FOOD LOSS AND WASTE GENERATION STUDY

Maine Department of Environmental Protection

PREPARED BY:

RRS | recycle.com

commissioned BY:

MAINE DEPARTMENT OF Environmental Protection

Executive Summary

Background: Organic waste, which constitutes over 40% of solid waste in Maine, poses serious environmental, economic, and societal issues. In response to this, the State of Maine Department of Environmental Protection commissioned an extensive study to gain deeper insights into the origins, quantities, types, and quality of surplus food, food scraps, and food waste tied to processing practices.

About the Study: Conducted between December 2023 and April 2024 ("the Study"), aimed to understand food loss and waste production across various sectors including residential, institutional, and commercial. It quantified total food loss and waste, broken down by subsector, with subsequent generation trends and characteristics. The insights will inform strategies and necessary infrastructures to reduce, recover, and recycle food loss and waste, along with mitigating greenhouse gas emissions. The research was executed by Resource Recycling Systems (RRS), the University of Maine Senator George J. Mitchell Center for Sustainability Solutions, and the Center for EcoTechnology, with support from the Maine Governor's Office of Policy Innovation and the Future and funding from the EPA's Climate Pollution Reduction Grant program.

Methods: The methodology involved a multi-step process to quantify food waste generation across sectors, which included residents, large multi-family complexes, farms, food manufacturers, grocery stores, among others. Sector-specific generation factors were identified and selected from existing literature. Preliminary estimates were compared with known and published data, and direct interviews contributed refinements such that the final estimates should serve as the most accurate estimates presently available to guide stakeholders in focusing food waste reduction efforts, considering the myriad factors that dictate actual surplus food production rates.

Key Findings: The findings of this study represent best estimates and are intended to provide guidance to stakeholders on where to concentrate efforts to reduce food waste, considering the numerous variables that influence actual surplus food generation rates.

- Approximately 361,000 tons of food loss and waste are generated annually in Maine.
- The residential and agricultural sectors are the most significant contributors, together producing 61% of Maine's food loss and waste.
- Commercial businesses are responsible for 130,846 tons, 37% of the total waste, with grocery and food manufacturing being the major contributors.
- An estimated 40,603 tons of food loss and waste are generated from 431 food manufacturing entities annually, equating to 11% of the total.
- Commercial food loss and waste are most prevalent in Cumberland and York counties, which have the highest population density and concentration of businesses.

Processing Capacity: Addressing food loss and waste requires strategic partnerships with entities like source reduction technologies, food recovery organizations, animal feed operations, composting facilities, and anaerobic digestion sites. Enhancing strategies across the EPA Wasted Food Scale is vital for mitigating and processing food loss and waste. The potential to recover 43,000 tons of edible surplus annually has been indicated by food recovery organizations. Currently, eight facilities in Maine are operational and have the capacity to process 83,600 tons of wasted food annually. To maximize impact, investments should focus on supporting efforts to reduce surplus first and foremost, expanding infrastructure across the Wasted Food Scale, and leveraging existing momentum in the state. The Study findings will guide strategic planning and investment, highlighting potential infrastructure development areas and impact zones based on food waste generation and quality.

Key Findings by County & Sector: Table 1 below offers a detailed assessment of the food loss and waste produced annually (TPY) within the highlighted sectors and delineates the counties in Maine where this waste is predominantly generated. Some key findings include:

- The largest source of food loss originates from Farms & Commercial Agriculture, with most in Aroostook (54,363 TPY),
- Residences account for a substantial portion of food waste, highest in Cumberland (27,747 TPY),
- Food Manufacturers contribute significantly highest loss in Cumberland County (18,487 TPY),
- Grocery Stores and Restaurants generate 37,955 TPY and 19,423 TPY, respectively, and,
- Food Distributors and K-12 Schools, primarily in Cumberland County, account for 3,393 TPY and 888 TPY, respectively.

Table 1: Annual Food Loss and Waste by Sector & County (Tons)

	Androscoggin (TPY)	Aroostook (TPY)	Cumberland (TPY)	Franklin (TPY)	Hancock (TPY)	Kennebec (TPY	Knox (TPY)	Lincoln (TPY)	Oxford (TPY)	Penobscot (TPY)	Piscataquis (TPY)	Sagadahoc (TPY)	Somerset (TPY)	Waldo (TPY)	Washington (TPY)	York (TPY)	Total (TPY)
Residences	10,047	6,686	27,747	2,897	9,019	11,963	4,035	3,569	5,551	10,964	1,722	3,628	4,945	3,877	3,105	19,843	**129,598**
Farms & Commercial Agriculture	3,976	54,363	1,045	37	7,816	1,272	2,381	64	6,311	4,986	658	12	765	157	6,179	448	**90,470**
Food Manufacturers	3,130	3,777	18,487	118	711	324	212	234	335	928	24	73	416	316	5,363	6,157	**40,603**
Grocery Stores	2,657	2,033	11,260	844	1,597	2,754	1,223	1,147	890	4,513	982	420	1,090	709	837	4,998	**37,955**
Restaurants	1,321	473	6,571	251	814	1,681	723	454	478	2,186	122	239	381	273	211	3,245	**19,423**
Hotels	250	263	3,575	212	1,274	406	611	428	470	1,144	80	181	201	163	142	2,189	**11,589**
Food pantries/ banks	1,455	968	1,230	314	419	1,047	340	262	733	1,047	183	131	419	366	288	707	**9,908**
Food Distributors	216	386	3,393	4	428	125	322	77	84	614	1	54	272	61	500	1,076	**7,615**
K-12 Schools	386	199	888	73	155	369	122	129	214	505	46	101	170	85	91	668	**4,200**
Hospitals	302	146	740	49	81	313	95	57	83	344	31	53	63	38	60	286	**2,742**
Large Office Buildings	325	66	1,106	66	92	518	31	9	26	230	-	31	35	28	-	115	**2,680**
Large Residential Buildings	221	51	1,229	8	46	76	10	6	39	147	1	22	14	1	6	272	**2,149**
Universities	93	66	385	32	233	147	1	-	-	102	-	-	37	-	22	139	**1,256**
Sports Arena & Large Festivals	122	6	260	9	1	185	8	-	47	288	2	16	10	10	3	108	**1,074**
Correctional Facilities	-	-	78	-	-	-	121	-	-	40	-	-	-	-	5	-	**244**
Total (excluding Farms & Residence)	10,479	8,436	49,201	1,980	5,852	7,943	3,818	2,802	3,398	12,088	1,471	1,322	3,108	2,051	7,528	19,960	**141,438**
Total (including Farms & Residence)	**24,501**	**69,486**	**77,993**	**4,914**	**22,687**	**21,178**	**10,235**	**6,435**	**15,261**	**28,038**	**3,850**	**4,962**	**8,818**	**6,085**	**16,813**	**40,250**	**361,506**

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BACKGROUND AND PURPOSE

Organic waste represents a considerable part of Maine's solid waste stream, as food scraps and related wastes, together with other organic materials, account for approximately 40% of the total waste generated. The production of food that subsequently becomes waste contributes substantially to climate change. Carbon dioxide emissions result from energy-intensive agricultural practices such as mechanization and irrigation, along with the creation of inputs such as fertilizers, herbicides, and pesticides. Additional greenhouse gases, such as methane and nitrous oxide, which possess a far greater potency than carbon dioxide, emerge from livestock and certain production methods, as well as from the use of synthetic fertilizers. Furthermore, the transformation of forests and natural landscapes into agricultural land triggers a significant diminishment of natural carbon sinks. Consequently, the cultivation and distribution of food that is ultimately wasted have highlighted the pressing need for effective waste management strategies.

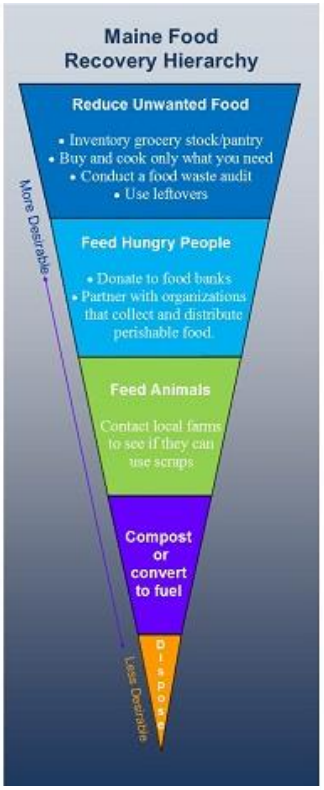

Figure 1: Maine Food Recovery Hierarchy

The consequences of food waste extend beyond the farm as products move through the value chain - shipment, transportation, storage, refrigeration, processing, packaging, and marketing - multiple environmental impacts accrue. These encompass energy consumption and emissions from transportation and refrigeration, waste generation during processing and packaging. Downstream, the disposal uneaten food compounds the impacts from waste management processes and methane generation in landfills. These climate impacts are notable, with over 6% of U.S. greenhouse gas emissions stemming from food loss and waste across the supply chain.[1]

The Food Recovery Hierarchy codified in Maine law and shown in Figure 1 is used as a tool in guiding further legislation regarding diversion of organics and waste management.[2] In 2020, the state of Maine adopted the "Maine Won't Wait" climate plan to reduce carbon emissions, increase the use of renewable sources of energy, and mitigate climate change, setting ambitious actionable targets to achieve by 2030.[3] Further, the 2019 Maine Solid Waste Management and Recycling Plan prioritizes strategies focused on continued focus on **increasing the diversion of organics from** disposal and increasing waste reduction, food rescue and reuse initiatives.[4]

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[1] ReFED. "Slow Progress, Big Opportunities in Food Waste Reduction: Insights from ReFED's Food Loss and Waste Estimates for 2022." December 18, 2023. https://refed.org/articles/slow-progress-big-opportunities-in-food-waste-reduction-insights-from-refed-s-food-loss-and-waste-estimates-for-2022/

2 Maine 127th Legislature. *Laws of the State of Maine as Passed by the One Hundred and Twenty-Seventh Legislature*. [Second regular session January 6, 2016 to April 29, 2016.] Revisor of Statutes, 2016. https://legislature.maine.gov/doc/1211.

3 Government of Maine. "Inspiring Climate Action for Maine." Maine Climate Plan. https://www.maine.gov/climateplan/.

4 Maine DEP. *2024 State Waste Management and Recycling Plan Update and 2022 Waste Generation and Disposal Capacity Report* [Report to the Joint Standing Committee on the Environment and Natural Resources. 131st Legislature, Second Session.] January 2024. https://www.maine.gov/dep/publications/reports/index.html.

Other notable progress to date includes the adoption food scrap composting pilot projects, publication by the Maine Department of Environmental Protection (DEP) of the Guide to Recovering and Composting Organics in Maine, and administration of Maine's Solid Waste Diversion Grant Program which helps fund composting and organics recover programs among other efforts. [5,6] Significant research and convening was also conducted by the University of Maine Senator George J. Mitchell Center for Sustainability Solutions. Exemplary work from the Center includes hosting an annual Maine Food Waste Solutions Summit from 2021, identifying and piloting six solutions to wasted food, and launching a food rescue software system for the state.

In early 2024, Maine Representative Stanley Zeigler, D-Montville introduced a statewide bill to reduce and recycle wasted food. If passed, Maine would become the final state in New England to enact an organic recycling law. In addition, U.S. Representatives Chellie Pingree (D-Maine) and Mike Lawler (R-N.Y.) are advocating for food waste recovery at the national level, having introduced the New Opportunities for Technological Innovation, Mitigation, and Education to Overcome Waste Act (No Time to Waste Act) with goals to reduce food loss and food waste by 50% by 2030.[7]

Maine's food recovery hierarchy serves to inform and guide state policies. The hierarchy prioritizes strategies such as reducing the production of surplus food at the source, donating surplus edible food to organizations that feed the hungry, diverting food scraps for animal feed, utilizing waste oils and scraps for energy recovery, and composting to create nutrient-rich soil amendments. The overarching goal is to minimize the disposal of food waste in landfills and incinerators, emphasizing reduction, recovery, recycling, and moving food waste to its highest and best use.

While many communities in Maine are already familiar with composting leaf and yard waste, there is potential for expanding these programs to include the collection of food scraps. Likewise, many commercial businesses and institutions have adopted programs to reduce and divert surplus food and waste, further opportunities are abundant.

To inform policy, infrastructure and funding decisions, the DEP commissioned this study to characterize the sources, quantity, quality, and types of surplus food, food scraps, and food processing-related wastes. This study analyzes food waste generation across the residential, institutional, and commercial sectors, seeking to document total food waste generation, generation by subsector, trends and frequencies of generation, as well as food waste characteristics to inform the selection of preferred management practices.

Study Objectives

The primary objective of this study is to comprehensively inventory and characterize surplus food generation and food waste in Maine. Specifically, it seeks to identify and quantify sources, quantity, quality, and types of surplus food, food loss, and food processing-related wastes in Maine, while examining current disposal methods. This study

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5 Maine 127th Legislature. *Laws of the State of Maine as Passed by the One Hundred and Twenty-Seventh Legislature*. [Second regular session January 6, 2016 to April 29, 2016.] Revisor of Statutes, 2016. https://legislature.maine.gov/doc/1211.

6 King, Mark A. and George M. Macdonald. *Guide to Recovering and Composting Organics in Maine*. Maine DEP, March 2016. https://www.maine.gov/dep/sustainability/compost/compost_guide2016.pdf.

7 Chellie Pingree – 1st District of Maine. "Reps. Pingree, Lawler Introduce Bipartisan, Bicameral Bill to Curb Food Waste." Press Releases, September 21, 2023. https://pingree.house.gov/news/documentsingle.aspx?DocumentID=4956.

aims to determine the annual generation of these wastes in commercial, residential, and institutional sectors. Additionally, the Study will help the State of Maine Department of Environmental Protection evaluate the potential greenhouse gas emissions impact associated with reducing, rescuing or diverting surplus food and food scraps to higher and better uses. Results can be used to determine reduction, collection and processing infrastructure needs as well as serve as a reference for policy making in the context of Maine's waste management system. Ultimately, findings are intended to help reduce surplus food generation and enhance the recovery of food waste for beneficial uses, such as addressing food insecurity, providing livestock feed, and enhancing local soil health.

Terminology and Acronyms

Anaerobic Digestion – Biological process and class of technologies that breaks down organic materials, such as food waste, agricultural residues, and wastewater, in the absence of oxygen to produce biogas and nutrient-rich digestate. This process is carried out by a diverse group of microorganisms that thrive in oxygen-free environments and work together to decompose organic matter.

Avoidable/Unavoidable Food Waste – Avoidable food loss and waste refers to food that could have been consumed or put to beneficial uses but is discarded instead. Overproduction and over purchasing, which occurs in households, commercial businesses, and institutions is included in avoidable food waste. This includes food loss and waste that could have been prevented through improved meal planning, storage practices, or portion sizes. Unavoidable is characterized predominantly by the food products that are not typically consumed, including inedible parts of fruits, vegetables, and animals.

Composting- The controlled aerobic decomposition of organic materials to produce a soil-like product beneficial to plant growth and suitable for agronomic use.

Diversion Activities – Methods of preventing, redistributing, and repurposing surplus food and waste. Activities include donating or upcycling edible foods, source separating food for livestock, sending material for composting or anaerobic digestion.

Edible/Non-Edible Food Waste – The edibility of food is determined through a qualitative assessment of the food waste, considering whether it is suitable for immediate human consumption or use in upcycled food products, suitable for animal feed, or not suitable for consumption but may be diverted from disposal through anaerobic digestion or composting.

Food Loss/Waste – Food intended for human consumption that is ultimately not consumed by humans and is either landfilled or recycled. Surplus food can both be an opportunity and a loss, depending on how the food is managed.

Generation Hotspots – Locations, businesses, and organizations that see the highest levels of food waste generation.

Generation Factor – The per unit number of a relevant sector, such as full-time employees, bed count, meals served, etc. to calculate estimated food waste generated.

NAICS Codes – North American Industry Classification System Codes; standardized classification system used to categorize businesses and industries in North America.

Offer versus Serve (OVS) – A provision in the National School Lunch Program (NSLP) and School Breakfast Program (SBP). It allows students to decline some of the food offered in a reimbursable lunch or breakfast. The

goals of OVS are to reduce food waste and food costs without jeopardizing the nutritional integrity of the meals served.

Pre/Post-Consumer Food Waste – Pre-consumer food waste consists of surplus food and food scraps that are produced before it reaches the end consumer, such as food prepared in the kitchen before being served to customers. Post-consumer that are generated after it reaches the consumer, such as plate scrapings.

Predictable/Unpredictable Food Waste – Predictable food waste is anticipated based on factors such as seasonality and expected surplus, such as the influx of surplus blueberries during the growing season. In contrast, unpredictable food waste may arise from unforeseen events like power outages or unexpected weather catastrophes. This characterization intends to highlight the timing of potential surplus food each year, as well as the processing capacity needed to address unforeseen circumstances that might contribute to unpredictable food waste.

Surplus Food – Food that is unsold or unused by a business, or food that is not eaten at home. Surplus food includes edible parts that are redistributed for human consumption, fed to animals, repurposed to other products.

METHODOLOGY

RRS conducted an analysis of food waste across the state of Maine ("the Study"), informed by a synthesis of existing literature and supplemented by state-specific studies, independent research, and stakeholder interviews. The Study, conducted between December 2023 and April 2024, was aimed at providing a robust estimate of surplus food and waste generated across selected sectors.

Preliminary estimates were formed by incorporating industry-specific assumptions from existing literature, thereby establishing a baseline understanding of food loss and waste in Maine. Data sources were used from public, private, and governmental institutions, in conjunction with previous RRS studies of food waste generation, characterization and management. A sensitivity analysis was subsequently conducted to accommodate the diverse data, including state-specific studies conducted by the University of Maine.

Data from national databases, such as the EPA Excess Food Opportunities Map, ReFED's Insights Engine, the Maine Solid Waste Generation and Disposal Capacity Reports were factored into modeling.[8,9,10] As a key collaborator, the University of Maine contributed data from its residential, commercial and institutional food waste studies and pilot programs. The data, aggregated on a statewide level, provided a comprehensive understanding of the volume of food loss and waste and identified regional hotspots. This information was instrumental in informing

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8 National Risk Management Research Laboratory – Land Remediation and Pollution Control Division. *Excess Food Opportunities Map – Technical Methodology*. US EPA, August 2023. https://www.epa.gov/sites/default/files/2018-06/documents/efom_methods_report_final_4-4-18_v5_508compliant.pdf.

9 ReFED. *ReFED Insights Engine*. https://insights.refed.org/?_ga=2.140367731.1514327391.170864244965549059.1706018543&_gac=1.112963190.1708642449.CjwKCAiA_tuuBhAUEiwAvxkgTilsUNqnk31ws3UCRKe7fcWRC2pTdYVBCCDNsdpvEbVDTI2XVvl9IxoChxYQAvD_BwE.

10 Maine DEP. *Maine Solid Waste Generation and Disposal Capacity Report for Calendar Years 2018 & 2019*. [Report to the Joint Standing Committee on the Environment and Natural Resources. 130th Legislature, First Session.] January 2021. https://www.maine.gov/dep/publications/reports/index.html.

specific sectors of interest for further study and served as a foundational dataset for comparative analyses during the literature review, interviews, site assessments and model development.

Refinements to the estimates were made using feedback from direct interviews with stakeholders within the sectors under analysis. Potential organizations were identified via the Dunn & Bradstreet business database with input from the State of Maine Department of Environmental Protection and the University of Maine to prioritize outreach to entities predicted to be the largest waste generators or those believed to have the most relevant data.[11] The University of Maine also provided many individual contacts, introductions, and select interviews. Tailored interview guides were developed for each sector, aiming to fill data and informational gaps to round out the model. These interviews were conducted via teleconference and online surveys. In addition to interviewing target industrial, commercial, and institutional sectors, the project team interviewed primary food waste haulers and processors operating in the state.

Sectors of interest, identified by Maine Department of Environmental Protection, included residences, farms, schools and universities, correctional facilities, hospitals, large office buildings, large multi-family complexes, food manufacturers, groceries, food distributors, restaurants, hotels, sports arenas & festivals, and food banks. The selected sectors were evaluated by size, utilizing universally accessible units of measurement such as the number of households, students, or employees. These measurements served as the foundation for the estimates of food waste generation. Upon completion of the sector sizing, generation factors were applied to ascertain the quantities of wasted food. Multiple generation factors were researched and critiqued for each sector. Generation factors were sourced from a comprehensive review of literature, which included numerous studies acknowledged within the EPA's Food Waste Measurement Methodology scoping memo.[12] This approach ensured that the estimates produced were both reliable and robust.

Throughout the process, the Center for EcoTechnology (CET) conducted interviews with multiple stakeholders, including representatives from the sectors of interest. These discussions yielded valuable insights and firsthand accounts, which served primarily to refine the data and contribute qualitative characteristics of food loss and waste. The amalgamation of established literature, original research, and stakeholder interviews not only enhanced the reliability of the Study but also ensured broad representation of the multifaceted issues influencing food loss and waste in the state.

Numbers derived from this study should be perceived as baseline estimates rather than precise figures. The methodology of the Study incorporates data from various sources, including secondary research on generation rates, employment counts, and reported revenues. Due to the generalized nature of this data, it may not be specifically applicable to the state of Maine or individual entities within Maine. Furthermore, the use of sector-related proxies, as opposed to actual waste tonnages or characterization work derived from waste sorts, introduces a margin of error into each estimate. To provide context for this margin of error, the sector results presented in Appendix A demonstrate the potential influence of different approaches or assumptions.

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11 Dun & Bradstreet. *D&B Hoovers*. Accessed December 2023-March 2024. https://www.dnb.com/products/dnb-hoovers.html.

12 Fabiano C; Meyer E; Carusiello C; Rubright T; Industrial Economics, Inc. *Wasted Food Measurement Methodology Scoping Memo*. US EPA, July 2020. https://www.epa.gov/sites/default/files/202006/documents/food_measurement_methodology_scoping_memo-6-18-20.pdf.

Finally, primary sector feedback was gathered to validate estimates. It should be noted that the number of interviews conducted was by no means statistically representative of the sectors at large. In total, 70 interviews were conducted across these target sectors. Interviews included calls and survey responses from four municipalities, seven schools and universities, three correctional facilities, five restaurants, three grocery stores, three food wholesalers, one hospital, one sports arena, fourteen food processors, one farm, twenty-one food pantries, two large commercial offices, and five service providers.

Results should therefore always be interpreted in context, leaving room for variation, particularly at the individual entity level. Nevertheless, numbers are assessed to be of reasonable quality to serve as a guide for stakeholders on where to focus food waste efforts, in a reality where resource intensive data collection efforts remain impractical in accommodating the host of variable factors affecting actual surplus food generation rates to derive a better estimate.

Methodology: Generation by Sector

The process of quantifying the food waste produced by each sector involved four primary steps:

1. **Identification and Selection of Generation Factors:** A thorough review of the literature was conducted to identify existing generation factors for use in calculating food waste generation across various sectors. Generation factors may include the number of full-time employees, revenue, meals served, etc. depending on the sector.

    - For 13 out of the 15 sectors (all except Farms and Food Banks) the EPA's Wasted Food Measurement Methodology was utilized since it is considered to be a comprehensive collection of relevant published literature.[13] The document aggregates existing U.S. based literature and highlights those with relevant quantitative studies to calculate excess food and food waste. Furthermore, the document aligns with the global Food Loss and Waste Accounting and Reporting Standard ("FLW Standard") and is taken to be the equivalent guidance for U.S. based studies.[14] For each sector, the literature was thoroughly reviewed and the most valid studies for application in Maine were selected. Following the synthesis of the individual studies that underlie the average generation factor calculated by the EPA, the most appropriate methodology for each sector was identified. From there, a range of estimates were computed in context of Maine using state-specific studies, individual business-level data within the state, as well as primary data from interviews conducted. The High, Low and 2024 ME DEP Study Estimate (that is recommended by the project team as the most plausible number) is presented as results of the Study.

13 Fabiano C; Meyer E; Carusiello C; Rubright T; Industrial Economics, Inc. *Wasted Food Measurement Methodology Scoping Memo*. US EPA, July 2020. https://www.epa.gov/sites/default/files/202006/documents/food_measurement_methodology_scoping_memo-6-18-20.pdf.

14 Hanson, C., Lipinski, B., Robertson, K., Dias, D., Gavilan, I., Gréverath, P., Ritter, S., Fonseca, J., VanOtterdijk, R., Timmermans, T., Lomax, J., O'Connor, C., Dawe, A., Swannell, R., Berger, V., Reddy, M., Somogyi, D., Tran, B., Leach, B., & Quested, T. *Food Loss and Waste Accounting and Reporting Standard*. Food Loss + Waste Protocol, 2016. https://www.wri.org/research/food-loss-and-waste-accounting-and-reporting-standard.

- For Farms and Commercial Agriculture: ReFED's "Food Waste Monitor" methodology on estimating Farm Surplus was determined to be the most comprehensive and accessible literature published on this sector to date.[15] The estimate was combined with USDA data to better understand the geographical spread of surplus food generated by this sector.
- For Food Banks/Pantries: The food waste generation methodology for food banks was developed with information gathered from a prominent regional food bank. For food pantries, additional interviews were conducted to determine typical waste generation factors for these entities.
- Estimates presented within this report represent the total food waste generation prior to any diversion activities.
- Details of generation factors and estimates per sector can be found in Appendix A: Methodology and Detailed Results by Sector.

2. **Data compilation:** This process involved compiling pertinent data from Maine-based sources to derive initial estimates.

    - A combination of business databases including D&B Hoovers and IBISWorld was used in 5 out of 13 sectors (Food Manufacturers, Groceries, Food Distributors, Restaurants and Hotels).[16,17] The D&B Hoovers database was cross-referenced with data published by the state of Maine to curate a dataset for the Large Offices sector. It should be noted that the estimates derived from these two databases exhibit significant variance.
        - IBISWorld provides credible market research in the form of industry reports by leveraging publicly accessible secondary sources, industry contacts, associations, and proprietary sources. Study analysts determined that some data points, particularly revenue numbers, appear to be overstated, likely a result of capturing the financial reporting of parent companies or groups rather than individual entities.
        - D&B Hoovers maintains an extensive database of both public and private companies. The database is updated with information from publicly available registers, public data sources as well as from direct questions to relevant company personnel or a network of data suppliers. After a quality check of the data lists, this database was found to be most reliable for the purpose of this study which required numbers for specific single-site entities. Where there were missing values, companies were excluded or filled in with average ratios.
    - Each sector includes a statistical analysis that compared the data, featuring the final estimation, and the estimates derived from industry and state-specific studies.

3. **Validation of Data**: Data validation was an important step throughout the analysis. Preliminary estimates were cross referenced, where possible, with other existing food waste studies and data specific to Maine as well as through direct conversations within target sectors. These include:

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15 ReFED. "Food Waste Monitor." ReFED Insights Engine, 2022. https://insights-engine.refed.org/food-waste-monitor?view=overview&year=2022.

16 Dun & Bradstreet. *D&B Hoovers*. Accessed December 2023-March 2024. https://www.dnb.com/products/dnb-hoovers.html.

17 Ibis World. [Industry Reports.] Accessed December 2023-March 2024. https://www.ibisworld.com.

- Publicly available data from the EPA's "Excess Food Opportunities Map" by sector. [18]
- Publicly available data from ReFED's "Food Waste Monitor" by sector. [19]
- Latest available data from the University of Maine's "Maine Circular Food System & Resource Locator GIS Map" by sector.[20]
- Findings and insights from additional studies, referenced throughout the Study.
- Specific data provided from over seventy interviews conducted by the project team.

4. **Estimate finalization:** Adjustments were made to the preliminary estimate to provide the most current "best estimate" for the sector.

Methodology for Estimating Diversion Activities

In addition to estimating generation, notable food waste diversion activities were identified. The Center for EcoTechnology (CET) conducted comprehensive interviews with compost facilities, food recovery organizations, and haulers to estimate diversion rates in the state, guided by RRS and the University of Maine's recommendations. These results were cross-referenced with the prior state waste characterization study for comparison.[21] These interviews with service providers help to assess current diversion activities, common challenges or interests, and key sectors of interest. Understanding the available infrastructure and resources for managing food loss and waste helps identify where additional infrastructure is needed, promotes educational opportunities to reduce contamination, and serves as a resource that may help the affected parties employ these solutions successfully.

Methodology for Estimating Food Waste Characteristics

Finally, food waste was evaluated according to three primary characteristics: (A) avoidable or unavoidable, (B) predictable or unpredictable, and (C) edibility. The significance of this assessment lies in informing the potential for rescuing edible portions, determining the types and scale of infrastructure required for recovery and processing, and guiding the development of appropriate waste management systems.

- **Avoidable vs Unavoidable:** Avoidable food waste encompasses discarded food that could have been prevented, consumed, or utilized beneficially. This includes surplus from overproduction or overordering, and waste that is preventable through enhanced meal planning, improved storage practices, or appropriate

18 National Risk Management Research Laboratory – Land Remediation and Pollution Control Division. *Excess Food Opportunities Map – Technical Methodology*. US EPA, August 2023. https://www.epa.gov/sites/default/files/2018-06/documents/efom_methods_report_final_4-4-18_v5_508compliant.pdf.

19 ReFED. "Food Waste Monitor." ReFED Insights Engine, 2022. https://insights-engine.refed.org/food-waste-monitor?view=overview&year=2022.

20 University of Maine – Mitchell Center for Sustainability Solutions. "Solution 4 Pilot – Pilot 5: Maine Circular Food System GIS Map and Resource Locator." Food Rescue MAINE, August 10, 2023. https://umaine.edu/foodrescuemaine/2023/08/10/pilot-5-maine-circular-food-system-gis-map-and-resource-locator/.

21 Criner, George K., Blackmer, Travis L. *2011 Maine Residential Waste Characterization Study*. [School of Economics Staff Paper #601.] University of Maine, School of Economics, 2012. https://umaine.edu/wp-content/uploads/sites/2/2017/04/2011-Maine-Residential-Waste-Characterization-Study.pdf.

portion sizes. Unavoidable food waste is primarily characterized by food products not typically consumed, such as inedible parts of fruits, vegetables, and animals.

- **Predictable vs Unpredictable:** Food waste was evaluated to discern between predictable and unpredictable instances. Predictable food waste is anticipated based on factors like seasonality and expected surplus, such as the influx of surplus blueberries during the growing season. Conversely, unpredictable food waste may arise from unforeseen events, including power outages or unexpected weather catastrophes. This distinction aims to emphasize the timing of potential surplus food each year, as well as the processing capacity needed to address unforeseen circumstances that might contribute to unpredictable food waste.
- **Edibility:** This refers to a qualitative assessment of the edibility of food waste, considering factors such as immediate human consumption, potential upcycling for human consumption, suitability for animal feed, or designation as inedible for processes like anaerobic digestion or composting. The Study, through interviews and examples, sought to illuminate the qualitative aspects of food waste.

The project team designed a set of interview questions encompassing various scenarios outlined above. These questions probed critical aspects such as the edibility of generated food waste and loss for either human consumption or livestock, the impact of unforeseen weather conditions causing power outages and subsequent overstock, and an approximate breakdown of the potential reduction achievable through the adoption of enhanced knife skills training or other interventions. The responses were then analyzed to either formulate qualitative descriptions delineating the characteristics of surplus food within each sector or, where feasible, provide estimated percentages as part of their comprehensive assessment.

Key Findings and Discussion

The Study goal was to conduct a comprehensive statewide study in Maine to characterize the sources, quantity, quality, location, and types of surplus food, food scraps, and food processing-related wastes. The Study intended to define the annual generation and characterization of food loss and waste in specific sectors, helping the Maine Department of Environmental Protection (DEP) assess the potential economic, feeding, and emissions impact of reducing and recovering avoidable surplus and diverting food scraps through recovery or recycling. In collaboration with Maine DEP, University of Maine, and Center for EcoTechnology, the analysis relied on industry data, state-specific studies, and direct interviews to estimate and characterize this material across various sectors in the state.

This comprehensive analysis also aimed to unearth key findings for further exploration. These findings will play a crucial role in shaping future policies, initiatives, and programs in Maine, with a focus on promoting reduction, recovery, and recycling of food loss and waste. This material includes avoidable surplus, as well as unavoidable, inedible food scraps.

The subsequent section is structured to provide a detailed overview of food loss and waste generated per sector, sector-specific findings, the geographic distribution of food waste, thresholds impacting businesses with regulatory requirements, characteristics of food loss and waste, seasonality considerations, case studies highlighting exemplary activities, existing processing infrastructure, and overall considerations derived from these findings.

Food Loss and Waste in Maine- Total

Overall, this study estimates food loss and waste in Maine to be approximately **361,506 tons per year** across all sectors (**271,036 tons per year**, excluding Farms). [22] This approach is based on identifying applicable generation factors and applying them to data specific to Maine for each sector. For comparison, the overall number is close to other established food waste estimates. This includes:

- the U.S. EPA's 328 pounds of food waste per person estimate from 2016 where, based on the US 2020 Census' Maine's population of 1,362,729, the surplus food generated by all sectors in the state of Maine, excluding Farms, should be about **223,488 tons per year** [23] and;
- falling within the range computed using the 5-year average of Maine Solid Waste Generation and Disposal Capacity Report for Calendar Years 2018-2022[24,25,26] (i.e., about 0.9 million tons per year) and the fraction of food waste reported by municipalities within the Maine Municipal Review Committee (17.5% to 25% of general municipal waste i.e., **between 157,500 to 225,000 tons per year.**)[27] This methodology of establishing a baseline comparison was corroborated in a Maine specific 2018 study on food waste. In that study, a range of 14.9% derived from a 2014 EPA estimate and 27.9% derived from the 2011 Maine Waste Composition Study, was applied to the MSW generated to compute a baseline understanding of the total amount of food waste generated by households and businesses within Maine.[28]

The ReFED's Insights Engine estimates the overall surplus food for the state of Maine to be **425,004 tons per year** in 2022.[29] The ReFED estimate is higher than this study's estimate mainly due to divergence in the "Residential" sector estimate. Where possible, ReFED's estimate is compared to this study's estimate at the sector-level in Appendix A.

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[22] Food loss from Farms are typically not captured under the MSW stream as they are left on the fields or "loss at source". WWF. "What farmers found when they measured fresh produce left in the field" March 15, 2022 https://www.worldwildlife.org/stories/what-farmers-found-when-they-measured-fresh-produce-left-in-the-field

23 US EPA. "United States 2030 Food Loss and Waste Reduction Goal." Last updated February 21, 2024. https://www.epa.gov/sustainable-management-food/united-states-2030-food-loss-and-waste-reduction-goal.

24 Maine DEP. *Maine Solid Waste Generation and Disposal Capacity Report for Calendar Years 2018 & 2019*. [Report to the Joint Standing Committee on the Environment and Natural Resources. 130th Legislature, First Session.] January 2021. https://www.maine.gov/dep/publications/reports/index.html.

25 Maine DEP. *Maine Solid Waste Generation and Disposal Capacity Report for Calendar Years 2020 & 2021*. [Report to the Joint Standing Committee on the Environment and Natural Resources. 131st Legislature, First Session.] January 2023. https://www.maine.gov/dep/publications/reports/index.html.

26 Maine DEP. *2024 State Waste Management and Recycling Plan Update and 2022 Waste Generation and Disposal Capacity Report*. [Report to the Joint Standing Committee on the Environment and Natural Resources. 131st Legislature, Second Session.] January 2024. https://www.maine.gov/dep/publications/reports/index.html.

27 Municipal Review Committee (MRC). "[Home] Now Is The Time To Join The MRC." Accessed March 7, 2024. https://www.mrcmaine.org/.

[28] University of Maine – Mitchell Center for Sustainability Solutions Cynthia Isenhour. LD 1534 Stakeholder Working Group "Waste is not the Maine way final report" [Report to the Natural Resources Council of Maine (NRCM)] January 10, 2018 https://www.nrcm.org/wp-content/uploads/2019/04/LD-524attachments.pdf

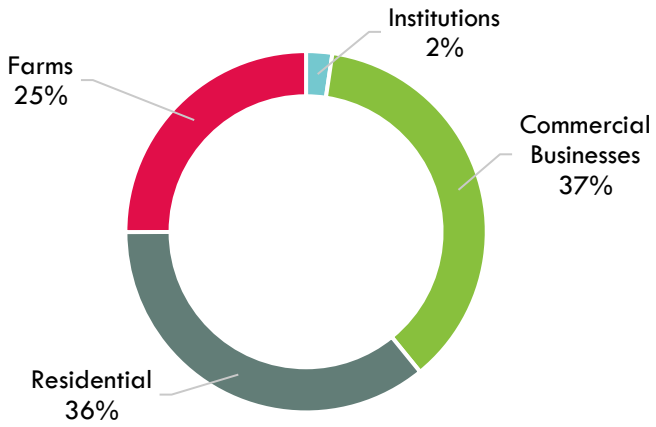
29 ReFED. "Food Waste Monitor." ReFED Insights Engine, 2022. https://insights-engine.refed.org/food-waste-monitor?view=overview&year=2022.

Food Loss and Waste in Maine- By Sector

Understanding the quantity of food loss and waste generated by sector as well as where the majority of food waste is generated is required to develop effective solutions for reducing and diverting food loss and waste. Policies and programs may vary depending on the sector. For example, a sector with large food loss and waste from many numerous small generators may pose challenges in enforcement and collection but have potential to collectively yield significant overall environmental impacts. On the other hand, a smaller sector generation with fewer individual businesses may support easier enforcement and collection but result in lower total diversion. Figure 2 presents the percentage of the food waste stream attributed to Residential, Agricultural, Institutional, and Commercial sectors.

- This study estimates that 361,506 tons of surplus food are generated annually across 593,081commercial businesses, institutions, and individuals (residential and farm or agriculture entities) in the state.
- The Residential sector and the Agricultural sector together comprise the largest generators of food waste by weight, together contributing 61% of the total waste generated.
- Commercial businesses (large office buildings, food manufacturers, grocery stores, food distributors, restaurants, hotels, food banks, and sports arenas) account for about 37% of total food waste generated. Grocery stores and food manufacturers make up the largest part of this sector.
- Institutions (k-12 schools, universities, correctional facilities, and hospitals) represent about 2% of the food waste generated.

Figure 2: Food Waste Generation by Major Sectors in Maine



The residential and farm sectors represent the two largest sources of surplus food within Maine. Table 2, below, delineates the quantity of food loss and waste generated by various sectors in Maine, including the number of entities within each sector. Residential encompasses the greatest number of individual generators (households) accounting for 36% of the total food waste generation in the state. It is evident that Food Manufacturers, Grocery Stores, and Restaurants are the primary contributors to annual food waste generation within the commercial sector. Despite hosting only 431 entities, Food Manufacturers generate an estimated 40,603 tons of food waste annually, representing 11% of the total waste. This equates to an average of 94.2 tons per entity per year. Grocery Stores, with a count of 1,654 entities, contribute approximately 37,955 tons annually, accounting for 10% of the total waste and averaging 22.9 tons per entity per year. Interestingly, while Restaurants are the most numerous with

3,852 entities, their contribution to the total annual food waste is only 5%. This means an approximation of 19,423 tons of waste annually, translating to around 5.04 tons per entity per year.

Table 2: Annual Generation of Food Waste in Maine by Sector (Tons)

Sector	Number of Entities	Tons Generated	Percent of Total	Average per Entity
Residential	582,247	129,598	36%	0.22
Farms & Agriculture	873	90,470	25%	103.6
Food Manufacturers	431	40,603	11%	94.2
Grocery Stores	1,654	37,955	10%	22.9
Restaurants	3,852	19,423	5%	5.04
Hotels	1,602	11,589	3%	7.23
Food Pantries/ Banks	351	9,908	3%	28.22
Food Distributors	601	7,615	2%	12.67
K-12 Schools	392	4,200	1%	10.71
Hospitals	736	2,742	1%	3.72
Large Office Buildings	71	2,680	1%	37.75
Large Multi-Family Complexes	190	2,149	1%	11.31
Universities	30	1,256	<1%	41.87
Sports Arenas & Large Festivals	45	1,074	<1%	23.87
Correctional Facilities	6	244	<1%	40.67
Total	**593,081**	**361,506**	**100%**	-

While the Study determined an optimal estimate specific to the context of each sector for Maine, as corroborated by pertinent literature and primary data where possible, it recognizes a margin of error inadvertently exists from statistical sampling methods. As such, the Study presents a range of values in by including a "high estimate" and a "low estimate" as summarized in Table 3. Broadly, these estimates are formed based on alternative assumptions detailed further in Appendix A: Methodology and Detailed Results by Sector.

Table 3: Summary of 2024 Maine DEP Study Estimates Relative to High and Low Estimates of Annual Food Surplus by Sector

Sector	Maine DEP 2024 Study Estimate (Tons)	High Sensitivity (Tons)	Low Sensitivity (Tons)
Residential[30]	129,598	158,878	68,035
Large Family Complexes	2,149	12,587	2,149
Farms and Commercial Agriculture	90,470	311,552	46,579
Food Manufacturers	40,603	98,113	30,011
Grocery Stores	37,955	55,369	22,773
Restaurants	19,423	46,023	14,026
Hotels	11,589	20,259	3,820
Food Banks and Pantries	9,908	11,248	794
Food Distributors (Wholesale)	7,615	27,174	5,330
K-12 Schools	4,200	7,860	5,290
Universities	1,256	2,297	1,203
Hospitals	2,742	6,288	1,172
Large Office Buildings	2,680	3,429	794
Sports Venues and Special Events	1,074	1,560	555
Correctional Facilities	244	476	162
Totals	**361,506**	**763,113**	**202,693**

Specific Sector Findings

The data analysis and interviews identified several key findings for the sectors below. Where possible, the project team compared established sector data with interviews from Maine entities to better understand the sector characteristics, explore their current activities to mitigate food loss and waste, and identify opportunities to improve food waste solutions. More detailed sector food waste data and analysis are detailed further in Appendix A: Methodology and Detailed Results by Sector.

1. **Residential**: Consistent with numerous waste characterization studies conducted nationwide, the residential sector typically constitutes 20-30% of the overall waste stream. In various communities throughout Maine, initiatives have been adopted that are aimed at reducing this figure, such as residential drop-off food waste recycling programs, campaigns to urge consumers to adopt practices that reduce food waste, and backyard composting. With a population exceeding 500,000 households and the potential to address over 129,000 tons of food waste that primarily goes to landfill, municipalities have opportunities to

[30] Large Family Complexes computed as a subset of Residential Sector. The subsector is subtracted based on the estimate in this table to avoid double counting though this may not be necessarily comparable for the High and Low estimate. Please see Appendix A for additional details.

promote and implement important solutions for reducing food waste. See Appendix A Residential - Additional Sector Details Section for further investigation on seasonal impacts of residential food waste.

2. **Farms and Agriculture**: Farms commonly encounter food loss from unharvested products, and to address this issue food recovery organizations actively engage in gleaning activities. While the collaboration between farms and food banks is a positive step, there is untapped potential for further collaboration and exploration of innovative solutions. The challenge in quantifying on-farm waste arises from annual unpredictability, the variety of small-scale crops grown in Maine, and the fact that a notable portion of the loss remains unaccounted for, as it does not follow the conventional route of disposal. Estimates show that over 870 farms experience over 90,000 tons per year of food loss annually, although the majority is plowed under in the fields. There is great potential to fight hunger by recovering this surplus and redistributing it to feed Mainers.
3. **Food Manufacturers**: Despite a lower number of food manufacturers in comparison to other service sectors, the potential for reduction, recovery, and diversion of food waste is significant. The sector, comprising over 430 entities, generates an estimated 40,000 tons annually, accounting for 16% of total waste. Based on interview findings, on average the distribution of edible and inedible food from food processing facilities is nearly the same, with each respectively accounting for 51% and 49% of food waste generated per year. Opportunities for collaboration exist, with the aim of minimizing surplus and loss, interviews indicated that several Maine food manufactures have successfully implemented strategies to minimize food waste by partnering with buyers interested in their byproducts. Potential avenues for upcycling include the exploration of byproducts that require research or product testing, and waste reduction through technological or packaging improvements in the manufacturing process.
4. **Grocery Stores:** It is estimated that more than 1,300 grocery stores are responsible for over 37,000 tons of food waste annually. The existing strong partnerships between Maine food banks and select grocery stores were highlighted during interviews and could be leveraged to further education on liability protections and overall benefits of donating edible surplus. Infrastructure development or training to handle unpredictable edible surplus could be essential, especially considering possible power outages caused by increasingly frequent storms. Other challenges include the need for staff training and additional employees to recover and upcycle products in-store.
5. **Restaurants:** Over 3,800 restaurants, generating more than 19,000 tons annually, offer substantial opportunities for diversion activities. Interviews with restaurant operators revealed potential strategies for reduction such as adjusting portion sizes in response to observed customer plate waste. Some restaurants have established informal partnerships to divert edible scraps to animal farms, thereby contributing to the production of nutrient-rich animal feed. Seasonal fluctuations affect this sector, underlining the importance of targeted strategies to manage changes in waste generation patterns. In recognizing post-consumer/plate waste as a key driver and feedback suggesting the tourist economy values preservation of our environment, particular attention should be paid to this sector during peak tourism months. The estimated impact is explored in Table 4.
6. **Hotels:** More than 1,600 hotels are expected to generate more than 11,500 tons annually. This sector, characterized by varied levels of food production, could experience considerable seasonal fluctuations, and might not yield substantial volumes of recoverable food for donation. Catered events may generate avoidable, unpredictable, edible prepared foods, and could be redistributed with food recovery organizations that have the capacity to recover prepared food. Nevertheless, preparation waste from

kitchens and plate waste from consumers have the potential to be redirected for animal feed, soil amendments, or energy production through anaerobic digestion. The methodology outlined in the Appendix considers the diverse nature of this sector, accommodating facilities that range from those with limited or no kitchen facilities to those with multiple dining options on-site.

7. **Educational Sector (K-12 Schools and Universities):** The education sector, encompassing K-12 schools and universities, has been identified as a major contributor to food waste, with over 400 institutions producing more than 6,000 tons of food waste annually. While some of the interviewees highlighted their programs to segregate food scraps from back-of-house operations, they acknowledged the ample opportunities to reduce student plate waste. Detailed studies on this sector have been conducted by the University of Maine. It was found that elementary schools can reduce surplus food by almost 20% through the implementation of student-led food waste reduction programs. However, confusion and policy barriers often serve as significant impediments to progress in this area. Mandatory bundling of food items often leads to waste, as students are compelled to take more food than desired. To mitigate these challenges, several solutions have been proposed. Further exploration of policies that can encourage these menu options and behavior changes is recommended:
    - Tasting menus: Permitting universities to sample fractions of various dishes could reduce waste by allowing for more informed meal decisions.
    - Share Baskets: Designating areas where students can leave unwanted food items for others can help reduce wastage.
    - Education: Utilizing the cafeteria as a classroom where students can conduct waste audits, support sort separation stations, learn about wasted food, and more.
    - Food recovery initiatives: On-site refrigeration to make surplus food more easily accessible to the school community.
    - Composting: Establishment of on-site compost collection stations for recycling inedible food waste into compost for use in school gardens or landscaping.
8. **Food Banks:** In Maine, 350+ food recovery organizations (food banks, food pantries, etc.) have been identified as contributing over 9,000 tons of food loss and waste annually. These organizations primarily collaborate with grocery stores and distribution centers to recover edible surplus food. Untapped opportunities may exist to expand partnerships with farms and other generators, especially if food recovery organizations are provided with support for additional refrigeration or processing equipment to handle large volumes of products. When designing measures to address food loss and waste within the state, it is critical for this sector to refrain from becoming an outlet for materials that are better suited for other beneficial uses if they are not edible and appropriate for human consumption. Food recovery organizations acknowledged their donations often include spoilage or products that cannot be recovered for human consumption.
9. **Food Distributors:** The 600 food distributors evaluated contribute over 7,000 tons of food loss and waste annually. Surplus food and loss often occurs due to recalls, spoilage, over-ordering, and/or damage during transportation, characterized as avoidable surplus. While partnerships between food recovery organizations and food distributors were confirmed, further opportunities were identified to prevent loss and assist food recovery organizations in processing this surplus, which frequently occurs in large quantities.

10. **Hospitals**: Over 1,000 hospitals and health care facilities in the state were estimated to contribute to over 3,000 tons of food loss and waste annually. Industry data highlights the opportunity to reduce plate waste from patients by offering reduced portion sizes and a room service style delivery model. Additionally, outdated, and damaged food accounted for most of the food waste in both weight and cost. Modifying orders and addressing delivery issues with suppliers were identified as potential solutions. Additional food recovery solutions such as employee meals, on-site pantries, and donations to local food pantries were all identified as opportunities. While further studies are required to scale solutions, effectiveness of the solutions listed have been quantified at the entity level by the University of Maine based on field work conducted in partnership with Northern Light/Blue Hill Hospital.[31]
11. **Large Multi-Family Complexes:** The significance of this sector lies in its potential to generate concentrated sources of residential waste from a single location. Given that single-family housing is predominant in Maine, the analysis was directed towards identifying the principal municipalities likely to possess a significant "large multi-family complexes" sector. As expected, this sector was larger in more populous cities such as Portland and Bangor. However, it was found that even at extreme thresholds where large multi-family complexes were defined as those with 50 or more housing units in structure, it is not likely that entities in this sector would produce more than an average of 2 tons per week of food waste.
12. **Large Office Buildings**: While readily available industry data is limited for this sector, over 70 large office buildings that provide in-house dining services were identified, contributing over 1,400 tons of food waste annually. Challenges included donating edible surplus from these buildings, where the prepared product was not always easily recoverable by local food pantries. Additionally, gaps in understanding when and how food waste occurs were identified due to remote work flexibility and reduced dining services.
13. **Sports Arena & Festivals**: Over 40 sports arenas and festivals which serve food, were estimated to contribute to over 1,000 tons of food waste annually. These activities represent a short-lived, but highly impactful. For example, the Fryeburg Fair, which runs for 1 week a year, is expected to produce approximately 24 tons based on 160,000 visitors in that week alone. The annual average appears far less significant at 0.48 tons per week. It will be critical to consider how standalone events can develop relationships with collection services that will need to vary in service levels throughout the year.
14. **Correctional Facilities:** A study conducted by the University of Maine revealed opportunities to reduce food loss and waste within the prison sector. Six state facilities were found to generate over 300 tons of food loss and waste annually, primarily due to overproduction of grain servings. Implementing facility-based meal planning and preparation, as well as introducing choice through offer versus service demonstrated success in reducing waste by 66%. Interviews with these facilities revealed that most of the food waste comes from uneaten plated food and an estimated 36% of the generated waste is edible for animal consumption.

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31 University of Maine – Mitchell Center for Sustainablity Solutions."Solution1 Pilot – Pilot 5: Northern Light/Blue Hill Hospital." Food Rescue MAINE, August 8, 2023. https://umaine.edu/foodrescuemaine/2023/08/04/solution-1-pilot-1-2023-healthcare-food-waste-tracking-measuring-study-northern-light-health-blue-hill/.

Geographical Distribution of Food Loss and Waste

The following maps provide a visualization for the analysis of waste generation from different sectors across counties in Maine. The first map, Figure 3, illustrates the distribution of food waste from all sectors, pinpointing areas with operational sites with processing capacity for food waste. The second, Figure 4, excludes the residential and agricultural sectors. These maps show countries with substantial waste production that may necessitate targeted interventions or resource allocation. It is noted that food waste is primarily concentrated in the Cumberland and York counties, correlating with the population density and the concentration of businesses in these areas. Additional food waste generation estimates across counties in Maine can be found in Appendix C: Geographic Distribution of Food Loss & Waste.

Figure 3: Annual Food Surplus by County and Currently Operating Processing Infrastructure

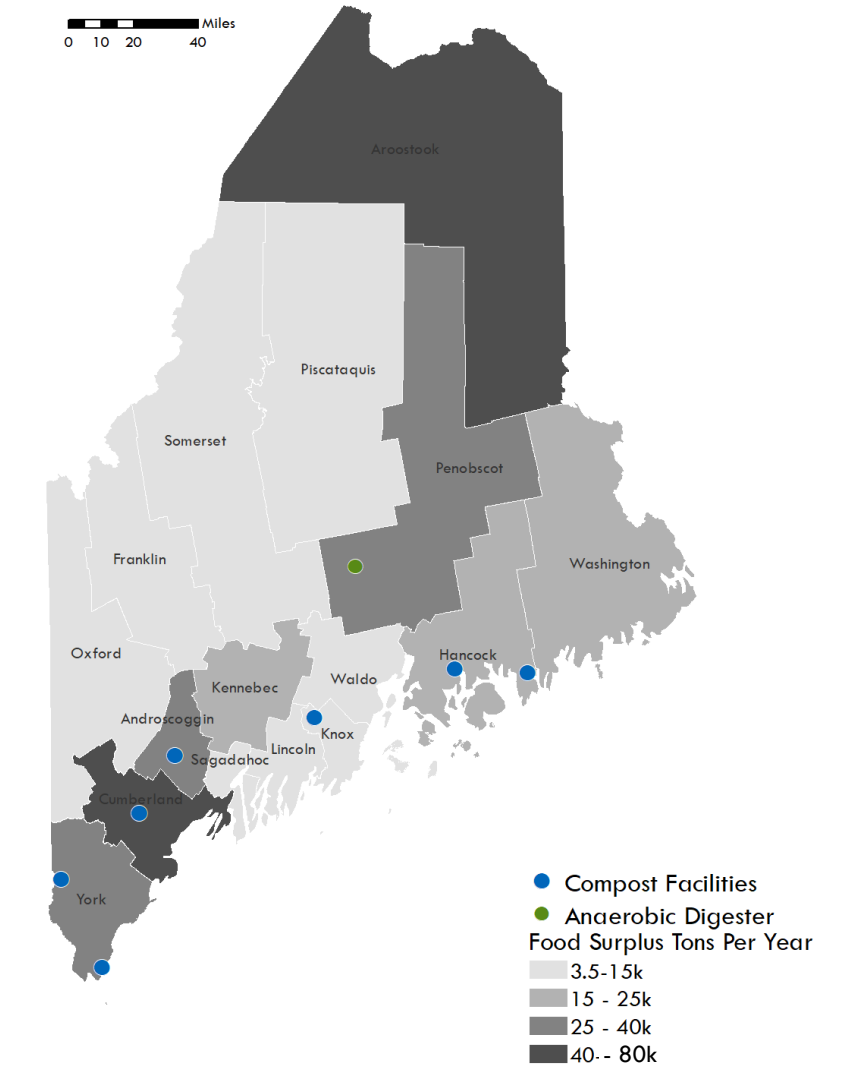
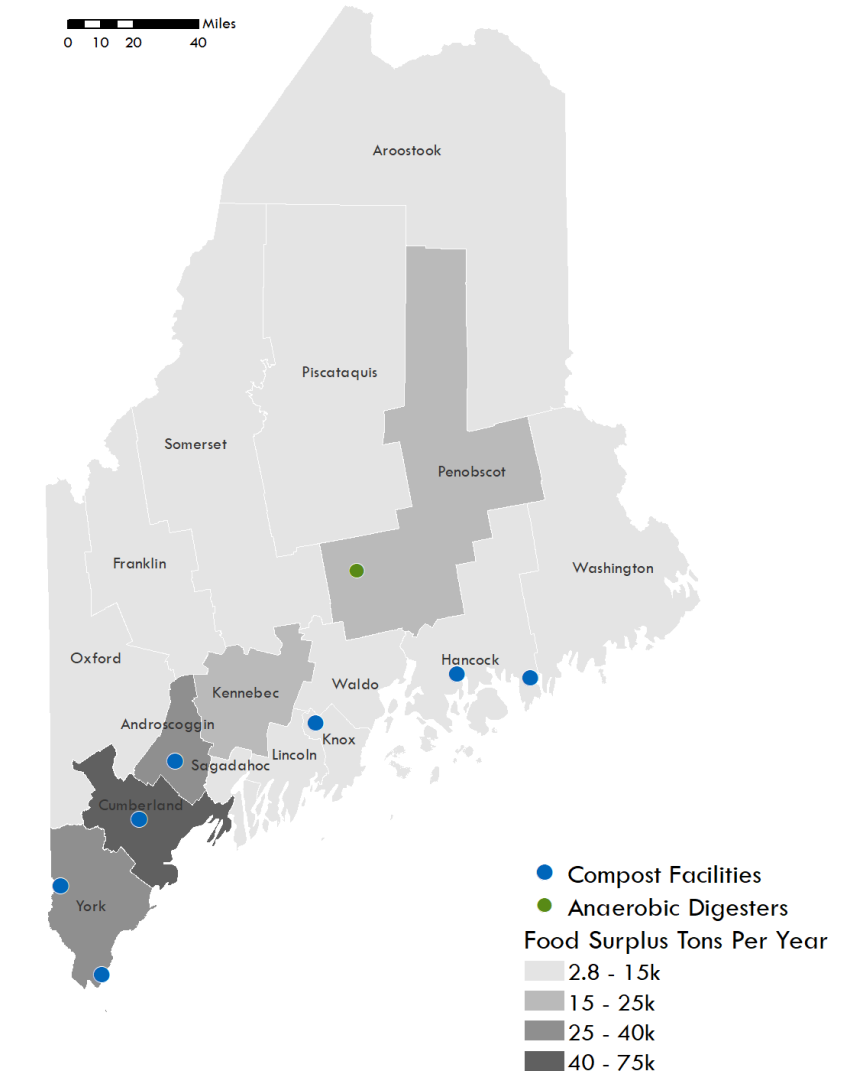


Figure 4: Annual Food Surplus by County, Commercial and Institutional Only, by County with Currently Operating Processing Infrastructure



Commercial and Institutional Sector Food Waste Generation by County- Seasonal Variation

In general, concerns arise regarding the primary method of calculating food waste generation, especially for seasonal operations such as restaurants and hotels. The D&B database fails to specify if the figures provided for full-time employees account for the entire year or peak seasons only. This ambiguity could potentially result in an underestimation of food loss and waste generated within these sectors. For the purposes of this study, we assumed the provided metrics accounted for the entire years, and then utilized seasonal data from Maine's Office of Tourism to project peak activities.

Table 4 illustrates the potential impact of seasonal variation on Hospitality sectors: Restaurants, Hotels and Sports Arenas/ Fairs. Should compliance obligations be triggered by any week exceeding 2 tons of food waste rather

than per annual average, the impact on these sectors in terms of number of entities affected, as well as the overall tons captured, is expected to be significant, particularly for sports venues and large festivals.

Table 4: Annual Generation of Food Waste by Sector Accounting for Seasonal Variation

	Restaurants	Restaurants (Peak Season)	Hotels	Hotels (Peak Season)	Sports Arena & Large Festivals	Sports Arena & Large Festivals (Peak Season)
Tons Per Year	19,423	No impact	11,589	No impact	1,074	No impact
Number of Entities	3,852	No impact	1,602	No impact	45	No impact
Number of Entities That Generate More Than 2 Tons per Week	15	228	5	193	1	29
Percent of Entities That Generate More Than 2 Tons per Week Within Sector	0%	6%	0%	12%	2%	64%
Total Tons Generated Annually from Entities Generating More Than 2 Tons per Week	42	1,249	35	1,027	5	519
Percent of Total Tons Year from Entities Generating 2 Tons per Week Within Sector	0%	6%	0%	9%	0%	48%

Sector Review Categorized by Minimum Generation Thresholds

A detailed breakdown by the number of entities generating specific tonnage thresholds enhances the understanding of waste generation distribution within each sector. A county-level analysis provides insights into regional variations, showcasing the number of entities, total tons generated, and entities surpassing certain waste thresholds (greater than 2 tons per week, 1 ton per week, and ½ ton per week) in Table 5 and Table 6. These tables serve as valuable tools for evaluating environmental impact and waste generation concentration across different sectors and counties. The tables identify the number of businesses that may be affected based on tons generated annually or weekly.

Table 5: Annual Commercial and Institutional Generation, by Sector Size Thresholds (Part I)

	All Entities within Sector		Entities Generating 2+ Tons per Week		
Sector	Number of Entities	TPY	Number of Entities (Percent within Sector)	TPY (Percent within Sector)	Percent of Total (Across all Sectors)
Food Manufacturers	431	40,603	43 (10%)	35,427 (87%)	53.4%
Grocery Stores	1,654	37,955	81 (5%)	18,199 (48%)	27.4%
Restaurants	3,852	19,423	15 (0%)	2,193 (11%)	3.3%
Hotels	1,602	11,589	5 (0%)	1,807 (16%)	2.7%
Food Pantries/ Banks	351	9,908	1 (0%)	748 (8%)	1.1%

	All Entities within Sector		Entities Generating 2+ Tons per Week		
Sector	Number of Entities	TPY	Number of Entities (Percent within Sector)	TPY (Percent within Sector)	Percent of Total (Across all Sectors)
Food Distributors	601	7,615	20 (3%)	4,725 (62%)	7.1%
K-12 Schools	392	4,200	23 (6%)	1,565 (37%)	2.4%
Hospitals	736	2,742	1 (0%)	127 (5%)	0.2%
Large Office Buildings	71	2,680	4 (6%)	587 (22%)	0.9%
Large Multi-Family Complexes	190	2,149	-	-	-
Universities	30	1,256	6 (20%)	708 (56%)	1.1%
Sports Arenas & Large Festivals	45	1,074	1 (2%)	238 (22%)	0.4%
Correctional Facilities	6	244	-	-	0.0%
Total	**9,961**	**141,438**	**200**	**66,325**	**100%**

Table 6 reveals significant differences between the number of entities generating 0.5+ tons per week of food waste relative to those that generate greater than 1 ton per week. In the Food Manufacturers sector, the 98 entities generating 0.5+ tons per week is 64% greater than the 62-generating 1+ ton per week. This illustrates that while a considerable number of entities in this sector generate significant amounts of food waste, a smaller core group generates exceedingly large amounts. The Grocery Stores sector exhibits a similar pattern, with 188 (11%) of entities generating 0.5+ tons per week, compared to 111 (7%) for those generating more than 1 ton per week. This indicates a smaller subset of grocery stores are responsible for the larger quantities of food waste.

In contrast, the Food Pantries/Banks sector shows virtually all entities generating 0.5+ tons per week, and only one generating 1+ ton per week. This stark disparity suggests that while all entities in this sector generate some level of food waste, none are producing it at an exceedingly high rate. A similar pattern is seen in the Hospitals sector. In most sectors, a smaller number of entities are responsible for generating the larger quantities of food waste which suggests a focus on these high-waste entities.

A comparison of annual quantities can also be made. Some sectors, such as Food Manufacturers and Grocery Stores, saw a modest increase in the total annual food waste when comparing entities that produce over 0.5 tons per week to those producing 1+ ton per week. In other sectors, such as Large Office Buildings and Universities, the total annual food waste for entities producing over 1 ton per week is quite high compared to those producing 0.5+ tons. This suggests that in these sectors, even though the number of entities is smaller, each entity tends to produce a large amount of food waste.

In contrast, for other sectors such as Food Pantries/Banks and Hospitals, sports arenas and festivals, and large office buildings, the difference in total annual food waste between the two groups is exceptionally large, indicating that in these sectors, significant number of entities are generating between 0.5 tons and 1 ton per week.

It can also be seen that the distribution of food waste production varies widely between sectors within these generation tiers. Some sectors have a few high-waste entities that contribute to a large portion of the total, while

others have a more even distribution. This information could be useful for developing targeted strategies to reduce food waste in different sectors.

Table 6: Annual Commercial and Institutional Generation, by Sector Size Thresholds (Part II)

	Total		1+ Tons per Week			0.5+ Tons per Week		
Sector	Number of Entities	TPY	Number of Entities (Percent within Sector)	TPY (Percent within Sector)	Percent of Total (across all sectors)	Number of Entities (Percent within Sector)	TPY (Percent within Sector)	Percent of Total (across all sectors)
Food Manufacturers	431	40,603	62 (14%)	36,854 (91%)	48.1%	98 (23%)	38,207 (94%)	39%
Grocery Stores	1,654	37,955	111 (7%)	20,222 (53%)	26.4%	188 (11%)	22,974 (61%)	24%
Restaurants	3,852	19,423	48 (1%)	4,946 (25%)	6.5%	104 (3%)	7,030 (36%)	7%
Hotels	1,602	11,589	23 (1%)	2,904 (25%)	3.8%	60 (4%)	4,222 (36%)	4%
Food Pantries/ Banks	351	9,908	1 (0%)	748 (8%)	1.0%	351 (100%)	9,908 (100%)	10%
Food Distributors	601	7,615	25 (4%)	5,093 (67%)	6.6%	46 (8%)	5,978 (79%)	6%
K-12 Schools	392	4,200	61 (16%)	2,947 (70%)	3.8%	91 (23%)	3,462 (82%)	4%
Hospitals	736	2,742	2 (0%)	210 (8%)	0.3%	12 (2%)	569 (21%)	1%
Large Office Buildings	71	2,680	11 (15%)	1,059 (40%)	1.4%	44 (62%)	2,182 (81%)	2%
Large Multi-Family Complexes	190	2,149	NA	NA	NA	NA	NA	NA
Universities	30	1,256	11 (37%)	937 (75%)	1.2%	19 (63%)	1,169 (93%)	1%
Sports Arenas & Large Festivals	45	1,074	5 (11%)	541 (50%)	0.7%	13 (29%)	839 (78%)	1%
Correctional Facilities	6	244	2 (33%)	168 (69%)	0.2%	3 (50%)	208 (85%)	0%
Total	**9,961**	**141,438**	**362**	**76,629**	**100%**	**1,029**	**96,750**	**100%**

Table 7 shows an in-depth breakdown of entities in each county based on annual food waste quantities for two different tiers: entities generating over 1 ton per week and entities generating over 0.5 tons per week. Emerging with a total of 2,635 entities, Cumberland County surpasses all other counties, collectively contributing an annual 49,006 tons. The second-highest county, York, generates 19,833 tons, less than half of Cumberland's output. Thus, Cumberland County is the most substantial generator among all the counties in terms of both the number of entities and the magnitude of waste generation.

In Cumberland County, 103 entities are generating 1+ tons per week, compared to 61 entities generating 2+ tons per week, a difference of 42 entities (+69%). The annual generation, however, shows a less dramatic difference: 31,858 tons from entities generating 1+ tons per week, compared to 29,145 tons from entities generating 2+ tons per week, a difference of 9%.

In York County, 48 entities generate 1+ tons per week compared to 28 entities generating 2+ tons per week, representing a 71% increase. Waste quantities show a more notable difference, with 9,827 tons from entities making 1+ tons per week, compared to 8,561 tons from entities generating 2+ tons per week, a difference of 15%.

Table 7: Commercial and Institutional Generation by County (Annual Tons)

County	Number of Entities	Annual Generation (Tons)	Number of Entities 2+ Tons per Week	Annual Generation (Tons)	Number of Entities 1+ Tons per Week	Annual Generation (Tons)
Androscoggin	610	10,479	15	4,836	34	6,005
Aroostook	419	8,436	15	4,849	23	5,311
Cumberland	2,635	49,201	61	29,145	103	31,858
Franklin	219	1,980	3	405	4	468
Hancock	672	5,852	8	1,538	14	1,919
Kennebec	690	7,943	15	2,353	28	3,203
Knox	411	3,818	5	821	13	1,353
Lincoln	382	2,802	3	487	8	737
Oxford	339	3,398	5	730	11	1,103
Penobscot	844	12,088	23	4,929	45	6,384
Piscataquis	119	1,471	2	764	2	764
Sagadahoc	191	1,322	1	54	5	330
Somerset	279	3,108	5	851	10	1,130
Waldo	247	2,051	2	401	3	432
Washington	293	7,528	9	5,603	11	5,806
York	1,612	19,960	28	8,561	48	9,827
Total	**9,961**	**141,438**	**200**	**66,325**	**362**	**76,629**

Characterization of Food Loss and Waste

The fundamental aim in examining food loss and waste is to identify ways to prevent avoidable surplus, and then direct it towards its highest and best use while understanding the necessary infrastructure for collection and processing. This investigation involved conducting interviews to ascertain the properties of surplus food and food waste generated in each sector. These attributes include whether the waste is avoidable or unavoidable, predictable or unpredictable, and whether it is edible or inedible.

Food loss and waste can happen across the supply chain, from edible food loss on farms due to cosmetic imperfections, to prep waste at restaurants, to the forgotten food left in residential refrigerators. In the commercial sector, the material is generated both back-of-house and front-of-house, and both generate different types of food quality (e.g., over-ordering vs. plate waste). For instance, front-of-house food waste is often not suitable for food recovery, but can be source-separated for animal feed, composting, or anaerobic digestion. Typically, front-of-house source-separated food waste from sectors like universities, schools, and restaurants is best suited for animal feed, composting, and anaerobic digestion. Surplus and loss generated back-of-house (i.e., prep) offer opportunities for food recovery and feeding animals. Utilizing tools such as prevention technologies can showcase improved purchasing methods and routine overproduction. The findings below were identified during the conversations with stakeholders across the sectors.

Edibility

Restaurants and hotels generate potentially donatable food following catered events, emphasizing the need for support for food recovery organizations which can recover prepared food. While primary grocery stores in Maine are already redirecting edible surplus to food recovery organizations, there is an opportunity to enhance educational efforts and pre-separation of the products sought by these organizations. Conversations with food recovery organizations highlighted the need to maintain awareness of the nutritional and edible value of the food. To prevent food pantries from unintentionally becoming outlets for inedible surplus, ongoing education and conversations around appropriate food for donation are essential. Interviews with food banks also highlighted their interest in receiving quality, edible surplus from donors, and noted that not all edible food has the nutritional value they seek. Further exploration could evaluate expansion of infrastructure to process edible surplus that is often left on farms or not accepted by grocers due to cosmetic imperfections.

Preventability

There are some strategies to prevent food loss and waste first and foremost. Processors typically generate inedible byproducts during manufacturing, necessitating equipment investments for managing these materials. Additionally, processors have concentrated byproducts with potential for repurposing, suggesting a need for technical assistance to explore opportunities for converting edible byproducts into alternative products.

Predictability

Predictable surplus occurs throughout the year, such as farms working with gleaning organizations during the growing season. Grocery stores experience predictable surplus during holidays, offering an opportunity for increased support to food recovery organizations during these times of predictable surplus. Seasonality impacts food waste generation and characterization in the state, with the hospitality sector generating more prep and plate waste during increased tourism. Findings noted this fluctuation is not one directional and this impact is experienced in both Summer and Winter seasons. These findings highlight specific challenges and opportunities

within each sector, providing a foundation for targeted interventions in Maine's ongoing efforts to address and manage food waste.

Current Maine Food Waste Diversion Initiatives

The State of Maine showcases multiple initiatives aimed at managing surplus food and waste. Highlighted in 2015, the University of Maine Mitchell Center for Sustainability Solutions (Center) identified elimination of food waste as a critical component of a sustainable waste system in Maine.[32] The Center, in 2019, joined forces with leading food businesses and organizations in Maine, identifying and pursuing six solutions to food waste. These pilot projects encompass strategies and solutions for the prevention, recovery, monitoring, and diversion of edible food and waste from disposal. This leadership initiative sparked activities across the state. For example, the State of Maine Department of Corrections worked in tandem with the Center to evaluate food loss and waste generated at its facilities and characterize waste to pinpoint options to prevent avoidable surplus and waste. Additional initiatives were driven by the Center, such as hosting the annual Maine Food Waste Solutions Summit, partnering with Food Rescue US software to increase food recovery, and developing a Circular Food System GIS Map.

The Study revealed robust partnerships between grocery stores, warehouses, and food recovery organizations in the state. These major retail partners not only supported food donation programs but also introduced additional programs to source separate surplus food for animal feed, composting, and anaerobic digestion. Partnerships with animal feed operations for non-packaged products or specific products unsuitable for food donation were noted. Food processors, such as breweries and bakeries, also reported their partnerships with animal feed operations. DEP may want to collaborate with Maine Department of Agriculture, Conservation and Forestry to support these livestock facilities, and their potential to accept applicable food waste.

The hospitality sector, including restaurants and hotels, appeared to offer a potential expansion opportunity for the collection of prepared foods, despite contributing to a smaller portion of the overall food waste generated in the state. Organizations such as Wayside and Catholic Charities support this effort by working with donors to recover perishable, prepared goods.

In 2023, Governor Janet Mills proclaimed September 25-29, 2023, as Maine Food Waste Awareness Week. This week was devoted to raising awareness about food loss and waste and urging schools in the state to reduce surplus, host educational food waste-related events, and adopt solutions. These educational efforts could be amplified to stimulate investment, behavior change, and environmental progress.

Current Maine Food Waste Processing Capacity

Maine possesses a varied landscape for processing surplus food and waste. Existing service providers such as food banks and composting facilities actively recover edible food and create soil amendments with scraps. The role of food banks and food recovery organizations in Maine is critical. With sufficient investment and staffing, the food recovery organizations could double their capacity to recover and redistribute edible surplus, resulting in a capacity of 43,000 tons. However, food banks present an intriguing dynamic as they not only recover surplus food

32 University of Maine – Mitchell Center for Sustainablity Solutions. "Our Six Solutions." Food Rescue MAINE. https://umaine.edu/foodrescuemaine/our-six-solutions/.

but also manage inedible items, often donated. Prioritizing the recovery and redistribution of food with nutritional value is a key focus for these organizations.

Partnerships between surplus food generators (commercial businesses and institutions), and food rescue organizations are key. Strengthening these collaborations enhances the overall value of the food products sent for redistribution. Distinguishing between food waste that should be donated and the food that should be sent for higher and better uses is important to supporting Maine's processing capacity. With 1 in 7 Maine children and 1 in 10 Maine adults facing hunger, there is a great need to prevent surplus, and recover and distribute the edible food to people.[33] Priorities to reduce the volume of surplus food first and foremost, and then donation surplus food to food recovery recipients also aligns with Maine's Food Recovery Hierarchy.

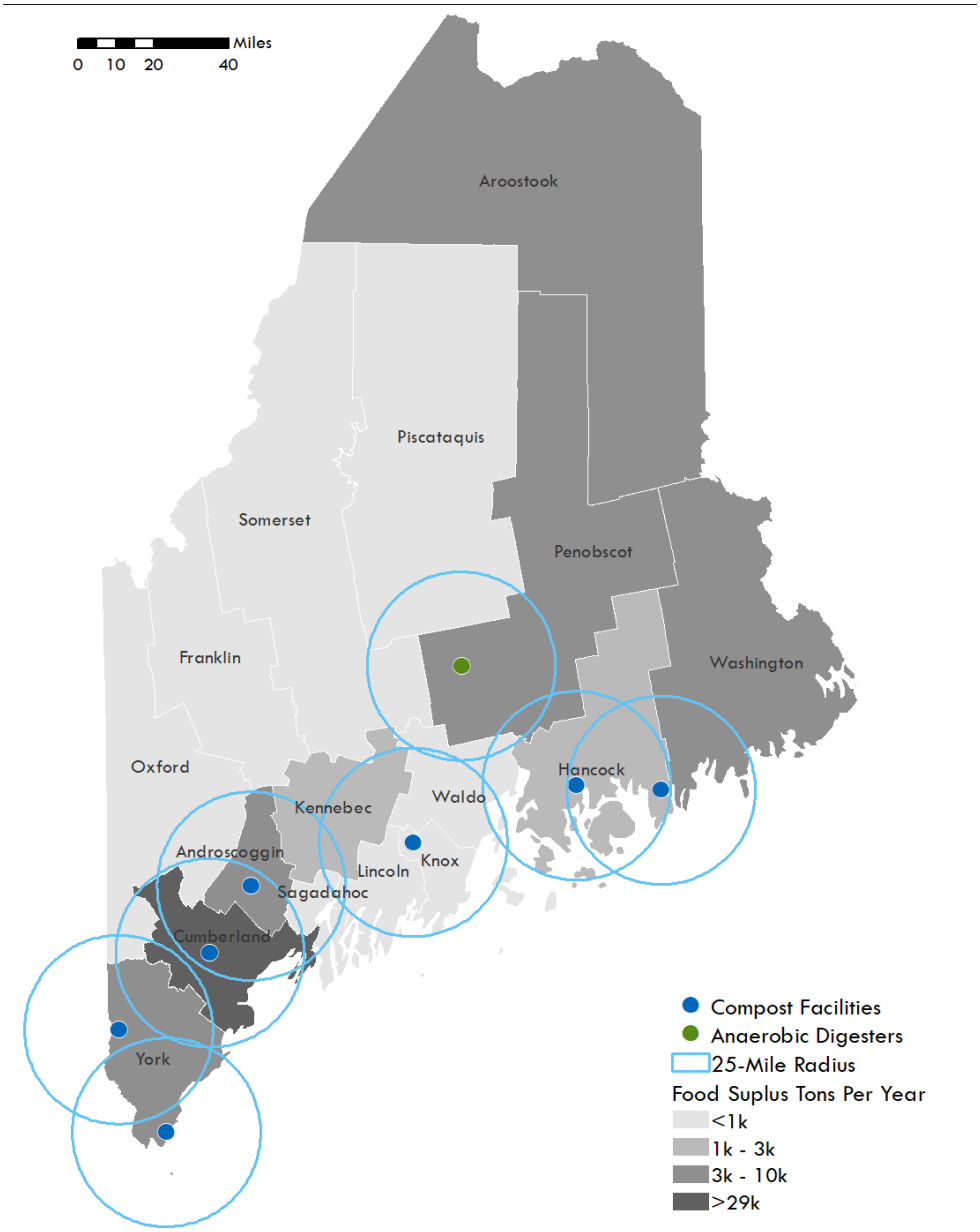
Currently there are 8 compost sites and anaerobic digestion facilities that are operational and have the capacity to process approximately 83,600 tons of wasted food. Exeter Agri-Energy is notable for its ability to process a significant portion of this material, permitted to process over 80,000 tons annually. While composting and anaerobic digestion are essential in managing inedible food waste, the opportunities for preventing and recovering edible surplus should not be disregarded. For this study, only operational compost sites and anaerobic digestion facilities with permitted capacity were included. Interviews with municipalities highlighted their interest in growing processing capacity for wasted food. There are developments for anaerobic digestion facilities, including one which will process 180,000 tons of residential waste annually.

Locating animal feed operations in Maine posed a notable challenge during the research. Currently there is no readily available list of farms engaged in animal feeding. There is an opportunity to collaborate with these farms to elect to receive suitable byproducts. The interviews indicated that certain entities are actively diverting surplus food to pig farms and other livestock operations. Further investigation is needed to identify the farms currently accepting byproducts, or those that may in the future.

Figure 5 below illustrates a radius of 25 miles around the processing facilities that are currently operational and have the capacity to accept food waste. It is acknowledged that collection and hauling services for food waste may not always travel to the nearest processing site (animal feed, compost, anaerobic digestion). Nevertheless, an understanding of the distances between concentrated generation centers (Cumberland and York County) and available waste processing sites is crucial in evaluating infrastructure needs.

33 Feeding America. "Hunger in Maine." Accessed February 27, 2024. https://www.feedingamerica.org/hunger-in-america/maine.

Figure 5: Annual Surplus by County, Commercial and Institutional, Entities Generating >1 TPW and Operational Processing Infrastructure



Key Study Findings

This analysis identified key aspects and themes of the data categorized as key findings and insights.

Residential and Agricultural Sectors These sectors were found to be the primary producers of food loss and waste. This insight underlines the importance of focused initiatives to educate these sectors about waste reduction and recovery strategies, and to involve them in these initiatives. Preliminary interviews suggest that food loss is a significant reality on farms, and much of this waste is currently either gleaned or turned over on-site. There is potential for increased recovery of this surplus either for feeding people or converting it into shelf-stable products. Residential waste also makes a significant contribution to Maine's waste stream, often ending up being disposed of in landfills. This major source should be factored in when evaluating processing capacities for surplus food and waste management. These two major contributors should influence policy and program decisions addressing surplus food and loss.

Seasonal Variation: With its popularity as a summer vacation destination, Maine's population sees a significant surge during this period from 1.3 million residents to 15 million. This population influx leads to increased employment, meals served, and hotel stays. Data from the Office of Tourism was used to account for these seasonal fluctuations, particularly affecting the hotel and restaurant sectors.[34]

Significance of Food Banks: Food banks play a vital role in the recovery of edible, surplus food, as recognized in the Study. However, it is essential to emphasize that they should not serve as outlets for disposing of inedible food. Unfortunately, these inedible products are sometimes donated and thus alternative solutions such as composting are also needed for food recovery organizations. Education and collaboration are important to helping donors ensure donations meet food safety and quality standards of their partners.

Emphasizing the EPA Wasted Food Scale: The Study highlighted the need to consider the EPA Food Recovery Hierarchy in its entirety when planning the capacity required to process food waste. The hierarchy prioritizes prevention first, followed by food donation, animal feed, composting, and anaerobic digestion, with traditional disposal being the last resort. Last resort options include sending food down the drain, landfilling, or incinerating with or without energy recovery.

Variations in Food Waste Generation Within and Across Sectors: Average food waste generation per sector was calculated. However, it is important to note that there can be substantial variations within any given sector. For example, some businesses might have implemented practices to divert surplus edible food for donation, or separate food scraps for alternate uses such as composting. While this analysis identifies some of these key activities, it was beyond the scope of the Study to cover every possible scenario. These findings compile the average and usual scenario across all sectors.

34 Email correspondence with the University of Maine.

Key Strategic & Policy Considerations

Going Forward

This comprehensive study delves into the sources, quantities, and characterization of surplus food, food scraps, and food processing waste produced annually in Maine. The focus is particularly on the commercial, residential, and institutional sectors that may be targeted for landfill diversion efforts. The overarching aim is to garner significant insights that will underpin strategic approaches to address food loss and waste. These insights will also guide future research into suitable infrastructure enhancements that will propel the management of surplus and waste food up the food recovery hierarchy, effectively mitigating the negative impacts these wastes have on greenhouse gas emissions.

Maine law (38 M.R.S. § 2132(1-B)) sets a goal of reducing the per capita waste disposal rate by 5% every half-decade.[35] To actualize this outcome for the food sector, innovative strategies will be required involving both the private and public sectors. These strategies may include policy measures. The findings of this investigation will be pivotal in informing future regulatory decisions regarding the disposition and management of surplus food.

Prioritizing Solutions

Prevention of food waste should be the cornerstone of any food waste strategy as it offers remarkable economic, environmental, and social advantages. By averting overproduction and maximizing the value of food resources, the most substantial economic, environmental, and social benefits will be realized. Numerous strategies can be employed across different sectors to accomplish this, such as meal planning, right-sizing purchases and portion sizes, and effective food storage. Prevention not only circumvents food wastage but also reduces unnecessary resource usage and environmental impacts, like greenhouse gas emissions, linked with food production and distribution. While recycling food waste is environmentally preferable compared to landfill and incineration, averting overproduction, and ensuring that food that is produced is consumed is of paramount importance.

Preserving edible food in the supply chain can drastically lessen environmental burdens, even when compared to the most effective recycling methods. As such, an effective food waste strategy should prioritize source reduction, maximize food donations, and explore ways to enhance upcycling. This approach will curtail the percentage of surplus food that humans do not directly consume. Priority should be assigned to the creation of markets for upcycled products, the transformation of non-edible food into livestock feed, and the cultivation of market demand for high-quality compost generated from unrecoverable food waste.

Transparency

The quantification and characterization of food loss and waste in Maine requires a nuanced approach that acknowledges the challenges inherent in gathering consistent and robust industry data. The preventability, edibility, and predictability of food waste are all factors that have been investigated. However, the commercial sector often refrains from revealing waste-related data due to the intensely competitive nature of the food retail industry.

Potential solutions could include fostering cooperation between producers, retailers, and recovery organizations to enhance edible food recovery rates. Encouraging reporting from the major generators could facilitate the

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35 Maine Legislature. *Title 38, §2132.* https://legislature.maine.gov/statutes/38/title38sec2132.html.

identification of effective solutions and establish baselines for measuring progress. It may also be beneficial to reassess infrastructure developments or the impacts of an organics recycling law.

It is crucial to consider the following:

- The need for more comprehensive on-ground food waste data in Maine.
- The potential benefits of implementing periodic surveys, such as annual reviews, of key sectors.
- The utility of stakeholder working group meetings.

For Further Consideration

To amplify the actionable impacts of this study's findings, the following suggestions highlight opportunities to build upon the current knowledge base. Meaningful data collection and further research will play a central role in pinpointing policy obstacles and potential levers that could help incentivize and encourage residents, farms, businesses, and institutions to embrace programs aimed at solving food loss and waste. Potential areas for future study could encompass:

1. **Economic Impacts:** Conducting a detailed **economic analysis** to determine the financial benefits of reducing food waste could provide valuable insights for businesses, farmers, households, and institutions. These insights could help understand the economic motivations for adopting waste prevention or recovery solutions. Economically viable approaches might include preventive measures to reduce surplus food or increasing fees for conventional waste disposal to fund needed recovery infrastructure. States like Massachusetts and New York have already carried out cost-impact analyses before or after implementing their organic recycling laws.

   The valuation of **economic benefits** derived from addressing food waste should be assessed. Furthermore, improvements in managing food surplus and waste can be realized through the implementation of measures designed to generate revenue and introduce disincentives for landfilling. Such measures could stimulate the growth of food waste diversion businesses and reduce associated disposal costs. To encourage behavior change, some states have implemented grant programs to reduce potential barriers to starting an initiative. For instance, the Food Waste Reduction Program in New York provides reimbursements to offset the cost of technologies or programs which reduce, recover, or recycle surplus food and waste.[36]

2. **Social Impacts:** Strategies to **feed people:** approaches that can capture a higher percentage of edible food waste for human consumption warrant exploration. Research revealed that there is significant demand to feed more people in Maine with nutritional surplus food. Food recovery organizations need additional support to help meet this demand. Such strategies could potentially address food insecurity.

   Additional impacts include the potential to **create new jobs** in various sectors such as food recovery and recycling such as upcycling, anaerobic digestion, and composting.

[36] New York State Department of Environmental Conservation. "Organics Management for Businesses [Funding Opportunities]." https://dec.ny.gov/environmental-protection/recycling-composting/organic-materials-management/businesses#:~:text=The%20Food%20Waste%20Reduction%20%26%20Diversion,that%20promise%20to%20reduce%20or.

Plans that utilize **food waste for animal feed** could support livestock production and lower feed costs for farmers.

3. **Environmental Impacts:** Food waste prevention and management strategies should be recognized as a meaningful instrument for **climate change mitigation**, by achieving a significant decrease in greenhouse gas emissions.

   The promotion of **food waste for compost** could enhance soil health and agricultural productivity. Food waste is a valuable resource for compost as it is rich in nutrients, including nitrogen and carbon, that are essential for plant growth.

4. **Recognition Ongoing Diversion Initiatives:** Acknowledging **existing efforts** to reduce, recover, and recycle surplus food and waste is important. Research has revealed that significant efforts are already underway, such as donating edible surplus and sending food for animal feed. It will be important to contemplate which diversion pathways are more suitable for the type of surplus food and waste, and if there is the infrastructure to handle the varied approaches.

5. **Education:** Providing outreach and education around wasted food will continue to be essential. Educational opportunities include liability protections for recovering surplus, edible food, the appropriate edible food to donate to food rescue organizations, source separation of wasted food and associated certified compostable products to reduce contamination, and avenues to utilize finished compost. These educational opportunities will pave the way for more resilient infrastructure to handling food loss and waste.

6. **Necessity of More Data:** Accurate data on food waste is essential as it supports informed analysis and decision-making. To facilitate this information, **partnerships** with service providers, including source reduction technologies, food recovery organizations, haulers, animal feed operations, composters, and anaerobic digestors, can be furthered to enhance **data collection**. Implementing regular sector-based surveys or working group meetings can help aggregate this information and

7. **Value-Added Products:** Opportunities for developing **higher-value end products** such as upcycled food products should be explored. This could create new markets and incentivize waste reduction further while maximizing utilization of food resources and repurposing surplus and byproducts into edible products. Value-added products can be created through various processing methods, such as making soups, sauces, sausages, pet food, and other products.

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APPENDICES

APPENDIX A: METHODOLOGY AND DETAILED RESULTS BY SECTOR

This section presents the details of the sector estimates in the main report. For each sector, this includes the sector description, the final estimate and how it was computed, as well as the detailed characterization of the surplus food from the sector All food waste characterizations are quantified with reference to the 2024 ME DEP Study Estimate based on existing literature, including past studies on Maine and/or data from primary interviews where available. Percentages applied to the 2024 ME DEP Study Estimate for respective sector may be referenced in Table 28. Additional details that led to the finalization of the estimate, such as the methodology selection process, sensitivity analysis and data validation process are also included.

Residential

Sector Description

This sector quantifies surplus food generated by Maine residents from their place of living. According to the 2020 U.S. Census, Maine has a population of about 1.4 million. The top 3 populous counties are Cumberland (22% of ME population), York (16% of ME population) and Kennebec (9% of ME population). These 3 counties collectively occupy 9% of the state's landmass. This means the population of Maine is not evenly distributed where the southwestern part of the state is much more densely populated than the northwestern and eastern-interior regions of the state.[37]

For the purposes of data collection and analysis, a housing unit is defined as a separate living space that could include a house, an apartment, a group of rooms, or a single room. The primary criteria for separate living quarters are that the occupants live independently from other individuals within the building and have direct exterior access or access through a common hall. This definition designates each apartment in a multi-unit building as a separate housing unit.[38]

Study Estimate of Food Loss & Waste (Annual Tons)

This estimate was derived by applying the generation factor of 452.4 pounds per household per year to the number of occupied households in Maine. This concentration of population density in Cumberland and York Counties will impact food waste generation in these counties. The methodology selection, data application, sensitivity analysis and validation may be referenced under Additional Sector Details. Consideration of the seasonality of residential food waste (e.g. seasonal homes and rentals) is discussed under the sensitivity analysis.

2024 ME DEP Study Sector Estimate: (TPY): 131,747 tons per year (inclusive of large multi-family complexes)

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37 Encyclopædia Britannica. "Maine [Land (Plant and animal life)]." https://www.britannica.com/place/Maine-state/Plant-and-animal-life.

38 US Census Bureau. "Characteristics of New Housing [Definitions]." July 29, 2019. https://www.census.gov/construction/chars/definitions/index.html.

Characterization

All food waste characterizations are quantified with reference to the 2024 ME DEP Study Estimate based on existing literature, including past studies on Maine and/or data from primary interviews where available. Percentages applied to the 2024 ME DEP Study Estimate for respective sector may be referenced in Table 28. The sector total estimate is 129,598 tons per year (with 2,149 tons per year are estimated to be generated by Large Multi-Family Complexes).

Avoidable vs unavoidable: Surplus food from this sector has the potential to be reduced by about 21,384 tons per year. The Maine Home Food Waste Challenge 2023 Analysis showed that households could achieve up to an average of 16.65% (rounded to 17%) of food waste reduction.[39] In various communities throughout Maine, initiatives have been adopted that are aimed at reducing household surplus food, such as residential drop-off programs, campaigns to urge consumers to adopt practices that enhance the shelf life of food products, and backyard composting. This is viewed as a generous estimate given the participants tended to be higher income and perhaps better resourced to participated in a food tracking and reduction exercise. However, residential interviews indicated a high likelihood of backyard composting activities in rural communities across Maine.

Predictable vs unpredictable: Surplus food from this sector is characterized as highly unpredictable. Interviews cited individual household surplus food to have no distinct pattern.

Edibility: About 14,904 tons per year of surplus food from this sector is characterized as edible by humans. This is based on a 2020 food waste generation and composition study that conducted a series of waste sorts within the state of Minnesota. The study estimated wasted edible food to comprise about 11.5% for mixed municipal solid waste.[40] Interviews cited "(they have) no idea on residential food waste composition," describing the surplus food as "food scraps from kitchen" or "(plate waste) from residential/ restaurant sources." The feedback suggests it would be logistically intensive to develop a program to rescue edible food given the need to cater to the high variation between individual households. The ability to maintain the quality of surplus edible food for donation, such that it does not ironically end up being wasted as part of their own operations, was also highlighted in interviews with food pantries. Additionally, interviews cited the presence of home and community compost programs to divert surplus food from landfill.

Additional Sector Details

Methodology Selection. Numerous studies have delved into the topic of surplus food production at the household level, with some measuring the surplus per household, and others exploring it on a per capita basis. The U.S. Environmental Protection Agency (EPA) examined these various research methods and provided a summary of the range of generation rates, citing fourteen foundational studies. The average findings from these studies are as follows:

- EPA average pounds per household method (Method 1): 340.4 pounds per household per year

39 University of Maine – Mitchell Center for Sustainablity Solutions. "Solution 1 Pilot – Pilot 4: Maine Home Food Waste Challenge 2023." https://umaine.edu/foodrescuemaine/2023/08/04/solution-1-pilot-4-maine-home-food-waste-challenge-2023-first-annual/.

40 Minnesota Pollution Control Agency "Food Waste Generation and Composition study Analysis 2021" https://www.pca.state.mn.us/sites/default/files/w-sw1-67.pdf

- EPA average percentage of waste method (Method 2): Represents 5.8% - 29.55% of total sector waste
- EPA average pounds per person method (Method 3): 264.7 pounds per person per year

This study extrapolates the surplus food production for the residential sector in Maine, like Methods 1 and 3 above and applying the same generation factors as in these methods. A 'percentage of waste' method was not attempted because of the necessary methodological adjustments needed for adequate representation of Maine. Additionally, the Municipal Solid Waste data for Maine does not differentiate waste produced at the household level from the total municipal waste, further complicating that approach.

Data Compilation & Application. The 2020 U.S. Census data was utilized to extract the number of households, along with the total population in Maine.

- Method 1: Generated 99,137 tons per year
- Method 3: Generated 180,334 tons per year

It was noted in the studies underlying the generation factor for Method 3 that they likely included waste from other sectors within the municipality, explaining the significantly higher estimate from Method 3 compared to Method 1. Consequently, for the purposes of this sector, Method 1 was selected as the best method. To enhance the precision of the model, only occupied housing units were considered for the generation of surplus food. This was assessed to be the most accurate means of quantifying the residential sector on an average annual basis as it would include medium to long term leases, for example, college student rentals for the academic year. Seasonality in the form of shorter-term leases is discussed in the computation of the 2024 ME DEP Study Estimate High (TPY) estimate for the sector.

Sensitivity Analysis: Range of Estimates based on Selected Methodology

In recognizing a margin of error arises from statistical sampling methods, the Study presents a range of values in Table 8 by including a "high estimate" and a "low estimate." These estimates are formed based on alternative assumptions documented in subsequent paragraphs. Nonetheless, this study determined an optimal estimate specific to the context of the sector for Maine, as corroborated by pertinent literature.

Table 8: Residential Estimate vs. High and Low Estimates Based on Household Generation Rate Assumptions

Sensitivity Estimate - High (TPY)	Sensitivity Estimate - Low (TPY)	2024 ME DEP Study Estimate (TPY)
171,465	70,184	131,747

The 2024 ME DEP Study Estimate High (TPY) estimate is derived from the application of findings from a 2016 InSinkErator study.[41] The survey, self-reported across four cities (Philadelphia PA, Tacoma WA, Milwaukee WI, and Boston MA), calculated an average generation factor of 464 pounds of surplus food per household per year — the highest in the available literature compiled by the EPA. This figure pertained to households without food waste disposers installed. Furthermore, given the possibility of seasonal homes (e.g. summer homes), the generation factor

41 InSinkErator [Emerson Electric Co.]. *The Food Waste Disposer as a Municipal Tool for Waste Diversion*. March 30, 2016. https://www.emerson.com/documents/commercial-residential/insinkerator-5-cityinitiativereport-en-us-1494964.pdf.

was applied to the total households in Maine rather than just the occupied households (about 1.3x the number of occupied households according to the US 2020 Census).

The lower approximation was based on findings from U.S. EPA (2016b).[42] This study examined residential surplus food in eleven cities/counties throughout the country, resulting in an average generation factor of 241 pounds per household per year - the lowest in the available literature. While the coverage of counties/ cities was comprehensive, this was a self-reported waste measurement and photo diary exercise which, inadvertently influence behavior or risks a sampling bias towards more conscientious consumers that were willing to participate in the first place.

Nevertheless, this range, i.e. between 464 to 241 pounds per household, was found to be credible, corroborating with that of the Waste and Resources Action Programme (WRAP), a UK-based internationally credible source of studies estimating food waste generation at the household level. The WRAP study suggests this number to be 78.4kg per person i.e. 396 pounds per household for Maine, which, has an average of 2.29 persons per household according to the US Census.[43,44]

While it may lean towards the higher end of the range, a 2017 study by NRDC was considered the most relevant for this sector.[45] This study, which covered 1,151 households in Nashville, Denver, and New York City, resulted in an average generation factor of 8.7 pounds per household per week (452.4 pounds per household per year). The study comprised 613 fully completed kitchen diaries, 1,357 completed surveys, and 277 bin digs (waste audits) in the residential sector. Given it is a US-specific study and actual waste audits were done to compute the generation factor, the 2024 ME DEP Study Estimate applies this generation factor to all occupied housing units in Maine.

Data Validation: Comparison with existing estimates.

The only available existing estimate for comparison was that of ReFED's Insights Engine (243,280 tons per year). This was assessed to be overestimated and not representative of the residential sector. ReFED's estimation methodology, derived from a factor in the "FLW Standard" surplus rate and a Nielson POS data set, calculated the residential surplus weight quantity using the following formula: (weight quantity procured from grocery outlets

42 Materials Management Forum Consumption Working Group [supported by EcoPraxis and TetraTech]. *Food: Too Good to Waste – An Evaluation Report for the Consumption Workingroup of the West Coast Climate and Materials Management Forum*. US EPA Region 10, April 2016. https://www.epa.gov/sites/default/files/2016-07/documents/ftgtw_finalreport_7_19_16.pdf.

43 US Census Bureau."QuickFacts Maine, Persons per household, 2018-2022" https://www.census.gov/quickfacts/fact/table/ME/HSD310222.

44 The Waste and Resources Action Programme (WRAP), Synthesis of Household Food Waste Compositional Data 2021, 23 November 2023. https://wrap.org.uk/resources/report/synthesis-household-food-waste-compositional-data-2021

45 Hoover, Darby. *Estimating Quantities and Types of Food Waste at The City Level*. Natural Resources Defense Council, October 2017. https://www.nrdc.org/sites/default/files/food-waste-city-level-report.pdf.

+ weight quantity obtained from other sources) x Surplus Rate.[46,47,48] This formula incorporated the weight quantity procured from grocery outlets and other sources, and subsequently multiplied it by the Surplus Rate. The study acknowledged the inherent risk of potential overestimation tied to this approximation. Since the estimation was based on grocery sales data, it could inadvertently include contributions from commercial or non-residential customers, such as local restaurants and food banks. Notably, this "double counting" alone cannot explain the difference as it would require almost 50% of the purchases to align with this study's estimate. Another potential contributor to the overestimate is the data collection process followed by Nielson in a Retail Audit involved the extrapolation of findings from a designed "representative sample," which carried inherent risks.[49] This was particularly true in a state like Maine, characterized by a diverse demography spread over a large geographical area with the southwestern part of the state being much more densely populated than the northwestern and eastern-interior regions that comprise a larger proportion of rural towns and townships. The most compelling reason as to why ReFED's estimate is considered too high is based on the analysis total MSW landfilled and incinerated in the state of Maine as referenced in "*Food Loss and Waste in Maine- Total*" that estimates food waste from MSW (households, businesses and institutions) to range from 157,500 to 225,000 tons per year. The estimate was assessed to be too high given the residential sector alone should not fall outside this range.

Estimate Finalization

Considering potential overestimation inherent in other existing methodologies and to avoid double-counting given the sector-based approach adopted for this study, a final estimation of was determined by applying the appropriate generation. This factor was informed by a Maine-specific evaluation and applied to the total number of occupied housing units. **2024 ME DEP Study Estimate (TPY): 131,747 tons per year (inclusive of "Large Multi-Family Complexes").**

Large Multi-Family Complexes

Sector Description

The focus of this sector is on surplus food originating from large multi-family complexes in Maine. As part of the residential sector, efforts have been made to prevent data overlap. The importance of this sector is highlighted by its capacity to produce concentrated sources of residential waste from a single location. Considering the prevalence of single-family housing in Maine, the analysis aimed to identify primary municipalities that could potentially have a significant sector of "large multi-family complexes." The evaluation also attempted to discern if

46 ReFED. "Food Waste Monitor." ReFED Insights Engine, 2022. https://insights-engine.refed.org/food-waste-monitor?view=overview&year=2022.

47 Hanson, C., Lipinski, B., Robertson, K., Dias, D., Gavilan, I., Gréverath, P., Ritter, S., Fonseca, J., VanOtterdijk, R., Timmermans, T., Lomax, J. , O'Connor, C., Dawe, A., Swannell, R., Berger, V., Reddy, M., Somogyi, D., Tran, B., Leach, B., & Quested, T. *Food Loss and Waste Acco unting and Reporting Standard*. Food Lodd + Waste Protocol, 2016. https://www.wri.org/research/food-loss-and-waste-accounting-and-reporting-standard.

48 Nielsen. "Nielson Retail Measurement Point of Sales Data." 2019. http://www.nielsen.com/us/en/solutions/measurement/retail-measurement/.

49 Nielsen. *Nielsen Retail Measurement Service*. Accessed February 28, 2024. https://unstats.un.org/unsd/bigdata/conferences/2019/workshops/scanner-data/Session%202.6%20Nielsen%20Data.pdf.

any of these complexes consistently produced an annual average of one or more tons of waste per week from a single location. Large multi-family complexes are largely found in Cumberland County.

Study Estimate of Food Loss & Waste (Annual Tons)

As a subset of the residential sector, this estimate was derived using information related to "units in structure," as aggregated by the Maine state housing authority from the 2020 U.S. Census. This study defined "Large Multi-Family Complexes" as structures containing 50 or more units to highlight the potential size of individual large generators within this sector. The methodology, data application, sensitivity analysis and validation may be referenced under Additional Sector Details.

2024 ME DEP Study Sector Estimate: (TPY): 2,149 tons per year

Characterization

All food waste characterizations are quantified with reference to the 2024 ME DEP Study Estimate based on existing literature, including past studies on Maine and/or data from primary interviews where available. Percentages applied to the 2024 ME DEP Study Estimate for respective sector may be referenced in Table 28.

Surplus food characterization was thought to be very similar to the rest of the "residences" sector in terms of how avoidable, how predictable, and how edible. While the aggregation of households could reduce the variation from a logistics perspective, the individual context of a large residence such as the demographics of the community, the presence of shared amenities, the cost of food in the surrounding community etc. would need to be studied in detail to provide a more meaningful conclusion. The NRDC's 2017 study estimated an average of 68% of household surplus food to be potentially edible, this sector's food is cited as inedible due to the high variation and dispersed nature of household surplus food.[50] As an example, should 68% of the food surplus generated by 50 units be edible for immediate consumption, and there is a food pantry in reasonable proximity, collecting 4 tons of edible food daily could be very beneficial for the community.

Additional Sector Details

Methodology. The scarcity of existing literature and data specific to this sector necessitated the formulation of an independent methodology for this study. Various thresholds were considered to define a large multi-family complex.

Data Compilation & Application. This sector utilized information related to "units in structure," as aggregated by the Maine state housing authority from the 2020 U.S. Census.[51] This data set segmented housing within Maine municipalities into the following categories:

- 1 unit, detached
- 1 unit, attached

50 Hoover, Darby. *Estimating Quantities and Types of Food Waste at The City Level*. Natural Resources Defense Council, October 2017. https://www.nrdc.org/sites/default/files/food-waste-city-level-report.pdf.

51 US Census Bureau. "Characteristics of New Housing [Definitions]." July 29, 2019. https://www.census.gov/construction/chars/definitions/index.html.

- 2 units
- 3 or 4 units
- 5 to 9 units
- 10 to 19 units
- 20 to 49 units
- 50 or more units
- Mobile home, Boat, RC, van etc.

Each municipality's allocation across categories was compiled, with the residential estimate being subsequently applied to the specific sector. This process yielded the ensuing estimates.

Sensitivity Analysis: Range of Estimates based on Selected Methodology

In recognizing a margin of error arises from statistical sampling methods, the Study presents a range of values in Table 9 by including a "high estimate" and a "low estimate." These estimates are formed based on alternative assumptions documented in subsequent paragraphs. Nonetheless, this study determined an optimal estimate specific to the context of the sector for Maine, as corroborated by pertinent literature.

Table 9: Estimate vs. High and Low Estimates from Large Multi-Family Complexes (subset of the residential sector)

Sensitivity Estimate - High (TPY)	Sensitivity Estimate - Low (TPY)	2024 ME DEP Study Estimate (TPY)
12,587	2,149	2,149

In the high estimate, large multi-family complexes were defined as structures containing five or more units. This accounted for approximately 9% of residential waste across a maximum of 6,514 entities. The top three cities, in terms of number of such complexes, were identified as Portland (1,045 complexes), Lewiston (661 complexes), and Bangor (359 complexes). Conversely, in the low estimate, large multi-family complexes were defined as structures containing 50 or more units. This represented approximately 2% of residential waste across a maximum of 190 entities. The top three cities in this estimate were identified as Portland (62 complexes), South Portland (20 complexes), and Westbrook (11 complexes).

Data Validation: Validation of this data revealed no existing estimates for comparison. However, the Study observed that the top cities, as highlighted, did corroborate with census data which cited these municipalities for their high percentages of multifamily homes. These cities are generally recognized as growing cities in Maine. Further, preliminary interview findings from interviews with service providers indicated that this sector does not appear to be significant in terms of collection.

Estimate Finalization

With the high estimate, defined as five or more units in a structure, the average generation rate stands at 1.34 tons per year (0.03 tons per week) per large complex. However, the low estimate, defined as 50 or more units in a structure, yields an average generation rate of 8.7 tons per year (0.168 tons per week) per large complex. The low estimate was chosen as the final figure to highlight the potential size of individual large generators within this sector. **2024 ME DEP Study Estimate (TPY): 2,149 tons per year (Residential Sector adjusted to 129,598 tons per year).**

Farms and Commercial Agriculture

Sector Description. This sector quantifies surplus food produced by farms and agricultural entities in Maine. Defined broadly, entities within this sector are food growers or producers. Several challenges arise when attempting to quantify food waste from this sector and understanding its geographical distribution. One significant challenge is the high variance in types of farm produce, which complicates generalizations and extrapolations without distinguishing individual crop types. Post-harvest losses vary by crop due to unique characteristics and processes that resist easy averaging. Additionally, obtaining data poses difficulties, whether through secondary sources like the USDA or via primary research. Comprehending the geographical distribution also presents challenges due to privacy concerns surrounding farmland locations. Consequently, data is typically available only at the county level.

Study Estimate of Food Loss & Waste (Annual Tons)

ReFED's 2022 estimate for surplus food from farms in Maine was used for this estimate. The methodology calculated the estimate utilizing the following formula: Food Surplus = Tons Never Harvested (Walk-by Fields) + Tons Left Behind After Harvest + Tons Packhouse Losses + Tons Unsold Buyer Rejections. This analysis incorporates four types of crops: Potatoes, Blueberries, Apples, and Sweet Corn. The geographical dispersion of these crops, modelled at the municipal level using complementary USDA data, allowed for further analysis of ReFED's estimate for the purpose of this study. Aroostook County is estimated to have the highest concentration of food loss and waste from Farms and Agriculture. This is mainly attributed to potato farms. Further details of the methodology, additional avenues explored and recommendations for further data collection to understand this sector more thoroughly can be referenced under Additional Sector Details.

2024 ME DEP Study Sector Estimate: (TPY): 90,470 tons per year

Characterization

All food waste characterizations are quantified with references to the 2024 ME DEP Study Estimate based on existing literature, including past studies on Maine and/or data from primary interviews where available. Percentages applied to the 2024 ME DEP Study Estimate for respective sector may be referenced in Table 28.

Avoidable vs unavoidable: According to the WWF, some key reasons for surplus food from farms are that the produce do not meet quality or retail standards, they are overripe, there are labor shortages and cost of labor leads to unharvested fields as well as the growers having less seller power than buyers due to market dynamics.[52] There is very high variation between farms and crop types with regards to this and thus the Study assumes all farm surplus is unavoidable. More in-depth studies need to be conducted at individual farms in order to estimate this on a case-by-case basis.

Predictable vs unpredictable: This study assumes surplus food from this sector is highly unpredictable. Farmers tend to attribute most losses to unpredictable events, which occur infrequently but have a substantial impact on volume. The primary drivers of food loss on farms are weather, labor, and market conditions. Market prices, grading

52 Pearson, P., McBride, M., & Prezkop, L. *No Food Left Behind – Part 1: Underutilized Produce Ripe for Alternative Markets*. WWF, August 21, 2018. https://files.worldwildlife.org/wwfcmsprod/files/Publication/file/1o0so2isvb_WWF_NoFoodLeftBehind820_2.pdf?_ga=2.22585083.1979158184.1709553979-1599758703.1707982806.

standards, and retailers' perceptions of consumer preferences establish quality standards and determine the amount harvested or left in the field.[53]

Edibility: Farmers often distinguish between produce that is edible and marketable. Questions arise regarding the definition of "edible." For instance, while a crop might be edible, it may not be sellable as food for human consumption. Furthermore, the concept of "edible now" versus "edible when it reaches the consumer" has been raised by several farmers. Imperfections in produce may seem minor at the field level but may render the produce unsellable by the time it reaches the consumer. According to ReFED, for Apples, Blueberries and Sweet Corn and Potatoes, about 30%, 2%, 2% and 5% of yield is left in the field.[54]

Furthermore, the extent of edibility varies by crop type due to their inherent characteristics. This is captured in Table 10 below where it can be observed that corn generates a relatively higher percentage of food waste than other produce due to the nature of the crop.

Table 10: Characterization of Edibility by Crop Type (Percent)

Crop	Edible (by Humans and Animals)	Inedible[55]
Apples	91%	9% (Core and stem)
Blueberries	95%	5% (Stems and green or spoiled berries)
Corn (Sweet Corn)	36%	64% (35% husk, silk, trimmings; 29% Cob)
Potatoes	75%	25% (Parings and trimmings)

For example, for Apples, of the 30% left in the field that is marketable, only 91% is edible food surplus. Thus, the percentage of edible surplus Apples is 91% of 30% i.e., 27%. The percentage of edible surplus Blueberries, Sweet corn and Potatoes is 2%, 1% and 4% respectively. When applied to the farm sector, this estimate is about 5,412 tons per year of edible produce left behind.

Additional Sector Details

Methodology Selection. Research was conducted to aggregate the available literature on farm food losses. The following approaches were adopted to better understand the surplus food and geographical spread of this sector.

1. ReFED's 2022 estimate for food waste in Maine is calculated utilizing the following formula: Food Surplus = Tons Never Harvested (Walk-by Fields) + Tons Left Behind After Harvest + Tons Packhouse Losses + Tons Unsold Buyer Rejections. This analysis incorporates four types of crops: Potatoes, Blueberries, Apples,

53 Pearson, P., McBride, M., & Prezkop, L. *No Food Left Behind – Part 1: Underutilized Produce Ripe for Alternative Markets*. WWF, August 21, 2018. https://files.worldwildlife.org/wwfcmsprod/files/Publication/file/1o0so2isvb_WWF_NoFoodLeftBehind820_2.pdf?_ga=2.22585083.1979158184.1709553979-1599758703.1707982806.

54 ReFED. "Appendix." In *Food Waste Monitor*. ReFED Insights Engine, 2023. https://docs.refed.org/methodologies/food_waste_monitor/appendix.html.

55 Powell, C., Curtis, P., & Lally, M. *U.S. Grocery Retail Food Inedible Parts Factor*. ReFED, 2019. https://refed.org/downloads/ReFED-U.S.-Grocery-Retail-Food-Inedible-Parts-Factors.pdf.

and Sweet Corn. The geographical dispersion of these crops, modelled at the municipal level using USDA data, enhances the precision of ReFED's estimates.

2. This study also endeavored to reevaluate food waste for Potatoes, Blueberries, Apples, and Corn based on available data, using ReFED's methodology. This was done in an attempt to corroborate the existing estimates and expand the variety of crops. This incorporated 50 additional crops (including corn instead of sweet corn). However, the lack of information concerning double cropping, pack house losses, and buyer rejections rendered this estimate less comprehensive than ReFED's 2022 estimate. For instance, the process of subtracting harvested acres from acres planted to obtain "unharvested acres" yielded negative values due to insufficient data on acres with more than one type of crop.
3. The University of Maine Mitchell Center Farms Surplus survey also suggested an average surplus percentage based on crop production volumes.

Studies specific to Maine were prioritized over others. For example, while the WWF provided some percentage estimates for loss rates by crop type, these estimates were derived from USDA data based on the harvested acres per crop and county.[56]

Data Compilation & Application

- Data on farm acreage and crop type at the municipality level was procured from a direct source at the USDA by the University of Maine. ReFED's estimated food surplus by crop was distributed based on the percentage of acreage from that database. The analysis confirmed findings from other reports specific to Maine, including the geographical distribution of farms (and therefore surplus food) by crop type such as potatoes in Aroostook County or blueberries in Washington county, among other coastal counties.[57] However, the following limitations were noted:
    - The analysis was confined to potatoes, blueberries, apples, and sweet corn.
    - The sum acreage from the USDA database accounted for approximately 32% of estimated total cropland in Maine. This suggests an underestimation in the number of farms contributing to the food surplus. Consequently, the average food surplus per farm is potentially overestimated.
- Data was primarily sourced from the United States Department of Agriculture query search tool which heavily sources the US 2017 census. However, the surplus estimate comprised numerous negative values due to multiple crops being harvested from the same acre of cropland, resulting in harvested acres exceeding total acreage. This corroborates the University of Maine's Mitchell Center Farms Surplus survey which recorded examples of multiple crops being grown from the same farm.[58] Furthermore, pack house losses and unsold buyer rejections also could not be computed. Due to incomplete data and the quality of the dataset, this estimate provides a potential high estimate for the sector of 311,552 tons per year for reference only.

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56 Pearson, P., McBride, M., & Prezkop, L. No Food Left Behind, Part 2: A Tale of Two Markets: A Model for Working Together to Fully Utilize the Surplus. WWF, July 9, 2019. https://files.worldwildlife.org/wwfcmsprod/files/Publication/file/31q2mdxzra_NFLB_Part_II__V4_Final__Low_res.pdf.

57 McBrady, Nancy. Maine Agricultural Overview. Maine Department of Agriculture Conversation & Forestry, September 5, 2023. https://www.maine.gov/labor/docs/2023/mwaw/MaineAgOverview9_23.pdf.

58 University of Maine – Mitchell Center for Sustainablity Solutions. "Solution 4 Pilot – Pilot 1: Maine Farm Surplus Survey." Food Rescue MAINE, August 9, 2023. https://umaine.edu/foodrescuemaine/2023/08/09/pilot-1-maine-farm-surplus-survey/.

- The University of Maine Mitchell Center Farms Surplus survey revealed that the average surplus percentage of respondents' farm product was 7.53%. When applied to the USDA production data for potatoes, blueberries, and corn as well as an estimate from the Maine Pomological Society for apples, this suggests the food surplus for the specified crops of this sector to be about 46,579 tons per year. The breakdown by crop type is illustrated in Table 11.

Table 11: Estimated Annual Crop Production and Surplus by Produce Type

Crop	Estimated Production (TPY)	Surplus Estimate Based on 7.53% of Production (TPY)
Apples	22,500[59]	1,694
Blueberries	96,135[60]	7,237
Corn	408,000[61]	30,713
Potatoes	92,125[62]	6,935
Total	**618,760**	**46,579**

Sensitivity Analysis: Estimations by Alternate Methodologies

In recognizing a margin of error arises from statistical sampling methods, the Study presents a range of values in Table 12 by including a "high estimate" and a "low estimate." These estimates are formed based on alternative methodologies, as documented in preceding paragraphs. Nonetheless, this study determined an optimal estimate specific to the context of the sector for Maine.

Table 12: Farms and Commercial Agriculture Sector Estimate vs. High and Low Estimates

Sensitivity Estimate - High (TPY)	Sensitivity Estimate - Low (TPY)	2024 ME DEP Study Estimate (TPY)
311,552	46,579	90,470

The high estimate is derived from the application of ReFED's methodology to aggregate USDA data to corroborate the existing estimate and expand the variety of crops. While this number could not be verified given gaps in the data, it was assessed to be a reasonable number for the high estimate of the sector. The low estimate is based on the 7.53% surplus estimate from the University of Maine study as computed in Table 8. Given the constraints of the applied methodologies, the original ReFED estimation for this sector was retained as the 2024 ME DEP Study Estimate.

59 Maine Pomological Society estimates one million bushels of apples grown in Maine each year. Conversion to tons used: 1 bushel = 45 pounds.

60 USDA/NASS. "2023 State Agriculture Overview – Maine." https://www.nass.usda.gov/Quick_Stats/Ag_Overview/stateOverview.php?state=MAINE.

61 Ibid.

62 Ibid.

Data Validation & Estimate Finalization

Validation of this sector's estimate through interviews was deemed unfeasible due to the need for multiple, crop-specific interviews to ensure representativeness. **2024 ME DEP Study Estimate (TPY): 90,470 tons per year.**

For enhanced precision in future estimates, additional studies are recommended. These should encompass:

- Identification of key crop types within Maine for targeted focus.
- Execution of primary research into the processes of individual farms producing identical crops to establish a reliable yield (in tons) per harvested acre and to gain insight into packhouse losses and shipping losses.
- Examination of existing surplus food mitigation activities.
- Close collaboration with the USDA to acquire a broader dataset of farms in Maine.

An example of an interesting crop for further exploration is broccoli, a key crop highlighted by Harvesting Good, a wholly owned subsidiary of Good Shepherd Food Bank, the largest Food Bank in Maine.[63] The United States Department of Agriculture query search tool withheld data on broccoli acres harvested to "avoid disclosing data for individual operations" of such farms and thus an estimation for surplus food could not be computed for the crop.

Food Manufacturers

Sector Description

This sector quantifies surplus food generated by the Maine food manufacturing and processing sector. This sector transforms raw ingredients into marketable food and beverage products for easy consumer use. Companies in this sector are classified under NAICS codes 311 (food manufacturing) and 3121 (beverage manufacturing). Over 40 categories of food and beverage manufacturing exist in Maine, with All Other Miscellaneous Food Manufacturing (12%), Commercial Bakeries (10%), Seafood Product Preparation and Packaging (8%), Breweries (6%), and Distilleries (5%) making up the top categories by establishment count.

Study Estimate of Food Loss & Waste (Annual Tons)

This estimate was derived using the pounds per revenue per year methodology. Given the significant variance between manufacturing processes, a comprehensive survey of foundational studies found the average generation factor of 0.095 pounds per dollar sales per year to be the best available estimate. This was used to estimate the food surplus generated by the majority of processors in the database. The accuracy of the model was improved by incorporating generation factors derived from interviews where feasible. Currently, the model employs the generation factors detailed in Table 13.

[63] Good Shepherd Food Bank. "Maine Food Bank Launches Harvesting Good." Good Shepherd Food Bank, August 3, 2022. https://www.gsfb.org/blog/2022/08/03/maine-food-bank-launches-harvesting-good/.

Table 13: Generation Factors (Lb. per $ of Sales) for Various Food Manufacturing Sectors

Category of Manufacturers	Generation Factor (Pounds/$ Sales/Year)
All Other Miscellaneous Food Manufacturing	0.18
Commercial Bakeries	0.01
Distilleries	0.07
Seafood Product Preparation and Packaging	0.01
Tortilla Manufacturing	0.01
All Others	0.095

These generation factors were applied respectively to data of companies extracted from the D&B database that was assessed to offer more precise sales revenue estimates, likely tailored to operational entities within Maine rather than overall corporate revenues. Counties with the most food waste generation in this sector include Cumberland, Washington, and York. The methodology selection, data application, sensitivity analysis and validation may be referenced under Additional Sector Details.

2024 ME DEP Study Sector Estimate: (TPY): 40,603 tons per year

Characterization

The characterization of surplus food further underscored the challenge of significant variance among types of food processors. This issue proved even more pronounced than the one encountered in quantifying the amounts generated. Numerous interviews were conducted to comprehend the major types of processors within Maine. All food waste characterizations are quantified with reference to the 2024 ME DEP Study Estimate based on existing literature, including past studies on Maine and/or data from primary interviews where available. Percentages applied to the 2024 ME DEP Study Estimate for respective sector may be referenced in Table 28.

Avoidable vs unavoidable: Surplus food from this sector is highly unavoidable. This was a consistent finding across the major types of processors interviewed where the surplus food was described as to be "unavoidable" or "inherent in the manufacturing process." Some examples cited included bakery "flour used for dusting" or "messy" butter and cream cheese (not deemed "clean" for consumption post processing), vegetable trimmings (which are already "minimal") and "skins." Entities in this industry are incentivized to design processes that minimize wastage of edible parts as it makes sense from a cost perspective. Studies indicate that 10% of food waste generated in the manufacturing industry is due to lack of standard procedures and operations.[64] These errors could be mitigated with technologic improvements and staff training.

Predictable vs unpredictable: About 38,532 tons per year of surplus food from this sector was characterized as highly predictable, in terms of production of inedible parts (correlated with production volume), that comprises most of the surplus food. Some interviews mentioned an unpredictable supply of food fit for immediate consumption e.g.,

64 Bhatia, L., Jha, H., Sarkar, T., & Sarangi, P.K. (2023). "Food Waste Utilization for Reducing Carbon Footprints towards Sustainable and Cleaner Environment: A Review." *International journal of environmental research and public health*, 20 no.3 (2023), 2318. https://doi.org/10.3390/ijerph20032318.

due to power outages (no generator onsite). The surplus food would then be given to staff or taken up by existing food donation partnerships. One interview explained that the cost of logistics, together with an unpredictable supply made it challenging to implement a regular donation program.

Edibility: About 2,071 tons per year of surplus food from this sector is characterized as edible by humans. The rest are likely only suitable for animal feed or inedible. While interview findings suggested an average distribution of edible and inedible food to be 51% and 49% respectively, of the 51%, most interviews described the surplus food as suitable for animals, rather than for human consumption. Of the inedible surplus food, processors were found to have specific downstream partnerships such as rendering companies or compost sites. One interviewee mentioned that while there may be potential avenues for upcycling, the exploration of byproducts requires research, product testing, and technological or packaging improvements in the manufacturing process, may be costly.

Additional Sector Details

Methodology Selection. The quantification of food waste generation per manufacturing facility presents challenges due to the diverse nature of the products. Three pathways to estimate food waste were identified, including pounds per annual sales, pounds per square foot, and pounds per employee, based on seven foundational studies. The findings from these studies are as follows:

- Average sales-based factor based on EPA-reviewed studies: 0.095 pounds/sales/year
- Average per-location factor based on EPA-reviewed studies: 862,608 pounds/establishment/year
- Average per-employee factor across EPA-reviewed studies 1,655 pounds/employee/year

It was noted in the studies underlying Method 3 that they were conducted in urban cities already implementing food waste landfill bans around the time of data collection and therefore the estimate is likely to be understated. Consequently, Method 3 was not selected for evaluation.

Based on interviews, variation was observed in the surplus of food produced, contingent upon the type of food and beverage manufacturer. This variation was evident in both the quantities produced and the characterization of food waste. Two methods were evaluated for their efficacy in accounting for this variance, with Method 1 offering more flexibility. Method 1, which is revenue-based, allows for the estimation of food waste generation to be adjusted in correlation to business revenue size. This adjustment is not feasible with Method 2, which employs an average generation rate per establishment. This limitation is explicitly acknowledged in the 2002 Massachusetts DEP study, a foundational study for Method 2. The Study recognizes the diversity of food waste generation patterns even within manufacturers under a single SIC code.[65] As such, Method 1 was chosen for calculations in this sector.

65 Draper/Lennon, Inc. *Identification, Characterization, and Mapping of Food Waste and Waste Generators in Massachusetts*. Massachusetts Department of Environmental Protection, September 19, 2002. https://www.mass.gov/doc/study-identification-characterization-mapping-of-food-waste-generators-in-massachusetts-2002/download.

Data Compilation & Application. This sector relied on business databases D&B Hoovers and IBISWorld.[66, 67]

- EPA average pounds per annual sales (Method 1):
  - D&B Hoovers: 54,828 tons per year[68]
  - IBISWorld: 127,449 tons per year

The D&B database offers a more precise sales revenue estimate, likely tailored to operational entities within Maine. The potentially inflated figure reported by IBIS might stem from the inclusion of sales revenue from chain companies operating out of state.

Sensitivity Analysis: Range of Estimates based on Selected Methodology

In recognizing a margin of error arises from statistical sampling methods, the Study presents a range of values in Table 14 by including a "high estimate" and a "low estimate." These estimates are formed based on alternative assumptions documented in subsequent paragraphs. Nonetheless, this study determined an optimal estimate specific to the context of the sector for Maine, as corroborated by pertinent literature and primary data collected through interviews.

Table 14: Food Manufacturing Sector Estimate vs. High and Low Estimates Based on the Lb./$ Revenue

Sensitivity Estimate – High (TPY)	Sensitivity Estimate – Low (TPY)	2024 ME DEP Study Estimate (TPY)
98,113	30,011	40,603

Under the first method, the high estimate of 0.17 pounds per dollar of sales was derived from a 2016 FWRA 2016 study. This study calculated findings for the manufacturing sector based on self-reported survey results.[69] Similarly, the low estimate of 0.052 pounds per dollar of sales is taken from a 2014 BSR study, which also utilized self-reported survey results for its findings in the manufacturing sector.[70] A 2013 BSR study employed the same methodology to compute the 0.062 pounds per dollar of sales generation factor.[71]

The 2024 ME DEP Study Estimate applies the average generation factor of 0.095 pounds per dollar of sales as well as specific generation factors where possible.

66 Dun & Bradstreet. *D&B Hoovers*. Accessed December 2023-March 2024. https://www.dnb.com/products/dnb-hoovers.html.

67 Ibis World. [Industry Reports.] Accessed December 2023-March 2024. https://www.ibisworld.com.

68 The data set contained 15% missing values, which were imputed by utilizing the average revenue per employee

69 BSR. *Analysis of U.S. Food Waste Among Food Manufacturers, Retailers, and Restaurants*. A joint project by the Food Marketing Institute, the Grocery Manufacturers Association & the National Restaurant Association, [Fall] 2016 https://foodwastealliance.org/wp-content/uploads/2020/05/FWRA-Food-Waste-Survey-2016-Report_Final.pdf

70 Ibid.

71 BSR. *Analysis of U.S. Food Waste Among Food Manufacturers, Retailers, and Wholesalers*. Food Waste Reduction Alliance, April 2013. https://www.foodwastealliance.org/wpcontent/uploads/2020/04/FWRA_BSR_Tier2_FINAL.pdf.

Data Validation

When compared to existing estimates, the estimate closely aligns with the higher range of the EPA Excess Food Opportunities Map (between 12,233 to 39,239 tons per year) for the sector. This should be expected given the EPA estimate, calculated in 2016, may be outdated and may not account for the growth of Maine's food processing industry, as reported by the Maine Department of Economic and Community Development.[72] The estimate similarly exceeds ReFED's Insights Engine estimate of 16,389 tons per year. ReFED's methodology, which is based on a detailed product-level analysis, determines the Tons of Unsold Food by considering quantities of Unutilized Ingredients, Finished Product Not Shipped, and Buyer Rejections.[73] Data sources include the U.S. Census Bureau Annual Survey of Manufactures, U.S. Census Bureau Annual Retail Trade Survey, U.S. Bureau of Labor Statistics Employee Levels, and additional manufacturing case studies. Since the 2022 estimate cited considers a subset of the broad array of food products manufactured in Maine, about 7 categories whereas Maine's manufacturing industry has over 40 categories of NAICS codes, the methodology may not be as comprehensive in accounting for the food surplus produced by this sector.

Estimate Finalization

Upon consideration of the potential for underestimation in alternate methodologies, the specific evaluation for Maine supported by interview data, and multiple findings citing high variance within the sector as a significant challenge in calculating an accurate estimate, a modified estimate was made. **2024 ME DEP Study Estimate (TPY): 40,603 tons per year.**

Grocery Stores

Sector Description

The objective of this sector is to provide a quantifiable measure of surplus food generated by Maine Grocery stores. This sector is distinguished from the Food Distributors sector by its position in the supply chain. Products from Grocery stores, unlike those from Distributors, are likely to be purchased by end-consumers, such as individual residents. The NAICS codes 44511 (Supermarkets and Other Grocery Retailers), 4452 (Specialty Food Stores), and 45291 (Warehouse Clubs and Supercenters) are included in this category, each offering a diverse range of food products for retail. Within Maine, Supermarkets and Other Grocery Retailers were identified as the largest contributors to this sector.

Study Estimate of Food Loss & Waste (Annual Tons)

This estimate was derived from applying the generation factor of 2.04 tons per employee per year (supermarkets) to the data of companies extracted from the D&B database. The employee-based estimation was found to be more comprehensive as compared to that of a revenue-based approach. Furthermore, in terms of the available

72 Camoin Associates. "Maine's Food Sector: Industry Profile." *Maine Department of Economic and Community Development*, September 2023. https://www.maine.gov/decd/sites/maine.gov.decd/files/inline-files/Final Report - Master Food Sector - DECD.pdf.

73 ReFED. "Manufacturing Methodology." *ReFED Insights Engine*, 2023. https://docs.refed.org/methodologies/food_waste_monitor/manufacturing.html#manufacturing.

databases, employee data was sampled to be more comprehensive than revenue data (which had missing reported values that had to be plugged). Concentration of food waste generation from Groceries was found to be in Cumberland, Penobscot, and York Counties. The methodology selection, data application, sensitivity analysis and validation may be referenced under Additional Sector Details.

2024 ME DEP Study Estimate (TPY): 37,955 tons per year

Characterization

All food waste characterizations are quantified with reference to the 2024 ME DEP Study Estimate based on existing literature, including past studies on Maine and/or data from primary interviews where available. Percentages applied to the 2024 ME DEP Study Estimate for respective sector may be referenced in Table 28.

Avoidable vs unavoidable: Surplus food was described by one interviewee to be avoidable up to about 18,977 tons per year based on interviews. Some commonly cited causes include over-ordering, spoilage due to the natural cycle of fresh produce and expiring foods. Additionally, interviews mentioned "there's always a certain level of inedible food scraps" including spent oil and meat scraps from cooked food or ready to eat counters. Inventory management, including both better training for staff as well as analytical tools were cited as key determinant factors.

Predictable vs unpredictable: Surplus food from this sector is highly unpredictable. Given Maine is a largely coastal community, storm loss has become more prevalent in recent years. Infrastructure development or training to handle unpredictable edible surplus could be essential, especially considering possible power outages caused by increasingly frequent storms. Supporting food recovery organizations' ability to recover this unpredictable surplus could be essential.

Edibility: Edibility of surplus food is highly variable for grocery stores. Interviews described examples edible by humans, edible by animals and inedible. Generally, edibility was reported to range from 0% to 52%. Of the surplus food, about 7,211tons per year is edible by humans, 4,175 tons per year edible by animals and 26,568 tons per year are inedible based on secondary literature (Raley's Case Study Food Waste Reduction by the Numbers).[74] This was used for the estimate due to the high variability observed in the interviews. Large grocery chains have established robust relationships with food rescue organizations. These partnerships not only facilitate the existing operations but also pave the way for the implementation of further diversion activities across numerous grocery stores. However, a challenge was reported by a smaller grocery store in terms of upcycling fresh produce. From a financial standpoint, it was deemed more economical to waste the food than to employ personnel (in accordance with minimum wage standards) to prepare dishes, such as pasta salad, without the certainty of it being sold. This issue might be more efficiently addressed by larger grocery chains, particularly those equipped with ready-to-eat or cooked food counters.

Additional Sector Details

Methodology Selection. Numerous studies have investigated surplus food production, employing measurement techniques such as per employee, per establishment, or per sales revenue. The EPA has evaluated these diverse

74 Pacific Coast Collaborative. *Case Study: How Raley's Is Optimizing its Operations to Reduce Food Waste*. 2022. https://pacificcoastcollaborative.org/wp-content/uploads/2022/12/PCFWC-Raleys-Case-Study-Final.pdf.

research methods and compiled a comprehensive summary of the generation rates. This summary, which cites eight underlying studies, examines food waste from different types of food retailers. The findings are encapsulated in the following data:

- Average per-employee factor across EPA-reviewed studies:
  - Commercial (Food Retail/ Wholesale) – Supermarkets: 2.04 Tons per employee per year
  - Commercial (Food Retail/ Wholesale) – Supercenters: 0.38 Tons per employee per year
- Average per-establishment factor across EPA-reviewed studies:
  - Supermarkets: 117 Tons per establishment per year
  - Convenience Stores: 83 Tons per establishment per year
- Average revenue-based factor across EPA-reviewed studies: 0.005 Tons of food waste per thousand dollars revenue

Only employee-based and revenue-based calculations were computed for this study given the limitation that Method 2 assumes every establishment, regardless of size, generates the same amount of food waste. The figure in Method 2 is the average of underlying studies that computed the average tons of food waste per entity under specific conditions such as the 2008 study by Okazaki, et al. that averaged information on entities in Hawaii which, may not be as applicable to individual entities within Maine.[75]

Data Compilation & Application: Sector entities were identified business databases D&B Hoovers and IBISWorld.[76, 77]

- Method 1:
  - D&B Hoovers: 37,955 tons per year
  - IBISWorld: 55,369 tons per year
- Method 3:
  - D&B: 14,311 tons per year[78]
  - IBISWorld: 42,318 tons per year

The underlying literature supporting employee-based estimation was found to be more comprehensive as compared to that of a revenue-based approach. The 6 studies citing the tons per employee method cited different studies for supermarkets (4 studies) and supercenters (2 studies). Furthermore, in terms of the available databases, employee data was sampled to be more comprehensive than revenue data (which had missing reported values that had to be plugged). Method 1 was used to compute the estimate for this sector.

Sensitivity Analysis: Range of Estimates based on Selected Methodology

In recognizing a margin of error arises from statistical sampling methods, the Study presents a range of values in Table 15 by including a "high estimate" and a "low estimate." These estimates are formed based on alternative

75 Okazaki, W.K., Turn, S.Q., & Flachsbart, P.G. "Characterization of food waste generators: a Hawaii case study." *Waste Management*, December 2008, 2483-2494. https://www-sciencedirect-com.proxy.lib.umich.edu/science/article/pii/S0956053X08000536.

76 Dun & Bradstreet. *D&B Hoovers*. Accessed December 2023-March 2024. https://www.dnb.com/products/dnb-hoovers.html.

77 Ibis World. [Industry Reports.] Accessed December 2023-March 2024. https://www.ibisworld.com.

78 The handling of missing values was addressed by substituting with the average revenue per employee, accounting for 11% of the data.

assumptions documented in subsequent paragraphs. Nonetheless, this study determined an optimal estimate specific to the context of the sector for Maine, as corroborated by pertinent literature and primary data collected through interviews.

Table 15: Grocery Estimate vs. High and Low Estimates Based on Tons per Employee Methodology

Sensitivity Estimate - High (TPY)	Sensitivity Estimate - Low (TPY)	2024 ME DEP Study Estimate (TPY)
55,369	22,773	37,955

The D&B database offers a more precise employee estimate as it breaks down data to individual, single-site entities, whereas IBISWorld data is aggregated at the county level. Consequently, the latter may include employees indirectly related to grocery store operations, such as corporate staff. The estimate derived from the IBISWorld dataset served as the upper limit for this sector. The lower limit was inferred from an interview with a significant player in the Supermarket sector, who estimated the food waste to be approximately 60% of the estimate generated by the average employee-based model. The data was extrapolated across the entire dataset to obtain the lower limit. A separate interview with a smaller, independent grocery store indicated a high degree of variability between individual grocery stores' generation rates.

The 2024 ME DEP Study Estimate employed the mean of all study estimates. Given the industry's highly varied nature, this mean was considered a reasonable assumption. The average of multiple foundational studies is expected to represent the grocery store industry more accurately in Maine which is comprised of both large chain grocery stores and smaller, independent grocery stores.

Data Validation

When compared to existing estimates, the 2024 ME DEP Study Estimate (Food Distributors (Wholesale) 7,615 tons per year + Grocery Stores: 37,955 tons per year = 45,569 tons per year) for this sector exceeds both the EPA Excess Food Opportunities Map (between 11,487 to 22,941 tons per year) as well as the ReFED's Insights Engine that had an existing estimate of 29,188 tons per year. EPA's measure was executed in 2016 and given Maine's considerable growth of population and the food industry since that time, it is believed that this measure may underrepresent a more current estimate.[79] ReFED's methodology relies on calculating surplus food in this sector by understanding the difference between quantities purchased by retailers and quantities sold to consumers. This approach could potentially overlook food distributors, depending on the dataset utilized. Additionally, ReFED's methodology is based on computing unsold food rates from literature between 2009 and 2012 which, similarly could overlook the considerable industry growth over the past decade.

Estimate Finalization

Given the comprehensiveness of the databases used, the estimate put forth is expected to be the most accurate available for Maine to date. A more comprehensive exercise to obtain primary data from a larger sample of

79 Camoin Associates. "Maine's Food Sector: Industry Profile." *Maine Department of Economic and Community Development*, September 2023. https://www.maine.gov/decd/sites/maine.gov.decd/files/inline-files/Final Report - Master Food Sector - DECD.pdf.

individual entities would need to be conducted to further improve the estimates, particularly for Fish and Seafood Merchant Wholesalers as well as smaller individual grocery stores. **2024 ME DEP Study Estimate (TPY): Food Distributors (Wholesale) 7,615 + Grocery Stores: 37,955 = 45,569.**

Restaurants

Sector Description

This sector quantifies surplus food produced by the Maine food retail industry, focusing specifically on businesses that offer dining options. This includes businesses defined by NAICS 2022 codes 722320 (caterers), 722511 (full-service restaurants) and 722513 (limited-service restaurants).

The distinction between these business types is important. Full-service restaurants typically generate more food waste on their premises as customers primarily consume food on-site. In contrast, limited-service restaurants generally produce less on-site food waste as customers often take their food off-premises, disposing of waste elsewhere. In Maine, the restaurant sector is primarily comprised of full-service restaurants (60%), followed by limited-service restaurants (35%), with caterers making up the remaining (5%) by entity count. Despite the number of entities within this sector, it is relatively fragmented, consisting of numerous small generators. However, collectively, it is a mid-sized generator.

Study Estimate of Food Loss & Waste (Annual Tons)

This estimate was derived from applying the generation factor of 33 pounds of food waste per thousand $ revenue per year to data of companies extracted from the D&B database that was assessed to offer more precise sales revenue estimates, likely tailored to operational entities within Maine rather than overall corporate revenues. The 2024 ME DEP Study Estimate takes the average of researched foundational studies as given the industry's diverse entities, the average was deemed a reasonable assumption, and is expected to be representative of the restaurant sector in Maine. Aligned with many of the sectors in this study, food waste generation was found predominately in Cumberland and York County. The methodology selection, data application, sensitivity analysis and validation may be referenced under Additional Sector Details.

2024 ME DEP Study Estimate (TPY): 19,423 tons per year

Characterization

All food waste characterizations are quantified with reference to the 2024 ME DEP Study Estimate based on existing literature, including past studies on Maine and/or data from primary interviews where available. Percentages applied to the 2024 ME DEP Study Estimate for respective sector may be referenced in Table 28.

Avoidable vs unavoidable: Surplus food from this sector has the potential to be reduced by about 4,985 tons per year (25%). ReFED's food waste monitor estimates that about 72% of surplus food from restaurants come from customer plate waste.[80] This was cited by a few interviews to be unavoidable. However, according to the ReFED solutions database, creating smaller size options for menu items to reduce over-portioning and plate waste is able

80 ReFED. "Stakeholder Recommendations – Restaurants and Foodservice." https://refed.org/stakeholders/restaurants-and-foodservice/.

to divert about 35.6% of plate waste.[81] This corroborated with feedback from several interview respondents that suggested a substantial portion of the surplus could be prevented such as less "wings and fries" or by allowing customers to choose their own sides. Beyond plate waste, overproduced food is another source of avoidable food waste.

Predictable vs unpredictable: The predictable portion comprises prep waste that is correlated to the production plan. ReFED's insights engine suggests these "trimmings and by products" could be as low as less than 2% while interviews suggest this is much higher at about 12 to 20%. Assuming 12%, the predictable surplus food from this sector is estimated to be about 2,331 tons per year. The bulk of food waste at restaurants appears unpredictable given human behavior, that affects plate waste and over production, varies between customers.

Edibility: One interview suggested edible surplus food was as high as 72% with 16% being suitable for animal feed and the remaining 12% as inedible. Should that apply to the rest of the sector, there is about 13,984 tons per year of edible food, 3,108tons per year of food suitable for animal feed and 2,331tons per year of surplus food that is inedible. This corroborated with secondary research that suggested about 25% of restaurant waste is pre-consumer kitchen waste.[82]

Additional Sector Details

Methodology Selection. Three leading methodologies are practical to estimate waste from this sector. The EPA documents eight underlying studies examining restaurants of varying service types. The findings from these studies are as follows:

- Average per-employee factor across studies reviewed by EPA:
    - 3,050.67 pounds per employee per year for 722511 Commercial (Hospitality) -Restaurants/Food Services (full service) and 722320 (Caterers)
    - 2,494.00 pounds per employee per year for Commercial (Hospitality) -Restaurants/Food Services 722513 (Limited-Service Restaurants)
- Average per-establishment factor across studies reviewed by EPA: 39 Tons/establishment /year
- Average sales-based estimate across studies reviewed by EPA: 33 pounds of food waste/ thousand $ revenue/ year.

The Study implemented both employee-based and sales-based methods. However, it must be noted that Method 2, which was not utilized, operates under the assumption that all establishments generate an equal amount of food waste, irrespective of their size. Further examination of the four studies that cited Method 2 revealed that two of them, a 2012 North Carolina DENR study, and a 2015 Battelle study, only encompassed full-service

81 ReFED. *Insights Engine Solutions Database – 2020 Methodology*. 2022. https://insights.refed.org/uploads/documents/refed-insights-engines-solution-database-methodology-vfinal2022-06-02.pdf?_cchid=5fd0d06141031a5b827039bc91060686.

82 ReFED. *A Roadmap to Reduce US Food Waste by 20% - Technical Appendix*. Latest Revision, March, 2016. https://refed.org/downloads/ReFED_Technical_Appendix.pdf.

restaurants.[83,84] Additionally, the average tons of food waste per entity was computed under specific conditions in the underlying studies. For example, the 2008 study by Okazaki, et al. was based on entities in Hawaii, and might not be directly applicable to entities within Maine.[85]

Data Compilation & Application. The business databases D&B Hoovers and IBIS World supported the business entity dataset for this sector.[86,87]

- Method 1:
  - D&B: 72,006 tons per year
  - IBISWorld: 61,720 tons per year
- Method 3:
  - D&B: 19,423 tons per year[88]
  - IBISWorld: 46,023 ton per year

While three underlying studies were cited under Method 1, only CalRecycle (2006) distinguished the generation rates between full-service and limited-service restaurants.[89] The estimate seems extraordinarily high, which might be attributed to the limitations of the employed business databases that do not differentiate between full-time and part-time employees. Moreover, the employee-based estimate encounters challenges in accounting for potential seasonal fluctuations or reporting in the business databases that also do not distinguish between employees consistently employed year-round or only during peak seasons. To prioritize an accurate estimate on an annual basis, a sales-based approach was taken for this sector.[90]

Sensitivity Analysis: Range of Estimates based on Selected Methodology

In recognizing a margin of error arises from statistical sampling methods, the Study presents a range of values in Table 16 by including a "high estimate" and a "low estimate." These estimates are formed based on alternative assumptions documented in subsequent paragraphs. Nonetheless, this study determined an optimal estimate specific to the context of the sector for Maine, as corroborated by pertinent literature.

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83 North Carolina Department of Environment and Natural Resource. *North Carolina 2012 Food Waste Generation Study*. August, 2012. https://files.nc.gov/ncdeq/North%20Carolina%202012%20Food%20Waste%20Generation%20Study.pdf.

84 Rock, Steven & Lan, Alexis. *Organic Waste Diversion in Columbia, South Carolina – Feasibility Study*. US EPA (Office of Research and Development), September, 2017. https://nepis.epa.gov/Exe/ZyPDF.cgi/P100SUMM.PDF?Dockey=P100SUMM.PDF.

85 Okazaki, W.K., Turn, S.Q., & Flachsbart, P.G. "Characterization of food waste generators: a Hawaii case study." *Waste Management*, December 2008, 2483-2494. https://www-sciencedirect-com.proxy.lib.umich.edu/science/article/pii/S0956053X08000536.

86 Dun & Bradstreet. *D&B Hoovers*. Accessed December 2023-March 2024. https://www.dnb.com/products/dnb-hoovers.html.

87 Ibis World. [Industry Reports.] Accessed December 2023-March 2024. https://www.ibisworld.com.

88 8% missing values were plugged using average $revenue/ employee

89 Cascadia Consulting Group. *Targeted Statewide Waste Characterization Study: Waste Disposal and Diversion Findings for Selected Industry Groups*. CalRecycle, June 2006. https://www2.calrecycle.ca.gov/Publications/Details/1184.

90 Consideration has been given to the aspect of seasonality within this sector, as detailed in the Seasonality Analysis.

Table 16: Restaurant Sector Estimate vs. High and Low Estimates Based on Pounds of Food Waste per $1,000s of Revenue

Sensitivity Estimate – High (TPY)	Sensitivity Estimate – Low (TPY)	2024 ME DEP Study Estimate (TPY)
46,023	14,026	19,423

The D&B database offers a more precise estimate of sales revenue, likely tailored to operational entities within Maine. The potentially inflated figure reported by IBIS may be due to the inclusion of sales revenue from chain companies operating outside of the state. The high estimate for this sector, however, was based on the figure from IBISWorld.

The food waste figure of 33 pounds per thousand dollars of revenue comes from the 2014 BSR study, which conducted a series of surveys targeting various restaurants without distinguishing between full and limited services.[91] The food waste figure of 33 pounds per thousand dollars of revenue comes from a BSR (2014) study, which conducted a series of surveys targeting various restaurants without distinguishing between full and limited services. The average interview findings for full-service restaurants found the generation factor to be very close to the 33 pounds average (with a difference of less than 5%), while the average interview findings for limited-service restaurants found the estimate to be 30% less. Therefore, the food surplus generated by limited-service restaurants was reduced to 30% of the average estimate, forming the low estimate for this sector.

The 2024 ME DEP Study Estimate takes the average; given the industry's diverse entities, this average was deemed a reasonable assumption, and is expected to be representative of the restaurant sector in Maine.

Data Validation

When compared to existing estimates, the 2024 ME DEP Study Estimate for this sector aligns with the EPA Excess Food Opportunities Map (between 14,575 to 26,069 tons per year) and closely mirrors the University of Maine's findings from the Maine Circular Food System & Resource Locator GIS Map data base (17,179 tons per year). The ReFED's Insights Engine that had an existing estimate of 27,345 tons per year was notably higher. This could be because the ReFED estimate incorporates a comprehensive calculation of Pre-Consumer Surplus, Onsite Plate Waste, Catering Overproduction Tons, and Catering Plate Waste. One potential limitation is the use of a national dataset, allocated to the state level based on the top 500 restaurants. There could be a risk of overallocation, as the top 500 restaurants in Maine, from an approximate total 4000 entities, are estimated to account for over half of the estimated food waste (i.e. not expected to be proportionately represent all entities in the state).

Estimate Finalization

The 2024 ME DEP Study Estimate was assessed to be a reliable estimate for this sector given the validation from existing estimates. **2024 ME DEP Study Estimate (TPY): 19,423 tons per year.**

91 BSR. *Analysis of U.S. Food Waste Among Food Manufacturers, Retailers, and Restaurants*. A joint project by the Food Marketing Institute, the Grocery Manufacturers Association & the National Restaurant Association, [Fall] 2016 https://foodwastealliance.org/wp-content/uploads/2020/05/FWRA-Food-Waste-Survey-2016-Report_Final.pdf

Hotels

Sector Description

This sector quantifies surplus food by establishments within Maine that provide accommodations, meals, and additional services for travelers and tourists. is sector is defined under the NAICS code 7211, which includes short-term lodging in hotels and motels (721110), casino hotels (721120), bed-and-breakfast inns (721191), and all other traveler accommodations (721199). In the context of Maine, the majority of the industry is composed of Hotels and Motels (64%) and Bed-and-Breakfast Inns (30%) in terms of entity count.

Study Estimate of Food Loss & Waste (Annual Tons)

This estimate was derived from applying the generation factor of 1,137.83 pounds per employee per year to data of companies extracted from the D&B database that was assessed to offer more precise sales revenue estimates, likely tailored to operational entities within Maine rather than overall corporate revenues. The 2024 ME DEP Study Estimate takes the average of researched foundational studies as given the industry's diverse entities, the average was deemed a reasonable assumption, and is expected to be representative of the restaurant sector in Maine. Aligned with many of the sectors in this study, food waste generation was found predominately in Cumberland and York County. The methodology selection, data application, sensitivity analysis and validation may be referenced under Additional Sector Details.

2024 ME DEP Study Estimate (TPY): 11,589 tons per year

Characterization

All food waste characterizations are quantified with reference to the 2024 ME DEP Study Estimate based on existing literature, including past studies on Maine and/or data from primary interviews where available. Percentages applied to the 2024 ME DEP Study Estimate for respective sector may be referenced in Table 28.

Avoidable vs Unavoidable: Surplus food was assumed to be avoidable by up to 2,897 tons per year drawing insights from North American based hotel food waste reduction case studies. Efforts to reduce food waste included waste tracking of pre-consumer food waste and redesigning the standard hotel buffets.[92] The excess from this food can often be reduced and prevented with improved technologies to track guests' interest and dining experiences. Furthermore, food prepared and not displayed may be suitable for donation. While strategies exist to minimize the surplus often generated from catered events, many hotels noted the fear of running out of food at events or buffets, and audits have shown the preparation of 2 pounds of food per person, when the average person consumes one pound per siting, can lead to 800 pounds of excess food for one meal.[93] This challenge remains an industry obstacle due to the nature of the business where it is difficult to anticipate attendance and institutionalize prevention persists.

Predictable vs Unpredictable: Surplus food from this sector is characterized as predictable due to the correlation of surplus food produced with occupancy and tourism seasonality that is explored under the seasonality section of

92 Hotel Kitchen. "Hyatt Regency Orlando: From Prototype to Commitment." https://hotelkitchen.org/case-study/hyatt-regency-orlando/.

93 Pearson, Pete, & McBride, Monica. *Fighting Food Waste in Hotels*. WWF, November 13, 2017. https://files.worldwildlife.org/wwfcmsprod/files/Publication/file/jokyswl5j_Hotel_Kitchen_Final.pdf.

this report. It would be most impactful for hotels to have food waste management programs such as donation partnerships or paid services in place, particularly during peak seasons.

Edibility: Surplus food was assumed to be edible by humans (donatable) by about 695 tons per year and edible by animals by about 3,477 tons per year as demonstrated by North American based hotel food waste reduction case studies.[94,95]

Additional Sector Details

Methodology: Two approaches were considered for the sector, including five supporting studies providing methodological guidance. Four studies referenced were cited by the EPA, and the World Wildlife Fund (WWF), in collaboration with Greenview, developed the Hotel Waste Measurement Methodology in 2021.[96] The findings from these studies are as follows:

- EPA's average of employee-based reviewed studies: 1,137.83 pounds per employee per year
- Generation factors were computed by calculating the average food waste produced by hotels per square meter, using actual waste diversion data. US conversion factors were identified from the study as reference in Table 17. This table was converted to square footage in Table 18.
- For the computation of the average estimate using this methodology, it was assumed that all hotels in Maine fell within the upper quartile mean category.

Table 17: Annual Food Surplus from Hotel Sector, by Segment (Kg/SqM)

Smith Travel Research (STR) Segment[97]	Number of Hotels	Lower Quartile	Mean	Upper Quartile
Upper Midscale	19	0.18	0.75	1.17
Upscale	54	0.39	1.35	1.75
Upper Upscale	53	1.142	2.33	2.92
Luxury	22	0.75	2.3	3.21

Table 18: Annual Food Surplus from Hotel Sector, by Segment (Kg/SqM/10.76)

STR Segment	# of Hotels	Lower Quartile (Kg/SqM/10.76)	Mean (Kg/SqM/10.76)	Upper Quartile (Kg/SqM/10.76)
Upper Midscale	19	0.02	0.07	0.11
Upscale	54	0.04	0.13	0.16

94 Hotel Kitchen. "Washington Hilton: Partnership, Leadesrhip and Successful Adoption." https://hotelkitchen.org/case-study/washington-hilton/.

95 Hotel Kitchen. "Bucuti & Tara Beach Resort, Aruba: Tackling Food Waste Through Local Partners and Portion Sizes." https://hotelkitchen.org/case-study/bucuti-tara-beach-resort/.

96 Ricaurte, E., Ruggles-Brise, O., Aggarwal, S., & McBride, M. *Hotel Waste Measurement Methodology v1.0*. Greenview and WWF [prepared for the Sustainable Hospotality Alliance], January 27, 2023. https://sustainablehospitalityalliance.org/resource/hwmm/.

97 STR. "Class." Resources Glossary. Accessed February, 2024. https://str.com/resourcesglossary/class#:~:text=The%20class%20for%20a%20chain,Upper%20Midscale%2C%20Midscale%20and%20Economy.

STR Segment	# of Hotels	Lower Quartile (Kg/SqM/10.76)	Mean (Kg/SqM/10.76)	Upper Quartile (Kg/SqM/10.76)
Upper Upscale	53	0.11	0.22	0.27
Luxury	22	0.07	0.21	0.30

Data Compilation & Application: This sector relied on business databases D&B Hoovers and IBIS world.[98,99]

- Method 1:
  - D&B: 11,589 tons per year
  - IBISWorld: 7,507 tons per year
- WWF Methodology:
  - D&B: 1,958 tons per year[100]

The 2024 ME DEP Study Estimate was determined to follow the methodology in underlying studies documented by the EPA, driven by two primary factors. Firstly, the methodology developed by WWF in collaboration with major hotel chains was deemed less representative for the scope of this study, as these chains constitute less than 5% of the 1,602 entities in the dataset for Maine. Secondly, the WWF methodology's metric, based on floor area, failed to adequately account for the intensity and seasonal patterns of waste and food waste production.

Sensitivity Analysis: Range of Estimates based on Selected Methodology

In recognizing a margin of error arises from statistical sampling methods, the Study presents a range of values in Table 19 by including a "high estimate" and a "low estimate." These estimates are formed based on alternative assumptions documented in subsequent paragraphs. Nonetheless, this study determined an optimal estimate specific to the context of the sector for Maine, as corroborated by pertinent literature.

Table 19: Hotel Sector Estimate vs. High and Low Estimates Based on Lb./Employee Methodology

Sensitivity Estimate - High (TPY)	Sensitivity Estimate - Low (TPY)	2024 ME DEP Study Estimate (TPY)
20,259	3,820	11,589

The D&B database provided a refined employee count, likely tailored to operational entities in Maine, while the IBIS dataset seemed to exclude numerous bed and breakfast inns, which form a significant portion of Maine's sector. The highest estimate was extracted from CalRecycle's 2006 study that provided a generation factor of 1,983 pounds per employee per year. That work solely included "large hotels" with a minimum of 30

98 Dun & Bradstreet. *D&B Hoovers*. Accessed December 2023-March 2024. https://www.dnb.com/products/dnb-hoovers.html.

99 Ibis World. [Industry Reports.] Accessed December 2023-March 2024. https://www.ibisworld.com.

100 5% missing values were plugged using average square footage.

employees.[101] Similarly, CalRecycle (2015) sampled based on the presumption that large businesses constituted the majority (70%) of the industry in terms of employment. Another study, the Metro Vancouver (2015) study, obtained a generation factor of 997 pounds per employee from the sampling of 6 entities.[102] It was inferred that this was a high figure, considering the small number of employees listed as necessary to run the entire hotel operations. The lowest estimate of 375 pounds per employee originated from the 2008 Okazaki, et al. study, which covered 62 generators in Hawaii.[103]

The 2024 ME DEP Study Estimate adopts the average of the studies consolidated by the EPA, considering the objective of this estimation exercise was to identify the largest generators. It was observed that even when the high estimate was adopted, both the number of generators and the overall tonnage contributed by this sector remained relatively insignificant.

Data Validation

When compared to existing estimates, the 2024 ME DEP Study Estimate for this sector is higher than the EPA Excess Food Opportunities Map (between 1,061 to 5,612 tons per year) and exceeds the ReFED's Insights Engine that had an existing estimate of 8,707 tons per year. One possible reason is this reflects Maine's continued growth in the tourism sector.[104] Furthermore, ReFED's methodology primarily focuses on the food service sector within hotels, considering factors such as pre-consumer surplus, onsite plate waste, catering overproduction, and catering plate waste. However, this approach may underestimate the actual waste, as the variety of food waste sources typical in hotels are not fully captured.

Estimate Finalization

Considering the risk of underestimation posed by alternative methodologies, and to encompass all potential large generators within this sector, the final estimate retains the use of the average of generation factor across numerous studies. **2024 ME DEP Study Estimate (TPY): 11,589 tons per year.**

Food Banks and Pantries

Sector Description

This sector quantifies surplus food generated by food recovery or donation organizations in Maine. A food bank is defined as a non-profit or community-based facility that serves as a point of distribution for donated, surplus, or rescued food items. The sector includes food rescue organizations, food banks, and food pantries. Food banks are unique in that they are both potential recipients - as they receive food donations that would otherwise have been

101 Cascadia Consulting Group. *Targeted Statewide Waste Characterization Study: Waste Disposal and Diversion Findings for Selected Industry Groups*. CalRecycle, June 2006. https://www2.calrecycle.ca.gov/Publications/Details/1184.

102 Cascadia Consulting Group. *2014 Generator Based Characterization of Commercial Sector Disposal and Diversion in California*. CalRecycle, September 10, 2015. https://www2.calrecycle.ca.gov/Publications/Details/1543.

103 Okazaki, W.K., Turn, S.Q., & Flachsbart, P.G. "Characterization of food waste generators: a Hawaii case study." *Waste Management*, December 2008, 2483-2494. https://www-sciencedirect-com.proxy.lib.umich.edu/science/article/pii/S0956053X08000536.

104 Maine Department of Economic and Community Development. "Maine Office of Tourism Looks Forward to Busy Summer Season." May 22, 2023. https://www.maine.gov/decd/about/news/maine-office-tourism-looks-forward-busy-summer-season.

destined for landfill or composting - and generators of excess food, since some donated food may be deemed unfit for human consumption. The type of food received also elevates the probability of unintentional waste.

Study Estimate of Food Loss & Waste (Annual Tons)

This estimate was derived from computing an average generation factor from interview data of approximately 26.17 tons per entity. The generation factor was then applied to a comprehensive directory of food pantries. Food loss and waste from Food Banks and Pantries was found to be highest in Androscoggin and Cumberland Counties. The methodology selection, data application, sensitivity analysis and validation may be referenced under Additional Sector Details.

2024 ME DEP Study Estimate (TPY): 9,908 tons per year

Characterization

All food waste characterizations are quantified with reference to the 2024 ME DEP Study Estimate based on existing literature, including past studies on Maine and/or data from primary interviews where available. Percentages applied to the 2024 ME DEP Study Estimate for respective sector may be referenced in Table 28.

Avoidable vs unavoidable: Surplus food from this sector is characterized as highly unavoidable once the donated food has been accepted according to interviews. The only way to avoid wastage is to be stringent with the donations. For example, one interview mentioned avoiding accepting "food that cannot be used" such as highly processed items that lack nutritional value.

Predictable vs unpredictable: Surplus food from this sector is characterized as highly unpredictable. There are two sources of uncertainty namely the inputs of food received and the demand from receiving communities. One interview cited that food for donation could be used to make soup instead of distributing the fresh produce to increase the shelf-life.

Edibility: Surplus food and losses from this sector are characterized as only edible by animals or inedible. Estimates based on interview data suggest there is about 9,115 tons per year of surplus food edible by animals and 793 tons per year that is inedible. Should the food be edible for humans, it would have been donated and not considered "generated waste." Most interviewees mentioned they have an ongoing arrangement with animal feed programs to support this.

Additional Sector Details

Methodology Selection. A scarcity of research has identified methodologies for calculating food waste in this sector. The EPA previously depended on a Feeding America estimate of 299 tons per food bank, though this method was not utilized in more recent estimates. Within this study, that estimate was deemed too high, primarily because most of the dataset was composed of food pantries, not food banks. In the absence of secondary literature, this sector relied on primary data collected to calculate an estimate.

- For Food banks: The EPA analysis database includes one line item for Good Shepherd, estimating 748 tons, and interviews adjusted this figure closer to 800 tons per year. The figure reported in the EPA database was utilized.
- For Food Pantries: Of 18 interviews, seven indicated an average of approximately 26.17 tons per entity.

Data Compilation & Application

A comprehensive directory of food pantries, which includes Good Shepherd Food bank among its 337 entities, was revised down to 317 after eliminating duplicated entries based on addresses. This list was subsequently cross-referenced with the State of Maine Department of Agriculture, Conservation & Forestry's list of Food Assistance Programs by town. After incorporating entities from the state list, a final count of 350 entities was established. The computation method for this sector is as follows:

- (Estimated generation per food bank * number of food banks) + (Estimated generation per food pantry * number of food pantries)
- = (748.095 tons per year per food bank * 1 Food Bank) + (26.17 Avg tons per year per food pantry * 350 Pantries)

Sensitivity Analysis: Range of Estimates based on Selected Methodology

In recognizing a margin of error arises from statistical sampling methods, the Study presents a range of values in Table 20 by including a "high estimate" and a "low estimate." These estimates are formed based on alternative assumptions documented in subsequent paragraphs. Nonetheless, this study determined an optimal estimate specific to the context of the sector for Maine, as corroborated by primary data collected through interviews.

Table 20: Food Bank & Pantry Sector Estimate vs. High and Low Estimates Based on Lb./Entity

Sensitivity Estimate - High (TPY)	Sensitivity Estimate - Low (TPY)	2024 ME DEP Study Estimate (TPY)
11,248	794	9,908

Given the significant variance between interview findings, the highest and lowest estimates were determined to be exceedingly extreme. Thus, the second highest estimate (0.30 tons per entity) and the second lowest estimate (0.12 tons per entity) were employed to calculate the high and low estimates, respectively.

Data Validation & Estimate Finalization

No existing estimate. Validation for this sector was challenged due to limited available literature, however extensive interview data serves as the most reliable information available for the state of Maine to date. **2024 ME DEP Study Estimate (TPY): 9,908 tons per year.**

Food Distributors (Wholesale)

Sector Description

This report quantifies the surplus food generated by the Maine wholesale sector. For clarity, this sector is distinguished from the Grocery Store sector in terms of position in the supply chain. Food distributors dispatch products to other retailers, while products from Grocery stores are targeted for purchase by end-consumers. NAICS codes 4244 (grocery and related product merchant wholesalers) comprise the wholesale sector. In Maine, the food distributor sector is primarily constituted by Fish and Seafood Merchant Wholesalers (47%) and General Line Grocery Merchant Wholesalers (33%) in terms of the number of entities.

Study Estimate of Food Loss & Waste (Annual Tons)

This estimate was derived from applying the generation factor of 0.005 tons per thousand dollars of revenue to data of companies extracted from the D&B database that was assessed to offer more precise sales revenue estimates, likely tailored to operational entities within Maine rather than overall corporate revenues. Food waste generation from this sector was found to be concentrated in Cumberland and York Counties. The methodology selection, data application, sensitivity analysis and validation may be referenced under Additional Sector Details.

2024 ME DEP Study Estimate (TPY): 7,615 tons per year

Characterization

All food waste characterizations are quantified with reference to the 2024 ME DEP Study Estimate based on existing literature, including past studies on Maine and/or data from primary interviews where available. Percentages applied to the 2024 ME DEP Study Estimate for respective sector may be referenced in Table 28.

Avoidable vs unavoidable: Surplus food was described by one interviewee to be avoidable up to about 3,087 tons per year based on interviews. Some commonly cited causes include recalls, spoilage, over-ordering, and/or damage during transportation. Inventory management, which is staff dependent, was cited to be a key determining factor in avoiding recalls and spoilage. The high turnover rate during the pandemic for example saw more errors and waste, largely due to inexperienced staff. Cold chain failure was cited as another example where best practices could be implemented to avoid wastage and mitigate risk. However, over ordering and spillage/ damage in transportation was cited to be unavoidable or part of inherent business risk. It was suggested that "rejecting products" they receive by being more stringent with their quality measures, could reduce over orders but this would likely shift the problem of food surplus and losses back up the supply chain rather than reduce it in real terms.

Predictable vs unpredictable: Surplus food from this sector is highly unpredictable. Assuming best practices are in place, surplus and losses occur due to either over ordering or accidents during transportation.

Edibility: Of the surplus food, about 523 tons per year is edible by humans, 5,330 tons per year edible by animals and 761 tons per year are inedible. This means surplus food from this sector is characterized as mostly suitable for animal feed while the remaining surplus may be edible by humans or inedible. There is a very short time window where the food remains edible by humans described as "not very much longer" beyond the point of packing for transportation ("shrinking"). Existing partnerships between food recovery organizations and food distributors were confirmed. Further studies need to be conducted to develop a reasonable process to assist food recovery organizations in leveraging these unpredictable large quantities of surplus. Upcycling could be another solution to explore where one interview with a Fish and Seafood Merchant Wholesaler suggested surplus could be used to make "fish cake". However, the interviewee noted that there may not be a market for that. Furthermore, at a minimum, the cost of transportation to accommodate such activities would need to be less than the cost of disposal.

Additional Sector Details

Methodology Selection. The research for this sector identifies two methodologies based on three underlying studies examining food waste from food wholesalers. The findings from these studies are as follows:

- Average per-facility factor across EPA-reviewed studies: 120.68 tons per facility per year
- Average sale-based factor from EPA-reviewed studies: 0.005 tons per thousand dollars of revenue

Of the two methods, the pound per annual sales option provides more flexibility in accounting for the different sizes of food distributors. Here, at a minimum, the resulting food waste generation estimate is adjusted in correlation to the size of the business revenue. This adjustment cannot be made under the pound per establishment method, which utilizes an average generation rate per establishment. This limitation has also been explicitly cited in the Massachusetts DEP (2002) study, the study underlying the US EPA Region 1 (2011), acknowledging the diversity of food waste generation patterns even for manufacturers under a single SIC code.[105] Consequently, the average pounds per annual sales method has been selected to compute this sector.

Data Compilation & Application: This sector relied on business databases D&B Hoovers and IBISWorld.[106,107]

- EPA average pounds per annual sales:
  - D&B: 7,615 tons per year[108]
  - IBISWorld: 27,174 tons per year

Sensitivity Analysis: Range of Estimates based on Selected Methodology

In recognizing a margin of error arises from statistical sampling methods, the Study presents a range of values in Table 21 by including a "high estimate" and a "low estimate." These estimates are formed based on alternative assumptions documented in subsequent paragraphs. Nonetheless, this study determined an optimal estimate specific to the context of the sector for Maine, as corroborated by pertinent literature and primary data collected through interviews.

Table 21: Food Distributor Sector Estimate vs. High and Low Estimates Based on Tons per $1000 Revenue

Sensitivity Estimate - High (TPY)	Sensitivity Estimate - Low (TPY)	2024 ME DEP Study Estimate (TPY)
27,174	5,330	7,615

The D&B database provides a more precise sales revenue estimate, likely tailored to operational entities within Maine. The potentially inflated figure reported by IBIS might stem from the inclusion of sales revenue from chain companies operating out of state. Nevertheless, the resulting estimate based on the IBISWorld estimate was used as the high estimate for this sector.

The 2014 BSR study collected data through surveys targeting large food retailers.[109] However, it was not specifically focused on the wholesale sector. In this context, the wholesale sector was treated as part of the grocery retail sector. Therefore, interviews were essential to validate the estimates. The lower estimate was calculated based on the information obtained from an interview with a representative from a major entity in the General Line

105 Government of Massachusetts. Summary Analysis of Massachusetts Commercial/Institutional Food Waste Generation Data. 2011. https://www.mass.gov/doc/summary-analysis-massachusetts-commercialinstitutional-food-waste-generation-data-2011/download.

106 Dun & Bradstreet. *D&B Hoovers*. Accessed December 2023-March 2024. https://www.dnb.com/products/dnb-hoovers.html.

107 Ibis World. [Industry Reports.] Accessed December 2023-March 2024. https://www.ibisworld.com.

108 8% missing values were plugged using average $revenue/employee.

109 BSR. *Analysis of U.S. Food Waste Among Food Manufacturers, Retailers, and Restaurants*. A joint project by the Food Marketing Institute, the Grocery Manufacturers Association & the National Restaurant Association, [Fall] 2016 https://foodwastealliance.org/wp-content/uploads/2020/05/FWRA-Food-Waste-Survey-2016-Report_Final.pdf

Grocery Merchant Wholesalers group. This representative reported an estimate of food waste produced to be approximately 70% of the estimate derived from the 0.005 Tons food waste/thousand $ revenue model. The representative also mentioned a reduction in operations due to the COVID-19 pandemic. This reduction might not be reflected in business databases that partially depend on self-reporting. Consequently, this information was extrapolated to the entire dataset to compute the lower estimate.

Notably, Fish and Seafood Merchant Wholesalers make up a significant portion of this sector, an observation unique to Maine and not extensively covered in existing literature. Challenges were encountered in arranging interviews to acquire primary data from this group. The 2024 ME DEP Study Estimate therefore adopts the original estimate based on findings from general grocery distributors.

Data Validation and Estimate Finalization

The process of data validation and estimate finalization should be conducted in conjunction with the Grocery Stores Sector, as these two sectors are combined under a single category by the EPA Excess Food Opportunities Map database and ReFED's Insights Engine.

Schools and universities

Sector Description

The objective of this sector is to quantify surplus food produced by educational institutions that provide meals. This includes private and public K-12 schools, universities, and colleges. In Maine, approximately 190,000 students are enrolled in 400 K-12 schools (private and public) and 92,000 students are enrolled in 30 universities and colleges.[110]

Study Estimate of Food Loss & Waste (Annual Tons)

This estimate was derived in two parts. First, the generation factor for K-12 schools was determined via a weighted average of 0.28 pounds per meal from interview findings. The number of meals was derived from enrollment data from both public and private schools was obtained from the National Center for Educational Statistics and the average number of meals per student was calculated from the total number of meals served and the total student enrollment in the National School Lunch Program and School Breakfast reported by the USDA for the fiscal year 2023 for the state of Maine. Second, the generation factor for universities and colleges was determined via a weighted average of 0.21 pounds per meal from interview findings. The number of meals was derived from publicly available data on public colleges and universities, private colleges and community colleges listed on the state of Maine website and corroborated by The National Center for Educational Statistics Integrated Postsecondary Education Data System. The ratio of residential (24%) to non-residential students (76%) was inferred from interviews conducted with the two largest universities in the state and he EPA's aggregated average number of meals per residential student (285 meals per student) and non-residential student (108 meals per student) was utilized. School season was assumed to be 25 weeks per year for K-12 schools and 34 weeks per

110 Fabiano, C., Meyer, E., Carusiello, C., Rubright, T., & Industrial Economics, Inc. *Wasted Food Measurement Methodology Scoping Memo*. U S EPA, July 2020. https://www.epa.gov/sites/default/files/202006/documents/food_measurement_methodology_scoping_memo-6-18-20.pdf.

year for Universities/ Colleges. In Maine, generation of wasted food was predominately found in Cumberland, Penobscot, and York Counties. The methodology selection, data application, sensitivity analysis and validation may be referenced under Additional Sector Details.

2024 ME DEP Study Estimate (TPY) 5,456 tons per year (K-12 schools 4,200 tons per year + Universities/ Colleges 1,256 tons per year).

Characterization

All food waste characterizations are quantified with reference to the 2024 ME DEP Study Estimate based on existing literature, including past studies on Maine and/or data from primary interviews where available. Percentages applied to the 2024 ME DEP Study Estimate for respective sector may be referenced in Table 28.

Avoidable vs Unavoidable: Surplus food from this sector has the potential to be reduced by about 1,091 tons per year. The Maine School Cafeteria Food Waste Study 2023 suggests that elementary schools can reduce surplus food by almost 20% through the implementation of student-directed food waste reduction programs.[111] ReFED cites a more conservative rate (Diversion Potential of food surplus) to average 12.4% for K-12 Schools.[112] In contrast to these findings, interview feedback for this sector did not suggest any surplus food to avoidable as they viewed food waste by students or "plate waste" to be unavoidable. This highlights the importance of educating school management as well as students in the avenues to reduce post-consumer food wastage. Interviews with universities and colleges cited similar feedback stating that "capturing post-consumer food waste" is what they believe to be the best opportunity for food waste reduction.

Predictable vs Unpredictable: Surplus food from this sector is characterized as highly unpredictable by interviews. Surplus food is mainly from students not finishing their plates with one interview citing that up to 95% of surplus food is attributed to this. Another example of unpredictability cited was an extended power outage that caused $4,000 of product to be discarded. Interviews with universities and colleges cited similar feedback where "prepared food waste that is not used (can be predicted), but student behaviors (cannot be predicted)."

Edibility: Surplus food from this sector is characterized as mostly inedible for human consumption, as most of the waste is post-consumer plate scrapings. One example plate scrapping is untouched or unfinished milk cartons in K-12 schools. National studies have indicated the possibilities of reducing milk carton waste by switching to milk dispensers, with certain schools experiencing an 83% reduction in milk waste.[113] Universities and colleges also cited supporting on-campus food pantry programs with any edible food where available.

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111 University of Maine – Mitchell Center for Sustainablity Solutions. "Solution 3 – Pilot 4: Maine School Cafeteria Food Waste Study - 2023." Food Rescue MAINE, September 20, 2023. https://umaine.edu/foodrescuemaine/2023/08/08/pilot-5-maine-school-cafeteria-food-waste-study-2023/.

112 ReFED. *Insights Engine Solutions Database – 2020 Methodology*. 2022. https://insights.refed.org/uploads/documents/refed-insights-engines-solution-database-methodology-vfinal2022-06-02.pdf?_cchid=5fd0d06141031a5b827039bc91060686.

113 WWF. *The Business Case for Transitioning to Bulk Milk Dispensers Single-Use Milk Cartons in K-12 Schools*. December 5, 2022. https://files.worldwildlife.org/wwfcmsprod/files/Publication/file/9qd76qqy5c_School_Bulk_Milk_Business_Case_DRAFT4.pdf?_ga=2.109118917.1109334809.1710969735-1011264998.1708019320.

Additional Sector Details

Methodology Selection. Due to the demographic differences and distinct activities between K-12 schools and higher education institutions, separate methodologies have been adopted for these two groups.

Numerous studies have examined the topic of surplus food production for both groups, with some measuring the surplus per student, and others on a per meal basis. The EPA has reviewed these various research methods and provided a summary of the range of generation rates. It cited 6 foundational studies for K-12 schools and ten for colleges and universities. Additionally, the methodology from a recent World Wildlife Fund (WWF) study was also considered.[114] The findings from these studies are as follows:

- EPA average of pounds per meal method:
    - **K-12 Schools:** 0.43 pounds per meal, with 163 meals per student per year (National Average 2017)
    - **Universities/Colleges**: 0.36 pounds per meal with 108 Meals per non-residential student based on Connecticut Department of Environmental Protection (2001) and 285 Meals per residential student based on average of Connecticut Department of Environmental Protection (2001), Ebner et al. (2014) and Whitehair et al. (2013).[115,116]
- EPA average of student per year method:
    - K-12 Schools: 22 pounds per student per year
    - Universities/ Colleges: 22 pounds per student per year
- WWF method:
    - K-12 Schools: 39 pounds per student per year

Data Compilation & Application. Estimates were generated for this sector where data was available. Multiple data sources were utilized to verify school enrollment data.

For K-12 Schools, data from both public and private schools was obtained from the National Center for Educational Statistics.[117] The statistics for public and private K-12 schools in Maine were calculated based on the total number of meals served and the total student enrollment in the National School Lunch Program and School Breakfast. These figures were reported by the USDA for the fiscal year 2023.[118] The population estimate for public schools was further corroborated with reports published by the state of Maine. This data was collated and used to calculate a "Meals per Student" metric as referenced in Table 22.

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114 WWF. *Food Waste Warriors: A deep dive into food waste in US schools*. December 4, 2019. https://c402277.ssl.cf1.rackcdn.com/publications/1271/files/original/FoodWasteWarriorR_CS_121819.pdf?1576689275. [Each of the 46 schools was averaged.]

115 Draper/Lennon, Inc. & Atlantic Geoscience Corp. *Identifying, Quantifying, and Mapping Food Residuals from Connecticut Businesses and Institutions*. [Submitted to K.C. Alexander of Connecticut Department of Environmental Protection.] September, 2001. https://portal.ct.gov/-/media/DEEP/compost/ssomfile/ssomreportpdf.pdf.

116 Whitehair, K. J., Shanklin, C. W., & Brannon, L. A. "Written messages improve edible food waste behaviors in a university dining facility." *Journal of the Academy of Nutrition and Dietetics* vol. 113,1 (2013): 63-9. https://doi.org/10.1016/j.jand.2012.09.015.

117 Institute for Education Sciences (IES) – National Centers for Education Statistics (NCES). *Common Core of Data – National Center for Education Statistics*. Accessed December 2023-March 2024. https://nces.ed.gov/ccd/districtsearch/.

118 USDA – Food and Nutrition Service U.S. Department of Agriculture. "Child Nutrition Tables." https://www.fns.usda.gov/pd/child-nutrition-tables.

Table 22: Meals per Student, 2023

	Meals Served	Participation (Number of Students)	Meals per Student
National School Lunch	18,207,299	113,430	160.5
School Breakfast	10,899,846	67,686	161.0
Total	**29,107,145**	**181,116**	**161**

For Colleges and Universities, the list of public colleges and universities, private colleges and community colleges was obtained from the state of Maine website.[119] The National Center for Educational Statistics Integrated Postsecondary Education Data System provided data for the year 2022.[120] Further desktop research allowed cross-referencing of student enrollment numbers for the 30 entities identified. Satellite campuses, despite being part of the same university, were analyzed separately from the main campus due to their potential to contribute surplus food to diverse regions within the state. The ratio of residential (24%) to non-residential students (76%) was inferred from interviews conducted with the two largest universities in the state. These universities collectively represent almost 30% of the student enrolment in the state. The EPA's aggregated average number of meals per residential and non-residential student was utilized.

- The EPA's calculations for average pounds per meal revealed the following:
  - K-12 Schools: 6,499 tons per year
  - Universities/ Colleges: 1,969 tons per year
- The EPA's student-per-year method yielded:
  - K-12 Schools: 2,065 tons per year
  - Universities/ Colleges: 1,011 tons per year
- The WWF method resulted in:
  - K-12 Schools: 3,661 tons per year

The most comprehensive extrapolated surplus food production figures for both K-12 schools and Universities/ Colleges were found using the pounds-per-meal methodology. This methodology allowed for the application of Maine-specific data, such as the meals per student (for K-12), as well as the residential vs. non-residential student ratio (for Universities/Colleges). The estimates for K-12 schools align with the Natural Resources Council of Maine, which projects that Maine's K-12 public schools likely produce more than seven million pounds of surplus food and food scraps (3,500 tons) annually.

Sensitivity Analysis: Range of Estimates based on Selected Methodology

In recognizing a margin of error arises from statistical sampling methods, the Study presents a range of values in Table 23 by including a "high estimate" and a "low estimate." These estimates are formed based on alternative assumptions documented in subsequent paragraphs. Nonetheless, this study determined an optimal estimate specific

119 Information Resource of Maine (InforME). "Higher Education in Maine." Maine.gov. Accessed December 2023-March 2024. https://www.maine.gov/portal/education/colleges.html.

120 IES – NCES. *IPEDS*. Accessed December 2023-March 2024. https://nces.ed.gov/ipeds/.

to the context of the sector for Maine, as corroborated by pertinent literature and primary data collected through interviews.

Table 23: Schools & University Sector Estimate vs. High and Low Estimates Based on Lb/Meal

	Sensitivity Estimate - High (TPY)	Sensitivity Estimate - Low (TPY)	2024 ME DEP Study Estimate (TPY)
K-12 Schools	7,860	5,290	4,200
Universities	2,297	1,203	1,256

The high estimate for K-12 Schools was calculated based on the study by Byker et al. (2014), which analyzed 304 meals from one pre-kindergarten class and five kindergarten classes, resulting in 0.52L pounds per meal.[121] This is likely an overestimation, as surplus food generation is expected to be more significant per younger student. The lower estimate was derived from a study by Connecticut DEEP (2001), which averaged a range of studies conducted between 1997 and 2001, resulting in 0.35 pounds per meal. The 2024 ME DEP Study Estimate was determined via a weighted average of 0.28 pounds per meal from interview findings.

For colleges and universities, the high estimate was determined based on Sarjahani et al. (2009), estimating an average surplus food generation with and without trays of 0.42 pounds per meal.[122] The low estimate was calculated based on the three-month waste audit findings of Ebner et al. (2014), resulting in 0.22 pounds per meal. The 2024 ME DEP Study Estimate was determined via a weighted average of 0.23 pounds per meal from interview findings.

Data Validation:

When compared to existing estimates, the K-12 school estimate is towards the lower range of the EPA Excess Food Opportunities Map (between 3,641 to 17,253 tons per year). It is possible this is due to Maine experiencing a decline in student population and it is likely that enrollment numbers were higher at the time the EPA estimate was computed (2016). The University estimate is also lower than that of EPA's estimated range (between 1,545 to 9,253 tons per year). Both the Schools and Universities estimate is very close to ReFED's Insights Engine estimate of 3,826 tons per year for K-12 Schools and 1,055 tons per year for universities. ReFED's estimate is expected to be an accurate given the granularity of calculations used.[123] Specifically, the ReFED methodology focused on the food service sector within schools, colleges and universities where it accounts for pre-consumer surplus, onsite plate waste, catering overproduction, and catering plate waste.

121 Byker, CJ., Farris, AR., Marcenelle, M., Davis, GC., & Serrano, EL. "Food waste in a school nutrition program after implementation of new lunch program guidelines." Journal of nutrition education and behavior, vol. 46 no.5 (2014), 406-411. https://doi.org/10.1016/j.jneb.2014.03.009.

122 Sarjahani A., Serrano E.L., & Johnson R. "Food and Non-Edible, Compostable Waste in a University Dining Facility." *Journal of Hunger & Environmental Nutrition,* vol. 4 no.1(2009), 95-102. *http://dx.doi.org/10.1080/19320240802706874*.

123 ReFED. "Food Waste Monitor." ReFED Insights Engine, 2022. https://insights-engine.refed.org/food-waste-monitor?view=overview&year=2022.

Estimate Finalization

Given the extent of literature reviewed for this sector, the application of Maine specific data and the alignment with ReFED's estimate, the interview data adjusted numbers were utilized as the final estimate. **2024 ME DEP Study Estimate (TPY): 5,456 tons per year (K-12 schools 4,200 tons per year + Universities/ Colleges 1,256 tons per year).**

To note, the following assumptions were applied to convert tons per year to Peak Season Generation per week:

- K-12 school year = 175/365 (i.e., 25 weeks)[124]
- Universities/ colleges= Assume average 17weeks x 2 semesters (i.e., 34 weeks)

Hospitals

Sector Description

This sector focuses on the qualification of surplus food produced by live-in care facilities such as hospitals, hospice care, and other related services. Most live-in facilities in Maine are nursing homes (approximately 85%) and assisted living establishments (approximately 11%), while general acute care and critical access care compose the remainder of facilities (approximately 4%).

Study Estimate of Food Loss & Waste (Annual Tons)

The estimate was derived from applying an adjusted generation factor of 544.3 pounds per bed per year to the number of occupied beds in live-in care facilities identified within the state of Maine. Food loss and waste generation was predominately found in Cumberland County. The methodology selection, data application, sensitivity analysis and validation may be referenced under Additional Sector Details.

2024 ME DEP Study Estimate (TPY) 2,742 tons per year

Characterization

All food waste characterizations are quantified with reference to the 2024 ME DEP Study Estimate based on existing literature, including past studies on Maine and/or data from primary interviews where available. Percentages applied to the 2024 ME DEP Study Estimate for respective sector may be referenced in Table 28.

Avoidable vs Unavoidable: Surplus food from this sector has the potential to be reduced by about 1,124 tons per year. The Northern Light Health Blue Hill study suggested that outdated and spoiled surplus food comprised 41% of all surplus food weight.[125] Procurement analytics and process improvements could reduce the amount of surplus food generated by the back-end processes of this sector. This was corroborated by interviews that suggested

124 Child Development Services. "2022 to 2023 School Calendar." Maine Department of Education. https://www.maine.gov/doe/sites/maine.gov.doe/files/inline-files/2022 to 2023 School Calendar.xls.pdf.

125 University of Maine – Mitchell Center for Sustainablity Solutions."Solution1 Pilot – Pilot 5: Northern Light/Blue Hill Hospital." Food Rescue MAINE, August 8, 2023. https://umaine.edu/foodrescuemaine/2023/08/04/solution-1-pilot-1-2023-healthcare-food-waste-tracking-measuring-study-northern-light-health-blue-hill/.

surplus food came from a variety of sources including "food scraps from kitchen", "(surplus) product produced for a meal but not consumed" and "food scraps from customer/ patient plates."

Predictable vs unpredictable: About 1,317 tons per year of surplus food from this sector is characterized predictable. This includes the avoidable outdated and spoiled surplus food, as well as an assumed amount of inedible kitchen scraps. Interview respondents acknowledge tools to track and measure consistent wastage could help them predict which ingredients could be reduced. The unpredictable portion is attributed to post-consumer plate scrapings, and over-production. Predictability could be enhanced by exploring analytics for consistent over production and subsequently refining menu ideas.

Edibility: About 137 tons per year of the surplus food is edible where interviews indicated that about 5% of the food waste generated on hospital campuses could be donated or upcycled to new menu ideas in house. Interview respondents mentioned internal food pantries could be supported to utilize surplus ingredients for recovery within their operations. The rest of the food surplus is characterized as inedible i.e., either expired, kitchen scraps or plate waste. The Northern Light Health Blue Hill study also indicated that reducing plate waste through smaller portion sizes can also minimize food waste costs by 38%.

Additional Sector Details

Methodology Selection. Various studies have been conducted to examine surplus food production within the healthcare sector. These investigations largely define quantities of surplus on per-bed or per-meal basis. After reviewing these methodologies, the EPA provided a summary of the generation rates from seven foundational studies.

- Average per-bed estimate across EPA-reviewed studies: 653.14 pounds per bed per year
- Average per-meal estimate across EPA-reviewed studies: 0.42 pounds per meal per year

Significant overlap was observed in estimates from the two methods. Given the correlation between the number of meals and the number of beds and the availability of comprehensive data, the pounds per bed methodology was selected for statistical analysis.

Data Compilation & Application. Multiple data sources were utilized to verify the number of beds in healthcare facilities. The DHS database provided the most comprehensive data on bed count for hospitals and nursing homes.[126] Due to the similar average pounds per bed generation factor for hospitals and nursing homes, the Study did not distinguish between the two types of facilities. To enhance the model, an average occupancy rate of 73.53%, based on the CDC's Hospital occupancy rate for 2023, was applied. The same rate was used throughout the sector, despite the MHCA Nursing Home reporting a slightly higher average occupancy of 78.96%.[127]

- EPA average pounds per bed per year: 3,290 tons per year

126 HIFLD Open Data. Accessed December 2023-March 2024. https://hifld-geoplatform.hub.arcgis.com/pages/hifld-open.

127 Maine Health Care Association. "Maine Health Care Association." [Information Prepared for Human Services Committee Supplemental B udget Work Sesson.] January 31, 2023. https://legislature.maine.gov/doc/9688.

Sensitivity Analysis: Range of Estimates based on Selected Methodology

In recognizing a margin of error arises from statistical sampling methods, the Study presents a range of values in Table 24 by including a "high estimate" and a "low estimate." These estimates are formed based on alternative assumptions documented in subsequent paragraphs. Nonetheless, this study determined an optimal estimate specific to the context of the sector for Maine, as corroborated by pertinent literature and primary data collected through interviews.

Table 24: Hospital Sector Estimate vs. High and Low Estimates Based on Lb./Bed

Sensitivity Estimate - High (TPY)	Sensitivity Estimate - Low (TPY)	2024 ME DEP Study Estimate (TPY)
6,288	1,172	2,742

The method of calculating food waste as pounds per bed per year yields varying estimates. The higher estimate comes from the Connecticut Department of Environmental Protection (2001) study, which aggregates data suggesting an average of 5.7 meals served per day per bed, leading to a generation factor of 1,248.3 pounds per bed per year.[128] A lower estimate is derived from the CalRecycle 2015 study, which distinguishes between two subgroups: "Ambulatory Health Care Services" and "Hospital, Nursing, and Residential Care Facilities."[129] As surplus food was not expected to be generated per bed in "Ambulatory Health Care Services," it is plausible that the generation factor was underestimated.

An adjusted average generation factor was applied for this sector based upon findings from interviews. These interviews suggested that the average surplus food estimate was 1.2 times higher than the estimate derived from collected interview data. Consequently, the average of 653.14 pounds per bed per year was revised to 544.3 pounds per bed per year.

Data Validation

When compared to existing estimates the 2024 ME DEP Study Estimate is towards the higher range of the EPA Excess Food Opportunities Map (between 455 to 2,442 tons per year). Upon further analysis of the EPA's data set utilized for the estimation of surplus food, it was noted that numerous entities without generation rates. This could potentially be attributed to the absence of explicit clarification regarding whether the listed healthcare entities operated live-in care facilities. Gaps in the estimates could also be a result of incomplete entries for the number of beds. In contrast, the estimate is higher than ReFED's Insights Engine that had an existing estimate of 1,790 tons per year. ReFED's methodology focuses primarily on the food service sector within hospitals, which encompasses pre-consumer surplus, onsite plate waste, catering overproduction, and catering plate waste.[130] A Maine-specific study conducted on Northern Light Health Blue Hill indicated that plate waste and pre-consumer overproduction waste constituted approximately 59% of the overall surplus food by weight. By applying this finding to ReFED's estimate,

128 Draper/Lennon, Inc. & Atlantic Geoscience Corp. *Identifying, Quantifying, and Mapping Food Residuals from Connecticut Businesses and Institutions*. [Submitted to K.C. Alexander of Connecticut Department of Environmental Protection.] September, 2001. https://portal.ct.gov/-/media/DEEP/compost/ssomfile/ssomreportpdf.pdf.

129 Cascadia Consulting Group. *2014 Generator Based Characterization of Commercial Sector Disposal and Diversion in California*. CalRecycle, September 10, 2015. https://www2.calrecycle.ca.gov/Publications/Details/1543.

130 ReFED. "Food Waste Monitor." ReFED Insights Engine, 2022. https://insights-engine.refed.org/food-waste-monitor?view=overview&year=2022.

the overall surplus food by this sector was revised to be 3,034 tons per year, a figure closer to the 2024 ME DEP Study Estimate.

Estimate Finalization

Given the depth of considering the estimation for this sector in context of live-in care facilities specific to the State of Maine and corroboration with the existing estimate by ReFED, the estimate derived from the interview data adjusted generation factor and detailed data set of live in care facilities within Maine was selected. **2024 ME DEP Study Estimate (TPY): 2,742 tons per year.**

Large Office Buildings

Sector Description

This sector quantifies surplus food generated by commercial buildings not already covered under other sectors in this report. For example, restaurants located in commercial buildings would be accounted for under the Restaurants sector. Instead, this sector includes office workers that are not easily associated with a well delineated set of NAICS codes but may exist in numerous settings such as academic research, financial services, software development, and public administration. An added complexity is that office settings feature an array of food consumption and food waste generation conditions. Office workers may bring their own lunches, eat at an on-site cafeteria, or leave the premises to eat in commercial restaurants. A reliable generation factor and dataset should provide consideration for these factors.

Top employers by employee headcount per site comprised over 40 industries with the top 10 as follows: Commercial Printing, Courts, All Other Miscellaneous Retailers, Executive Offices, General Freight Trucking, Long-Distance, Truckload Administrative Management and General Management Consulting Services, Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology), Direct Life Insurance Carriers, Automobile and Other Motor Vehicle Merchant Wholesalers, Freight Transportation Arrangement.

Study Estimate of Food Loss & Waste (Annual Tons)

This estimate was derived in two parts. First, the square foot methodology generation factor of 0.17 Tons/ 1000sq ft/ year was applied to offices larger than 30,000 square feet. Second, the employee methodology of 80.9 pounds per employee per year was applied to the remaining offices. This hybrid approach was designed based on feedback from interviews that suggested a high likelihood of overestimation from both models. One possible explanation is that existing literature on generation factors were studies completed before the onset of the COVID-19 pandemic has impacted office norms in recent years. Food waste generation was found to be concentrated predominately in Cumberland and Kennebeck County. The methodology selection, data application, sensitivity analysis and validation may be referenced under Additional Sector Details.

2024 ME DEP Study Estimate (TPY) 2,680 tons per year

Characterization

All food waste characterizations are quantified with reference to the 2024 ME DEP Study Estimate based on existing literature, including past studies on Maine and/or data from primary interviews where available. Percentages applied to the 2024 ME DEP Study Estimate for respective sector may be referenced in Table 28.

Avoidable vs unavoidable: Surplus food from this sector has the potential to be reduced by about 884 tons per year or 33% based on interviews conducted. The distinction between avoidable and unavoidable food waste becomes clear when examining dining services within large office buildings. There exists an opportunity to mitigate food loss through the reuse of surplus in additional menu items and the donation of edible food to local food recovery organizations. This is corroborated by secondary research that revealed strategies such as the removal of trays from in-house cafeterias have demonstrated a reduction in plate waste by 30%.[131]

Predictable vs unpredictable: Surplus food from this sector is characterized as highly unpredictable by interviews. Food loss and waste varies, marked by the fluctuating number of employees served daily. The catering requirements can significantly differ; some days necessitate catering for more than 500 employees, while other days only require service for 100-200 onsite individuals. Consumption habits of office workers are also driven by individual preference, and it is challenging to consider the changes in number of meals served due to remote working, skipped meals, packed lunches, or take away/ delivery from restaurants. The task of anticipating consumer volume presents a logistical challenge for food service providers.

Edibility: Assuming systems are in place, about 268 tons per year of the surplus food could be edible by humans where interview findings identified that food waste from daily overproduction and catering remains fit for human consumption. Approximately 10% of total food waste falls into this category while the remaining 90% is inedible. The inedible portion includes kitchen waste with compostable packaging, poor quality or food deemed to be not compliant with "food safety" regulations as well as plate waste where "trims, bones and shells" were cited as examples. While larger office buildings may have the capacity for a designated freezer for surplus edible food that is intended for food recovery, logistical concerns regarding space and timing arise, as an effective system requires a partner capable of collecting these items with appropriate frequency. The edible food surplus is also generated predominately from offices which have in-house cafeterias where meals are prepared.

Additional Sector Details

Methodology Selection. The complexity of this sector has resulted in a limited number of applicable studies. The EPA compiled studies employing two different methodologies based on three foundational studies that examined food waste from office buildings. The findings from these studies are as follows:

- Average per-employee estimate across EPA-reviewed studies: 169.85 Pounds/Employee/Year
- Average area-based estimate across EPA-reviewed studies: 0.22 Tons/ 1000sqft/ Year

131 Pearson, Pete, & McBride, Monica. *Fighting Food Waste in Hotels*. WWF, November 13, 2017. https://files.worldwildlife.org/wwfcmsprod/files/Publication/file/jokyswl5j_Hotel_Kitchen_Final.pdf.

Both methodologies were limited since their foundational studies were waste characterization studies performed at office buildings across various sectors.[132] These industries did not align perfectly with the top few corporate settings in Maine, but both methodologies were applied to obtain preliminary estimates.

Data Compilation & Application. To compile a corporate data set representing the largest generators for this sector within Maine, the Top Employers reported by the state were aggregated along with the D&B Hoovers business database filtered to those with more than 500 employees located in a single site within Maine.[133]

- Per-employee estimate across EPA-reviewed studies: 7,200 tons per year
- Area-based estimate across EPA-reviewed studies: 1,027 tons per year

The comparison between employee based and square footage-based estimates revealed a significantly higher estimate from the former, as evidenced in the CalRecycle (2015) study.[134] The employee-based generation factor, at 258.8 pound per employee per year, resulted in 10,971 tons per year from this sector. In contrast, the square footage estimate (0.26 tons per 1000 square feet/year) from the same study only derived a total of 1,214 tons per year.

These generation factors were initially computed based on waste characterizations across California, with a particular focus on California (mostly concentrated in the Bay Area and Southern California) and office types including Management, Administrative, Support, & Social as well as Professional, Technical, & Financial services. Despite their common origin, a stark discrepancy is evident between the employee-based in square footage-based estimates.

It was found through interviews that the food waste generated per square foot of facility space is likely closer to actual than estimates on a per-employee basis. The food estimate was based on actual food waste volumes cited in interviews or a per meal estimate, as referred to in the RecyclingWorks in Massachusetts Food Waste Estimation guide.[135] The discrepancy could potentially be attributed to the data set for Maine, which primarily focused on "large offices" with more than 500 employees. This might have resulted in a higher employee to square footage ratio than what was sampled in the CalRecycle (2015) study. Another plausible explanation could be an overstated employee count in the database, although this was not substantiated through sample checks.

Sensitivity Analysis: Estimations by Alternate Methodologies

In recognizing a margin of error arises from statistical sampling methods, the Study presents a range of values in Table 25 by including a "high estimate" and a "low estimate." These estimates are formed based on alternative

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132 Fabiano, C., Meyer, E., Carusiello, C., Rubright, T., & Industrial Economics, Inc. *Wasted Food Measurement Methodology Scoping Memo*. U S EPA, July 2020. https://www.epa.gov/sites/default/files/202006/documents/food_measurement_methodology_scoping_memo-6-18-20.pdf.

133 Maine Department of Labor, Center for Workforce Research and Information. "Top Private Employers in Maine by Average Monthly Employment – 2nd Quarter 2023." Maine.gov, 2023. https://www.maine.gov/labor/cwri/publications/pdf/MaineTop50Employers.pdf

134 Cascadia Consulting Group. *2014 Generator Based Characterization of Commercial Sector Disposal and Diversion in California*. CalRecycle, September 10, 2015. https://www2.calrecycle.ca.gov/Publications/Details/1543.

135 RecyclingWorks Massachusetts. Food Waste Estimation Guide. Updated November, 2022. https://recyclingworksma.com/food-waste-estimation-guide/.

assumptions documented in subsequent paragraphs. Nonetheless, this study determined an optimal estimate specific to the context of the sector for Maine, as corroborated by pertinent literature and primary data collected through interviews.

Table 25: Large Office Building Sector Estimate vs. High and Low Estimates Based on Lb./Employee & Tons /Sq Ft

Sensitivity Estimate - High (TPY)	Sensitivity Estimate - Low (TPY)	2024 ME DEP Study Estimate (TPY)
3,429	794	2,680

Given the varied results between methodologies, the high estimate was derived from an employee-generation factor sourced from a 2015 Metro Vancouver study.[136] The factor of 80.9 pounds per employee per year was calculated based on 25 characterization studies within the "business commercial services" category, with samples drawn from individual businesses managing their own waste (20%), and large offices overseen by property management companies (80%). This approach was deemed to provide a more accurate representation of the 'large offices' dataset for Maine.

The low estimate, on the other hand, was determined from a 2006 CalRecycle study, which exclusively sampled buildings exceeding 30,000 square feet. This generation factor of 0.17 Tons/ 1000sq ft/ year was formulated from the disposal data of 21 samples. In the dataset of Maine's largest offices, this constitutes roughly 30% of the identified offices. Therefore, a hybrid approach was used for this estimate, applying the square foot methodology for offices larger than 30,000 square feet, and the employee methodology for the remaining offices.

Data Validation

No existing estimate. Validation through interviews.

Estimate Finalization

Interviews revealed the model overestimated the surplus food from the large office building by about 3 times. While it was noted they tended to already have food waste reduction programs in place and were paying for any additional surplus food to be collected for composting or anaerobic digestion, the surplus food including those currently diverted were all considered. Some initiatives included cafeterias using fast freezers to minimize food spoilage before they get eaten as well as staff optimizing kitchen scraps by using leftover cut vegetables for stew on the following day. Another explanation could be that work norms have changed since the onset of the COVID-19 pandemic. The final estimate is retained given the understanding that conscientious companies would fall closer to the lower range of the estimate. **2024 ME DEP Study Estimate (TPY): 2,680 tons per year.**

136 Tetra Tech EBA Inc. *2014 ICI Waste Characterization Program*. Metro Vancouver, June 1, 2015. https://metrovancouver.org/services/solid-waste/Documents/ici-waste-characterization-program-2014.pdf.

Sports Venues and Special Events

Sector Description

This sector quantifies surplus food arising by periodic or seasonal events in Maine, including sports venues and large festival events. Sports venues include stadiums, ballparks, arenas, sports centers, fields, racetracks, college stadiums, and other permanent sports facilities where food is served. Festival information was researched and cross-referenced with information from the Maine Association for Agriculture Fairs and the Maine Tourism Association. [137, 138, 139]

Study Estimate of Food Loss & Waste (Annual Tons)

This estimate was derived from applying the generation factor of 0.31 pounds per visitor to desktop research collated information. Various sources including the Maine Sports Commission, past research conducted by the University of Maine and the State of Maine Department of Environmental Protection were referenced to verify the number of visitors to stadiums. Food loss and generation from Sports Venues and Special Events was found predominantly in Cumberland and Penobscot Counties. The methodology selection, data application, sensitivity analysis and validation may be referenced under Additional Sector Details.

2024 ME DEP Study Estimate (TPY): 1,074 tons per year

Characterization

All food waste characterizations are quantified with reference to the 2024 ME DEP Study Estimate based on existing literature, including past studies on Maine and/or data from primary interviews where available. Percentages applied to the 2024 ME DEP Study Estimate for respective sector may be referenced in Table 28.

Avoidable vs Unavoidable: Surplus food was assumed to be highly unavoidable for this sector. Interviews revealed that uneaten guest portions contributed to waste though a comprehensive system to track this waste was not in place. It was noted that this conflicts with industry data where over 96% of food waste at venues and events stems from off-site, pre-game preparation, with only 24% originating from within the stadium itself.[140]

Predictable vs unpredictable: Surplus food from this sector is characterized as predictable due to the correlation of surplus food produced with the specific game dates or fair seasons. The impact of seasonality is explored under the seasonality section of this report. It would be most impactful to have food waste management programs such as donation partnerships or paid services in place, particularly during peak seasons. Interviews suggest that one

137 US EPA – Region 5 (Materials Management). "A Guide to Recycling at Sports Venues." January 2011. https://www.epa.gov/sites/default/files/documents/recyclingsportsvenues.pdf.

138 Maine Association of Agricultural Fairs. "Home." https://www.mainefairs.net.

139 Maine Tourism Association. "Festivals & Fairs." https://www.mainetourism.com/events/festivals-fairs/?bounds=false&view=list&sort=qualityScore.

140 Costello, C., Mcgarvey, R., & Birisci, E. "Achieving Sustainability beyond Zero Waste: A Case Study from a College Football Stadium." *Sustainability*, 9, no. 7 (2017): 1236. https://doi.org/10.3390/su9071236.

source of unpredictable food waste may occur if a game, event, or festival is postponed. Prepared items, such as hamburgers, pizza, and popcorn, may be suitable for food recovery during these unpredictable events.

Edibility: Surplus food was assumed to be highly varied for this sector. Interviews suggested most food surplus would be "inedible or contaminate." However, given the predictability of the event, food that is prepared and not served could be redistributed through food donation activities.

Additional Sector Details

Methodology Selection. The methodology utilized for this sector is based on the number of visitors, though there is data to support alternative approaches such as meal-based or seat-based. The Recycling MA Food Waste estimation guide presented two alternative methodologies: pounds per seat per day and pounds per meal. However, the Study employed the most comprehensive literature on pounds per visitor. It is important to note that the 0.45 pounds per visitor estimate provided by the RecyclingWorks in MA Food Waste Estimation guide likely originates from the 2006 CalRecycle study which is also cited as one of the underlying studies for the average computed by the EPA.[141]

- Per-employee factor based on studies reviewed by EPA: 0.31 pounds per visitor
- RecyclingWorks in MA Food Waste estimation guide:
    - 0.6 pounds per seat per day
    - 1 pounds per meal
    - 0.45 pounds per visitor[142]

Data Compilation & Application: Data compilation for this sector was standardized to a per-visitor-per-year basis. The process involved collating information from various sources to verify the number of visitors to stadiums. The Maine Sports Commission provided a foundational list of sports venues and their capacities. For fairs, data was acquired through desktop research, complemented by existing information from past research conducted by the University of Maine and the State of Maine Department of Environmental Protection. The desktop research necessitated manual consolidation of yearly attendance figures published on venue websites. In instances where specific data points were not available, an average ratio was applied based on known stadium capacities, facilitating a comprehensive estimation of attendee numbers.

Sensitivity Analysis: Range of Estimates based on Selected Methodology

In recognizing a margin of error arises from statistical sampling methods, the Study presents a range of values in Table 26 by including a "high estimate" and a "low estimate." These estimates are formed based on alternative assumptions documented in subsequent paragraphs. Nonetheless, this study determined an optimal estimate specific to the context of the sector for Maine, as corroborated by pertinent literature and primary data collected through interviews.

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141 Cascadia Consulting Group. *Targeted Statewide Waste Characterization Study: Waste Disposal and Diversion Findings for Selected Industry Groups*. CalRecycle, June 2006. https://www2.calrecycle.ca.gov/Publications/Details/1184.

142 RecyclingWorks Massachusetts. Food Waste Estimation Guide. Updated November, 2022. https://recyclingworksma.com/food-waste-estimation-guide/.

Table 26: Sports Venue and Special Event Sector Estimate vs. High and Low Estimates Based on Lb/Visitor

Sensitivity Estimate - High (TPY)	Sensitivity Estimate - Low (TPY)	2024 ME DEP Study Estimate (TPY)
1,560	555	1,074

The high estimate was derived from the 2006 CalRecycle study, which resulted in a value of 0.45 pounds per visitor. This study utilized a combination of surveys and waste audits where available, encompassing venues such as convention centers, stadiums, theme parks, performing arts centers, movie theaters, fairgrounds, special event sites, and miscellaneous venues. The chosen sites generally met the large venue or event criteria as described in the California statute, which might explain the higher range.

On the other hand, the low estimate was calculated based on the 0.16 pounds per visitor generation factor from the Costello et al. (2017) study.[143] This number was derived from waste audits conducted on landfill-bound waste generated at the University of Missouri football stadium in 2014.

Given the diversity of events encompassed by this sector, the 2024 ME DEP Study Estimate employed the average generation factor across the three studies. Notably, the average is closely aligned with that of the 2015 CalRecycle study, which covered a similar range of stadiums, performance centers, parks, fairgrounds, bowling alleys, movie theaters.

Data Validation

No existing estimate. Validation through interviews.

Estimate Finalization

Validation was achieved through a series of interviews. Interviews conducted demonstrated an accurate estimation based on the average model. As the estimate is calculated on an annual basis, seasonality was not factored into the overall figure. However, the impact of seasonality is explored under the seasonality section of the report.

Correctional Facilities

Sector Description

The sector describes the prison surplus food quantification. It includes waste generated by both live-in correctional facilities and privately operated correctional facilities. In Maine, six significant facilities have been identified and examined for this study.

Study Estimate of Food Loss & Waste (Annual Tons)

The estimate was derived from applying an adjusted generation factor of 305 pounds per inmate per year, computed from the weighted average of interview results and applies it to reported inmate population with an assumed occupancy rate of 70% (rounded average of occupancy as of September 2023 and February 2024).

143 Costello, C., Mcgarvey, R., & Birisci, E. "Achieving Sustainability beyond Zero Waste: A Case Study from a College Football Stadium." *Sustainability*, 9, no. 7 (2017): 1236. https://doi.org/10.3390/su9071236.

Marginally, the most food waste generation from this sector was found in Knox County. The methodology selection, data application, sensitivity analysis and validation may be referenced under Additional Sector Details.

2024 ME DEP Study Estimate (TPY) 244 tons per year

Characterization

All food waste characterizations are quantified with reference to the 2024 ME DEP Study Estimate based on existing literature, including past studies on Maine and/or data from primary interviews where available. Percentages applied to the 2024 ME DEP Study Estimate for respective sector may be referenced in Table 28.

Avoidable vs unavoidable: Surplus food from this sector has the potential to be reduced by about 161 tons per year. This is based on the Maine Department of Corrections (DOC) Food Waste Study 22-23 that found tracking food waste and allowing inmates to choose the contents of their meals can reduce waste by about 2/3 per inmate or 66%.[144] This corroborated with interviews that cited plate waste to be the major contributor of surplus food ranging from 76 to 94% of overall food. In comparison, less than 5% of kitchen waste was cited to be avoidable.

Predictable vs unpredictable: Surplus food from this sector is characterized as highly unpredictable by interviews given majority of it is plate waste. Other sources include prep waste from back-of-house and overproduction.

Edibility: About 88 tons per year of surplus food from this sector is characterized as edible for animals, while the remaining 156 tons per year is inedible based on interview data. However, interviews cited challenges in continuing animal feed programs such as proximity to livestock as well as having to follow "regulations" requiring "recooking" to "sterilize plate waste" or separating fresh scraps from served food. Another mentioned animal feed programs were disrupted during the pandemic. They highlighted the importance of instilling how valuable the programs are and supporting them for such initiatives to continue.

Additional Sector Details

Methodology Selection. Various research methodologies have been employed to explore surplus food production in correctional facilities. Most studies make estimates based on surplus per inmate, with one study examining surplus on a per-meal basis. The EPA provided a summary of generation rates in the literature, citing seven foundational studies. The conclusions drawn from these investigations indicated an average of 1.12 pounds of surplus per inmate per day, according to the EPA, and 0.30 pounds of surplus per meal.

The per meal factor, based on a 1997 study, is likely to be an overestimation, as it implicitly assumes that all organic waste generated at the facilities is food waste. The pound per inmate per day factor, on the other hand, is based on six different foundational studies. With the number of meals being highly correlated with the number of inmates (three meals per inmate, 365 days a year), there is significant overlap in the estimates for both methods. However, the literature for the pound/ inmate/ day generation factor was comparatively comprehensive, leading to its adoption for this sector.

144 Fitzmaurice, Ryan. *Food Waste in Facilities of the Maine Department of Corrections With Attached Food Waste Tracking Guide [2022-2023]*. University of Maine.

Data Compilation & Application

The sector relied on inmate data published by the state of Maine. The EPA's average pounds per inmate per year was 363 tons per year.

Sensitivity Analysis: Range of Estimates based on Selected Methodology

In recognizing a margin of error arises from statistical sampling methods, the Study presents a range of values in Table 27 by including a "high estimate" and a "low estimate." These estimates are formed based on alternative assumptions documented in subsequent paragraphs. Nonetheless, this study determined an optimal estimate specific to the context of the sector for Maine, as corroborated by pertinent literature and primary data collected through interviews.

Table 27: Correctional Facility Sector Estimate vs. High and Low Estimates Based on Lb/Inmate

Sensitivity Estimate – High (TPY)	Sensitivity Estimate – Low (TPY)	2024 ME DEP Study Estimate (TPY)
476	162	244

The high estimate was based on a Goldstein (2015) study that worked with the food service contractor to conduct waste sorts. This study determined that about 1.4 pounds of pre-consumer and post-consumer food waste was generated per inmate per day at maximum capacity.[145] The low estimate was based on a CalRecycle (2018) study, estimating 0.5 pounds per inmate per day to upward of 1.2 pounds per inmate per day. This study acknowledges the variation of generation per inmate by type of prison and feeding program.

The 2024 ME DEP Study Estimate is based on a generation factor of 305 pounds per inmate per year, computed from the weighted average of interview results and assumes an inmate occupancy of 70% (rounded average of occupancy as of September 2023 and February 2024).

Data Validation

When compared to existing estimates, the 2024 ME DEP Study Estimate is outside of the lower range of the EPA Excess Food Opportunities Map (between 704 to 1,159 tons per year). The EPA's estimate may be overstated, as it does not account for inmate occupancy rates and uses the average generation factor computed across multiple studies. The U.S. Census data indicates that Maine is likely to be on the lower end of the spectrum in terms of prison size and occupancy. The estimate is closer to ReFED's Insights Engine that had an existing estimate of 320 tons per year. ReFED's methodology, which focuses on the food service sector within correctional facilities, accounts for pre-consumer surplus, onsite plate waste, catering overproduction, and catering plate waste.[146] The high level of control over activities in correctional facilities and the consistency of food service suggest that this methodology provides accurate results.

145 Goldstein, Nora. "Food Scraps To Orchard Amendment At Philadelphia Prison Complex." BioCycle, September 17, 2015. https://www.biocycle.net/food-scraps-to-orchard-amendment-at-philadelphia-prison-complex/.

146 ReFED. "Food Waste Monitor." ReFED Insights Engine, 2022. https://insights-engine.refed.org/food waste-monitor?view=overview&year=2022.

Most pertinently, the 2024 ME DEP Study Estimate aligns with the range (between 197 to 283 tons per year) detailed in the "Food Waste in Facilities of the State of Maine Department of Corrections" (Maine DOC Food Waste Study 22-23) study conducted by the University of Maine in partnership with the State of Maine Department of Corrections. This study analyzed the food waste generated by three facilities in Maine: The Southern Maine Women's Reentry Center (Windham), Bolduc Correctional Facility (Warren), and the Maine State Prison (Warren). These three facilities house over half of Maine's inmate population and represent a wide range of prison types in terms of size, security level, and kitchen location. The study also considered unique factors, such as the presence of a bakery at the Bolduc Correctional Facility. The estimated range of food waste generated by correctional facilities in Maine, according to this study, is between 394,508 pounds per year (197 TPY) and 565,950 pounds per year (283 TPY).

Estimate Finalization

Given the highly specific data used and the corroboration with the Maine based study, the 2024 ME DEP Study Estimate was adopted as the final estimate. **2024 ME DEP Study Estimate (TPY): 244 tons per year.**

Appendix B: Surplus Food Characterization Assumptions by Sector

All food waste characterizations are quantified with reference to the 2024 ME DEP Study Estimate based on existing literature, including past studies on Maine and/ or data from primary interviews where available. Percentages applied to the 2024 ME DEP Study Estimate for respective sector may be referenced in Table 28.

Table 28: Food Surplus Characterization by Avoidable, Predictable, and Edible by Sector (Percent)

	Annual Generation (Tons)	Percent Avoidable	Percent Predictable	Percent Edible	Percent Edible if Upcycled	Percent Animal Feed	Percent Inedible	Remarks
Residential	129,598	17	0	12	0	0	100	Interviews, Maine past studies
Farms & Agriculture	90,470	0	0	Apples: 91%, Blueberries: 2%, Corn: 1%, Potatoes: 4%	Potential to explore further	Potential to explore further	Apples: 9%, Blueberries: 98%, Corn: 99%, Potatoes: 96%	Secondary literature; best guess assumptions
Food Manufacturers	40,603	0	95	5	Potential to explore further	46	49	Interviews
Grocery Stores	37,955	50	0	19	Potential to explore further	11	70	Interviews; Secondary literature
Restaurants	19,423	26	12	72	Potential to explore further	16	12	Interviews; Secondary literature
Hotels	11,589	25	50	6	Potential to explore further	30	64	Secondary literature, best guess assumptions
Food Pantries/ Banks	9,908	0	0	0	0	92	8	Interviews
Food Distributors	7,615	50	0	0	20	70	10	Interviews
K-12 Schools	4,200	20	0	0	0	0	100	Interviews, Maine past studies
Hospitals	2,742	41	50	5	0	0	95	Interviews, Maine past studies
Large Office Buildings	2,680	33	0	10	0	0	90	Interviews
Large Multi-Family Complexes	2,149	Same as 'Residences'	Same as 'Residences'	68	0	0	32	Maine past studies; Secondary

	Annual Generation (Tons)	Percent Avoidable	Percent Predictable	Percent Edible	Percent Edible if Upcycled	Percent Animal Feed	Percent Inedible	Remarks
								literature; best guess assumptions
Universities	1,256	20	0	0	0	0	100	Maine past studies, interviews
Sports Arenas & Large Festivals	1,074	0	50	Potential to explore further	0	0	100	Interviews, best guess assumptions
Correctional Facilities	244	66	0	0	0	36	64	Maine past studies, interviews
Overall	**361,506**	**15**	**13**	**13**	**0**	**12**	**75**	-

Seasonality

The objective of incorporating seasonality into the modelling exercise was to gain comprehensive insight into the potential impact of various policy thresholds on entities within and across sectors. This necessitated the identification of the "peak season" for food waste generation. The hospitality sector, specifically hotels, restaurants, and sports arenas/fairs, was identified as most susceptible to this phenomenon.

Data procured from the Maine Office of Tourism proved instrumental in developing a "peak season" factor applicable to hotels and restaurants. Table 29 presents the original data obtained, while Table 30 illustrates the interpretation of this data and its application across the relevant sectors to simulate a "peak season."

Table 29: Peak Season Population Increase vs. Off-Season

Region (Counties)	Est. Visitors	Est. Visitor Days	Est. Population	Est. Population Increase
Aroostook County (Aroostook)	282,900	1,105,200	67,000	4x
Downeast Acadia (Hancock, Washington)	2,097,800	9,766,500	87,313	24x
Greater Portland (Cumberland – primarily)	2,541,800	11,692,280	305,231	8x
Kennebec Valley (Kennebec, Somerset)	830,300	4,099,600	175,078	5x
Maine Lakes & Mountains (Androscoggin, Oxford, Franklin)	1,936,700	8,808,100	199,380	10x
The Maine Beaches (York)	4,784,200	14,352,600	214,591	22x
The Maine Highlands (Penobscot, Piscataquis)	876,000	5,845,700	169,930	5x

Region (Counties)	Est. Visitors	Est. Visitor Days	Est. Population	Est. Population Increase
Midcoast & Islands (Knox, Lincoln, Sagadahoc, Waldo)	2,013,900	9,832,100	153,895	13x

The spread of visitor increase throughout the year was modelled based on the assumption that about 65% of our visitors come in the summer months (May-Aug) followed by about 25% in fall (Sep-Nov) and the remainder in winter (Dec-Apr). Table 30 reflects this modeling.

Table 30: Interpretation of Data from the Office of Tourism

	Distribution of Visitors by Season	65% increase in visitors	25% increase in visitors	10% increase in visitors
	Multiplication Factor of Visitor Increase	Peak (Summer)	Fall (Sep-Nov)	Winter (Dec-Apr)
Androscoggin	10	6.5	2.5	1
Aroostook	4	2.6	1	0.4
Cumberland	8	5.2	2	0.8
Franklin	10	6.5	2.5	1
Hancock	24	15.6	6	2.4
Kennebec	5	3.25	1.25	0.5
Knox	13	8.45	3.25	1.3
Lincoln	13	8.45	3.25	1.3
Oxford	10	6.5	2.5	1
Penobscot	5	3.25	1.25	0.5
Piscataquis	5	3.25	1.25	0.5
Sagadahoc	13	8.45	3.25	1.3
Somerset	5	3.25	1.25	0.5
Waldo	13	8.45	3.25	1.3
Washington	24	15.6	6	2.4
York	22	14.3	5.5	2.2

The peak season multiple was applied to the weekly estimate per entity for both the Hotel and Restaurants sector to model for the waste generation during busy weeks. One limitation noted from an interview was that a sports stadium cited their peak season as winter, fall and spring months rather than the summer months. While we provide consideration in modelling for seasonality for the sports arenas accordingly, the same limitation was not addressed for some in the hotel and restaurants sector such as the ski resorts in Maine.

Given the sports arenas and festivals sector behave differently from hotels and restaurants, the following approach was adopted instead. The total annual waste estimate was spread over shorter time periods to model for peak season for this sector and the impact is illustrated in Table 31below.

Table 31: # Entities in Sports Arenas and Festivals Sector Generating 2+ Tons of Food Surplus Per Week (TPW)

	Number of Entities > 2TPW Annual (Peak Season)	Percent of Entities > 2TPW Annual (Peak Season)
Annual Average/Week	1	2%
Assume Peak Season = 2 weeks	29	62%
Assume Peak Season = 1 month	26	55%
Assume Peak Season = 2 months	18	38%
Assume Peak Season = 3 months	10	21%

The 2-week estimate was applied to model for peak season in the analysis for this sector. This was assessed to be an appropriate average assumption for the sector as it was a conservative estimate for fairs with the longest lasting up to 2 weeks and an exaggerated estimate for sports arenas that may be active for more than 6 months a year.

Service Providers

This study evaluated the operational anaerobic digestion facilities and compost sites in Maine with capacity for processing food waste. Table 30 details the facility name, city, and permitted capacity of the site. This list does not factor in the net capacity of the site based on material accepted and processed currently.

Table 32: Operational Compost and Anaerobic Digestion Facilities in Maine

Facility Name	Facility City	Permitted Capacity (TPY)
Stonyvale Farm / Exeter Agri-Energy, LLC Digester	Exeter	80,000
John Watts Construction LLC	York	365
We Compost It/ MB Mark	Auburn	1,500
Scraps Dogs Community Compost	Washington	365
Garbage to Garden	Windham	365
Diggers Cooperative	Acton	365
Chickadee Compost	Surry	365
White Buffalo Forest	Gouldsboro	365

Appendix C: Geographic Distribution of Food Loss & Waste

Tables 33 - 48 provide a country-level sector analysis. They serve as valuable tools for evaluating environmental impact and waste generation concentration across different sectors, within each county. The tables identify the number of businesses that may be affected based on tons generated annually for each sector, showcasing the number of entities, total tons generated, and entities surpassing certain waste thresholds (greater than 2 tons per week, 1 ton per week, and ½ ton per week).

Food Waste Generation across Counties with Estimated Tons Per Week per Sector

Table 33: Androscoggin County – Annual Generation by Sector, Total & by Entity Size Thresholds

			Entities Generating 2+ TPW		Entities Generating 1+ TPW		Entities Generating 0.5+ TPW	
County: Androscoggin	Food Surplus (TPY)	Number of Entities	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)
Residences	10,047	45,373	-	-	-	-	-	-
Farms & Commercial Agriculture	3,976	-	-	-	-	-	-	-
Food Manufacturers	3,130	31	5	2,694	8	2,903	10	2,972
Grocery Stores	2,657	120	5	915	10	1,267	19	1,575
Restaurants	1,321	250	1	165	3	312	8	484
Hotels	250	40	-	-	-	-	1	46
Food pantries/ banks	1,455	28	1	748	1	748	28	1,455
Food Distributors	216	25	1	124	1	124	2	171
K-12 Schools	386	20	2	189	7	360	7	360
Hospitals	302	62	-	-	-	-	4	150
Large Office Buildings	325	7	-	-	3	231	4	276
Large Multi-Family Complexes	221	20						
Universities	93	3	-	-	1	58	2	89
Sports Arena & Large Festivals	122	4	-	-	-	-	3	116
Correctional Facilities	-	-	-	-	-	-	-	-
Total (excluding Farms & Residence)	**10,479**	**610**	**15**	**4,836**	**34**	**6,005**	**88**	**7,693**
Total (including Farms & Residence)	**24,501**	**45,983**						

Table 34: Aroostook County – Annual Generation by Sector, Total & by Entity Size Thresholds

			Entities Generating 2+ TPW		Entities Generating 1+ TPW		Entities Generating 0.5+ TPW	
County: Aroostook	Food Surplus (TPY)	Number of Entities	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)
Residences	6,686	29,780	-	-	-	-	-	-
Farms & Commercial Agriculture	54,363	-	-	-	-	-	-	-
Food Manufacturers	3,777	23	8	3,559	9	3,635	10	3,669
Grocery Stores	2,033	74	6	1,047	9	1,290	14	1,436
Restaurants	473	123	0	-	1	52	1	52
Hotels	263	54	-	-	-	-	1	30
Food pantries/ banks	968	37	-	-	-	-	37	968
Food Distributors	386	31	1	242	1	242	2	288
K-12 Schools	199	32	-	-	3	92	4	111
Hospitals	146	33	-	-	-	-	-	-
Large Office Buildings	66	3	-	-	-	-	1	27
Large Multi-Family Complexes	51	4	-	-	-	-	-	-
Universities	66	3	-	-	-	-	2	53
Sports Arena & Large Festivals	6	2	-	-	-	-	-	-
Correctional Facilities	-	-	-	-	-	-	-	-
Total (excluding Farms & Residence)	**8,436**	**419**	**15**	**4,849**	**23**	**5,311**	**72**	**6,634**
Total (including Farms & Residence)	**69,486**	**30,199**						

Table 35: Cumberland County – Annual Generation by Sector, Total & by Entity Size Thresholds

			Entities Generating 2+ TPW		Entities Generating 1+ TPW		Entities Generating 0.5+ TPW	
County: Cumberland	Food Surplus (TPY)	Number of Entities	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)
Residences	27,747	127,991	-	-	-	-	-	-
Farms & Commercial Agriculture	1,045	-	-	-	-	-	-	-
Food Manufacturers	18,487	117	14	17,478	15	17,576	23	17,877
Grocery Stores	11,260	452	19	6,035	30	6,722	44	7,276
Restaurants	6,571	1,161	6	981	15	1,736	42	2,775
Hotels	3,575	326	1	934	7	1,275	24	1,889
Food pantries/ banks	1,230	47	-	-	-	-	47	1,230
Food Distributors	3,393	177	8	2,508	10	2,643	17	2,956
K-12 Schools	888	48	7	512	14	795	15	808
Hospitals	740	156	1	127	1	127	3	202
Large Office Buildings	1,106	26	2	262	5	448	20	985
Large Multi-Family Complexes	1,229	109	-	-	-	-	-	-
Universities	385	7	3	309	3	309	5	368
Sports Arena & Large Festivals	260	7	-	-	2	156	4	225
Correctional Facilities	78	2	-	-	1	71	-	71
Total (excluding Farms & Residence)	**49,201**	**2,635**	**61**	**29,145**	**103**	**31,858**	**244**	**36,661**
Total (including Farms & Residence)	**77,993**	**130,626**						

Table 36: Franklin County – Annual Generation by Sector, Total & by Entity Size Thresholds

			Entities Generating 2+ TPW		Entities Generating 1+ TPW		Entities Generating 0.5+ TPW	
County: Franklin	Food Surplus (TPY)	Number of Entities	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)
Residences	2,897	12,841	-	-	-	-	-	-
Farms & Commercial Agriculture	37	-	-	-	-	-	-	-
Food Manufacturers	118	10	-	-	-	-	-	-
Grocery Stores	844	40	2	355	3	418	5	485
Restaurants	251	84	0	-	-	-	-	-
Hotels	212	41	-	-	-	-	-	-
Food pantries/ banks	314	12	-	-	-	-	12	314
Food Distributors	4	4	-	-	-	-	-	-
K-12 Schools	73	7	1	50	1	50	2	64
Hospitals	49	15	-	-	-	-	-	-
Large Office Buildings	66	2	-	-	-	-	2	66
Large Multi-Family Complexes	8	1						
Universities	32	1	-	-	-	-	1	32
Sports Arena & Large Festivals	9	2	-	-	-	-	-	-
Correctional Facilities	-	-	-	-	-	-	-	-
Total (excluding Farms & Residence)	**1,980**	**219**	**3**	**405**	**4**	**468**	**22**	**961**
Total (including Farms & Residence)	**4,914**	**13,060**						

Table 37: Hancock County – Annual Generation by Sector, Total & by Entity Size Thresholds

			Entities Generating 2+ TPW		Entities Generating 1+ TPW		Entities Generating 0.5+ TPW	
County: Hancock	Food Surplus (TPY)	Number of Entities	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)
Residences	9,019	40,071	-	-	-	-	-	-
Farms & Commercial Agriculture	7,816	-	-	-	-	-	-	-
Food Manufacturers	711	31	1	196	3	327	8	516
Grocery Stores	1,597	74	4	721	4	721	9	878
Restaurants	814	219	0	-	1	81	1	81
Hotels	1,274	189	1	284	2	369	6	488
Food pantries/ banks	419	16	-	-	-	-	16	419
Food Distributors	428	71	1	124	1	124	3	193
K-12 Schools	155	32	-	-	1	29	3	71
Hospitals	81	29	-	-	-	-	-	-
Large Office Buildings	92	3	-	-	1	55	1	55
Large Multi-Family Complexes	46	4						
Universities	233	3	1	211	1	211	1	211
Sports Arena & Large Festivals	1	1	-	-	-	-	-	-
Correctional Facilities	-	-	-	-	-	-	-	-
Total (excluding Farms & Residence)	**5,852**	**672**	**8**	**1,538**	**14**	**1,919**	**48**	**2,912**
Total (including Farms & Residence)	**22,687**	**40,743**						

Table 38: Kennebec County – Annual Generation by Sector, Total & by Entity Size Thresholds

			Entities Generating 2+ TPW		Entities Generating 1+ TPW		Entities Generating 0.5+ TPW	
County: Kennebec	Food Surplus (TPY)	Number of Entities	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)
Residences	11,963	53,216	-	-	-	-	-	-
Farms & Commercial Agriculture	1,272	-	-	-	-	-	-	-
Food Manufacturers	324	22	1	116	2	183	2	183
Grocery Stores	2,754	124	7	1,416	7	1,416	11	1,565
Restaurants	1,681	289	3	356	7	742	10	846
Hotels	406	60	-	-	-	-	3	109
Food pantries/ banks	1,047	40	-	-	-	-	40	1,047
Food Distributors	125	27	-	-	1	82	1	82
K-12 Schools	369	22	1	62	6	260	9	316
Hospitals	313	78	-	-	-	-	2	77
Large Office Buildings	518	10	2	325	2	325	6	436
Large Multi-Family Complexes	41	7						
Universities	147	3	1	77	2	117	3	147
Sports Arena & Large Festivals	185	8	-	-	1	78	2	127
Correctional Facilities	-	-	-	-	-	-	-	-
Total (excluding Farms & Residence)	**7,943**	**690**	**15**	**2,353**	**28**	**3,203**	**89**	**4,936**
Total (including Farms & Residence)	**21,178**	**53,906**						

Table 39: Knox County – Annual Generation by Sector, Total & by Entity Size Thresholds

			Entities Generating 2+ TPW		Entities Generating 1+ TPW		Entities Generating 0.5+ TPW	
County: Knox	Food Surplus (TPY)	Number of Entities	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)
Residences	4,035	17,882	-	-	-	-	-	-
Farms & Commercial Agriculture	2,381	-	-	-	-	-	-	-
Food Manufacturers	212	17	-	-	1	66	2	112
Grocery Stores	1,223	71	2	310	3	373	7	495
Restaurants	723	139	1	151	3	324	3	324
Hotels	611	81	1	185	2	241	3	267
Food pantries/ banks	340	13	-	-	-	-	13	340
Food Distributors	322	41	1	175	1	175	2	223
K-12 Schools	122	12	-	-	2	75	4	107
Hospitals	95	29	-	-	-	-	-	-
Large Office Buildings	31	2	-	-	-	-	-	-
Large Multi-Family Complexes	10	1	-	-	-	-	-	-
Universities	1	1	-	-	-	-	-	-
Sports Arena & Large Festivals	8	2	-	-	-	-	-	-
Correctional Facilities	121	2	-	-	1	98	-	98
Total (excluding Farms & Residence)	**3,818**	**411**	**5**	**821**	**13**	**1,353**	**34**	**1,967**
Total (including Farms & Residence)	**10,235**	**18,293**						

Table 40: Lincoln County – Annual Generation by Sector, Total & by Entity Size Thresholds

			Entities Generating 2+ TPW		Entities Generating 1+ TPW		Entities Generating 0.5+ TPW	
County: Lincoln	Food Surplus (TPY)	Number of Entities	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)
Residences	3,569	15,802	-	-	-	-	-	-
Farms & Commercial Agriculture	64	-	-	-	-	-	-	-
Food Manufacturers	234	21	-	-	1	83	2	109
Grocery Stores	1,147	57	3	487	4	542	5	583
Restaurants	454	134	0	-	-	-	1	27
Hotels	428	81	-	-	1	52	1	52
Food pantries/ banks	262	10	-	-	-	-	10	262
Food Distributors	77	32	-	-	-	-	-	-
K-12 Schools	129	24	-	-	2	60	2	60
Hospitals	57	21	-	-	-	-	-	-
Large Office Buildings	9	1	-	-	-	-	-	-
Large Multi-Family Complexes	6	1						
Universities	-	-	-	-	-	-	-	-
Sports Arena & Large Festivals	-	-	-	-	-	-	-	-
Correctional Facilities	-	-	-	-	-	-	-	-
Total (excluding Farms & Residence)	**2,802**	**382**	**3**	**487**	**8**	**737**	**21**	**1,092**
Total (including Farms & Residence)	**6,435**	**16,184**						

Table 41: Oxford County – Annual Generation by Sector, Total & by Entity Size Thresholds

			Entities Generating 2+ TPW		Entities Generating 1+ TPW		Entities Generating 0.5+ TPW	
County: Oxford	Food Surplus (TPY)	Number of Entities	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)
Residences	5,551	24,709	-	-	-	-	-	-
Farms & Commercial Agriculture	6,311	-	-	-	-	-	-	-
Food Manufacturers	335	11	1	179	2	261	2	261
Grocery Stores	890	55	2	355	2	355	3	403
Restaurants	478	109	0	-	2	169	3	200
Hotels	470	67	1	124	2	180	3	223
Food pantries/ banks	733	28	-	-	-	-	28	733
Food Distributors	84	13	-	-	-	-	1	27
K-12 Schools	214	20	1	73	3	139	7	206
Hospitals	83	28	-	-	-	-	-	-
Large Office Buildings	26	1	-	-	-	-	1	26
Large Multi-Family Complexes	39	3	-	-	-	-	-	-
Universities	-	-	-	-	-	-	-	-
Sports Arena & Large Festivals	47	4	-	-	-	-	-	-
Correctional Facilities	-	-	-	-	-	-	-	-
Total (excluding Farms & Residence)	**3,398**	**339**	**5**	**730**	**11**	**1,103**	**48**	**2,079**
Total (including Farms & Residence)	**15,261**	**25,048**						

Table 42: Penobscot County – Annual Generation by Sector, Total & by Entity Size Thresholds

			Entities Generating 2+ TPW		Entities Generating 1+ TPW		Entities Generating 0.5+ TPW	
County: Penobscot	Food Surplus (TPY)	Number of Entities	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)
Residences	10,964	49,110	-	-	-	-	-	-
Farms & Commercial Agriculture	4,986	-	-	-	-	-	-	-
Food Manufacturers	928	26	3	640	4	732	5	775
Grocery Stores	4,513	126	13	2,922	16	3,119	24	3,393
Restaurants	2,186	335	2	289	9	896	15	1,139
Hotels	1,144	104	1	280	4	448	6	521
Food pantries/ banks	1,047	40	-	-	-	-	40	1,047
Food Distributors	614	27	1	432	2	503	3	546
K-12 Schools	505	50	2	129	6	270	12	379
Hospitals	344	104	-	-	1	82	1	82
Large Office Buildings	230	9	-	-	-	-	4	136
Large Multi-Family Complexes	147	13	-	-	-	-	-	-
Universities	102	4	-	-	2	94	2	94
Sports Arena & Large Festivals	288	5	1	238	1	238	2	267
Correctional Facilities	40	1	-	-	-	-	-	40
Total (excluding Farms & Residence)	**12,088**	**844**	**23**	**4,929**	**45**	**6,384**	**114**	**8,418**
Total (including Farms & Residence)	**28,038**	**49,954**						

Table 43: Piscataquis County – Annual Generation by Sector, Total & by Entity Size Thresholds

			Entities Generating 2+ TPW		Entities Generating 1+ TPW		Entities Generating 0.5+ TPW	
County: Piscataquis	Food Surplus (TPY)	Number of Entities	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)
Residences	1,722	7,615	-	-	-	-	-	-
Farms & Commercial Agriculture	658	-	-	-	-	-	-	-
Food Manufacturers	24	7	-	-	-	-	-	-
Grocery Stores	982	21	2	764	2	764	2	764
Restaurants	122	33	0	-	-	-	1	38
Hotels	80	24	-	-	-	-	-	-
Food pantries/ banks	183	7	-	-	-	-	7	183
Food Distributors	1	3	-	-	-	-	-	-
K-12 Schools	46	11	-	-	-	-	1	21
Hospitals	31	12	-	-	-	-	-	-
Large Office Buildings	-	-	-	-	-	-	-	-
Large Multi-Family Complexes	1	1						
Universities	-	-	-	-	-	-	-	-
Sports Arena & Large Festivals	2	1	-	-	-	-	-	-
Correctional Facilities	-	-	-	-	-	-	-	-
Total (excluding Farms & Residence)	**1,471**	**120**	**2**	**764**	**2**	**764**	**11**	**1,007**
Total (including Farms & Residence)	**3,850**	**7,734**						

Table 44: Sagadahoc County – Annual Generation by Sector, Total & by Entity Size Thresholds

			Entities Generating 2+ TPW		Entities Generating 1+ TPW		Entities Generating 0.5+ TPW	
County: Sagadahoc	Food Surplus (TPY)	Number of Entities	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)
Residences	3,628	16,134	-	-	-	-	-	-
Farms & Commercial Agriculture	12	-	-	-	-	-	-	-
Food Manufacturers	73	5	-	-	-	-	1	32
Grocery Stores	420	29	-	-	2	151	2	151
Restaurants	239	81	0	-	-	-	-	-
Hotels	181	27	-	-	1	85	1	85
Food pantries/ banks	131	5	-	-	-	-	5	131
Food Distributors	54	15	-	-	-	-	-	-
K-12 Schools	101	8	1	54	2	94	2	94
Hospitals	53	17	-	-	-	-	-	-
Large Office Buildings	31	1	-	-	-	-	1	31
Large Multi-Family Complexes	22	2	-	-	-	-	-	-
Universities	-	-	-	-	-	-	-	-
Sports Arena & Large Festivals	16	1	-	-	-	-	-	-
Correctional Facilities	-	-	-	-	-	-	-	-
Total (excluding Farms & Residence)	**1,322**	**191**	**1**	**54**	**5**	**330**	**12**	**524**
Total (including Farms & Residence)	**4,962**	**16,325**						

Table 45: Somerset County – Annual Generation by Sector, Total & by Entity Size Thresholds

			Entities Generating 2+ TPW		Entities Generating 1+ TPW		Entities Generating 0.5+ TPW	
County: Somerset	Food Surplus (TPY)	Number of Entities	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)
Residences	4,945	21,923	-	-	-	-	-	-
Farms & Commercial Agriculture	765	-	-	-	-	-	-	
Food Manufacturers	416	20	-	-	3	199	5	273
Grocery Stores	1,090	45	3	558	3	558	8	762
Restaurants	381	86	0	-	-	-	3	122
Hotels	201	39	-	-	-	-	2	73
Food pantries/ banks	419	16	-	-	-	-	16	419
Food Distributors	272	9	1	242	1	242	1	242
K-12 Schools	170	21	1	50	2	93	5	138
Hospitals	63	37	-	-	-	-	-	-
Large Office Buildings	35	2	-	-	-	-	-	-
Large Multi-Family Complexes	14	1						
Universities	37	1	-	-	1	37	1	37
Sports Arena & Large Festivals	10	2	-	-	-	-	-	-
Correctional Facilities	-	-	-	-	-	-	-	-
Total (excluding Farms & Residence)	**3,108**	**279**	**5**	**851**	**10**	**1,130**	**41**	**2,066**
Total (including Farms & Residence)	**8,818**	**22,202**						

Table 46: Waldo County – Annual Generation by Sector, Total & by Entity Size Thresholds

			Entities Generating 2+ TPW		Entities Generating 1+ TPW		Entities Generating 0.5+ TPW	
County: Waldo	Food Surplus (TPY)	Number of Entities	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)
Residences	3,877	17,143	-	-	-	-	-	-
Farms & Commercial Agriculture	157	-	-	-	-	-	-	-
Food Manufacturers	316	12	1	181	1	181	3	262
Grocery Stores	709	49	1	220	1	220	4	318
Restaurants	273	78	0	-	-	-	-	-
Hotels	163	47	-	-	-	-	-	-
Food pantries/ banks	366	14	-	-	-	-	14	366
Food Distributors	61	17	-	-	-	-	1	43
K-12 Schools	85	15	-	-	1	32	2	55
Hospitals	38	13	-	-	-	-	-	-
Large Office Buildings	28	1	-	-	-	-	1	28
Large Multi-Family Complexes	1	1	-	-	-	-	-	-
Universities	-	-	-	-	-	-	-	-
Sports Arena & Large Festivals	10	1	-	-	-	-	-	-
Correctional Facilities	-	-	-	-	-	-	-	-
Total (excluding Farms & Residence)	**2,051**	**248**	**2**	**401**	**3**	**432**	**25**	**1,072**
Total (including Farms & Residence)	**6,085**	**17,390**						

Table 47: Washington County – Annual Generation by Sector, Total & by Entity Size Thresholds

			Entities Generating 2+ TPW		Entities Generating 1+ TPW		Entities Generating 0.5+ TPW	
County: Washington	Food Surplus (TPY)	Number of Entities	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)
Residences	3,105	13,756	-	-	-	-	-	-
Farms & Commercial Agriculture	6,179	-	-	-	-	-	-	-
Food Manufacturers	5,363	17	6	5,129	7	5,230	9	5,303
Grocery Stores	837	45	1	132	2	234	7	403
Restaurants	211	66	0	-	-	-	-	-
Hotels	142	44	-	-	-	-	-	-
Food pantries/ banks	288	11	-	-	-	-	11	288
Food Distributors	500	38	2	341	2	341	4	409
K-12 Schools	91	42	-	-	-	-	2	28
Hospitals	60	25	-	-	-	-	-	-
Large Office Buildings	-	-	-	-	-	-	-	-
Large Multi-Family Complexes	6	1	-	-	-	-	-	-
Universities	22	2	-	-	-	-	-	-
Sports Arena & Large Festivals	3	1	-	-	-	-	-	-
Correctional Facilities	5	1	-	-	-	-	-	-
Total (excluding Farms & Residence)	**7,528**	**293**	**9**	**5,603**	**11**	**5,806**	**33**	**6,431**
Total (including Farms & Residence)	**16,813**	**14,049**						

Table 48: York County –Annual Generation by Sector, Total & by Entity Size Thresholds

			Entities Generating 2+ TPW		Entities Generating 1+ TPW		Entities Generating 0.5+ TPW	
County: York	Food Surplus (TPY)	Number of Entities	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)	Number of Entities	Food Surplus (TPY)
Residences	19,843	88,900	-	-	-	-	-	-
Farms & Commercial Agriculture	448	-	-	-	-	-	-	-
Food Manufacturers	6,157	61	3	5,254	6	5,478	16	5,864
Grocery Stores	4,998	272	11	1,962	13	2,072	24	2,486
Restaurants	3,245	665	2	252	7	633	16	940
Hotels	2,189	378	-	-	4	252	9	439
Food pantries/ banks	707	27	-	-	-	-	27	707
Food Distributors	1,076	71	4	536	5	616	9	798
K-12 Schools	668	28	7	445	11	596	14	645
Hospitals	286	77	-	-	-	-	2	59
Large Office Buildings	115	3	-	-	-	-	3	115
Large Multi-Family Complexes	272	24	-	-	-	-	-	-
Universities	139	2	1	111	1	111	2	139
Sports Arena & Large Festivals	108	4	-	-	1	69	2	104
Correctional Facilities	-	-	-	-	-	-	-	-
Total (excluding Farms & Residence)	**19,960**	**1,612**	**28**	**8,561**	**48**	**9,827**	**124**	**12,296**
Total (including Farms & Residence)	**40,250**	**90,512**						

Appendix D: Project Team

Resource Recycling Systems (RRS) is a mission-driven consultancy with four decades of experience developing materials management and circular economy strategies for our clients. We work with stakeholders across the public and private sectors to implement waste, recycling, and material sustainability strategies. The RRS team is made up of engineers, economists, industry veterans, technical analysts, policy experts, and communications specialists to serve industries in both the North American and international markets.

The Mitchell Center for Sustainability Solutions at the University of Maine is a research center focused on innovative stakeholder-engaged, solutions-driven, interdisciplinary research projects to tackle and find solutions to a wide range of urgent sustainability challenges that directly benefit Maine and other regions.[147] These challenges reside at the intersection of environmental, social, and economic issues, including renewable energy, local agriculture, municipal planning, forest management, materials management, and coastal water quality. Specifically, the Mitchell Center launched the Food Rescue MAINE research program in 2020 to work directly with Maine food system stakeholders to develop and pilot solutions to end food waste.

The Center for EcoTechnology (CET) is an innovative non-profit organization that offers practical solutions to save money, reduce waste, increase the health and comfort of homes, and help businesses perform better. They work with partners throughout the country to transform the way we live and work – for a better community, economy, and environment – now and for the future.[148]

147 University of Maine. *Senator George J. Mitchell Center for Sustainablity Solutions*. https://umaine.edu/mitchellcenter/.

148 CET. "About CET – Resilient Climate Solutions." https://www.cetonline.org/about-cet/.

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