Georgia, and Alabama (DOC-FL, DOC-GA, DOC-AL, BOP).
2. 3.75 inmates per employee, estimated using data from the BJS (BJS 2008, BJS 2014).

The number of employees for correctional facilities was provided by Hoover's, Inc., and the CT Study used a generation factor of 1.0 lb of excess food per inmate per day. Using this data, the following equations will generate an estimate of excess food for correctional facilities:

$$\text{Correctional Facilities Excess Food High End } \frac{\text{tons}}{\text{year}} =$$

$$\text{Number of employees} \times 5.28 \frac{\text{inmates}}{\text{employee}} \times \frac{1.0 \frac{\text{lb}}{\text{inmate}}}{\text{day}} \times 365 \frac{\text{days}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

$$\text{Correctional Facilities Excess Food Low End } \frac{\text{tons}}{\text{year}} =$$

$$\text{Number of employees} \times 3.75 \frac{\text{inmates}}{\text{employee}} \times \frac{1.0 \frac{\text{lb}}{\text{inmate}}}{\text{day}} \times 365 \frac{\text{days}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

Table 2-8 summarizes the variables and generation factors of different methodologies to estimate the excess food generation rate for correctional facilities. The amount of excess food from the two equations above produced a range of excess food generated by each facility. The amount of excess food was not estimated for facilities where employee data was not available.

Table 2-8. Parameters Used to Estimate Excess Food Generation Rates for Correctional Facilities

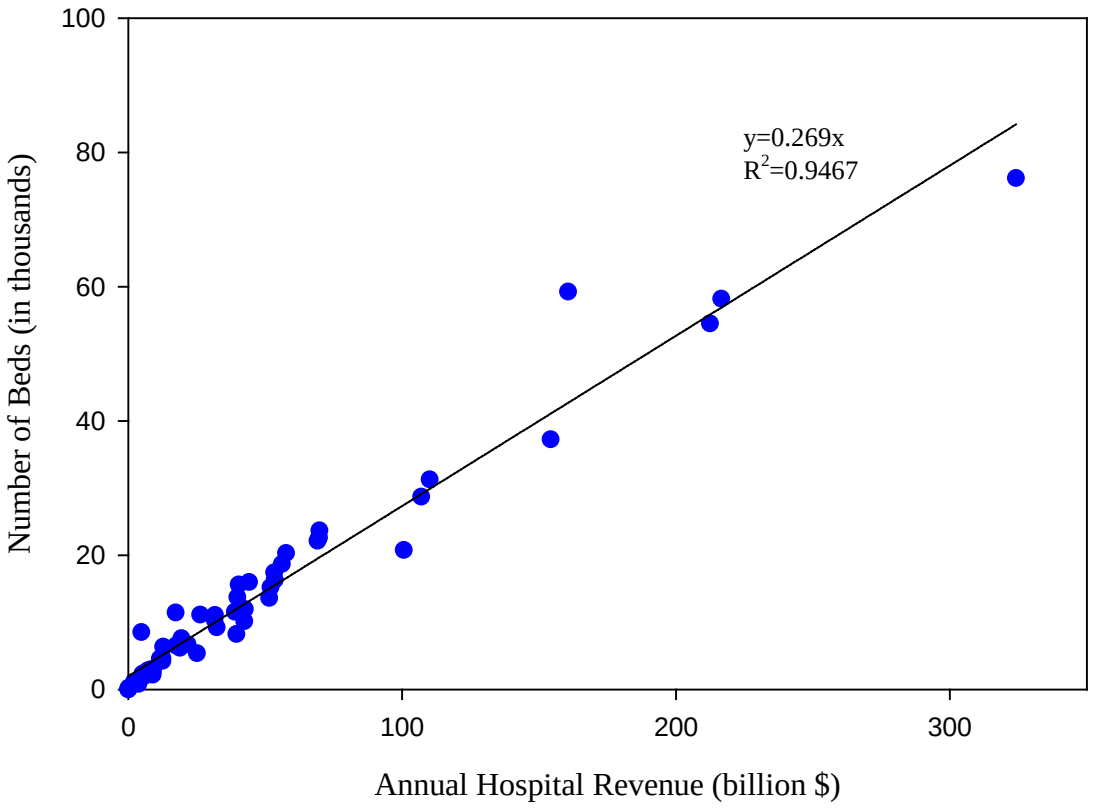
Facility Type	Variable	Excess Food Generation Factors
Correctional facilities	Number of employees	5.28 inmates/employee 1.0 lb/inmate/day
	Number of employees	3.75 inmates/employee 1.0 lb/inmate/day

2.7. Healthcare Facilities

To estimate the amount of excess food generated by healthcare facilities, facility-level data for NAICS code 622110 (General Medical and Surgical Hospitals) were collected from Hoover's, Inc.

The CT, MA, SC, and VT Studies estimated the amount of excess food generated from healthcare facilities using the number of beds, number of meals served per week, or amount of food served per week. Hoover's, Inc. did not provide these data. The American Hospital Directory (AHD) provides an open-access database for hospitals across the US listing staffed beds and hospital revenue (AHD, 2015). This data was downloaded and a relationship between the number of staffed beds and hospital revenues was evaluated. As shown in Figure 2-1, a linear relationship of 0.269 beds per $1 million in revenue was observed with a very high degree of correlation. Using this relationship and revenue data obtained from Hoover's, Inc., the number of beds in each hospital was calculated and used as a parameter to estimate the amount of excess food generated by each facility.

Figure 2-1. Relationship between Number of Beds and U.S. Hospital Revenue



The amount of excess food was estimated using equations developed by the CT and VT Studies. The CT Study used an average value of 3.42 lbs of excess food per bed per day (5.7 meals per bed per day and 0.6 lb excess food per meal, explicitly accounting for excess food generated staff and visitor meals), whereas the VT Study used 1.5 lbs of excess food per bed per day (3 meals per bed per day and 0.5 lb excess food per meal). The following two equations were used to generate a high and low estimate of excess food generated from healthcare facilities:

$$\text{Healthcare Facilities Excess Food High End } \frac{\text{tons}}{\text{year}} = \text{Revenue (\$ million)} \times 0.269 \frac{\text{beds}}{\text{Revenue (\$ million)}} \times \frac{3.42 \frac{\text{lb}}{\text{bed}}}{\text{day}} \times 365 \frac{\text{days}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

$$\text{Healthcare Facilities Excess Food Low End } \frac{\text{tons}}{\text{year}} = \text{Revenue (\$ million)} \times 0.269 \frac{\text{beds}}{\text{Revenue (\$ million)}} \times \frac{1.5 \frac{\text{lb}}{\text{bed}}}{\text{day}} \times 365 \frac{\text{days}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

Table 2-9 summarizes the variables and generation factors used by different methodologies to estimate excess food generation at healthcare facilities. The amount of excess food was not estimated if data for revenue or beds was not available.

Table 2-9. Parameters Used to Estimate Excess Food Generation Rates for Healthcare Facilities

Facility Type	Variable	Excess Food Generation Factors
General Medical and Surgical Hospitals	Revenue ($ million)	0.269 beds/Revenue ($ million) 3.42 lbs/bed/day
	Revenue ($ million)	0.269 beds/Revenue ($ million) 1.5 lbs/bed/day

2.8. Food Services Sector

Food services sector industries considered for this study are listed in Table 2-10. Establishment-level information, like that generally provided by Hoover's, Inc., was not obtained due to lack of resources.

Table 2-10. NAICS Codes for the Food Services Sector

No.	NAICS Code	NAICS Code Description
1	722310	Food Service Contractors
2	722320	Caterers
3	722511	Full-Service Restaurants
4	722513	Limited-Service Restaurants
5	722514	Cafeterias, Grill Buffets, and Buffets
6	722515	Snack and Nonalcoholic Beverage Bars

The MA, SC, and VT Studies estimated the amount of excess food generated from the food services sector using number of employees, number of meals served per week, number of seats, or number and volume of dumpster pickups per week. Excess food generation for the food services sector can be estimated based on a number of studies discussed in Appendix A using the following equation, along with number of employees and a generation factor ranging from 260 to 3,392 lbs of excess food per employee per year, as follows:

$$\text{Food Services Sector Excess Food } \frac{\text{tons}}{\text{year}} = \text{Number of employees} \times \frac{x\ \frac{\text{lb}}{\text{employee}}}{\text{year}} \times \frac{\text{tons}}{2{,}000\ \text{lb}}$$

Note: x = 260 to 3,392 lbs per employee per year

An alternative methodology to estimate excess food generation from the food services sector was developed using a revenue-based generation factor for restaurants reported by FWRA (2014). The

following equation can be used to estimate excess food generation from restaurants using annual revenue or sales.

$$\text{Food Services Sector Excess Food } \frac{\text{tons}}{\text{year}} =$$

$$\text{Establishment's Annual Revenue \$} \times 0.033 \frac{\text{lb}}{\text{Annual Revenue (\$)}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

2.9. Food Banks

Food banks (NAICS code 624210) are considered potential generators as well as potential recipients of excess food. This is because some of the food they receive as donations may be expired, degrading, or otherwise deemed unfit for human consumption. In 2015, food bank data were provided by Feeding America, a nationwide network of food banks, food pantries, and meal programs. Feeding America is the nation's leading domestic hunger-relief organization and serves virtually every community in all 50 states, Washington D.C., and Puerto Rico. Specifically, Feeding America provided data on generation of excess food as reported by individual food banks in its network, where available.

2.10. Data Analysis

Approximately 1.3 million establishments that potentially generate excess food were identified from ICI sectors based on 89 NAICS codes. Because data could not be obtained for the food services and farm sectors, the Dataset contains just over 500,000 establishments. The Dataset provides establishment-level information including name and geographic location, and includes common business statistics such as revenue, number of employees, or number of students which was used to estimate excess food generation using sector-specific equations, as detailed in sections 2.2 to 2.9. Excess food generation rates were estimated for roughly 86% of establishments. For some sectors, there were several equations available to generate an excess food estimate, resulting in minimum and maximum values. Establishments for which generation rates could not be estimated were still mapped.

The data itself was reviewed and filtered in the following ways:

- Duplicates were defined as establishments with identical name and physical address. They were identified and then filtered such that the establishment with the lowest waste generation estimate was kept in the dataset. In cases where duplicates had either the same or no waste generation estimate, just one of the establishments was kept in the dataset.
- Establishments identified as "Headquarters" were excluded from the dataset because these establishments typically serve an administrative function and do not generate excess food.
- Educational institutions with the word "online" in their name were removed because they are not assumed to have a physical campus on which excess food would be generated.
- In the educational institutions dataset, certain establishments included the words "juvenile", "detention", or "correctional" in their names. These properties were moved to the correctional facilities dataset and are identifiable in the Map because their UniqueID starts with the letters "EDU" instead of "COR".

3. Macro Analysis of Sector-Specific Excess Food Generation Rates

The Dataset provides establishment-level estimates of excess food in each identified sector except for the food services sector (which accounts for approximately 50% of all identified establishments). Data for the 587,572 establishments was obtained primarily from Hoover's, Inc. and the NCES databases. Excess food generation rates were estimated for approximately 86% of all establishments. Estimation was not possible if generation factor data were missing, in which case no excess food estimate was reflected in the Dataset, though the establishment was still mapped.

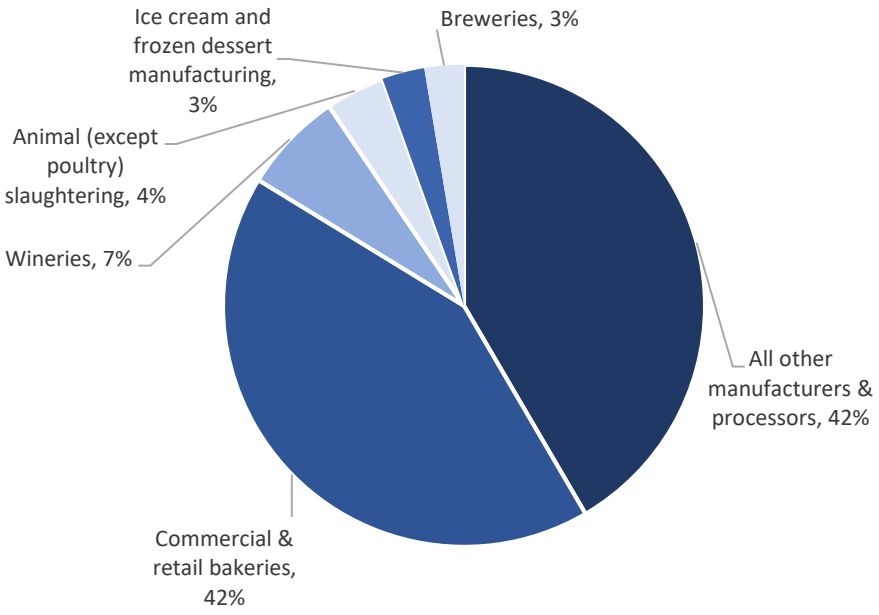
Table 3-1. Establishments Included in the Dataset by Sector

Sector	Establishments in the Dataset	Establishments with Excess Food Estimate	% Establishments with Excess Food Estimate
Food Manufacturers & Processors	54,898	45,782	83%
Food Wholesalers & Distributors	289,941	236,550	82%
Educational Institutions	136,534	130,206	95%
Hospitality Industry	82,794	81,363	98%
Correctional Facilities	6,341	4,658	73%
Healthcare Facilities	16,747	5,082	30%
Food Banks	316	154	49%
Total	587,572	503,795	86%

3.1. Food Manufacturers and Processors

The food manufacturers and processors sector, as described in Section 2.2, includes 54 NAICS codes. Data were obtained for 54,898 establishments associated with NAICS codes other than those associated with animal, milk, and egg producers, and excess food estimates were generated for roughly 86% of the establishments. The edible fraction of excess food for manufacturers and processors could not be estimated. Figure 3-1 shows the proportion of food manufacturers and processors by industry type.

Figure 3-1. Proportion of Food Manufacturers and Processors by Industry Type



3.2. Food Wholesalers and Distributors

The food wholesalers and distributors sector, as described in Section 2.3, encompasses 22 NAICS codes. Data were obtained for 289,942 establishments associated with these codes, and excess food estimates were generated for roughly 82% of establishments.

Figure 3-2 shows the proportion of food wholesalers and distributors by industry type, approximately one-third of which are supermarket and grocery (except convenience) stores. Table 3-2 shows more granular data about data availability across this sector.

Jacob (1993) conducted a survey of eight supermarkets and observed that approximately 95% of excess food generated by the bakeries, and 15% of excess food generated by produce departments, would be acceptable to food banks. Edible waste from other types of wholesalers and distributors could not be estimated. FWRA (2014) reported that the retail and wholesale sectors donate approximately 13% of all excess food.

Figure 3-2. Proportion of Food Wholesalers and Distributors by Type

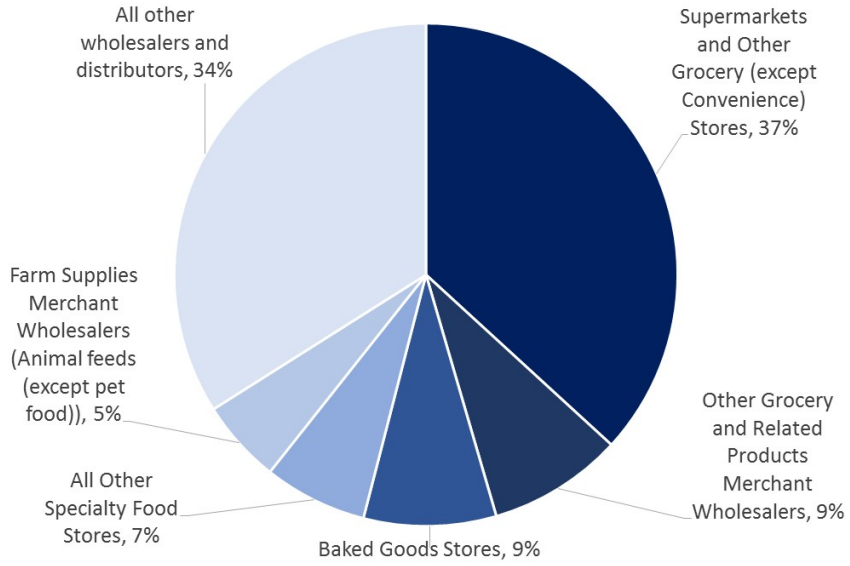


Table 3-2. Number of Food Wholesalers and Distributors Included in the Dataset

Sector	Establishments in the Dataset	Establishments with Excess Food Estimate	% Establishments with Excess Food Estimate
Food Wholesalers and Distributors (except Supermarkets and Grocery Stores)	183,185	131,005	72%
Supermarkets and Grocery Stores	106,757	105,545	99%
Total	289,942	236,550	82%

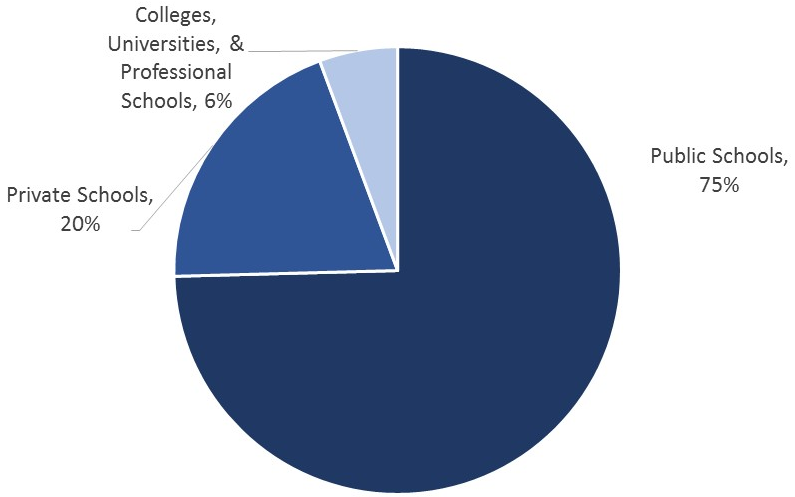
3.3. Educational Institutions

The educational institutions sector, as described in Section 2.4, encompasses two NAICS codes. These are elementary and secondary schools (public and private); and, colleges, universities, and professional schools. Figure 3-3 shows the proportion of educational institutions by type, and Table 3-4, shows more granular information about data availability across the sector. Estimates of plate waste were generated for the colleges, universities, and professional schools.

Table 3-3. Number of Educational Institutions Included in the Dataset

Sector	Institutions in the Dataset	Institutions with Excess Food Estimate	% Institutions with Excess Food Estimate
Colleges, Universities, & Professional Schools	7,734	7,451	96%
Private Schools	26,961	26,961	100%
Public Schools	101,839	95,794	94%
Total	136,534	130,206	95%

Figure 3-3. Proportion of Educational Institution Establishments by Type



3.4. Hospitality Industry

The hospitality industry, as described in Section 2.5, encompasses three NAICS codes. Data were obtained for 82,794 establishments associated with these codes, and excess food estimates were generated for roughly 98% of the sample. The edible fraction of excess food for the hospitality industry could not be estimated.

Figure 3-4 shows the proportion of hospitality establishments by industry type for which hotels and motels represent the vast majority at 98% of the total. Table 3-4 shows more granular information about data availability across the sector.

Figure 3-4. Proportion of Hospitality Industry Establishments by Type

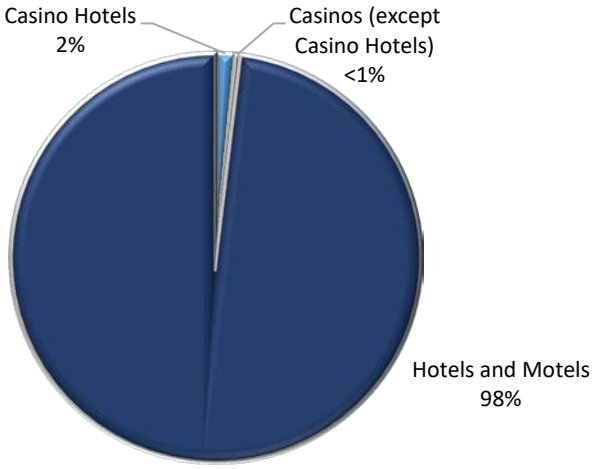


Table 3-4. Number of Hospitality Establishments Included in the Dataset

Sector	Establishments in the Dataset	Establishments with Excess Food Estimate	% Establishments with Excess Food Estimate
Hotels and Motels	81,334	80,028	98%
Casino Hotels	1,127	1,026	91%
Casinos (except Casino Hotels)	333	308	92%
Total	82,794	81,362	98%

3.5. Correctional Facilities

The correctional facilities sector, as described in Section 2.6, encompasses one NAICS code. Data were obtained for 6,341 facilities associated with this code, and excess food estimates were generated for roughly 73% of the sample. The edible fraction of excess food for correctional facilities could not be estimated.

3.6. Healthcare Facilities

The healthcare facilities sector, as described in Section 2.7, encompasses one NAICS code. Data were obtained for 16,747 establishments associated with this NAICS code, and excess food estimates were generated for roughly 30% of the sample. The edible fraction of excess food for healthcare facilities could not be estimated.

3.7. Food Services Sector

The food services sector, as described in Section 2.8, encompasses six NAICS codes. Due to resource constraints, establishment-level data were not accessible in order to generate excess food estimates. The food services sector is not included in this version of the Map.

3.8. Food Banks

Food banks, as described in Section 2.9, encompass one NAICS code. Data were obtained for 316 establishments associated with this code, and excess food generation data exist for 49% of the sample. The edible fraction of excess food for food banks could not be estimated.

4. Data Sources for Recipients

4.1. Overview

The Map displays facility-specific information for four categories of potential recipients of excess food, the data sources for which are described below. Recipients make use of excess food in different ways, depending on the state of the resource (i.e., pre-consumer, post-consumer), as well as its macro-nutrients (i.e., lipid, carbohydrate, protein) and other biological characteristics. Appendix B summarizes common excess food characteristics by NAICS industry.

4.2. Food Banks

Food banks (NAICS 624210) are considered potential generators as well as potential recipients of wholesome food that would otherwise be excess. This is because some of the food they receive as donations may be deemed unfit for human consumption. Food bank data were provided by Feeding America, a nationwide network of food banks, food pantries, and meal programs. Feeding America is the nation's leading domestic hunger-relief organization and serves virtually every community in all 50 states, Washington D.C., and Puerto Rico. The data provided in 2015 includes 316 food banks for which Feeding America provided data on how much food is received and how much excess food is generated each year.

4.3. Composting Facilities

Data on 2,499 composting facilities was compiled in 2015 through EPA review of state government websites, usually state departments of natural resources or environmental protection, and communication with state government employees. Composting data were available for 36 states, and associated websites are listed in the Map metadata, where available. The type of feedstock accepted at the facility is reflected in the Map, where information was available.

4.4. Anaerobic Digestion Facilities

EPA compiled the list of 1,381 anaerobic digestion facilities using Agency and non-Agency sources (US EPA, 2016c; ABC, 2017). The main data sources include facilities that had been listed in the EPA Waste to Biogas Mapping Tool. These data were supplemented by a list of facilities maintained by the EPA AgStar program, as well as other facilities tracked by or known to EPA through other collaborative program work.

4.5. Animal, Milk, and Egg Producers

Animal, milk and egg producers (NAICS 112111 through 112420) are considered potential generators as well as potential recipients of excess food since it is possible for animal feeding operations to use excess food in feed preparation, while also generating other waste products. Animal, milk, and egg producers are not included in the Map.

5. Data Sources for Communities with Residential Source Separated Organics Programs

Communities with residential source separated organics programs that collect excess food were identified in a 2011 survey published by BioCycle (Yepsen, 2012). Of the 156 communities, data was available to map 130. An additional community was identified in a publication by Layzer (2014), resulting in 131 mapped communities.

6. Limitations and Future Research Needs

This section summarizes limitations associated with the methodology as well as recommendations for future improvements.

Map and methodology limitations include the following:

1. **Generation factors**. Generation factors in the methodologies adopted for this study are based on very limited measured data. For example, the MA Study generation factor for restaurants is based on data collected from a survey of 27 California full-service restaurants during one-day sites visit between 2004 and 2005. The data used to estimate excess food generation factors for colleges and universities are based on studies conducted in the late 1990s and may not represent current college and university structuring. Furthermore, the data sources used by the CT, VT, MA, and SC Studies to develop the methodologies were not reviewed to assess data quality. Although the methodologies adopted for the Map provide a simple approach to estimate excess food generation from an ICI source, on-site measurement is always preferred.

2. **Edible fraction of excess food**. The edible fraction of excess food can be used to feed people, which represents the most preferred use of excess food. A reliable estimate of the edible fraction of excess food is critical data needed to pursue its best use. Due to a lack of data, the edible fraction of excess food could not be estimated for any of the sectors except grocery stores and supermarkets. Additionally, the single study used to estimate the edible portion of excess food from supermarkets and grocery stores was conducted more than 20 years ago and may not be reflective of current excess food generation and handling practices.

3. **Inclusion of food services establishments and animal, milk, and egg producers**. Due in part to resource constraints, food services and animal, milk, and egg producer information could not be included in the Dataset. These sectors account for roughly 56% of establishments potentially generating excess food in the US.

4. **On-farm loss**. This report does not address on-farm loss, including unharvested crops, processing by-products, or unmarketable crops. Some reports estimate that as much as 10 million pounds of excess food per year are produced on farms (ReFED 2016).

5. **Establishment-specific data.** Excess food generation estimation was not possible if generation factor data (e.g., revenue, employees) was missing. While excess food generation rates were estimated for roughly 86% of all establishments (other than food

service establishments), there are three sectors for which data were available for less than 75 percent of establishments: healthcare facilities (30%); food banks (49%); and, correctional facilities (73%).

6. **Potential recipients.** Some of the data for potential recipients, specifically composters and food banks, is limited. The composting facilities were identified via state databases of which only 36 were available. The data for food banks was drawn from Feeding America's regional and partner distribution organizations. There are other food pantries and kitchens that could use excess food, and should also be mapped.

Recommendations for improving the Map and methodology going forward include:

1. **Encourage development of additional studies on excess food generation.** This is needed to develop more up-to-date generation factors, as well as to estimate the edible fraction of excess food across ICI sectors. These rigorous studies should also emphasize collection of data over longer timeframes and geographic regions to allow for more confident adoption of generation factors for the Map. Encourage state and local government, non-governmental organizations, academia, and other stakeholders to contribute to development of studies producing generation factors reflective of current practices.

2. **Include food services establishments data in the Dataset.** This key sector is required to provide the most complete and useful Map, and EPA hopes to include these establishments in an upcoming version.

3. **Expand map content to include other sources of excess food.** Continue research for map improvement through review of additional industries that could be included, depending on data availability. These industries could encompass on-farm loss, including unharvested crops, processing wastes, or unmarketable crops.

4. **Improve percentage of establishments in Map that have excess food generation estimate.** Research is needed for additional sources of publicly and commercially available data to supplement and/or improve the Map. Additionally, introducing assumptions into the excess food generation estimates could fill a gap for establishments for which an estimate is currently missing.

5. **Increase number of mapped potential recipients.** Research is needed for additional sources of composting and food pantry and distribution organization data.

References

ABC (2017). Operating Biogas Systems in the U.S. American Biogas Council. http://www.americanbiogascouncil.org/biogas_maps.asp (Accessed June 2017).

AgSTAR (n.d.). Biogas Recovery in the Agriculture Sector. http://www.epa.gov/agstar (Accessed June 2017)

AHD (2015). American Hospital Directory, state statistics. https://www.ahd.com/state_statistics.html (Accessed June 2017)

BJS (2008). Number of employees in correctional facilities under state or federal authority, by occupational category. Bureau of Justice Statistics, December 30, 2005 http://www.bjs.gov/index.cfm?ty=pbdetail&iid=1683 (Accessed June 2017)

BJS (2014). Prisoners in 2013. NCJ 247828, Bureau of Justice Statistics, September 2014. http://www.bjs.gov/content/pub/pdf/p13.pdf (Accessed June 2017)

BOP (2017). Federal Bureau of Prisons statistics. http://www.bop.gov/about/statistics (Accessed June 2017)

California Assembly Bill No. 1826, Chapter 727 (2014). available at http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB1826&search_keywords (Accessed June 2017)

CCG (2006). Waste Disposal and Diversion Findings for Selected Industry Groups. No. 341-06-006. A report prepared by Cascadia Consulting Group for the California Integrated Waste Management Board, June 2006. http://www.calrecycle.ca.gov/publications/Documents/Disposal/34106006.pdf. (Accessed June 2017)

CCG (2015). 2014 Generator-Based Characterization of Commercial Sector Disposal and Diversion in California. A report prepared by Cascadia Consulting Group for Department of Resources Recycling and Recovery (CalRecycle), September 2015. http://www.calrecycle.ca.gov/publications/Documents/1543/20151543.pdf (Accessed December 2017)

Clark, S. and Law, D. (2000). Multipurpose Program at Kentucky College. *BioCycle, September 2000*, 69.

CTDEEP (n.d.) Connecticut Department of Environmental Protection, Connecticut Food Residual Map. http://www.depdata.ct.gov/maps/recycling/foodresidualmap.htm (Accessed June 2017)

CTDEP (2001). Identifying, Quantifying, and Mapping Food Residuals from Connecticut Businesses and Institutions. A report prepared by Draper/Lennon Inc. and Atlantic Geoscience Corp. for Connecticut Department of Environmental Protection, September, 2001. http://www.ct.gov/deep/lib/deep/compost/ssomfile/ssomreport.pdf (Accessed June 2017)

De la Cruz, F.B. and Barlaz, M.A. (2010). Estimation of Waste Component-Specific Landfill Decay Rates Using Laboratory-Scale Decomposition Data. *Environmental Science & Technology, 44 (12),* 4722-4728.

DOC-AL. "Annual Report Fiscal Year 2014", Alabama Department of Corrections. http://www.doc.state.al.us/docs/AnnualRpts/2014AnnualReport.pdf (Accessed June 2017)

DOC-FL. Quick Facts about the Florida Department of Corrections. http://www.dc.state.fl.us/oth/Quickfacts.html (Accessed June 2017)

DOC-GA. Georgia Department of Corrections website. https://georgia.gov/agencies/georgia-department-corrections (Accessed June 2017)

Feeding America (2015). Internal list of food banks and associated Partner Distribution and Regional Distribution Organizations shared by Liz Baldrige and Carrie Calvert.

FWRA (2014). Analysis of US Food Waste Among Food Manufacturers, Retailers, and Wholesalers. A report prepared by BSR for Food Waste Reduction Alliance, 2014. http://www.foodwastealliance.org/wp-content/uploads/2014/11/FWRA_BSR_Tier3_FINAL.pdf (Accessed June 2017)

Hinshaw, J. Braun, I. (1991). Targeting Commercial Businesses for Recycling. *Resource Recycling, November 1991,* 27-32.

Hoover's, Inc. (2015). Commercially available datasets related to potential generators of excess food from the correctional, hospitality, healthcare, food manufacturers and processors, and food wholesalers and distributors industries.

Jacob, M. (1993). Classifying the Supermarket Food Waste Stream. *BioCycle, February 1993,* 46-51.

KCI (2004). Waste Reduction and Recycling Guide for Florida Correctional Facilities. A report prepared by Kessler Consulting, Inc. for the Florida Department of Environmental Protection and the Solid Waste Authority of Palm Beach County, 2004. http://www.calrecycle.ca.gov/StateAgency/CaseStudies/Florida.pdf (Accessed December 2017)

Kim, T., Shanklin, C.W., Su, A. Y., Hackes, B.L., and Ferris. D. (1997). Comparison of Waste Composition in a Continuing-Care Retirement Community. *Journal of the American Dietetic Association, 97, 4,* 396-400.

Layzer, J. and Alexis Schulman. 2014. "Municipal Curbside Compostable Collection: What Works and Why?" Work product of the Urban Sustainability Assessment (USA) Project, Department of Urban Studies and Planning, Massachusetts Institute of Technology.

Luboff, C., May, K. (1995). Measuring Generation of Food Residuals. Commercial and Institutional Organics. *BioCycle, July 1995,* 66-68.

Marion, J. (2000). Composting 12,000 Tons of Food Residuals a Year. *BioCycle, May 2000,* 35.

Massachusetts 310 CMR 19.000, Final Commercial Organic Material Waste Ban Amendments (January 2014). available at http://www.mass.gov/eea/docs/dep/service/regulations/wbreg14.pdf (Accessed June 2017)

MassDEP (2002). Identification, Characterization, and Mapping of Food Waste and Food Waste Generators in Massachusetts. A report prepared by Draper/Lennon Inc for the

Massachusetts Department of Environmental Protection, September, 2002. http://www.mass.gov/eea/docs/dep/recycle/priorities/foodwast.pdf (Accessed June 2017)

MassDEP (2008). Massachusetts Food Waste Generator Map, Massachusetts Department of Environmental Protection. http://www.mass.gov/eea/docs/dep/recycle/priorities/foodmap.pdf (Accessed June 2017)

MassDEP (2011). Food Waste Generators in Massachusetts, Massachusetts Department of Environmental Protection http://www.mass.gov/eea/docs/dep/recycle/priorities/foodgen.pdf (Accessed June 2017)

Mount, D. J. and Frye, W. D. (2006). The Impact of Hotel Size and Service Type on Employee Job Satisfaction. *Hospitality Review, 24,* 60-68.

NCES (2017a). Integrated Postsecondary Education Data System http://nces.ed.gov/ipeds/datacenter (Accessed June 2017)

NCES (2017b). Private Schools Universe Survey http://nces.ed.gov/surveys/pss/pssdata.asp (Accessed June 2017)

NCES (2017c). Public Elementary/Secondary School Universe Survey http://nces.ed.gov/ccd/pubschuniv.asp (Accessed June 2017)

Newell, T., Markstahler, E., and Snyder, M. (1993). Commercial Food Waste from Restaurants and Grocery Stores. *Resource Recycling, February 1993*, 56-61.

Newell, T., and Snyder, M. (1996). Analyzing Collection of Commercial Organics. *BioCycle, July 1996*, 63-65.

ReFED (2016). A Roadmap to Reduce US Food Waste by 20 Percent. Rethink Food Waste Through Economics and Data. https://www.refed.com/downloads/ReFED_Report_2016.pdf (Accessed June 2017)

RWMA (n.d.). Food Waste Estimation Guide, Recycling Works Massachusetts. https://recyclingworksma.com/food-waste-estimation-guide (Accessed June 2017)

SCDOC (2015a). South Carolina Food Waste Generation Report. Prepared by South Carolina Department of Commerce, April 2015. http://www.recyclinginsc.com/sites/default/files/all/scfoodwastegeneration_summary_updated_1.pdf (Accessed June 2017)

SCDOC (2015b). South Carolina Food Waste Generation Map. http://www.recyclinginsc.com/food (Accessed June 2017)

Shanklin, C.W. (2001). Targeting the Food Service Sector. *BioCycle, April 2001,* 38-43.

UNEP (n.d). Food and Food Waste. http://drustage.unep.org/resourceefficiency/what-we-do/sustainable-lifestyles/food-and-food-waste (Accessed June 2017)

USCB (2007). 2007 Economic Census Data. http://factfinder.census.gov/faces/nav//jsf/pages/searchresults.xhtml?refresh=t#none (Accessed on July 2015)

USDA (2014). The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States.

https://www.ers.usda.gov/webdocs/publications/43833/43680_eib121.pdf?v=41817 (Accessed June 2017)

US EPA (1998). Don't Throw Away That Food: Strategies for Record-Setting Waste Reduction. Washington, DC: US Environmental Protection Agency. https://archive.epa.gov/wastes/conserve/pubs/web/pdf/foodmain.pdf (Accessed December 2017)

US EPA (2014). A Guide to Conducting and Analyzing a Food Waste Assessment. Washington, DC: US Environmental Protection Agency. https://www.epa.gov/sites/production/files/2015-08/documents/r5_fd_wste_guidebk_020615.pdf (Accessed June 2017)

US EPA (2015). Food Recovery Hierarchy. http://www.epa.gov/sustainable-management-food/food-recovery-hierarchy (Accessed June 2017)

US EPA (2016a). Resources for Assessing Wasted Food. https://www.epa.gov/sustainable-management-food/tools-assessing-wasted-food (Accessed June 2017)

US EPA (2016b). Advancing Sustainable Materials Management: 2014 Fact Sheet. Washington, DC: U.S. Environmental Protection Agency. https://www.epa.gov/sites/production/files/2016-11/documents/2014_smmfactsheet_508.pdf (Accessed June 2017)

US EPA (2016c). List of known anaerobic digestion facilities provided by US EPA's AgStar program and Melissa Pennington, US EPA Region 3.

US EPA (2017a). Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2015. Washington, DC: U.S. Environmental Protection Agency. https://www.epa.gov/sites/production/files/2017-02/documents/2017_complete_report.pdf (Accessed June 2017)

US EPA (2017b). Landfill Gas Energy Project Data and Landfill Technical Data. https://www.epa.gov/lmop/landfill-gas-energy-project-data-and-landfill-technical-data (Accessed June 2017)

Vt. Act 148 (2012). available at http://www.leg.state.vt.us/docs/2012/Acts/ACT148.pdf (Accessed June 2017)

VTANR (2014). Universal Recycling Materials Management Map, Vermont Agency of Natural Resources. http://anrmaps.vermont.gov/websites/Organics/default.html (Accessed June 2017)

VTDEC (2014a). ANR Universal Recycling Materials Management Database & Map Methodology. Vermont Agency of Natural Resources, Department of Environmental Conservation.

VTDEC (2014b). Food Scrap Generator Database Calculations. Vermont Agency of Natural Resources, Department of Environmental Conservation. http://dec.vermont.gov/sites/dec/files/wmp/SolidWaste/Documents/Universal-Recycling/FoodScrapVolume_Estimator.pdf (Accessed June 2017)

Walsh, P. Pferdehirt, W., O'Leary, P. (1993). Collection of Recyclables from Multifamily Housing & Businesses. *Waste Age, April 1993,* 97-106.

Whitehair, K.J., Shanklin, C.W., and Brannon, L.A. (2013). Written Messages Improve Edible Food Waste Behaviors in a University Dinning Facility. *Journal of the Academy of Nutrition and Dietetics, 113(1),* 63-69.

Williams, Peter G., and Karen Walton. (2011). Plate Waste in Hospitals and Strategies for Change. E-SPEN – The European E-journal of Clinical Nutrition and Metabolism 6th Ser. 6 (2011), e235-e241.

Yepsen, R. (2012). Residential Food Waste Collection in the U.S. *BioCycle, January 2012,* 23.

APPENDICES

Appendix A- A Review of Excess Food Estimation Methods

State environmental agencies in Connecticut, Massachusetts, Vermont, and South Carolina have conducted studies to identify the sources of excess food and estimate the quantity of excess food generated by each entity. Each study developed or adopted quantification methodologies for the various excess food generating sectors covered in their reports CTDEP (2001) ("CT Study"), MassDEP (2002) ("MA Study"), SCDOC (2015a) ("SC Study"), and VTDEC (2014a, 2014b) ("VT Study"). Where these studies provided methodologies that could not be used (for example, if the methodologies were based on data not provided by Hoover's database), methodologies from other studies were used for those sectors. These additional sources include RWMA, FWRA (2014), and CCG (2006). The seven studies that were relied upon are summarized below and Table A-1 lists methodologies included in those studies. This Appendix also reviews other existing studies that contain sector-specific methodologies, but it is not intended to be exhaustive.

Table A-1. Studies that used Methodologies to Estimate Excess Food Generation Rates

Sector	CT	MA	SC	VT	CCG (2006)	FWRA (2014)	RWMA
Food Manufacturers and Processors							
Bakeries	-	-	-	✓	-	-	-
Other Food Manufacturers and Processors	-	-	-	-	-	✓	-
Food Wholesalers and Distributors							
Supermarkets and Grocery Stores	✓	✓ (CT)	✓ (CT)	✓	✓	-	✓
Market, Beer/wine/liquor, Farmers' Market, Online Market, Specialty Foods	-	-	-	✓	-	-	-
Other Food Wholesalers and Distributors	-	-	-	-	-	✓	-
Educational Institutions							
Colleges and Universities	✓	✓ (CT)	✓ (CT)	✓	-	-	✓
Independent and Private Schools (Primary/Secondary)	✓	✓ (CT)	✓	-	-	-	-
Elementary School, Middle School, Elementary/Middle School, High School, Pre-K	-	✓	-	✓	-	-	✓
Hospitality Industry							

Resorts and Conference Facilities	✓	✓ (CT)	✓ (CT)	-	-	-	-
Lodging and Hotels	-	-	-	-	✓	-	✓
Venues and Events	-	-	-	-	✓	-	✓
Correctional Facilities	✓	✓ (CT)	✓ (CT)	✓	-	-	✓
Healthcare Sector							
Hospital	✓	✓ (CT)	✓ (CT)	✓	-	-	✓
Nursing Home, Extended Care facilities, Assisted Living Facility, Residential Home, Therapeutic Community Residence	✓	✓	✓ (MA)	✓	-	-	✓
Food Services Sector							
Restaurant	-	✓	✓ (MA)	✓	✓	✓	✓
Restaurant - Bars and Pubs, Cafeteria, Concession, Deli, Senior Meals, Camp, Caterers, Private Club	-	-	-	✓	-	-	-

✓if the study used an excess food estimation methodology
( ) parenthesis has the name of the state from which the excess food estimation methodology was adopted
- if the study did not use that sector as a specific category or did not estimate excess food generation rate

The symbol ✓ represents sector-specific wasted food estimation methodologies. If a methodology was adopted from another state's study, the state that developed the excess food estimation methodology is listed in parenthesis. As shown in Table A-1, the MA and SC Studies adopted multiple methodologies from the CT Study.

The Connecticut Department of Environmental Protection (CTDEP) collected and quantified statewide data for major excess food producers based on the Standard Industrial Classification (SIC) codes for the following industrial categories: food manufacturers and processors, food wholesalers and distributors, supermarkets, colleges and universities, private schools, hospitals and other healthcare institutions, resort and conference facilities, correctional facilities, and major private employers (CTDEP (2001)). A comprehensive database of all excess food producers in the state, including the estimated amount of excess food generated by these establishments, was developed. Size-specific cutoffs were used for these producer categories to exclude establishments that were estimated to produce a relatively small proportion of excess food as these may not be commercially attractive targets for large scale excess food collection and recycling. The excess

food sources included in the database were integrated into a publicly-accessible online mapping tool (CTDEEP (n.d.)).

The Massachusetts Department of Environmental Protection (MassDEP) identified and quantified generation rate data for the following excess food sources (based on SIC codes) in MA: food manufacturers and processors, food wholesalers and distributors, supermarkets, colleges and universities, private schools, hospitals and other healthcare institutions, resort and conference facilities, correctional facilities, and restaurants (MassDEP (2002)). A size cutoff was established for six of the producer categories. Similar to the CT Study, the establishment-specific data were collected from multiple sources. For all sectors other than nursing homes and restaurants, excess food estimates were based on the methodologies from the CT Study. MassDEP provides a pdf map titled *Food Waste Generators in Massachusetts* (MassDEP (2008)) and a pdf spreadsheet containing excess food generators' names, generation estimates, and location information (MassDEP (2011)).

The Vermont Department of Environmental Conservation (VTDEC) identified and estimated excess food from the following sectors in VT in 2014: food manufacturers, grocery stores and other food distributors, food shelves (pantries), hospitals and nursing facilities, correctional facilities, restaurants, colleges and universities, and schools. A comprehensive database of excess food generated was created using three main datasets: the Vermont Department of Health's (VDH) 2013 Food Producers data, Stone Environmental Inc's (Stone) original food scrap generator list for all towns from the 2009 Vermont Compost/Biogas Data Viewer project (developed with assistance and input from the Central Vermont Solid Waste Management District (CVSWMD)), and Vermont Sustainable Jobs Fund's (VSJF) 2013 Farm-to-Plate Food Atlas datasets. Datasets were organized based on generator types from Stone's dataset. Excess food estimation equations for each sector were developed or adopted from previous studies conducted by Stone (VTDEC (2014a), (2014b)). All excess food generators across the state as well as the estimated amount of excess food generated by each establishment were included in a publicly accessible online map (VTANR (2014)).

The South Carolina Department of Commerce (SCDOC (2015a)) adopted methodologies used in the CT and MA Studies to estimate the excess food generation rates of the following sectors (based on SIC codes) in SC in 2015: food manufacturers and processors, food wholesalers and distributors, supermarkets, groceries, colleges, private schools, correctional facilities, hospitals, nursing homes, resort and conference facilities, and restaurants. Multiple data sources were used to collect the establishments' information for these sectors. The CT or MA methodologies were used for estimating the excess food generation rate. Similar to the CT and MA Studies, relatively small establishments in several sectors were excluded. The identified excess food generators were mapped in a publicly accessible online map (SCDOC (2015b)).

The Food Waste Reduction Alliance (FWRA), comprised of representatives from The Food Marketing Institute (FMI), the Grocery Manufacturers Association (GMA), and the National Restaurant Association (NRA), published a study in 2014 that analyzed excess food data (FWRA (2014)). FMI, GMA, and NRA sent a paper-based survey to a cross-section of their members in 2014 in order to get a better understanding of excess food reduction efforts of food manufacturers, wholesalers, grocery retailers, and restaurants in the US. The study resulted in excess food

generation factors for the manufacturing, retail and wholesale, and restaurant sectors that are based on revenue.

RecyclingWorks Massachusetts (RWMA) compiled industry data from various reports and studies (including CCG (2006) and the MA Study, as well as others) to create a excess food estimation guide available on its website. This webpage lists excess food estimation methodologies by industry categories, and includes the following: colleges and universities, correctional facilities, hospitals, lodging and hotels, nursing homes, elementary and secondary schools, restaurants, supermarkets and grocery stores, and venues and events. The website aims to help businesses calculate their own excess food estimates.

The California Integrated Waste Management Board (CIWMB) commissioned a study of waste disposal and diversion practices by key types of commercial establishments. The study, conducted by the Cascadia Consulting Group (CCG), quantified and characterized waste disposed of (74 material types) and diverted (56 material types) from 371 commercial establishments belonging to 14 industry groups, and included many materials in addition to food (CCG (2006)). The sites selected for the study were located in Los Angeles, Sacramento, San Diego, and San Francisco. The study included the following industry groups: fast food restaurants, full service restaurants, food stores, durable and non-durable wholesale goods distributors, large hotels, certain retail stores, shopping malls, public venues and events, and large office buildings.

In general, these studies estimated or adopted sector-specific *excess food generation factors* (amount of excess food per meal, meals per seat per day, amount of excess food per employee per year, amount of excess food per student per year, etc.) based on the data collected from sector-specific surveys and/or literature-reported generation factors along with assumptions. For example, to estimate the excess food generation rate per student per year, the CT Study used literature-reported values of the amount of excess food generated per meal and multiplied it by a survey-estimated value of number of meals served per student per day and an assumed value of number of open school days per year. The estimated sector-specific excess food generation factor, along with establishment-specific data, was used to calculate the excess food generation rate for each establishment. For example, the excess food generation rate for a college was calculated by multiplying the excess food generation factor with the respective number of students in the college.

A.1 Food Manufacturers and Processers

A.1.1 Food Manufacturers and Processors except Bakeries

To develop the food manufacturer and processors' database, the CT Study obtained business information for establishments with five or more employees from the Connecticut Economic Resource Center (CERC), InfoUSA, and Harris Infosource. These sources manage nationwide data of manufacturers and other establishments. The collected data were merged, duplicate entries were eliminated, and a comprehensive database was generated. A survey of selected business establishments was conducted based on SIC codes for industries related to meat and meat products, dairy products, vegetable products, grain products, bakery and related products, candy and confectionery, and beverages to obtain the amount of excess food generated and the management practices employed. The following data were gathered with the survey:

1. Type of excess food or other organic residuals generated at the facility.

2. Amount of excess food generated at the facility (per week, per month, per year, etc.). If the amount of excess food generated was not available, data for the number of trash containers filled per day and the size of the container was provided.
3. Method of excess food disposal.
4. Contact information.

The MA Study also used a size cutoff of five or more employees and collected business establishment data from CERC, public web sources, internet search results, industry sources such as Thomas's Register of American Manufacturers, and trade associations. As in the CT Study, a survey of business establishments selected based on food manufacturer and processor SIC codes was conducted. In addition to the industries surveyed in the CT Study, the MA Study also collected data from industries related to animal and marine fats and oils and vegetable oils.

The SC Study also used a size cutoff of five or more employees for the food manufacturers and processors sector and obtained their information from the Hoover's database, which contains data for business establishments across the US.

The VT Study used Stone's excess food generation data collected through a survey of state manufacturers and processors of alcohol, bakery products, dairy, feed/animal products, fruit and vegetable products, manufactured foods such as snacks, and specialty foods such as coffee, fats, oils, rendering, and sweets. Establishments without an estimate from Stone were left blank in the database.

The CT, MA, and SC Studies could not use or develop a generalized relationship between the amount of excess food generated and parameters such as the size, sales, or number of employees of a particular food manufacturer or processor. Each observed significant variation in excess food generation and handling approaches across the industries in this sector. For example, the approaches used by meat processing facilities for excess food generation and handling are generally different than by candy and confectionary products manufacturers. The CT Study reported that excess food generation may even vary within establishments of the same SIC code. For example, one meat packer may buy partially processed meat and generate a small fraction of excess food, while another meat packer with similar revenue may process meat from whole carcasses and generate a large amount of excess food. However, the CT Study reported that within a given SIC code, if other variables are constant, sales data may be a good indicator of excess food generated.

CT, SC, and VT display the food manufacturers' and processors' contact and location information in their online maps. For reasons outlined in the previous paragraph, estimates of the amount of excess food generated by each establishment or the other establishment-specific information such as number of employees are not included.

CCG (2015) conducted a study to quantify and characterize waste disposed of and diverted from 837 commercial establishments belonging to 16 industry groups including food and non-durable manufacturers and wholesalers in California. CCG (2015) considered establishments associated with NAICS codes 311, 312, 424; our study considered NAICS code 424 in food wholesalers and distributors sector. The sites selected for the study were located in five designated regions of the state: Bay Area, Coastal, Mountain, Southern, and Central Valley. Waste characterization

sampling and generation rate estimation was conducted during four seasonal visits to each site. The waste composition of the disposal stream was characterized by hand sorting of a 200-lb sample (into 82 material categories) collected at each of the 51 facilities. The composition of each diversion stream was characterized by hand sorting of a 125-lb sample (into 82 material categories) at each of 26 facilities. Waste quantities for disposal and diversion were estimated through measurements of material accumulated in dumpsters, interviews with staff, review of diversion and disposal records, and inspection of recycling and diversion systems. The overall waste generation (disposal+diversion) for food manufacturers and wholesalers was reported to be 1.85 tons per employee per year. The excess food was reported to constitute approximately 45.6% of the overall waste. The excess food generation rate for this sector was estimated to be approximately 0.84 tons per employee per year, which is equivalent to 1680 lbs per employee per year. Because of the inconsistencies between the NAICS codes included in our study and CCG (2015), the data reported by CCG (2015) were not used for excess food estimation for this sector.

Limitation: As discussed previously, the major limitation in determining a specific excess food estimation methodology for food manufacturers and processors was the differences in excess food generation and processing approaches. Further research including surveys is recommended to accurately obtain the excess food generation from such establishments.

A.1.2 Bakeries

The VT Study established a methodology for bakeries based on number of seats and used the following equation to estimate the amount of excess food generated:

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of seats} \times 0.5 \frac{\text{lb}}{\text{meal}} \times \frac{3 \frac{\text{meals}}{\text{seat}}}{\text{day}} \times 365 \frac{\text{days}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

Fixed values of 0.5 lb per meal and 3 meals per seat per day were adopted from the Stone database. The 0.5 lb per meal value appears to be assumed based on other such establishments such as restaurants, sub/sandwich shops, bars, etc., as shown in the Stone database.

A.2 Food Wholesalers, Distributors, and Supermarkets and Grocery Stores

A.2.1 Food Wholesalers and Distributors except Supermarkets and Grocery Stores

The CT, MA, and SC Studies surveyed these types of business establishments using a similar approach as for the food manufacturers and processors described in Section A.2.1. To develop the food wholesalers and distributors database, the CT Study used a size cutoff of greater than or equal to five employees and collected establishment information using CERC and InfoUSA. Similar to the approach used for food manufacturers and processors, a survey was conducted with business establishments selected by SIC codes for industries related to general line grocery, dairy products, poultry and poultry products, fish and seafood, meat and meat products, fresh fruits and vegetables, other groceries and related products, and grain and field beans to collect data on amounts of excess food and management practices.

The MA Study also used a size cutoff of greater than or equal to five employees and obtained data from CERC, public web sources, search engines, industry sources such as Thomas's Register of

American Manufacturers, and trade associations as used in the food manufacturers' database generation. A survey was conducted with establishments selected based on SIC codes for industries related to dairy products, eggs and poultry products, fish and seafood, meats, and fresh fruits and vegetables wholesalers and distributors to collect data for the excess food amount and management practices.

The SC Study collected the business establishments' information using the Hoover's database for food wholesalers and distributors with a size cutoff of greater than or equal to five employees. Similar to the CT and MA Studies, establishments were selected based on SIC codes; however, a specific list of industries or SIC codes is not presented in the report.

The VT Study used Stone's and CVSWMD excess food generation data for specific markets, including establishments such as beer/wine/liquor stores, farmers' markets, online marketplaces, and specialty food stores, and provided an estimated amount of excess food generated by these entities based on the amount of excess food generated by grocery stores. The study estimated that these markets generate approximately one quarter of the excess food of grocery stores.

FWRA (2014) conducted a survey of excess food generation from retailers and wholesalers and reported that approximately 10 lbs of excess food were generated per 1,000 dollars of revenue. The FWRA survey collected data from 13 survey respondents generating approximately 31.8% of the total projected sales of US retailers and wholesalers.

CCG (2015) conducted a study to quantify and characterize waste disposed of and diverted from 837 commercial establishments belonging to 16 industry groups including retail trade (food and beverages stores) in California. CCG (2015) considered establishments associated with NAICS codes 445, including convenience stores (NAICS code 445120), and beer, wine, and liquor stores (NAICS code 445310), which were not considered in our study; our study also included NAICS codes 424XXX in food wholesalers and distributors sectors. The sites selected for the study were located in five designated regions of the state: Bay Area, Coastal, Mountain, Southern, and Central Valley. Waste characterization sampling and generation rate estimation was conducted during 4 seasonal visits to each site. The waste composition of the disposal stream was characterized by hand sorting of a 200-lb sample (into 82 material categories) collected at each of the 53 retail stores. The composition of each diversion stream was characterized by hand sorting of a 125-lb sample (into 82 material categories) at each of the 24 retail stores. Waste quantities for disposal and diversion were estimated through measurements of material accumulated in dumpsters, interviews with staff, reviews of diversion and disposal records, and inspection of recycling and diversion systems. The overall waste generation (disposal+diversion) for the food and beverages retail stores was reported to be 6.64 tons per employee per year. The excess food was reported to constitute approximately 30.4% of the overall waste. The excess food generation rate for food and beverages retail stores was estimated to be approximately 2.02 tons per employee per year, which is equivalent to 4,040 lbs per employee per year. Because of the inconsistencies between the NAICS codes included in our study and CCG (2015), the data reported by CCG (2015) were not used for excess food estimation for this sector.

Limitations: Similar to the food manufacturers and processors sector, the CT, MA and SC Studies reported a lack of correlation between excess food generation and sales, employment, or other size-specific parameters for all food wholesalers and distributors except supermarket and grocery

stores. Therefore, a methodology for this sector could not be developed by these studies. A survey is recommended to accurately obtain the excess food generation from these establishments as well.

A.2.2 Supermarkets and Grocery Stores

All four state studies developed or used one or more methods for estimating excess food generation from these businesses. The CT Study collected the state's supermarket-related data (name, location, type of business, sales, square footage, and/or number of employees) from CERC using a size cutoff of greater than $1.5 million sales or greater than 15 employees. The collected data were verified through individual contact with all chains of three or more stores in the state. The amount of excess food generated was calculated using number of employees as a variable and a generation factor of 3,000 lbs of excess food per employee per year. The average amount of excess food generated per employee per year was based on the average excess food generated per employee per year as reported by Newell et al. (1993), Jacob (1993), and Newell and Snyder (1996). The following equation was used to estimate the amount of excess food generated from supermarkets and grocery stores:

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of employees} \times \frac{3{,}000 \dfrac{\text{lb}}{\text{employee}}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

The MA Study also collected supermarket data from CERC for a size cutoff similar to the CT study and estimated excess food using the same equation as the CT Study. The data were verified by contacting major supermarket chains. The SC Study also used the same excess food estimation methodology as the CT and MA Studies and obtained establishment data from the Hoover's database for a size cutoff of greater than 10 employees.

The RWMA website provides an alternative method based on input variables, including volume of dumpsters, number of dumpsters, and number of trash pickups per week. Assuming that excess food constitutes 63% of disposed of materials, as reported by CCG (2006) based on a statewide study in California and a dumpster density of 450 lb per cubic yard, the excess food generation rate was estimated as:

$$\text{Excess food } \frac{\text{tons}}{\text{year}} =$$
$$\text{Number of trash dumpsters} \times \text{Volume of dumpster } (\text{yd}^3) \times \frac{\text{Number of pickups}}{\text{week}}$$
$$\times 450 \frac{\text{lbs}}{\text{yd}^3} \times 63\% \text{ of disposed waste by weight} \times 52 \frac{\text{weeks}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

The VT Study estimated that 0.72 tons per week of excess food are generated at grocery stores based on the average excess food generation rate suggested by the CVSWMD database. The VT methodology did not state whether any size cutoff was used in estimating the excess food generation from such establishments.

CCG (2006) reported the overall waste generation (disposal+diversion) for food stores with 15 or more full-time employees to be 16,578 lbs per employee per year. The excess food was reported

to constitute approximately 27.9% of the overall waste generation. The excess food generation rate for food stores was estimated to be approximately 4,625 lbs per employee per year for food stores.

A.3 Educational Institutions

A.3.1 Colleges and Universities

All four states' studies used number of students as the parameter to estimate the amount of excess food generated from educational institutions. The excess food generation amount per meal, number of meals served per day, and the number of school days per year varied among methodologies and school type. The CT Study compiled a list of all public and private colleges and universities in the state from the Connecticut Department of Higher Education web site (www.ctdhe.org). Information on school size (number of students) was obtained from published sources and contacts with individual schools. The excess food generation rate was estimated using the number of students as a variable. The excess food generation factor was based on the amount of excess food generated per meal, and number of meals consumed by each student per year. The following equations were used for residential and non-residential schools:

$$\text{Excess food (residential)}\ \frac{\text{tons}}{\text{year}} = \text{Number of students} \times 0.35\frac{\text{lb}}{\text{meal}} \times \frac{405\frac{\text{meals}}{\text{student}}}{\text{year}} \times \frac{\text{tons}}{2{,}000\ \text{lb}}$$

$$\text{Excess food (non-residential)}\ \frac{\text{tons}}{\text{year}} = \text{Number of students} \times 0.35\frac{\text{lb}}{\text{meal}} \times \frac{108\frac{\text{meals}}{\text{student}}}{\text{year}} \times \frac{\text{tons}}{2{,}000\ \text{lb}}$$

The generation factor of 0.35 lb excess food per meal was estimated based on data reported by the US EPA (1998), Kim et al. (1997), Shanklin et al. (1997), and Clark and Law (2000). These studies reported excess food based on per meal averages ranging from 0.27 lb per meal to 0.73 lb per meal with a mean value of 0.39 lb per meal, and a median value of 0.34 lb per meal. A value of 0.35 lb per meal between the mean and median of literature values was used to estimate excess food generation in the CT Study. The food services data from seven residential and five non-residential schools suggested an average of 1.5 and 0.4 meals per student per day, respectively. Assuming 270 days of food services operation in a year in an educational institution, 405 and 108 meals per student per year was estimated for residential and non-residential institutions, respectively. The average number of meals was estimated based on number of students enrolled in the school and whether the institution is considered residential or non-residential.

Limitation: The excess food generation factor was determined using studies that were conducted in late 1990s; the excess food generation practices might have varied since. Further studies need to be performed for an accurate estimate based on recent data.

The MA and SC studies used the same protocol in data collection and excess food estimation for colleges and universities as the CT Study. The MA Study collected information from the National Center for Education Statistics (www.nces.ed.gov) (NCES), supplemented by information from the Massachusetts Department of Higher Education (www.mass.edu) and the New England Association of Schools and Colleges (www.neasc.org). The SC Study used the Hoover's database to collect these institutions' information; each university website was then used to estimate residency and student enrollment.

The VT Study collected information on the numbers of students at each college and university from the VT Agency of Education (http://education.vermont.gov), NCES, and individual institution websites. Based on Stone's and CVSWMD databases, the VT Study used 1.13 lb of excess food per student per week and assumed that institutions were open for 31 weeks a year to estimate annual generation rate from colleges and university. The VT Study used the following equation to estimate the amount of excess food generated:

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of students} \times \frac{1.13 \frac{\text{lb}}{\text{student}}}{\text{week}} \times 31 \frac{\text{weeks}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

The RWMA website includes two excess food generation factors for colleges and universities and assumes a steady level of food consumption over 52 weeks. For students living on campus, RWMA suggests using 141.75 lbs/student/year. The following equation could be used to estimate the amount of excess food generation for residential students:

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of residential students} \times \frac{141.75 \frac{\text{lb}}{\text{student}}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

For students living off campus, the RWMA website suggests using 37.8 lbs/student/year. The following equation could be used to estimate the amount of excess food generation for non-residential students:

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of non-residential students} \times \frac{37.8 \frac{\text{lb}}{\text{student}}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

CCG (2015) conducted a study to quantify and characterize waste disposed of and diverted from 837 commercial establishments belonging to 16 industry groups including educational institutions in California. CCG (2015) considered establishments associated with NAICS codes 611, which also includes elementary and secondary schools apart from universities and colleges. The sites selected for the study were located in five designated regions of the state: Bay Area, Coastal, Mountain, Southern, and Central Valley. Waste characterization sampling and generation rate estimation was conducted during four seasonal visits to each site. The waste composition of the disposal stream was characterized by hand sorting of a 200-lb sample (into 82 material categories) collected at each of the 51 educational institutions. The composition of each diversion stream was characterized by hand sorting of a 125-lb sample (into 82 material categories) at each of the 24 educational institutions. Waste quantities for disposal and diversion were estimated through measurements of material accumulated in dumpsters, interviews with staff, review of diversion and disposal records, and inspection of recycling and diversion systems. The overall waste generation (disposal+diversion) for the educational institutions was reported to be 0.5 tons per employee per year or 3.67 tons per 100 students per year. The excess food was reported to constitute approximately 30% of the overall waste. The excess food generation rate for educational institutions was estimated to be approximately 0.15 tons per employee per year, which is equivalent to 300 lbs per employee per year, or 1.1 tons per 100 students per year, which is equivalent to 22 lbs per student per year.

A.3.2 Elementary and Secondary Schools

The CT Study obtained a list of the state's private secondary school data from the Connecticut Department of Education. Information on location, contact, and size was obtained from the American Schools Directory website (www.asd.com). For independent schools, only boarding schools with more than 250 students were included in the database. Excess food generation was estimated with the same equation used for colleges and universities, assuming 0.35 lb per meal of excess food is generated by each student. The MA Study used the same protocol as the CT Study for this sector. The SC Study also assumed 0.35 lb per meal of excess food generated and assumed 180 meals served per student per year. The SC Study used the following equation to estimate the amount of excess food generated at elementary and secondary schools:

$$\text{Excess food (non-residential)} \ \frac{\text{tons}}{\text{year}} = \text{Number of students} \times 0.35 \frac{\text{lb}}{\text{meal}} \times \frac{180 \dfrac{\text{meals}}{\text{student}}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

The RWMA website suggests using 0.5 lb excess food per student per week as a generation factor for elementary and secondary schools. The following equation can be used to estimate an annual excess food generation rate assuming that schools are open for 40 weeks in a year; the VT Study assumed that schools are open for 40 weeks in a year:

$$\text{Excess food} \ \frac{\text{tons}}{\text{year}} = \text{Number of students} \times \frac{0.5 \dfrac{\text{lb}}{\text{student}}}{\text{week}} \times 40 \ \frac{\text{weeks}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

A waste audit conducted at seven public elementary, middle, and high schools in MA from 2007 to 2013 suggested that 0.5 lbs of excess food were generated per student per week. An alternative method using the volume and number of dumpsters and number of trash pickups per week as variables was also provided on the RWMA website. Assuming excess food comprises 45% of disposed materials, the amount of excess food generated from schools can be estimated by the following equation (assuming schools are open for 40 weeks in a year):

$$\text{Excess food} \ \frac{\text{tons}}{\text{year}} = \text{Number of trash dumpsters} \times \text{Volume of dumpster yd}^3 \times \frac{\text{Number of pickups}}{\text{week}} \times 450 \ \frac{\text{lb}}{\text{yd}^3} \times 45\% \text{ of disposed waste by weight} \times 40 \frac{\text{weeks}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

The VT Study collected data on the number of students at each school from the VT Agency of Education, NCES, and individual school websites for elementary, middle, elementary and middle, high school, Pre-K, and K-12. The following equation was used to estimate excess food generation:

$$\text{Excess food} \ \frac{\text{tons}}{\text{year}} = \text{Number of students} \times \text{x} \frac{\text{lb}}{\text{student}} \times 40 \ \frac{\text{weeks}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

The VT Study assumed 40 weeks of school per year, where x is the average pounds of excess food per student per week from various types of schools. Figure A-1 presents the excess food generation factors (excess food per student per week) used in the VT methodology for each school category. Table A-2 summarizes the excess food generated per meal, the number of meals served per student per year, and other variables used by the CT, MA, SC, and VT Study methodologies.

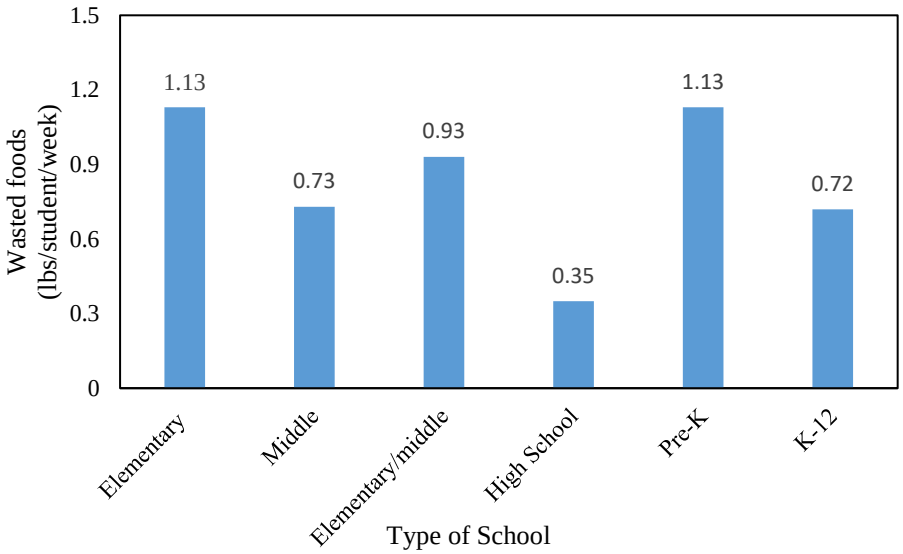


Figure A-1. Average Excess Food Generation Factor by School Type (VT Study)

Table A-2. Excess Food Generation Factors for Educational Institutions

Educational Institution Type	Variable	Excess Food Generation Factors	Study Reference
Colleges and Universities			
Residential Institution	Number of Students	0.35 lbs/meal 405 meals/student/year	CT, MA, SC
Non-Residential Institution	Number of Students	0.35 lbs/meal 108 meals/student/year	CT, MA, SC
All Colleges and Universities	Number of Students	1.13 lbs/student/week 31 weeks/year*	VT
Elementary and Secondary Schools			
Independent and Private Schools (Primary/Secondary)	Number of Students	0.35 lbs/meal 180 meals/student/year (SC)	CT, MA, SC
	Number of Students	0.5 lbs/student/week 40 weeks/year (VT)	RWMA
	Number of dumpsters Volume of dumpsters Number of pickups/week	450 lbs/yd^3 45% of disposed of waste (w/w) 40 weeks/year (VT)	RWMA
Elementary School	Number of Students	1.13 lbs/student/week 40 weeks/year*	VT
Middle School	Number of Students	0.73 lbs/student/week 40 weeks/year*	VT
Elementary/Middle School	Number of Students	0.93 lbs/student/week 40 weeks/year*	VT
High School	Number of Students	0.35 lbs/student/week 40 weeks/year*	VT
Pre-K	Number of Students	1.13 lbs/student/week 40 weeks/year*	VT
K-12	Number of Students	0.72 lbs/student/week 40 weeks/year*	VT
Educational Institutions	Number of Students	22 lbs/student/year	CCG (2015)
	Number of Employees	300 lbs/employee/year	

***Assumed value**

A.4 Hospitality Industry

A.4.1 Resorts and Conference Facilities

The CT Study developed a methodology to estimate the amount of excess food generated by resorts and conference facilities; MA and SC adopted this methodology for their studies. A review of 12 facilities that responded to the survey conducted by the CT Study showed a general split between facilities that make intensive use of their sit-down eating spaces and those that do not. Facilities that run at full capacity serve an average of 0.6 meals per seat per day, while facilities that run at

less intensity serve 0.25 meals per seat per day. The literature review by the CT Study found 1.0 lb of excess food per meal served in these facilities. Number of seats was used as a variable to estimate the amount of excess food generated by such facilities using the following equation:

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of seats} \times 1.0 \frac{\text{lb}}{\text{meal}} \times \frac{\text{Number of meals}}{\text{seat}} \times 365 \frac{\text{days}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

The VT Study did not estimate excess food generation from resorts and conference facilities. The CT and MA Study obtained information on resort and conference facilities from the convention and visitors bureau for a size cutoff of greater than or equal to 250 guests capacity, whereas the SC Study obtained information for all such facilities in the state from the Hoover's database.

A.4.2 Venues and Events

The CT, MA, SC, and VT Studies did not estimate excess food generation from venues and events facilities. The RWMA website provides four equations to estimate the excess food generated from such facilities. The number of seats, number of meals served, number of visitors, and number and volume of dumpster pickups can be used to estimate the excess food generation rate from various types of venues and events facilities, as reflected by the following equations:

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of seats} \times \frac{0.6 \frac{\text{lb}}{\text{seat}}}{\text{day}} \times 365 \frac{\text{days}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of meals served per week} \times 1.0 \frac{\text{lb}}{\text{meal}} \times 52 \frac{\text{weeks}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of visitors per week} \times 0.45 \frac{\text{lb}}{\text{visitor}} \times 52 \frac{\text{weeks}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of trash dumpsters} \times \text{Volume of dumpster yd}^3 \times \frac{\text{Number of pickups}}{\text{week}} \times 450 \frac{\text{lb}}{\text{yd}^3} \times 25\% \text{ of disposed waste by weight} \times 52 \frac{\text{weeks}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

The excess food generation factors of 0.6 lb per seat per day, 1.0 lb per meal, 0.45 lb per visitor, and 25% excess food per pound of waste discarded are assumed. The excess food fraction of disposed waste (25%) and the 0.45 lb excess food generated per visitor appear to be based on CCG (2006). No details were provided for the source of the average values of 0.6 lb per seat per day and 1.0 lb per meal; the excess food generation factor of 1.0 lb per meal is the same as that used for resort and conference facilities as discussed in section A.4.1. CCG (2006) reported the overall waste generation (disposal+diversion) for public venues and events to be 244 lbs per 100 visitors. The excess food was reported to constitute approximately 18.4% of the overall waste generation. The excess food generation rate for public venues and events was estimated to be approximately 45 lbs per 100 visitors, or .45 lbs per visitor for public venues and events.

A.4.3 Lodging and Hotels

The lodging and hotel sector includes establishments such as hotels and motels that provide extended stay (facilities with amenities such as kitchens, washing machines, and weekly housekeeping), limited service (with fewer amenities), and full service (includes amenities such as restaurants, room service, and health clubs). The CT, MA, SC, and VT Studies did not report an excess food estimation methodology for these establishments.

CCG (2006) reported the overall waste generation (disposal+diversion) for large hotels with 30 or more full-time employees to be 5049 lbs per employee per year. The excess food was reported to constitute approximately 39.3% of the overall waste generation. The excess food generation rate for large hotels was estimated to be approximately 1984 lbs per employee per year for large hotels.

The RWMA website provides three approaches to estimate the excess food generation rate from lodging and hotels based on the number of guests, number of guest rooms, or dumpster data (volume of dumpsters, number of dumpster, and number of dumpster pickups per week). The following equations are proposed by the RWMA website to estimate the excess food generation rate from lodging and hotel facilities:

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of guests} \times \frac{1.0 \ \frac{\text{lb}}{\text{guest}}}{\text{day}} \times 365 \frac{\text{days}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of rooms} \times \frac{345.64 \ \frac{\text{lb}}{\text{room}}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of trash dumpster} \times \text{Volume of dumpster yd}^3 \times \frac{\text{Number of pickups}}{\text{week}} \times 450 \ \frac{\text{lb}}{\text{yd}^3} \times 36\% \text{ of disposed waste by weight} \times 52 \frac{\text{weeks}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

The excess food generation rate values of 1.0 lb per guest per day and 345.64 lb per room per year used by RWMA appear to be based on data reported by the Northeast Waste Management Officials' Association (2011). The excess food fraction of discarded waste (36%) appears to be based on data reported by CCG (2006).

CCG (2015) conducted a study to quantify and characterize waste disposed of and diverted from 837 commercial establishments belonging to 16 industry groups including hotels and lodging in California. CCG (2015) considered establishments associated with NAICS code 721. The sites selected for the study were located in five designated regions of the state: Bay Area, Coastal, Mountain, Southern, and Central Valley. Waste characterization sampling and generation rate estimation was conducted during 4 seasonal visits to each site. The waste composition of the disposal stream was characterized by hand sorting of a 200-lb sample (into 82 material categories) collected at each of the 51 facilities. The composition of each diversion stream was characterized by hand sorting of a 125-lb sample (into 82 material categories) at each at each of the 25 facilities. Waste quantities for disposal and diversion were estimated through measurements of material accumulated in dumpsters, interviews with staff, review of diversion and disposal records, and

inspection of recycling and diversion systems. The overall waste generation (disposal+diversion) for the hotels and lodging sector was reported to be 2.14 tons per employee per year. The excess food was reported to constitute approximately 27.9% of the overall waste. The excess food generation rate for hotels and lodging sector was estimated to be approximately 0.6 tons per employee per year, which is equivalent to 1,200 lbs per employee per year.

A.4.4 Camps

The VT Study estimated excess food generated from camps based on number of seats using the following equation:

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of seats} \times 0.5 \frac{\text{lb}}{\text{meal}} \times \frac{3 \frac{\text{meals}}{\text{seat}}}{\text{day}} \times 365 \frac{\text{days}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

The excess food per meal (0.5 lb per meal) and meals per seat per day were obtained from Stone's database. The CT, MA, and SC Studies did not estimate excess food generation from camps. Table A-3 summarizes the variables and excess food generation factors used by the various studies.

Table A-3. Excess Food Generation Factors for the Hospitality Industry

Hospitality Industry Type	Variable	Excess food Generation Factors	Study Reference
Resorts and Conference Facilities	Number of Seats Number of meals/seat/day	1.0 lbs/meal	CT, MA, SC
Venues and Events	Number of Seats	0.6 lbs/seat/day	RWMA
	Number of meals/week	1 lb/meal	RWMA
	Number of visitors/week	0.45 lb/visitor	RWMA, CCG (2006)
	Number of dumpsters, Volume of dumpster, Number of pickups/week	450 lbs/yd^3 25% of disposed of waste (w/w)	RWMA
Lodging and Hotels	Number of guests	1.0 lb/guest/day	RWMA
	Number of rooms	345.64 lb/room/year	RWMA
	Number of dumpsters, Volume of dumpsters, Number of pickups/week	450 lbs/yd^3 36% of disposed of waste (w/w) 52 weeks/year	RWMA
	Number of employees	1984 lbs/employee/year	CCG (2006)
	Number of employees	1200 lbs/employee/year	CCG (2015)
Camps	Number of seats	0.5 lb/meal 3 meals/seat/day	VT

A.5 Correctional Facilities

The CT, MA, and SC studies used data from all identified correctional facilities in their states. The facility data were obtained from each state's Department of Corrections (DOC). The amount of excess food generated was estimated based on the number of inmates in the facility as follows:

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of inmates} \times \frac{1.0 \ \frac{\text{lb}}{\text{inmate}}}{\text{day}} \times 365 \frac{\text{days}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

The CT Study adopted the estimated average value of 1.0 lb excess food per inmate per day based on data reported by Marion (2000); Marion (2000) conducted a waste composition study at New York correctional facilities. The RWMA website provides an alternative method using number and volume of dumpster pickups per week as variables. Assuming that excess food comprises 30% of disposed materials (KCI, 2004) and a density of 450 lbs per cubic yard, the excess food generated at correctional facilities can be estimated as follows:

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of trash dumpsters} \times \text{Volume of dumpster } \text{yd}^3 \times \frac{\text{Number of pickups}}{\text{week}} \times 450 \frac{\text{lb}}{\text{yd}^3} \times 30\% \text{ of disposed waste by weight} \times 52 \frac{\text{weeks}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

The VT Study used number of beds as a variable to estimate the amount of excess food generated at correctional facilities. The excess food generation factors of 0.5 lb per meal and 3 meals per bed per day were obtained from Stone's estimates. The VT Study used the following equation to estimate the excess food generated from correctional facilities:

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of beds} \times 0.5 \frac{\text{lb}}{\text{meal}} \times 3 \frac{\frac{\text{meals}}{\text{bed}}}{\text{day}} \times 365 \frac{\text{days}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

Limitation: The generation factor (1.0 lb per excess food per inmate per day) was obtained using a relatively old study conducted in 2000. The excess food generation and handling practices should have changed since then; more recent studies need to be performed to determine the accuracy of the excess food generation factor.

Table A-4 summarizes the variables and excess food generation factors used by the various studies for Correctional facilities.

Table A-4. Excess Food Generation Factors for Correctional Facilities

Correctional Facility Type	Variable	Excess Food Generation Factors	Study Reference
Correctional facility	Number of inmates	1.0 lb/inmate/day	CT, MA, SC
	Number of dumpsters Volume of dumpsters Number of pickups/week	450 lbs/yd^3 30% of disposed of waste (w/w) 52 weeks/year	RWMA
	Number of beds	0.5 lb/meal 3 meals/bed/day	VT

A.6 Hospitals and Nursing Homes

A.6.1 Hospitals

All four studies developed or used a method for estimating the excess food generated by hospitals. The CT Study collected healthcare facility information from CERC and the Connecticut Hospital Association for hospitals, nursing homes, intermediate care facilities, rehabilitation centers, and extended care facilities. Data were included for facilities with inpatient or residential capabilities of greater than or equal to $500,000 in sales and greater than or equal to 10 employees. Number of beds was used as a parameter to estimate the excess food generated using the following equation:

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of beds} \times 0.6 \frac{\text{lb}}{\text{meal}} \times \frac{5.7 \frac{\text{meals}}{\text{bed}}}{\text{day}} \times 365 \frac{\text{days}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

The CT Study estimated 0.6 lb per meal of excess food based on data reported by the US EPA (1998), Kim et al. (1997), and Shanklin et al. (1997) studies. Additionally, based on a survey of seven institutions, the CT Study reported that the number of meals served per day per bed in healthcare facilities ranged from 4.1 to 7.4 with a mean of 5.7 meals per bed per day. The MA and SC Studies used similar methods to the CT Study for estimating hospital excess food; however, they used a different equation for nursing homes and similar facilities.

The RWMA website provides an additional method to estimate excess food generated from hospitals using the amount of food served per week. It appears that RWMA referred to a Williams and Walton (2011) study that suggests approximately 30% of food served in hospitals becomes waste. Using that assumption, the RWMA developed the following equation to estimate excess food from hospitals:

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{lb food served per week} \times 30\% \text{ of food served} \times 52 \frac{\text{weeks}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

The VT Study also used the number of beds as a variable to estimate the excess food generated by hospitals. However, the values used for the amount of excess food per meal and number of meals served per bed per day were lower than those used by the CT Study. Based on the CVSWMD dataset, the VT Study used a value of 0.5 lb of excess food per meal served as a generation factor. The following equation was used to estimate the amount of excess food from hospitals:

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of beds} \times 0.5 \frac{\text{lb}}{\text{meal}} \times \frac{3 \frac{\text{meals}}{\text{bed}}}{\text{day}} \times 365 \frac{\text{days}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

The hospital information in the MA Study was gathered from the Member Relations Department of the Massachusetts Hospital Association (www.mhalink.org), supplemented by information from the American Hospital Directory (AHD) (www.ahd.com), and the American Hospital Association (www.hospitalconnect.com). The SC Study collected data for the state's healthcare facilities from the AHD. The VT Study compiled hospital information from the Department of Aging and Independent Living, Vermont Associates of Hospitals & Health Systems (VAHHS) website, and individual hospital websites.

A.6.2 Nursing Homes and other Similar Care Facilities

The MA Study used number of beds as the variable to estimate the amount of excess food generated by nursing homes and similar facilities. Generation factors of 0.6 lb per meal and 3 meals per bed per day were used to estimate the amount of excess food per bed per day. The following equation was used by both the MA and SC Studies to estimate the excess food generated from nursing homes and similar facilities:

$$\text{Excess food}\ \frac{\text{tons}}{\text{year}} = \text{Number of beds} \times 0.6\frac{\text{lb}}{\text{meal}} \times 3\frac{\text{meals}}{\text{bed}} \times 365\frac{\text{days}}{\text{year}} \times \frac{\text{tons}}{2{,}000\ \text{lb}}$$

The RWMA website lists another method to estimate excess food generated from these facilities using the amount (in lbs) of food served per week and the fraction of food discarded as the excess food generation factor. The methodology assumes that on average, 20% by weight of the food served is discarded; not enough information was provided determine the source of the selected excess food generation factor. The equation for this method of excess food estimation is as follows:

$$\text{Excess food}\ \frac{\text{tons}}{\text{year}} = \text{lb food served per week} \times 20\%\ \text{of food served} \times 52\frac{\text{weeks}}{\text{year}} \times \frac{\text{tons}}{2{,}000\ \text{lb}}$$

The VT Study estimated excess food generation from nursing homes and similar facilities using the same method as for hospitals:

$$\text{Excess food}\ \frac{\text{tons}}{\text{year}} = \text{Number of beds} \times 0.5\frac{\text{lb}}{\text{meal}} \times 3\frac{\text{meals}}{\text{bed}} \times 365\frac{\text{days}}{\text{year}} \times \frac{\text{tons}}{2{,}000\ \text{lb}}$$

The MA Study used the database of the federal Medicare program (www.medicare.gov/Nursing/Overview.asp), which lists all Medicare-certified nursing homes and related extended-care facilities in the US. The SC Study collected data from the SC Office on Aging and South Carolina Healthy Connections (http://www.nfbl.sc.gov/). The VT Study used The Department of Aging and Independent Living and the VAHHS websites to gather information on Nursing Homes, Assisted Living, and Residential Care Facilities. Table A-5 summarizes the excess food generated per meal, the number of meals served per day, and other variables used by the CT, MA, SC, and VT Studies.

CCG (2015) conducted a study to quantify and characterize waste disposed of and diverted from 837 commercial establishments belonging to 16 industry groups including medical and health sector in California. CCG (2015) considered establishments associated with NAICS codes 621, 622, and 623. The sites selected for the study were located in five designated regions of the state: Bay Area, Coastal, Mountain, Southern, and Central Valley. Waste characterization sampling and generation rate estimation was conducted during four seasonal visits to each site. The waste composition of the disposal stream was characterized by hand sorting of a 200-lb sample (into 82 material categories) collected at each of the 25 ambulatory health care services and 30 hospitals (including nursing and residential care facilities). The composition of each diversion stream was characterized by hand sorting of a 125-lb sample (into 82 material categories) at each at each of the 15 ambulatory health care services and 14 hospitals (including nursing and residential care facilities). Waste quantities for disposal and diversion were estimated through measurements of material accumulated in dumpsters, interviews with staff, review of diversion and disposal records, and inspection of recycling and diversion systems. The overall waste generation (disposal+diversion) for the medical and health sector was reported to be 0.74 tons per employee per year. The excess food was reported to constitute approximately 20.4% of the overall waste. The excess food generation rate for medical and health sector was estimated to be approximately

0.15 tons per employee per year, which is equivalent to 300 lbs per employee per year. Because of the inconsistencies between the NAICS codes included in our study and CCG (2015), the data reported by CCG (2015) were not used for excess food estimation for this sector.

Table A-5. Excess Food Generation Factors for Healthcare Facilities

Healthcare Institution Type	Variable	Excess Food Generation Factors	Study Reference
Hospitals	Number of beds	0.6 lbs/meal 5.7 meals/bed/day	CT, MA, SC
	lb food served/week	30% of food served	RWMA
	Number of beds	0.5 lbs/meal 3 meals/bed/day	VT
Nursing homes and similar care facilities	Number of beds	0.6 lbs/meal 3 meals/bed/day	MA, SC
	lb food served/week	20% of food served	RWMA
	Number of beds	0.5 lbs/meal 3 meals/bed/day	VT
Medical and Health (NAICS code 621, 622, and 623)	Number of employees	300 lbs/employee/year	CCG (2015)

A.7 Food Services Sector

The MA Study estimated the excess food generated by food service facilities based on number of employees and assumed 3,000 lbs of excess food generated per employee per year, as reflected by the following equation:

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of employees} \times \frac{3{,}000 \frac{\text{lb}}{\text{employee}}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

The RWMA website lists three methods to estimate excess food generation based on the number of meals served, number of full-time employees, and discarded waste data (volume and number of dumpsters, and number of dumpster pickups per week). The RWMA website suggests using the following equations to estimate excess food from restaurants:

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of meals per week} \times 0.5 \frac{\text{lb}}{\text{meal}} \times 52 \frac{\text{weeks}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

$$\text{Excess food } \frac{\text{tons}}{\text{year}} = \text{Number of employees} \times 1{,}500 \frac{\frac{\text{lb}}{\text{employee}}}{\text{year}} \times \frac{\text{tons}}{2{,}000 \text{ lb}}$$

$$\text{Excess food (full-service)}\ \frac{\text{tons}}{\text{year}} = \text{Number of trash dumpster} \times \text{Volume of dumpster yd}^3 \times \frac{\text{Number of pickups}}{\text{week}} \times 450\ \frac{\text{lb}}{\text{yd}^3} \times 66\%\ \text{of disposed waste by weight} \times 52\ \frac{\text{weeks}}{\text{year}} \times \frac{\text{tons}}{2{,}000\ \text{lb}}$$

$$\text{Excess food (fast-food)}\ \frac{\text{tons}}{\text{year}} = \text{Number of trash dumpster} \times \text{Volume of dumpster yd}^3 \times \frac{\text{Number of pickups}}{\text{week}} \times 450\ \frac{\text{lb}}{\text{yd}^3} \times 51\%\ \text{of disposed waste by weight} \times 52\ \frac{\text{weeks}}{\text{year}} \times \frac{\text{tons}}{2{,}000\ \text{lb}}$$

The RWMA website suggests excess food generation factors of 0.5 lb per meal and 1,500 lbs per employee per year. The excess food portion of discarded waste (66% for full-service and 51% for fast-food restaurants) appears to be based on the data reported by CCG (2006). The RWMA defines full-service restaurants as restaurants in which the customer orders and is served at a table, while at fast-food restaurants food is picked up at a counter. It is noteworthy that the 2002 MA Study used 3,000 lbs of excess food generated per employee per year, whereas the RWMA website suggests this value as 1,500 lbs per employee per year or 0.5 lb per meal. The MA Study does not provide the basis of either generation factor. Based on the data presented by CCG (2006), the average rate of excess food generated for fast-food and full-service restaurants is approximately 3,000 lbs per employee per year.

The VT Study proposed unique methods for the following types of food service establishments: restaurants, bars and pubs, cafeterias, concessions, delis, private clubs, and caterers. A generation factor of 1.0 lb per meal is assumed for restaurants, cafeterias, and concessions. A generation factor of 0.5 lb per meal is assumed for delis, bars and pubs, private clubs, and caterers. All of these establishments are assumed to serve three meals per day. To estimate the amount of excess food generated, number of seats was used as a variable in the following equation:

$$\text{Excess food}\ \frac{\text{tons}}{\text{year}} = \text{Number of seats} \times x\ \frac{\text{lbs}}{\text{meal}} \times 3\ \frac{\text{meals}}{\text{day}} \times 365\ \frac{\text{days}}{\text{year}} \times \frac{\text{tons}}{2{,}000\ \text{lb}}$$

where x is the amount of excess food generated per meal by each type of restaurant. The MA Study collected data for restaurants with 10 or more employees and $200,000 or more in annual sales from CERC. The SC Study obtained data for restaurants with 10 or more employees from the Hoover's database.

Based on study conducted by the City of Long Beach, California in 1989, Hinshaw and Braun (1991) reported the composition of waste generated from six business sectors including food/entertainment as a category. A waste composition was estimated through hand sorting of 21 samples collected for food/entertainment sector; each sample weighed approximately 200 to 300 lbs. Excess food was reported to constitute approximately 38.1% of the total waste from food/entertainment sector. The estimated composition and literature-reported values of waste

generation rates for specific business categories were used to develop estimates of recoverable materials. Hinshaw and Braun (1991) did not measure the waste generation rate but used a waste generation rate of 1.9 to 12.49 lbs per employee per day for restaurants based on a previous study. Based on the excess food content and waste generation rate, the calculated excess food generation rate for restaurants ranges from 260 to 1,740 lbs per employee per year.

Newell et al. (1993) conducted an audit of the waste generated from four restaurants in Urbana Champaign, Illinois over a two-week duration; three of these appeared to be full-service restaurants and one was a limited-service restaurant. The waste containers were weighed and a visual characterization was conducted to estimate the volume fraction of excess food, corrugated containers, other recyclables and garbage. The excess food that was mixed with garbage was counted in the fraction reported as garbage. Waste generation rates for restaurants were estimated to range from 4.6 to 7.8 lb per employee per day (1,680 to 2,850 lb per employee per year). Based on the data reported by Newell et al. (1993) (Table 1 of the paper), waste food constituted approximately 45% of the total mass of the overall waste stream. Based on the overall waste generation rate and the excess food content, the excess food generation rate was calculated to range from 760 to 1280 lb per employee per year.

Walsh et al. (1993) cites data from two previous studies reporting generation rate and composition of waste from restaurants. Based on a study conducted by Illinois Department of Natural Resources in 1991, the overall waste generation rate for restaurants is reported as 200 lbs per thousand dollar of sales. Excess food is reported to constitute 36% of the overall waste stream from restaurants based on a Washington State Department of Ecology report published in 1987. No further details of the studies or their methodologies are provided. Based on the excess food content and waste generation rate, the excess food generation rate for restaurants in this study is approximately 72 lbs per thousand dollar of sales.

Luboff and May (1995) reported on excess food generation rates in Seattle and surrounding King County in Washington based on data from a weighing study conducted by a third-party consulting group. The excess food generation for restaurants cited in the article was 1,420 lbs per employee per year. However, it is noted that the calculated tonnages do not include excess food managed through grinding and subsequent disposal into the sewer system. Luboff and May (1995) stated that disposal through grinding could equal up to 20% of the total mass of excess food for restaurants; however, no supporting data or references were provided. The duration of the study and the number of participating restaurants are not reported.

Kunzler (1997) anecdotally reported an excess food generation rate of 1 ton per week from a 140-employee restaurant in Wisconsin. The excess food generation rate for the restaurant is estimated to be 0.371 ton per employee per year, which is equivalent to 740 lb per employee per year. The details regarding the measurement procedures (e.g., weighing or visual volume quantification) were not reported.

Shanklin (2001) reported generation of 0.89 lb of waste from a commercial chain restaurant per meal served. Excess food was reported to constitute approximately 64.6% (by weight) of the total waste. An excess food generation rate for restaurants could not be developed due to lack of additional data such as number of meals served per year, number of employee or annual sales.

Luken (2003) conducted an estimate of excess food generation from restaurants, grocery stores, university cafeteria, and school districts for developing a pre-consumer excess food composting program in Allegheny County (Pennsylvania). The generation factors from Orange County were used along with employment statistics for Allegheny County. The excess food generation rate of 0.42 ton per employee per year (840 lb per employee per year) was used for restaurants. The details, such as the duration, scope (e.g., total or pre-consumer excess food, number of restaurants), and measurement procedures used for Orange County were not reported.

CCG (2006) conducted a study to quantify and characterize waste disposed of and diverted from 371 commercial establishments belonging to 14 industry groups including fast-food and full-service restaurants in California; the sites selected for the study were located in Los Angeles, Sacramento, San Diego, and San Francisco. Diversion data were collected through interviews with employees and inspection of recycling and diversion systems during on-site visits of 24 fast-food and 27 full-service restaurants. Disposal was quantified through measurement of waste accumulated in dumpsters at the time of site visits or through interviews and review of waste disposal records at 22 fast-food and 23 full-service restaurants. The composition of disposed waste was characterized through hand sorting of 200 to 250-lb waste samples into 74 material categories. The overall waste generation (disposal+diversion) for the fast-food and full-service restaurants was reported to be 6,528 and 6,437 lbs per employee per year, respectively. The excess food was reported to constitute approximately 38.2% and 52.7% of the overall waste for fast-food and full-service restaurants, respectively. The excess food generation rate for restaurants was estimated to be approximately 2,494 and 3,392 lbs per employee per year for fast-food and full-service restaurants, respectively.

FWRA (2014) conducted a survey of excess food generation from restaurants and reported that approximately 33 lbs of excess food were generated per 1,000 dollars of revenue. The FWRA survey collected data from 27 survey respondents (14 companies with more than 10 locations each) generating approximately 15.2% of the total projected sales of US restaurants. Over 84% of the excess food generated at restaurants was reported to be landfilled.

CCG (2015) conducted a study to quantify and characterize waste disposed of and diverted from 837 commercial establishments belonging to 16 industry groups including restaurants in California. CCG (2015) included all the NAICS codes included in our study as well as mobile food services (NAICS code 722330) and drinking places (NAICS code 722410). The sites selected for the study were located in five designated regions of the state: Bay Area, Coastal, Mountain, Southern, and Central Valley. Waste characterization sampling and generation rate estimation was conducted during four seasonal visits to each site. The waste composition of the disposal stream was characterized by hand sorting of a 200-lb sample (into 82 material categories) collected at each of the 51 restaurants. The composition of each diversion stream was characterized by hand sorting of a 125-lb sample (into 82 material categories) each at 26 restaurants. Waste quantities for disposal and diversion were estimated through measurements of material accumulated in dumpsters, interviews with staff, review of diversion and disposal records, and inspection of recycling and diversion systems at each restaurant. The overall waste generation (disposal+diversion) for the restaurant sector was reported to be 2.92 tons per employee per year. The excess food was reported to constitute approximately 47.2% of the overall waste. The excess food generation rate for restaurants was estimated to be approximately 1.38 tons per employee per year, which is equivalent to 2,760 lbs per employee per year.

Table A-6 summarizes the excess food generated per meal, the number of meals served per day, and other variables used by the MA, SC, and VT Studies and other studies discussed above.

Table A-6. Excess Food Generation Rates for the Food Service Sector

Restaurant types	Variable(s)	Excess Food Generation Factors	Study Reference
Restaurant	# full time employees	3,000 lbs per employee per year	MA, SC
Restaurant	# meals served per week	0.5 lbs per meal	RWMA
Restaurant	# employees	1500 lbs per employee per year	RWMA
Restaurant-Full Service	vol of dumpster # pickups per week # trash dumpster	450 lbs per cu yd 66% of disposed waste per lbs	RWMA
Restaurant-Fast Food		450 lbs per cu yd 51% of disposed waste per lbs	RWMA
Restaurant	# seats	1 lbs per meal 3 meals per day	VT
Restaurant - Cafeteria			
Restaurant - Concession			
Restaurant - Bars & Pubs	# seats	0.5 lbs per meal 3 meals per day	
Restaurant - Deli			
Private Club			
Caterer			
Restaurant	# employees	260-1,740 lbs per employee per year	Hinshaw and Braun (1991)
Restaurant	# employees	760-1280 lbs per employee per year	Newell et al. (1993)
Restaurant	Sales/Revenue	72 lbs per thousand dollars of sales	Walsh et al. (1993)
Restaurant	# employees	1,420 lbs per employee per year	Luboff and May (1995)
Restaurant	# employees	740 lbs per employee per year	Kunzler (1997)
Restaurant	# meals served	0.89 lbs of waste per meal 64.6% of waste per weight	Shanklin (2001)
Restaurant	# employees	840 lbs per employee per year	Luken (2003)
Restaurant	Sales/Revenue	33 lbs per thousand dollars of sales	FWRA (2014)
Restaurant-Fast Food	# employees	2,494 lbs per employee per year	CCG (2006)
Restaurant-Full Service	# employees	3,392 lbs per employee per year	CCG (2006)
Restaurant	# employees	2,760 lbs per employee per year	CCG (2015)

A.8 Others

A.8.1 Food Pantries

The CT, MA, and SC Studies did not report an excess food generation methodology from food pantries. Based on interview data collected by the VT Study, food pantries (shelves) generate excess food at a rate of 0.01 tons per week.

A.8.2 Senior Meal Facilities

The CT, MA, and SC Studies did not report an excess food generation methodology by senior meal facilities. Similar to food pantries, the VT Study observed challenges for estimating the excess food from senior meal facilities without seating data. Based on an interview with CVSWMD, the VT Study proposed an excess food generation rate of 0.1 tons per week for senior meal centers.

Appendix B: Excess Food Characteristics

Recipients of excess food make use of it in different ways, depending on the state of the resource (i.e., pre-consumer, post-consumer), as well as its macro-nutrients. In general, excess food composition depends on the characteristics of its primary products. Table B-1 lists excess food characteristic categories and commonly associated industries.

Table B-1. Dominant Excess Food Characteristics and Associated Industry Examples

No	Excess Food Characteristics	Examples of Type of Industries
1	Lipids	Fats and oils refining and blending, fast food
2	Simple Carbohydrates	Bakeries, breweries, confectionaries and soda producers
3	Complex Carbohydrates	Fruits and vegetables processing, supermarkets and grocery stores
4	Proteins	Meat, poultry, and dairy processing
5	Ligno-cellulosic	Flower, nursery stock, and/or florist operations
6	Mixed Materials	Food services
7	Glycerin	Biofuel manufacturing

The types of excess food components generated by each industry based on NAICS code are listed in Table B-2. For the food manufacturers and processors, and food wholesalers and distributors sectors, excess food characteristics were based on the type of industry. For example, manufacturers in animal production and aquaculture industries were assumed to primarily generate high-protein excess food, while beverage manufacturers primarily generate simple carbohydrate-rich excess food. Jacob (1993) reported that supermarkets and grocery stores generate more than 90% of their waste, primarily complex carbohydrates, from the produce department. CTDEP (2001) reported that excess food generated by sectors such as educational institutions, healthcare facilities, correctional facilities, and the hospitality industry consists primarily of complex carbohydrates, mostly from fruit and vegetable residuals, with the balance divided between meat and bakery products, with dairy contributing just a small fraction. Excess food generated by the food services sector is generally comprised of mixed components. Table B-2 summarizes characteristics of excess food from the 89 industries selected for the Map. Note that along with proteins, simple and complex carbohydrates, and lipids, some excess food characteristics are reflected as a mix of these characteristics ("mixed"), or are denoted as "other" for certain sectors where these characterization categories are not a good fit (e.g., spice and extract manufacturing).

Table B-2. Characteristics of Excess Food Associated with Industries in the Excess Food Opportunities Map

NAICS Code	NAICS Code Description	Excess Food Characteristics
Food Manufacturers and Processors		
112111	Beef Cattle Ranching and Farming	Proteins
112112	Cattle Feedlots	Proteins
112120	Dairy Cattle and Milk Production	Proteins
112210	Hog and Pig Farming	Proteins
112310	Chicken Egg Production	Proteins
112320	Broilers and Other Meat Type Chicken Production	Proteins
112330	Turkey Production	Proteins
112340	Poultry Hatcheries	Proteins
112390	Other Poultry Production	Proteins
112420	Goat Farming	Proteins
112930	Fur-Bearing Animal and Rabbit Production	Proteins
311111	Dog and Cat Food Manufacturing	Complex Carbohydrates
311119	Other Animal Food Manufacturing	Complex Carbohydrates
311221	Wet Corn Milling	Complex Carbohydrates
311224	Soybean and Other Oilseed Processing	Lipids
311225	Fats and Oils Refining and Blending	Lipids
311230	Breakfast Cereal Manufacturing	Simple and Complex Carbohydrates
311313	Beet Sugar Manufacturing	Complex Carbohydrates
311314	Cane Sugar Manufacturing	Complex Carbohydrates
311340	Nonchocolate Confectionery Manufacturing	Simple Carbohydrates
311351	Chocolate and Confectionery Manufacturing from Cacao Beans	Simple Carbohydrates
311352	Confectionery Manufacturing from Purchased Chocolate	Simple Carbohydrates
311411	Frozen Fruit, Juice, and Vegetable Manufacturing	Simple Carbohydrates
311412	Frozen Specialty Food Manufacturing	Simple and Complex Carbohydrates
311421	Fruit and Vegetable Canning	Complex Carbohydrates
311422	Specialty Canning	Complex Carbohydrates
311423	Dried and Dehydrated Food Manufacturing	Proteins
311511	Fluid Milk Manufacturing	Proteins
311512	Creamery Butter Manufacturing	Proteins
311513	Cheese Manufacturing	Proteins
311514	Dry, Condensed, and Evaporated Dairy Product Manufacturing	Proteins
311520	Ice Cream and Frozen Dessert Manufacturing	Proteins

NAICS Code	NAICS Code Description	Excess Food Characteristics
311611	Animal (except Poultry) Slaughtering	Proteins
311612	Meat Processed from Carcasses	Proteins
311613	Rendering and Meat Byproduct Processing	Proteins
311615	Poultry Processing	Proteins
311710	Seafood Product Preparation and Packaging	Proteins
311811	Retail Bakeries	Simple Carbohydrates
311812	Commercial Bakeries	Simple Carbohydrates
311813	Frozen Cakes, Pies, and Other Pastries Manufacturing	Simple Carbohydrates
311821	Cookie and Cracker Manufacturing	Simple Carbohydrates
311824	Dry Pasta, Dough, and Flour Mixes Manufacturing from Purchased Flour	Simple and Complex Carbohydrates
311830	Tortilla Manufacturing	Simple and Complex Carbohydrates
311911	Roasted Nuts and Peanut Butter Manufacturing	Simple Carbohydrates
311919	Other Snack Food Manufacturing	Simple Carbohydrates
311920	Coffee and Tea Manufacturing	Complex Carbohydrates
311930	Flavoring Syrup and Concentrate Manufacturing	Simple Carbohydrates
311941	Mayonnaise, Dressing, and Other Prepared Sauce Manufacturing	Complex Carbohydrates
311942	Spice and Extract Manufacturing	Others
311991	Perishable Prepared Food Manufacturing	Simple Carbohydrates
311999	All Other Miscellaneous Food Manufacturing	Others
312120	Breweries	Simple Carbohydrates
312130	Wineries	Simple Carbohydrates
325193	Ethyl Alcohol Manufacturing	Simple Carbohydrates
Food Wholesalers and Distributors		
424410	General Line Grocery Merchant Wholesalers	Mixed
424420	Packaged Frozen Food Merchant Wholesalers	Mixed
424430	Dairy Product (except Dried or Canned) Merchant Wholesalers	Proteins
424440	Poultry and Poultry Product Merchant Wholesalers	Proteins
424450	Confectionery Merchant Wholesalers	Simple Carbohydrates
424460	Fish and Seafood Merchant Wholesalers	Proteins
424470	Meat and Meat Product Merchant Wholesalers	Proteins
424480	Fresh Fruit and Vegetable Merchant Wholesalers	Complex Carbohydrates
424490	Other Grocery and Related Products Merchant Wholesalers	Mixed
424510	Grain and Field Bean Merchant Wholesalers	Complex Carbohydrates
424520	Livestock Merchant Wholesalers	Proteins
424810	Beer and Ale Merchant Wholesalers	Simple Carbohydrates

NAICS Code	NAICS Code Description	Excess Food Characteristics
424820	Wine and Distilled Alcoholic Beverage Merchant Wholesalers	Simple Carbohydrates
424910	Farm Supplies Merchant Wholesalers (Animal feeds (except pet food)	Proteins, Complex Carbohydrates
424930	Flower, Nursery Stock, and Florists' Supplies Merchant Wholesalers	Ligno-cellulosic
445110	Supermarkets and Other Grocery (except Convenience) Stores	Complex Carbohydrates
445210	Meat Markets	Proteins
445220	Fish and Seafood Markets	Proteins
445230	Fruit and Vegetable Markets	Complex Carbohydrates
445291	Baked Goods Stores	Simple Carbohydrates
445292	Confectionery and Nut Stores	Simple Carbohydrates
445299	All Other Specialty Food Stores	Simple Carbohydrates
Educational Institutions		
611110	Elementary and Secondary Schools	Complex Carbohydrates, Proteins
611310	Colleges, Universities, and Professional Schools	Complex Carbohydrates, Proteins
Hospitality Industry		
713210	Casinos (except Casino Hotels)	Complex Carbohydrates
721110	Hotels and Motels	Complex Carbohydrates, Proteins
721120	Casino Hotels	Complex Carbohydrates, Proteins
Correctional Facilities		
922140	Correctional Institutions (Prisons)	Complex Carbohydrates, Proteins
Healthcare Facilities		
622110	General Medical and Surgical Hospitals	Complex Carbohydrates, Proteins
Food Services Sector		
722310	Food Service Contractors	Complex Carbohydrates, Proteins
722320	Caterers	Complex Carbohydrates, Proteins
722511	Full-Service Restaurants	Complex Carbohydrates, Proteins
722513	Limited-Service Restaurants	Complex Carbohydrates, Proteins
722514	Cafeterias, Grill Buffets, and Buffets	Complex Carbohydrates, Proteins
722515	Snack and Nonalcoholic Beverage Bars	Complex Carbohydrates, Proteins

Appendix C: Glossary

The definitions below are specifically tailored to the scope and aims of this paper.

AgSTAR: An EPA effort that promotes the use of biogas recovery systems to reduce methane emissions from livestock waste. AgSTAR assists those who enable, purchase or implement anaerobic digesters by identifying project benefits, risks, options and opportunities. AgSTAR also provides the Livestock Anaerobic Digester Database that offers basic information about anaerobic digesters on livestock farms in the United States.

ANAEROBIC DIGESTION: The biochemical decomposition of organic matter into methane gas and carbon dioxide by microorganisms in the absence of air.

ANTHROPOGENIC METHANE EMISSIONS: Methane (CH4), a potent greenhouse gas, emitted due to human activities.

COMPOST: An organic (derived from living matter) material that can be added to soil to help plants grow by enriching the soil, retaining moisture, suppressing plant diseases and pests, reducing the need for chemical fertilizers and encouraging the production of beneficial bacteria and fungi.

COMPOSTING: A process of combining organic wastes such as excess food, yard trimmings, and manures, in the right ratios into piles, rows, or vessels and adding bulking agents such as wood chips to create a soil amendment.

EDIBLE EXCESS FOOD: Food suitable for human consumption at or near the time of disposal, and suitable for donation or sale to secondary markets.

EXCESS FOOD: For purposes of this project, the phrase "excess food" generally refers to post-harvest food that is intended for human consumption but not eaten as originally intended and which then needs to be recovered, recycled, or disposed of safely.

Because EPA's goal is to maximize recovery and beneficial use of all discarded organics, some organic materials were included in this project that are not intended for human consumption, such as inedible parts (e.g., pits, rinds, bones), some green organic material (e.g., flower trimmings), pet food, and collected yard waste. The following materials were not included in this report's definition of excess food: unharvested crops, on-farm processing scraps, and used cooking oil (recycled for animal feed or biofuel).

"Wasted food", "food waste", "surplus food", or "excess food" are terms commonly used to describe food that is not eaten as originally intended. The terms "surplus food" or "excess food" are often used to describe wholesome, nutritious food when discussing food recovery for donation to feed people while the term "food waste" is commonly used to describe food unfit for human consumption that is recycled or sent for disposal. Food waste may be sent to feed animals, for composting, or to an anaerobic digester.

EXCESS FOOD GENERATION FACTORS: The values used to estimate excess food generation rates. Sector-specific surveys and/or literature-reported values were used to extract theses values which are consistent across a sector for each establishment. Examples of excess food generation factors are amount of excess food per meal, meals per seat per day, amount of excess food per employee per year, amount of excess food per student per year.

FOOD LOSS: As defined by the USDA, the edible amount of food, postharvest, that is available for human consumption but is not consumed for any reason. It includes cooking loss and natural shrinkage (for example, moisture loss); loss from mold, pests, or inadequate climate control; and excess food.

FOOD RECOVERY: The action of collecting excess food to feed people or animals.

MUNICIPAL SOLID WASTE (MSW): Garbage or refuse generated by households, commercial establishments or institutional facilities.

ORGANIC RESIDUALS: Materials such as biosolids, composts, excess food, and yard trimmings.

ORGANIC WASTE: Any discarded material that can decompose.

ORGANICS: Materials such as excess food, yard waste, food, plant based materials, animal feed, animal waste, wood, paper, and cardboard.

PLATE WASTE: Postconsumer leftover food, or food that has been served and not eaten. Also known as “front of house” excess food.

VARIABLES: The parameter used for excess food estimation, which varies for each establishment across the sector. For example, number of students or number of employees.