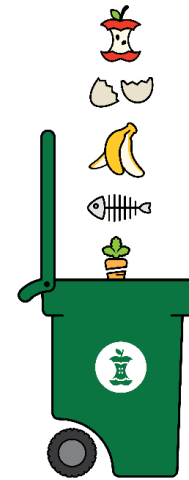


City of Cambridge Zero Waste Master Plan

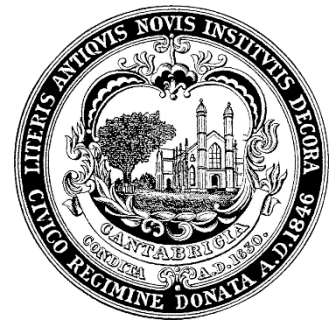
Published: October 1, 2019



COMPOST
MORE
TRASH
LESS



CAMBRIDGE
DEPARTMENT
OF PUBLIC
**THE
WORKS**



Content

1	Introduction	1
2	Overview of the Current Waste Management System	3
3	Challenges & Opportunities	4
4	Projected Long Term Needs and Goals.....	6
5	Recommended Options for the ZWMP	8
	5.1 Organics Diversion Program.....	8
	5.2 Trash Disincentives	10
	5.3 Recycling and Other Diversion Programs.....	15
	5.3.1 Reduction and Reuse Options	15
	5.3.2 Improvements to Curbside Recycling.....	16
	5.3.3 Enhancements to the Recycling Center/Mobile Collection	17
	5.3.4 Textile Recycling Program.....	19
	5.3.5 Mattress Recycling Program	19
	5.3.6 Carpet Recycling Program.....	20
	5.3.7 Waste Electronics Recycling Program	20
	5.4 Summary of Recommended Options	21
	5.5 Overlap with Existing City Plans.....	21
6	Commercial Waste Collection	24
7	Promotion and Education	25
8	Workforce Evaluation	26
9	Greenhouse Gas (GHG) Emissions Inventory	28
	9.1 Baseline GHG Emission Inventory	28
	9.2 Impact of Recommendations	29
10	Projected Diversion and GHG Performance	29
11	Financial Summary	33
	11.1 Program Costing for Recommended Options.....	33
	11.2 Impacts to MSW Tipping Fees	34
	11.3 Market Revenue Potential	34
	11.4 Funding Options/Mechanisms	34
	11.5 Other Revenue Potential	35
12	Implementation Plan.....	35
13	Measuring Performance in the Future	37
14	Zero Waste Master Plan Updates	38
	14.1 Updates and Revisions to the ZWMP	39
	14.2 Annual System Monitoring and Reporting.....	40
	14.3 Keys to Success.....	40
	14.3.1 Success Factors.....	40

14.3.2 Barriers and Risks..... 41

15 Conclusion..... 42

Tables

Table 2-1: Waste Management Services Provided by the City 4

Table 4-1: Waste Managed by the City of Cambridge (2016) 6

Table 4-2: Estimated tons of Divertible Material in the Trash (2016) 6

Table 5-1: Summary of Recommended Options..... 21

Table 6-1: Commercial Waste Generation by sector 25

Table 8-1: Current Solid Waste Division Staffing Complement 27

Table 9-1: GHG Emission Inventory 2012 to 2016 (metric tonnes CO₂e)..... 29

Table 11-1: Summary of Potential Costs..... 33

Table 13-1: Recommended Performance Metrics 37

Figures

Figure 5-1: Curbside Audit – Volume of Trash Container Space Used per Household 12

Figure 5-2: Curbside Audit - Average lbs of Trash per Household 13

Figure 5-3: Mobile Recycling Center Options 18

Figure 10-1: Estimated Change in Trash Disposal Based on New Program Implementation 31

Figure 10-2: Estimated Change in GHG Emissions Based on New Program Implementation 32

Figure 12-1: Implementation Timeline 36

Appendices

- Appendix A: Baseline Understanding Report
- Appendix B: Phase 1 Organics Report
- Appendix C: Enhancements to the Current Waste Management System and Additional Options for Consideration for the ZWMP
- Appendix D: Comparative Summary of Zero Waste Master Plan Options
- Appendix E: Results of the Curbside Collection Survey (Standardized Trash Barrels, Recycling and Organics set-outs)
- Appendix F: Summary of Public Engagement Results (December 2018 to March 2019)

This page is intentionally left blank.

1 Introduction

The City of Cambridge (the City) has embarked on a path to Zero Waste to build upon its current waste management system and programs. The development of a Zero Waste Master Plan (ZWMP) and strategy is intended to assist with achieving the City's goals of reducing waste and greenhouse gas emissions. The recommendations developed for the ZWMP are intended to support the Department of Public Works' (DPW) guiding principles of providing high-quality public services, protecting and supporting the health of employees and the public, managing costs and reducing trash.

Definitions of 'Zero Waste' vary. The concept adopted by the City of Cambridge is that Zero Waste is a long-term goal that envisions that after waste reduction and reuse, all remaining discarded materials would be destined/designed to become resources for others to use. This is generally consistent with the definition applied by organizations like the Zero Waste International Alliance.¹ Achieving Zero Waste will take time, and the engagement of all levels of society including government and private sector entities as well as people in their everyday activities.

The purpose of the ZWMP is to:

- Meet the City's waste reduction goals (discussed further below).
- Continue to maintain high quality public services.
- Maximize operational efficiency by making careful choices which offer both environmental benefits and cost control.
- Protect employee health & safety through the selection of approaches that can reduce risks to staff.
- Reduce GHG emissions through waste diversion and program design.
- Reduce costs by diverting materials from trash and effective diversion program design.

The development of the ZWMP was undertaken in three phases.

- Phase 1 of the project involved documenting the City's current waste management system, including services provided, quantity and type of materials managed by the City, service providers and associated contract provisions, and waste composition. This is documented in Appendix A. An assessment of implementing an expanded organics program in the City was

¹ Zero Waste International Alliance, <http://zwia.org/standards/zw-definition/>

conducted. Furthermore, recommendations were made for the expansion of the organics program. This is documented in the Technical Memoranda provided in Appendix B.

- Phase 2 outlines possibilities and recommendations for the City to reach their waste reduction and GHG emission reduction goals. A review and analysis of other aspects of the City's waste management system, with consideration of relevant policies, programs and infrastructure was undertaken to develop the long list of potential enhancements to the current waste management system and to identify additional options for consideration for the ZWMP. The results of Phase 2 are documented in the Technical Memoranda in Appendix C and a comparative analysis of these options is provided in Appendix D.
- Phase 3 involved undertaking a more in-depth analysis of current trash, recycling and green bin curbside set-outs in the City, to assist in determining the approach that could be used for standardized trash containers in the City. Phase 3 also included undertaking public consultation regarding the draft ZWMP recommendations through a Public Open House held on December 18, 2018, a meeting with the Cambridge Recycling Advisory Committee (RAC) held on December 19, 2018 and a public comment period on the Draft ZWMP report extending from January 31 to June 30, 2019. The results of the standardized trash survey are documented in the Technical Memoranda in Appendix E. The public consultation feedback is discussed further in the body of this report and is documented in Appendix F.

The purpose of this report is to summarize and document the findings of the Study and to recommend ZWMP options for implementation by the City.

This ZWMP provides an overview of the challenges and opportunities associated with a long-term waste management strategy, a discussion on the recommended options, and the impact of the recommended options on the DPW workforce, GHG emissions, overall performance and finances. Recommendations on implementing the options, monitoring and reviewing the system are also provided.

This document represents a 'road map' for the City and is intended to be a **living document** that will be monitored regularly and updated on a regular basis (as discussed in Section 14). Every 5 years, the ZWMP should be reviewed to account for new trends, evolving markets or programs, and other variables that may have impacted the waste management programs for the City.

2 Overview of the Current Waste Management System

The City of Cambridge currently provides an extensive range of waste management services to all residents, regardless of housing type². The City is also unique in that it has a public/private split in the provision of waste collection services. The City collects trash from residential sources using City forces, and contracts for collection of recyclables and other materials with the private sector. Waste processing and/or disposal is also contracted to the private sector. Most commercial collection services are provided by the private sector. One exception is that the City began a Small Business Recycling Pilot in November 2018 to collect recycling from 123 small businesses at no cost to the business.

Citizen satisfaction surveys consistently indicate most resident's rate City collection services for trash and recycling as "**excellent or good**". The recent 2018 survey reached 400 residents and indicated that the City's waste services were among the highest rated services, with 91% of residents ranking trash collection as "excellent or good" and 90% of residents ranking recycling collection as "excellent or good"³.

Cambridge is an attractive place to live as evidenced by its growing population. The City's population in 2015 was estimated to be 110,402⁴ and by 2030 it is expected to be 118,625⁵, living in approximately 50,000 households.

The City currently provides trash and source separated organics collection service to approximately 10,800 buildings and 32,000 households. The City provides recycling collection service to approximately 11,000 buildings and 45,000 households. The City provides no curbside collections to approximately 5,000 households in 70 buildings. To receive City trash collection a building must meet several criterions including barrels must not exceed 50 gallons, receptacles shall not be placed upon the sidewalks in a manner to inconvenience the use of the sidewalks by pedestrians, must not be set-out for collection before 6pm the night before collection, and must be brought back onto the property by 5pm on collection day. The City provides the following services as summarized in Table 2-1.

² At this time, curbside organics collection is only available to buildings with less than 13 units. Expansion of the program to larger buildings is anticipated beginning the fall of 2019.

³ Biannual Cambridge Residents Survey, 2018 Resident Telephone Survey, Opinion Dynamics.

⁴ U. S. Census Bureau, QuickFacts, Cambridge City, Massachusetts

⁵ Metro Boston 2030 Population and Housing Demand Projections, Municipal Report, Stronger Region Scenario: Population for Cambridge.

Table 2-1: Waste Management Services Provided by the City

Material Stream	Collection Frequency	Service Provider	Collection Details
Trash	Weekly	City Staff	Residents provide their own container. Manual collection. (32,000 households)
Recycling	Weekly	Private Service Provider	Single Stream, Cart-based, Semi-automated Collection. City provides carts. (45,000 households.)
Yard Waste	Weekly--Seasonal, April to Mid-December	Private Service Provider	Manual collection - paper bags or labeled rigid containers. (45,000 households)
Curbside Organics	Weekly	City Staff	Manual collection. City provides containers. (25,000 households as of April 2018)
Household Hazardous Waste (HHW)	4 Events	Private Service Provider	Events held in different areas of City. Residents bring material to events.
Waste Electronics	At curb, or by appointment	City staff	Collected at the curb by the City or brought to the Recycling Center.
Large Item Collection	At curb, or by appointment	City Staff	Collected at the curb on a scheduled basis, permits required for some items.
Small Business Recycling	Once/twice weekly at curb.	Private Service Provider	Single Stream, Cart-based, Collection (123 businesses)
Recycling Center	Open three days per week	City Staff	Customers must drop-off material themselves.

3 Challenges & Opportunities

The City provides a comprehensive suite of waste management services to its residents which is beyond the level typically offered by municipalities, with service provided to both multi-family and single-family residences. The City maintains some control and flexibility over its waste management program through provision of some services by City forces.

The City has implemented several progressive measures intended to increase diversion and/or reduce waste such as City ordinances banning polystyrene takeout containers, single use plastic bags and mandatory recycling. The City conducted a well-planned food scraps collection pilot from 2014-2018 and implemented a citywide food scrap collection (otherwise known as source separated organics collection) program to buildings with 1-12 residential units in April 2018.

The City has several waste and GHG emission reduction goals that mirror State goals, as discussed in further detail in the following section. The Massachusetts Department of Environmental Protection (MassDEP) has a moratorium on new incineration or landfills for municipal solid waste (MSW). Increasingly, MSW is hauled to facilities outside the state where more capacity exists, as landfill capacity in Massachusetts dwindles with the impending closure of some of the largest landfills in the state. This is anticipated to contribute to increased costs to manage trash and will result in increased GHG emissions through transportation. The diversion of materials through recycling or composting programs and other reduce/reuse initiatives is expected to realize increased reductions in costs and greenhouse gas emissions.

The City provides waste collection service to most residential buildings, but there are an increasing number of buildings being constructed that are unlikely to join the City's collection service due to the size and frequency of service needed at these large buildings. For buildings that the City does not service, these buildings are required to maintain a recycling program that meets the City's ordinances.

The City conducted a pilot curbside food scraps collection program from 2014 through March 2018. The expansion of the program Citywide in April 2018 (buildings of 1-12 units) will contribute significantly to the City's waste and GHG emissions reduction goals. The City has a forward-thinking and environmentally conscious population that has expressed interest in options that continue to contribute to an aspirational goal of zero waste and the development of a circular economy.

Other options considered as part of this study will further contribute to the City's waste reduction and GHG emissions reduction goals. Some options, such as a standard trash container have the additional benefit of improving worker safety, reducing rodent activity and further encouraging participation in diversion programs.

The City has carefully considered the selection of options for the Zero Waste Master Plan that are technically feasible, fiscally responsible and that contribute to the City's goals. Achieving these goals will contribute to the City's sustainability goals and will build awareness of waste as a resource.

4 Projected Long Term Needs and Goals

The City and the State of Massachusetts have set two trash reduction goals:

1. Reduce solid waste disposal by 30% by 2020 (from 2008 levels).
2. Reduce solid waste disposal by 80% by 2050 or before (from 2008 levels).

These trash reduction goals will be achieved through a combination of reducing, reusing, composting and recycling. The City's 2008 trash disposal rate was 22.8 pounds per household per week (lbs/HH/week). The 2020 goal is 16 lbs/HH/week and the 2050 target is 4.6 lbs/HH/week.

Table 4-1 presents the tons of waste managed as of 2016 through the status quo program (i.e. diversion of recyclables and pilot food scrap program only).

Based on a waste audit conducted by the City in Fall 2016, there is a significant number of recyclables, compostables, and other items currently in the trash that could be diverted. Based on the audit, approximately 60% of the trash generated in 2016 could have been diverted through organics and recycling collection. In reality residents generally only place a portion of this material out for diversion. Table 4-2 presents the estimated tons of divertible material in the trash based on the 2016 waste audit results.

Table 4-1: Waste Managed by the City of Cambridge (2016)

Year	Tons of Material Generated			Total Tons of Waste Managed
	Trash	Recycling	Other "Divertible" materials	Total
2016	14,419	9,204	532	24,155

Table 4-2: Estimated tons of Divertible Material in the Trash (2016)

Food Scraps	Compostable Fibers	Recycling
4,768	1,190	2,608

The waste managed by the City of Cambridge doesn't include commercial waste, and trash collected in residential buildings with private trash collection. Future analyses will consider how to measure waste reduction performance for buildings serviced by private trash collection providers.

The City and the State have set a goal of reducing GHG emissions by 80% by 2050⁶. Implementing the recommendations in the ZWMP will assist in decreasing the City's GHG emissions.

⁶ Relative to 1990 levels.

5 Recommended Options for the ZWMP

The following sections provide an overview of the recommended options for the ZWMP. Further details on the ZWMP options can be found in Appendices B and C and are compared in Appendix D.

5.1 Organics Diversion Program

The first phase of this study involved the development of recommendations for an expanded organics diversion program. The results are documented in Appendix B, Phase 1 Organics Report. The City applied many of the recommendations to support the roll-out of the curbside food scraps collection program to all residences (1-12 units) in April 2018. The remaining residences (13+ unit buildings) with City trash collection will be added into the program beginning the Fall of 2019. The expansion of the program to 13+ unit buildings will take more time and effort than the initial roll-out, as it is necessary to work with individual building managers/supervisors to determine the containers and support needed for each building and as it can be more difficult to engage residents in larger buildings in organics programs. The first phase of the 13+ unit building rollout will include buildings with City trash collection, approximately 7,500 households. The second phase of the 13+ unit building rollout will include buildings with City recycling service, but not City trash service, approximately 12,000 households. Phase 2 of the expansion will follow a reanalysis of the City's curbside collection operations. Phase 2 is expected to occur in 2021-2022. There are approximately 5,000 households that don't receive any City services which will be evaluated after Phase 2.

The City provided kitchen containers and curbside collection carts to all residences (1-12 units) in the spring of 2018, for weekly collection of food scraps and compostable items (e.g. paper towels, napkins, flowers, etc.).⁷ The City collects this material with City forces using separate vehicles and transports this material to a facility in Charlestown, which is operated by Waste Management where it is processed into a slurry. The slurry is hauled to the Greater Lawrence Sanitary District where it is anaerobically digested to make methane and fertilizer.

The organics program has the potential to significantly reduce trash disposal by 4 to 5 lbs/HH/week (23-28% reduction in trash) depending on the level of participation and capture rates that are achieved. Anaerobic digestion of the captured organics

⁷ Note: the evaluation of organics options documented in Appendix B, considered options to include pet waste or diapers in the organics stream, but found that this material would not be accepted by existing organic processors due to the presence of fecal matter.

has the potential to reduce GHG emissions by approximately 1,800 MTCO₂E annually compared to disposing of this material stream⁸.

Based on experience with other organics programs, and reflecting the feedback received through consultation on the draft ZWMP recommendations, it is recommended that the City continue to provide a robust promotion and education program to support the organics diversion program.

This could include providing materials and hands-on support to trouble shoot issues that discourage people from using the program (e.g. fruit flies), educational awareness through the City's school outreach activities, and providing residents with more compostable bags through public events etc. The curbside audit undertaken in the fall of 2018 (see Appendix E for more details) found that participation in the curbside organics program was less than 60%. Promotion and education, undertaking further research into residential behavior and means of improving participation (e.g. provision of additional compost bags, other promotional items like attractive compost bins), coupled with trash disincentives (see below) will be essential to boost participation and increase capture of organics for diversion.

It is recommended that once the organics diversion program has been rolled out to all residences in the City and residents have had an opportunity to adjust to the new program, the City should consider a change to the current ordinance regarding recycling to include diversion of food scraps and compostable fibers.

Achieving high participation and capture rates for organics collection will depend on several factors including ongoing public education, promotion and disincentives for placing organic materials in the trash. From a policy perspective, mandatory organics diversion under ordinance is an element of encouraging participation in the program and is consistent with the approach used by the City to encourage recycling. It is recommended that the City continue to monitor participation in the organics program through additional curbside audits similar to that undertaken in the fall of 2018. It is also recommended that the City review the requirement for a change to the ordinance requiring mandatory organics diversion as part of a five-year ZWMP review. Waste sort audits similar to that undertaken in 2016 would also be helpful to measure capture rates in the organics and recycling program and would inform the five-year review. Residential surveys, particularly targeting homes

⁸ Represents the incremental change between the status quo (landfilling and incineration of organics) and anaerobic digestion (AD) of organics, based on the EPA's WARM (v14) model. It should be noted that the WARM model has some limitations with respect to accounting for AD end products (e.g. upgrading biogas and soil carbon sequestration when the digestate/biosolids from the WTP are land applied).

that don't participate in the organics program should also provide helpful information that the City can use to help residents adapt to using the program.

Processing of the current organics stream is undertaken in two stages. The curbside organics are currently received by the Centralized Organics Recycling (CORe) facility in Charlestown which pre-processes the material into a slurry that is sent to the Greater Lawrence Sanitary District in North Andover. This organic material has higher energy value and increases biogas production. The current processing contract expires on April 1, 2021. MassDEP has tracked the increase in organics processing capacity statewide. The City should explore all options for organics processing in late-2020 in anticipation of the present contract's expiration.

5.2 Trash Disincentives

Trash disincentives are program elements with significant potential to reduce waste disposal and encourage participation in diversion programs. The options considered for the City included a standard size trash container, pay-as-you-throw (PAYT), clear bag programs and reduced frequency of trash collection (i.e. every other week). An assessment of these approaches was carried out to determine the approach which in the near term would best fit the City's needs. This is documented in Appendix C.

Based on the assessment of trash disincentives, it is recommended that the City consider providing a standard trash container to residents as the preferred trash disincentive as this approach:

- Reduces potential for vermin;
- Increases worker safety as containers can be emptied with semi-automated collection compared to manual collection;
- Has potential for decreased workers compensation claims with better ergonomics and reduced lifting of containers/bags;
- Increases collection efficiency with a reduced number of containers;
- Improves aesthetics of sidewalks with fewer containers at the curb and with a smaller footprint,
- Reduces trash spillage; and,
- Will encourage participation in diversion programs by limiting the capacity available for disposal of trash but providing adequately sized containers for recycling and organics.

As documented in Appendix E, an audit was undertaken in October 2018 to understand how much capacity (gallons) is currently used by residents when setting out trash. Other information that was collected included the quantity (lbs) of trash

set out by each household, set-out rates and capacity used for recycling, and the set-out rates and capacity used for organics.

The City looks at two factors to measure and assess waste generation and capacity in the City. Capacity refers to the amount of space (in gallons) available in a bin, or the amount of space allowed for placement at the curb for collection. For example, the City's trash ordinance reads: Trash receptacles "shall not exceed fifty-gallon capacity..." The ordinance also states the trash receptacle may not exceed fifty pounds, the quantity of waste allowed in a receptacle. Quantity is the amount of material (in pounds or tons) in a bin collected in a period of time. The City uses capacity to determine how much space residents need to manage their waste, while using quantity to measure the reduction of waste going to trash. The capacity for waste is important for helping scope out how much space is needed for waste management. The quantity of waste is important for determining how well we are recycling and composting our waste.

The overall average capacity (in gallons) of trash set out in the survey was 26 gallons. Figure 5-1 as follows, indicates the number of set-outs on each collection day that used different increments of trash container capacity. Generally, it was found that in the Monday, Tuesday, Wednesday and Friday collection area, the average amount of trash per household that was set out for collection was 20 gallons or less (the Thursday average was around 30 gallons per household). In the order of 75% of all households audited set out less than 32 gallons of trash. No clear explanation was possible based on the audit results, of the differences between the behavior in the Thursday collection area and the others. Further visual audits and/or outreach to residents in this area may help explain the differences in this behavior.

Figure 5-2 indicates the quantity of trash (in pounds) collected from each household during the audit. The results indicate some differences between the collection areas, and in particular, differences between the Monday area which has had curbside organics collection the longest and other areas of the community. Residents in the Monday audit area set out on average just over 9 lbs of trash, compared to between 11 and 18.3 lbs of trash for the other collection areas. Overall, the average quantity of trash set out was just over 12 lbs per household for this given week. Also, the trash set-outs pertain to the 32,500 households that have City trash collection. This indicates that the organics program in combination with the City's other diversion initiatives, has allowed residents to make some substantive progress towards achieving the goal of 16 lbs/household/week being sent to disposal by 2020.

Figure 5-1: Curbside Audit – Volume of Trash Container Space Used per Household

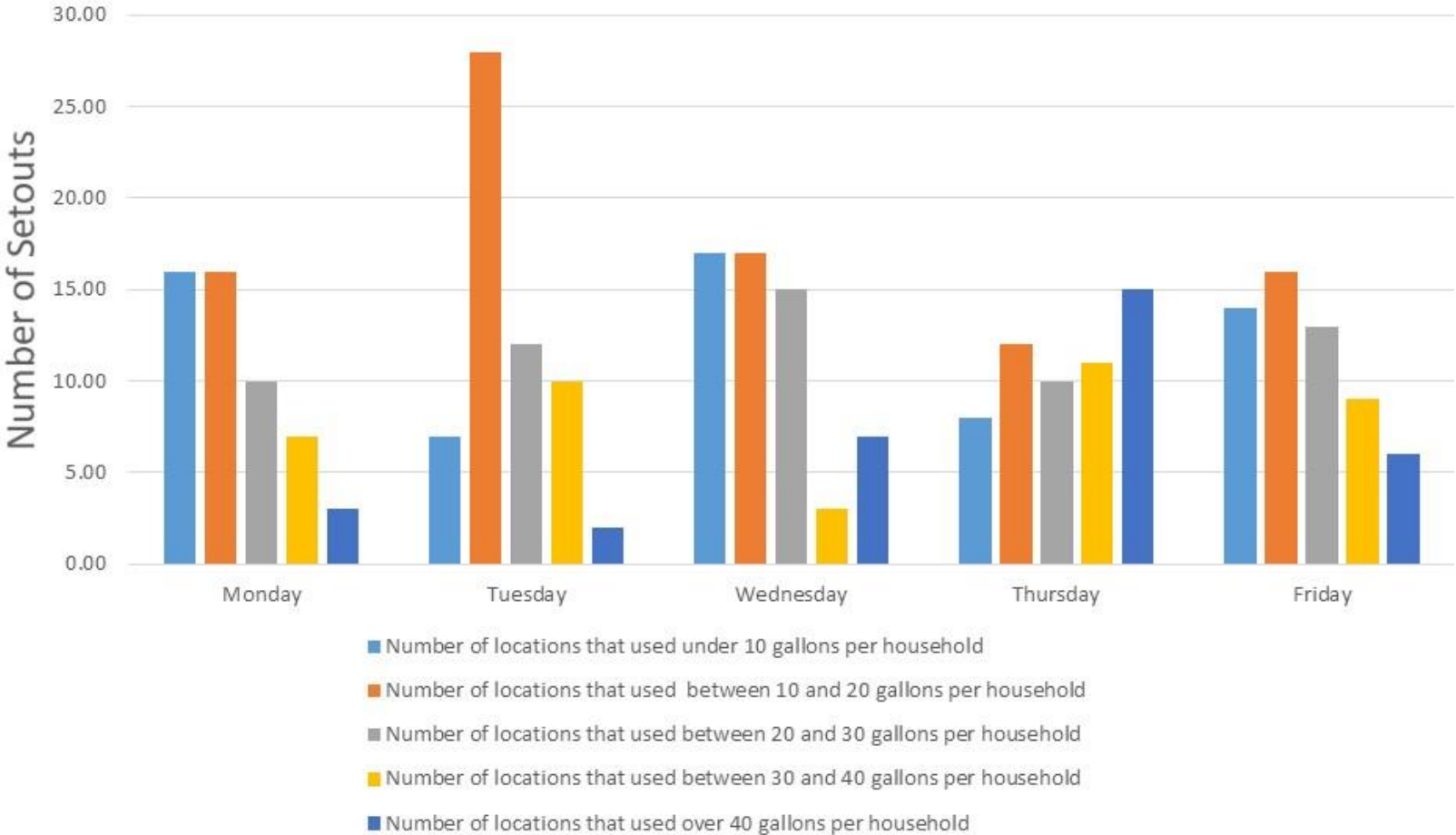
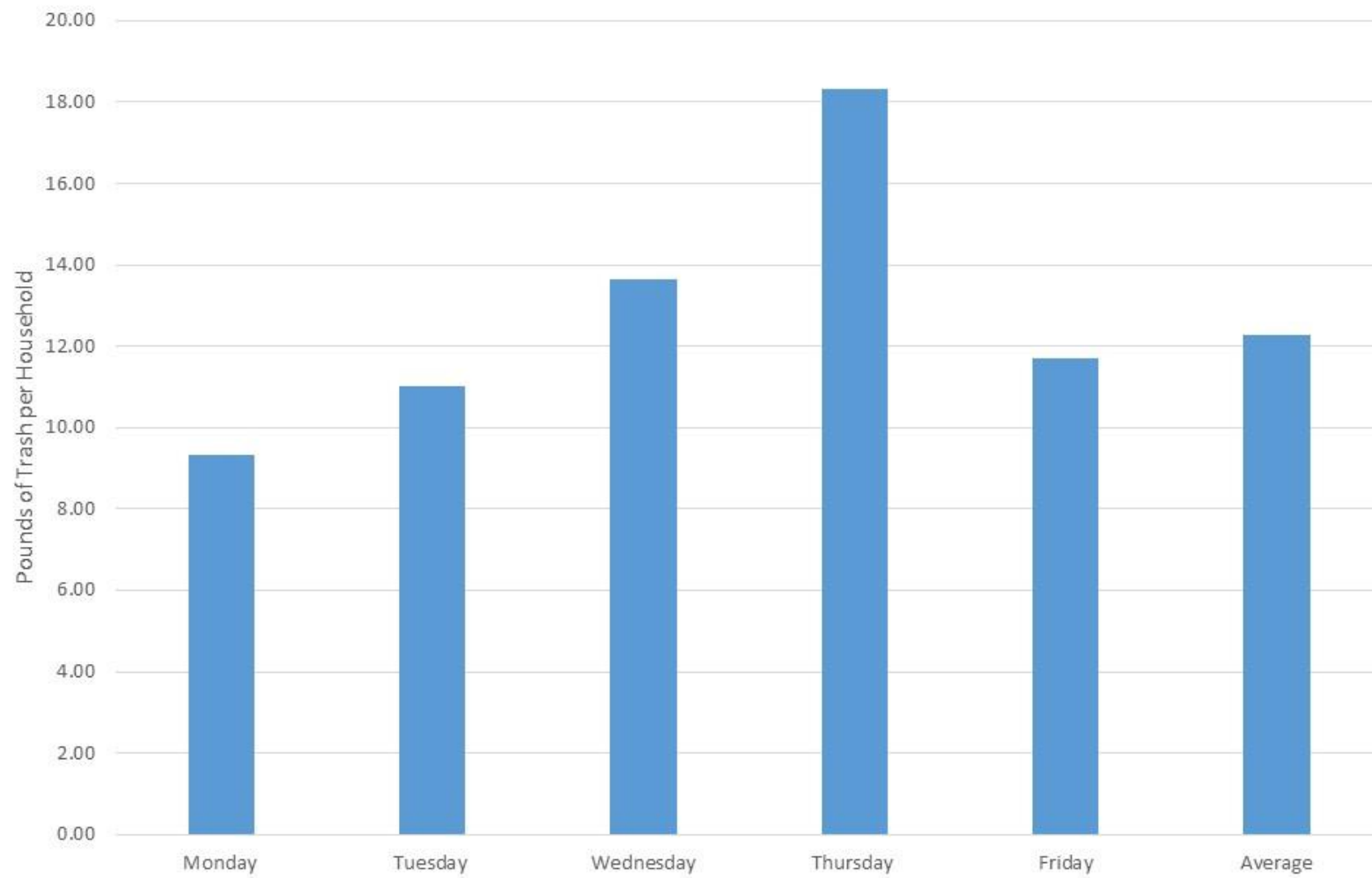


Figure 5-2: Curbside Audit - Average lbs of Trash per Household



It is recommended that, as an initial step, the City provide a trash container in the order of 32-48 gallons per unit/household. The trash container would be sized based on the number of households in each building (i.e. carts in increments of 32-48 gallons, and multiple carts as necessary) and reflecting household trash generation rates (compared to the current allowable setouts), tipper-compatible and made of reinforced plastic to deter vermin. The proposed capacity for the standard trash container should be sufficient to manage typical residential waste quantities from households that are participating in diversion programs. There should be no need to provide regular excess or overflow capacity. This will encourage waste reduction and use of the City's recycling and organics collection services. Feedback through public engagement in December 2018 and through public comments received up to May 2019 indicated general support for providing a standard trash bin, although feedback indicated some concerns that there would be some higher volume households (e.g. homes with small children in diapers) that could require some additional trash capacity.

While Pay As You Throw (PAYT) was carried through the analysis in Appendix C and D, neither PAYT (for all trash) or PAYT for excess trash has been carried through as a recommended option as it does not have the same potential for overall improved system performance as the standard container approach. A significant proportion of residents live in multi-family homes in Cambridge and it is difficult to administer an effective PAYT approach in this context. It is not recommended that the City implement partial PAYT for excess trash outside the limit of the standard containers through purchase of bag tags or specially marked bags. Allowing for regular overflow beyond the standard container would not encourage the same level of participation in diversion programs and could impact the City's efforts to reduce trash and GHG emissions as many residents may be willing to pay a small amount to dispose of waste that could otherwise be diverted. Instead, the City could consider a "double-up" day where residents would be allowed to put out one additional bag (i.e. one regular sized garbage bag) at no charge after holidays (e.g. Thanksgiving, Christmas) where some additional trash may be generated that cannot easily be diverted. The City could also provide an opportunity for households with specific circumstances (e.g. homes with small children in diapers, homes with a higher than average number of residents) to sign up for an option to be provided with extra capacity for curbside trash. Households would have to contact the City for this option. Eligibility would be based on a set of criteria, which would include their use of available diversion options.

It is anticipated that the City would implement a standard trash container program within the next 3-5 years, likely in FY21-FY23 following implementation of the expanded organics program to 13+ unit buildings.

As part of a 5-year review of the ZWMP, the City should review how residents are participating in the City's diversion programs by conducting another fullness/setout survey of curbside trash, recycling and organics containers to determine how resident's behavior has changed. The City may also consider conducting these surveys more frequently to monitor participation in diversion programs and adjust promotion and education campaigns

as necessary. The City may then consider if a further disincentive such as a shift to every other week trash collection to a) encourage participation in diversion programs if people are still disposing of divertible materials in the trash and/or b) reduce collection costs if residents are fully participating and have minimal trash requiring collection. Every other week trash collection has the potential to offer savings in collection costs and would also reduce GHG emissions associated with transportation/collection of trash. There is also a risk of overflowing trash bins and increased rodent activity if residents aren't properly using the recycling and organics programs.

5.3 Recycling and Other Diversion Programs

Other options proposed to reduce waste and GHG emissions are related to reduction and reuse, modifications to existing recycling programs and/or new recycling programs and are discussed in greater detail below. Further details on these options are provided in Appendix C and a comparative analysis of these options is provided in Appendix D.

5.3.1 Reduction and Reuse Options

Waste reduction and reuse options have the potential to significantly reduce GHG emissions through avoidance of the need to extract resources, manufacture products, transport products to/from markets, and dispose of them. Some of these options already exist informally in the City; however, more formal support from the City could help make these options a regular or permanent option for residents. These options are discussed in depth and analyzed in Appendix C.

Considerable support for reduction and reuse options was provided during the consultation sessions in December 2018, over 1/3 of all comments provided were focused on options and concepts for reduction and reuse. Comments received on the draft Zero Waste Master Plan also indicated broad support for reduction and reuse options. The range of input provided included:

- Emphasis on promotion and education, particularly communication on current reuse opportunities, promotion of reusables to replace single-use materials, food waste reduction and events/forums to allow for sharing of ideas.
- Support for more Fix-It clinics.
- Support for additional ordinances to ban materials (e.g. plastic straws, plastic produce bags, foam trays), policies and/or permit requirements to increase waste reduction at events, waste reduction during construction/demolition.
- Support for Extended Producer Responsibility (EPR) which would require producers to be more responsible for end of life management of the materials they produce.
- One or more dedicated reuse centers located in different areas of the City.

It is recommended that the City implement one or more of the following options:

- Continuing to support food waste reduction to raise awareness about food waste and encourage participation in actions to reduce food waste.
- Help enhance online exchange of goods via NextDoor, Facebook groups that are already active in the City and surrounding communities, and other online platforms that support reduce and reuse.
- Continuing to support Fix-It clinics.
- Continuing to support reuse events to keep gently used materials (furniture, toys, clothing) from disposal, including events geared to promote/advertise reuse and reduction activities.
- Exploring opportunities to support waste exchange of reusable items such as arts and crafts, school and office supplies, construction and demolition waste, used bicycles, sports equipment, tools etc., through partnerships with existing organizations or at a permanent location such as the Recycling Center or another City property if space is available.

These options are important to encourage and reinforce the concept of waste reduction and reuse to residents and to support the circular economy, rather than disposing of items in a linear fashion. The City will continue to support EPR efforts pursued at a state level. Future initiatives may be considered for target materials based on changes in the solid waste landscape and other environmental initiatives.

While the trash reduction potential for these approaches is not as great compared to some of the other recommended options, the GHG emission potential and societal benefits can be greater than recycling and composting options as these approaches address elements of the production/supply chain. These options generally have minor effects on financing of solid waste programs as they require primarily some staff time for support and associated promotion and education costs. It is likely that an additional staff position may be required to support expansion of reduction and reuse initiatives as well as to support the other programs noted below.

5.3.2 Improvements to Curbside Recycling

The City's curbside recycling system collects an extensive list of materials and has been a centerpiece of the City's overall diversion program. In recent years, there have been two key shifts that have affected both the cost and diversion performance of the system. First, markets for recovered recyclable materials have been affected by market changes that have tightened quality requirements by specifying lower contamination rates. Second, contamination rates in the curbside recycling stream have increased. Contamination rate increases reflect the broader spectrum of materials that households are managing.

As of Winter 2019, City audits indicate that 40% of recycling carts have moderate to major contamination. The result for the City is that, as per its existing contract with its recycling

processor, it is currently paying \$70 per ton for curbside recycling, versus \$35 per ton, because of excessive contamination (Note: the base rate increased to \$35 per ton in 2018 at low contamination rates, due to issues with recycling markets). The higher cost reflects the level of effort to remove and manage contaminants such as plastic bags, paper towels, take-out containers, textiles etc.

There are few/no materials that the City could add to its program that currently have markets. For example, while there is interest in the City providing an option to recycle plastic bags used in packaging, this material does not currently have a viable market. The focus for recycling, should be on capturing the recyclable materials that do have viable markets, and that are still being lost to trash (over 2,400 tons a year) and reducing contamination rates to 7% or less per our contract with the City's recycling processor.

It is recommended that the City expand its promotion and education program to encourage effective curbside recycling. Public feedback in December 2018 and March 2019 offered several suggestions including:

- Providing focused campaigns (i.e. target one contamination culprit per month) versus complex ads/materials.
- Using pictures to help people recognize what they should and shouldn't put out for recycling.
- Ultimately refusing to service carts with contamination.
- Providing an 'indoor' container (e.g. reusable bag) with pictures of acceptable material to show people what they should take out for recycling.

The curbside audit undertaken in October 2018 indicated that 90% of addresses set out their recycling cart for collection. Nearly 50% of the recycling carts were full or overfull on average. Areas with lower quantities of trash set-out (e.g. Monday) had over 60% of their recycling carts full or overfull. As the City moves to implementing a standard trash container program, the City should continue advertising additional carts for recyclables, which are free from the City.

5.3.3 Enhancements to the Recycling Center/Mobile Collection

The City should consider the role / function of the existing Recycling Center based on the evolution of the City's diversion programs.

Although the Recycling Center currently provides an outlet for diversion of materials such as organics, recyclables (including corrugated cardboard), books etc., the limited hours and shared space with DPW vehicles and the public are not ideal. Changes to the City's waste management programs, (citywide food scraps collection, commercial recycling, and electronics management) are expected to reduce the amount of the materials that would be managed at the Recycling Center. One option that the City could consider is reconfiguring the Recycling Center, focusing on material streams for which there is no curbside collection

option such as reusable materials, scrap metal, waste electronics and certain household hazardous materials (batteries, smoke alarms, fluorescent light bulbs). Reconfiguring the Recycling Center layout is not expected to be capital intensive but would draw upon City resources for design and execution of a plan.

An alternative would be to close the Recycling Center to public access, and to instead develop a mobile recycling center service for materials such as small electronics, HHW, small appliances etc. With a large proportion of the population lacking a convenient way to bring divertible materials to the Recycling Center, mobile collection would provide more accessibility and encourage participation in the programs. The City could use some space at the DPW yard to consolidate various materials to send to market. This would increase safety to the public and City staff as well as use the existing space at the DPW yard more efficiently. There was broad support from the public for a mobile recycling service to collect HHW and small appliances. The following images present examples of mobile collection options for various waste streams.

Figure 5-3: Mobile Recycling Center Options

		
<p>Mobile E-waste Collection Trailer (Tulsa)</p>	<p>Mobile E-waste Collection Trailer (Canada)</p>	<p>Mobile recycling station (Canada)</p>
		
<p>Container to collect small electronics and appliances (Switzerland)</p>	<p>Mobile HHW Collection Center (Germany)</p>	<p>Mobile HHW Collection Center (Germany)</p>

A mobile collection unit could be scheduled to provide service in various parts of the City on a frequent and rotating basis in order to provide more convenient and regular access to

diversion options for residents, particularly those without a car. It is recommended that the City consider the role and purpose of the Recycling Center at the DPW yard in 2020 based on use of the center and performance of the City's other diversion programs and consider implementing a mobile recycling center within the next 3 to 4 years.

5.3.4 Textile Recycling Program

Although there are various informal textile collection locations across the City, there is still a significant quantity of textiles that end up in the trash. It is estimated that around 80 pounds of textiles per person are disposed by residents of the U.S. each year. Residents dispose of textiles in the trash because they consider the items not reusable (torn, ripped etc.) or because it's easier than transporting them to a textile recycling location. Textile recycling has potential for GHG emissions reduction with avoided methane emissions from landfill and through reduced manufacturing of new products.

It is recommended that the City develop and implement a textile recycling strategy in 2020/2021, which would build on the current system to divert additional materials (e.g. worn clothing, shoes, handbags) from disposal. Members of the public indicated support for this option, particularly to manage textiles that are not reusable (i.e. ripped, stained). There are several organizations that offer textile collection programs, either curbside or at dedicated collection points, with whom the City could partner to reduce the required level of effort to roll-out its own program. For example, the City could enter into a contract for a textile collection service like the service provided by Simple Recycling in the City of Somerville and Town of Brookline. This service uses easily identified pink plastic bags that residents can use to place clothing and other household textiles along with other small household items at the curb for collection on their regular trash collection day. Bags are initially provided at the start of the program, and replacement bags are provided when materials are collected, at City locations, or upon request. Larger buildings (50 units or more) may need a different strategy for textiles collection than smaller buildings.

5.3.5 Mattress Recycling Program

Recycling more mattresses keeps these difficult to manage, bulky materials out of landfills and incinerators and reduce GHG emissions through the recycling of metal, textiles, and wood recovered from deconstructing the mattresses.

MassDEP has offered grants to encourage municipalities to collect mattresses and make mattress recycling a viable business. The City has applied and was awarded a grant for processing of residentially generated, source separated mattresses, but would have to collect and store mattresses separately.

As of April 2019, mattresses are collected curbside by the City's contractor, UTEC. MassDEP provided a grant to pay for the processing of mattresses until January 31, 2021. The curbside collection is paid for by the City.

5.3.6 Carpet Recycling Program

Carpet is another waste stream that is bulky and difficult to manage and that if diverted, offers the option to further reduce waste sent to disposal. While carpet recycling is an approach that has been implemented in other North American jurisdictions, at this time it does not appear that there is any grant program through MassDEP nor have any vendors been identified that offer service to collect and/or process used carpets for recycling/recovery within or near the City. It is recommended that the City monitor opportunities for recycling this material as processors come online and markets develop. This option should be revisited as part of the next update of the ZWMP.

5.3.7 Waste Electronics Recycling Program

There are currently several options for residents to properly dispose of waste electronics including take-back/recycling programs offered by vendors, drop off at the Recycling Center and curbside collection by the City. Depending on how/when some of the ZWMP options are implemented, the City could consider changes to how electronics are managed. Electronics could be managed through mobile recycling collection, or in combination with other events such as HHW collection events or locations (e.g. bottle depots or ecoATMs). It is recommended that the City monitor how electronics can be best managed through other ZWMP options and revisit this topic at the five-year ZWMP review.

5.4 Summary of Recommended Options

The following table provides an overview of the recommended options and their timing.

Table 5-1: Summary of Recommended Options

Option	Recommendation	Timing
Organics	Expand organics program to all residents on City's trash collection routes. Continued promotion and education. Consider a mandatory diversion ordinance at the 5-year review.	Phase 1 – 2019, 2020 Phase 2- 2021-2022
Trash	Provide a standard trash container in the order of 32-48 gallons per household. Provide a mechanism for occasional excess trash.	2021-2023
Reduce/Reuse	Continue to support reduction/reuse activities in the community including Fix-It clinics, reuse events, food waste reduction, and waste exchange/swaps.	2019 and ongoing
Curbside Recycling	Increase promotion and education, and curbside enforcement to improve capture of materials and reduce contamination.	2019 and ongoing
Recycling Center	Consider reconfiguration or repurposing the Recycling Center to focus on collection and/or consolidation of specific materials.	2020/2021
Mobile Recycling Center	Investigate mobile collection of materials such as small electronics, HHW, small appliances.	2020/2021
Textile Recycling	Develop and implement a textile recycling strategy either run by the City or in partnership with an existing organization.	2020/2021
Mattress Recycling	Continue to collect mattresses and recycle them	2019
Carpet Recycling	Continue to monitor opportunities to divert carpet.	2027/2028
Waste Electronics Recycling	Potentially adjust this program based on performance of other programs (recycling center, mobile collection)	2025/2026
Commercial Recycling & Composting	Expand Small Business Recycle Pilot Explore Small Business Compost Pilot	2020 2021-2022

5.5 Overlap with Existing City Plans

The City has overlapping Plans that address or touch on waste diversion. Many goals are shared across Plans, and as these other Plans evolve and the ZWMP evolves, synergies

should be pursued as much as possible. The two most relevant Plans are: Envision Cambridge and Climate Action Plan.

In 2015, the City embarked on a citywide planning process called Envision Cambridge. This citywide plan to envision what the City looks like in 2030 and beyond had a section on waste management. Recommendations from this Plan are highlighted in Table 5-2.

Table 5-2: Envision Cambridge recommendations for Waste Management

Action	Timeframe
Require new developments to submit a waste management plan to ensure adequate space for recycling and organics infrastructure.	Near term (<5 years)
Study the feasibility of different programs to incentivize trash reduction without causing a disparate impact on low-income communities	Near term (<5 years)
Advocate for statewide Extended Producer Responsibility (EPR) programs and policies.	Near term (<5 years)
Mandate and enforce residential and commercial food waste diversion	Medium term (5-10 years)
Institute commercial waste zones with reporting requirements	Long term (10+ years)
Maximize recycling rates across all sectors by stepping up enforcement and education	Ongoing
Add recycling bins around the city in places where there are only waste bins	Ongoing
Expand curbside organics collection citywide	Ongoing
Implement a food waste education program in public schools	Ongoing
Prohibit polystyrene food service containers	Ongoing
Encourage recycling via single-stream collection	Ongoing

In addition to Envision Cambridge, the City has a Climate Action Plan. The Plan assessed the City's overall greenhouse gas emissions by sector. "Waste contributes a modest 7% of Cambridge's GHG emissions, but it accounts only for the end of life emissions associated with incineration and landfill of waste, and not the life cycle emissions associated with the manufacturing and transportation of the products that eventually become waste." Although it's very difficult to measure and reduce greenhouse gas emissions associated with various waste activities, the Climate Action Plan, in Table 5-3 made recommendations for the City to pursue to minimize emissions from the waste sector.

Table 5-3: Climate Action Plan recommendations for Waste

Cambridge CAP - Strategies & Actions

WASTE

		Timeframe		
	Related Plan, Policy, or Initiative	Short Term (1-4 years)	Med. Term (4-10 years)	Long Term (10 years+)
Recycling and Composting				
Implement a standard trash container	Zero Waste Master Plan			
Implement a 'hybrid' pay-as-you-throw (PAYT) program	Zero Waste Master Plan & Envision Cambridge			
Expand organics collection for residential and small commercial customers	Envision Cambridge			
Mandate and enforce residential front-of-house food waste diversion	Zero Waste Master Plan & Envision Cambridge			
Mandate and enforce small commercial food waste diversion	Zero Waste Master Plan & Envision Cambridge			
Require building-scale waste prevention and management plans	Envision Cambridge			
Maximize recycling rates across all sectors by stepping up education and enforcement	Envision Cambridge			
Develop commercial waste zones (franchising) with reporting requirements	Envision Cambridge			
Source Reduction and Reuse				
Support sharing libraries	Zero Waste Master Plan			
Support reuse events	Zero Waste Master Plan			
Explore opportunities for waste exchange, including a Resource Recovery Center	Zero Waste Master Plan & Envision Cambridge			
Develop a food waste reduction strategy	Zero Waste Master Plan & Envision Cambridge			
Sustainable Materials Management				
Implement a mattress recycling program	Zero Waste Master Plan			
Implement textile collection and recycling	Zero Waste Master Plan			
Advocate for Statewide Extended Producer Responsibility (EPR) programs and policies	Zero Waste Master Plan			
Investigate lifecycle assessment for municipal purchasing	*New*			

Recommendations from the Climate Action Plan & Envision Cambridge should be evaluated in concert with updates and changes in the Zero Waste Master Plan.

6 Commercial Waste Collection

Nearly all commercial waste is handled privately with each commercial property contracting with a private service provider. The exception to this rule is the November 2018 launch of the Small Business Recycling Pilot, which serves 123 businesses. The businesses that the City provides recycling collection service to are smaller retail stores such as coffee shops, restaurants and general retailers. Participants in the program receive twice weekly collection of up to 3 recycling bins. It is recommended that the City consider expanding this program in Fall 2020 when the curbside residential recycling contract is up for renewal. Furthermore, the small business community has inquired about curbside compost for small businesses. The City will consider piloting a program such as that in 2021-2022.

There are several policies in the City Ordinance that reference commercial waste handling. In particular, Section 8.24.070 (C) lays out the requirements for mandatory recycling for all owners and occupants of buildings in Cambridge, regardless of service provider. In 2014, the Commonwealth of Massachusetts enacted a policy that bans the disposal of commercial organic wastes by businesses and institutions that dispose of one ton or more of these materials per week. Large institutions such as universities and large office/food service buildings must comply with this law.

While these two laws support waste diversion, it is mostly unknown how effective the commercial industry is at diverting waste in Cambridge. In future analyses, collecting data on how much waste is produced in the commercial sector in Cambridge would be a productive first step to diverting more waste. A 2014 study by CalRecycle helped calculate the total waste produced by sector. In future analyses of Cambridge's waste, this data could act as a good baseline for determining just how much waste is produced in the commercial sector in Cambridge. From there, the City could assess how it may help the commercial sector divert more waste.

Table 6-1: Commercial Waste Generation by sector⁹

Commercial Sector Classification	Annual Tons of waste per employee
Arts, Entertainment, & Recreation	3.08
Durable Wholesale & Trucking	2.99
Education	0.5
Hotels & Lodging	2.14
Manufacturing -Electronic Equipment	0.75
Manufacturing - Food & Nondurable Wholesale	1.85
Manufacturing - All Other	1.5
Medical & Health	0.74
Public Administration	0.39
Restaurants	2.92
Retail Trade - Food & Beverage Stores	6.64
Retail Trade - All Other	2.41
Services - Management, Administrative, Support, & Social	1.44
Services - Professional, Technical, & Financial	2.31
Services - Repair & Personal	1.5
Not Elsewhere Classified	1.2

7 Promotion and Education

All the recommended options will require a promotion and education (P&E) campaign to support implementation of options as well as to maintain awareness of the City’s diversion programs on an ongoing basis. In particular, the curbside organics program will require ongoing and consistent outreach to help the community adjust and effectively use the program.

The City has plans to overhaul their website and developed a “Get Rid of It Right” app to complement information available on its website. In the first 18 months since procuring the Recollect software tool, more than 50,000 residents have used the “Get Rid of It Right” search toolbar 200,000 times.

⁹ CalRecycle: “2014 Generator-Based Characterization of Commercial Sector Disposal and Diversion in California”

Ongoing P&E campaigns are crucial to ensuring residents are aware of and are participating fully in the programs and services offered by the City. This engagement is crucial to the City achieving its waste reduction and GHG emission targets.

A substantive part of the feedback provided by the public from December 2018 to March 2019, focused on promotion and education as a critical element of the City's waste diversion programs. The range of suggestions offered by residents and the Recycling Advisory Committee (RAC) included:

- More engagement in developing zero waste curriculum in schools.
- More opportunities for face-to-face engagement including use of volunteers, community discussions/debates, involvement with neighbors, community events.
- Educational programs/initiatives targeting small businesses.
- Promotion of community swaps, Fix-It events, Facebook groups for giveaway/sell used goods.
- More tips on how to avoid problem materials (e.g. how do I use less plastic).
- Tips on how to maximize space in recycling containers (e.g. flattening boxes, stack similar size containers etc.).
- Targeted messaging to various groups/demographics.

The ability of the City to expand and enhance promotion and education programs is linked to staff resources (see below) as it takes effort to develop and implement these initiatives. Assistance and participation from the public will be essential in supporting these programs, including an evolution in the role of the RAC to be engaged in delivering promotion/education programs.

8 Workforce Evaluation

The Department of Public Works (DPW) administers most waste materials management programs in the City. The Solid Waste Division is comprised of the following three divisions: Recycling, Rubbish and Street Cleaning.

The Recycling Division has six full-time employees (a director, two program managers, two inspectors, and an operations assistant), and three part-time employees who are responsible for the City's diversion programs and the Recycling Center. Collection of recyclables and yard waste is contracted out to various private service providers.

The Rubbish Division provides weekly curbside collection of trash from residences, public buildings, schools and some non-profit organizations. Collection of trash is undertaken by City of Cambridge staff, using six, three-person rear packers. Two trucks with three people on each truck collect organics curbside from 25,000 households, 14 schools, and 8 other

locations. Collection of large, bulky items from residents and four household hazardous waste collection events held annually are also provided by the Rubbish Division. This division also is responsible for oversight and enforcement of the City’s Refuse and Litter Ordinance. The City is currently piloting a small business recycling collection service using a private service provider.

The Street Cleaning Division is responsible for maintaining streets and sidewalks, as well as cleaning public area trash and recycling receptacles and removing graffiti using City staff.

Table 8-1 presents the breakdown of the current staffing complement and potential new staff positions that could be required over the next five years. Additional drivers & laborers may be needed for expansion of organics collection to all 13+ unit buildings.

Based on review of the current staff capacity and existing programs, and the increased staffing demands associated with the ZWMP recommendations, it is recommended that the City increase the staff support for Diversion programs. In the order of 2 full time positions will eventually be necessary to adequately support the proposed program expansions. This will include:

- Hands-on support for the expansion of organics collection from 13+ unit buildings with City trash to all 13+ unit buildings with City recycling service (Increasing service from 32,000 households to 44,500 households).
- Development and roll-out of the standard trash container program.
- Expanding waste reduction & reuse activities.
- Developing and implementing a mobile recycling center and textile recycling programs.
- Enhanced promotion and education programs.

Table 8-1: Current Solid Waste Division Staffing Complement

Environmental Services Manager	
Diversion Programs	Trash/Rubbish Programs
<ul style="list-style-type: none"> • Recycling Director • 2 Program Managers • 1 Recycling Operations Assistant • 2 interns • 2 Compliance Officers 	<ul style="list-style-type: none"> • Supervisor of Solid Waste Operations • 4 Supervisors • Sweeping – 17 drivers/laborers • Collection – 19 drivers/laborers • Organics – 4 drivers/laborers • Graffiti/Power Washing – 2 drivers/laborers • Public Area Bins – 4 drivers/laborers

9 Greenhouse Gas (GHG) Emissions Inventory

During the development of the ZWMP, GHG emission estimates were developed based on two approaches:

1. An inventory of the GHG emissions associated with the current waste management system in the City was developed based on guidance provided by the Protocol for Community-Scale Greenhouse Gas Emissions Inventories¹⁰ for applicable waste subsectors. GHG emissions in the inventory were calculated for the waste managed by the City (i.e. it doesn't include private service provider managed tonnage), based on an average landfill gas emission factor; Environmental Protection Agency (EPA) Center for Corporate Climate Leadership¹¹ published emission factors for mobile sources; and EPA Waste Reduction Model (WARM)¹² for landfilled and incinerated tonnages. The results of the GHG emission inventory exercise is discussed below. The inventory did not account for waste generated in the City from residential, commercial, industrial and institutional sources that are not managed by the City.
2. The potential for changes in life-cycle GHG emissions with the implementation of new diversion initiatives, associated with the reduction, reuse and recycling of materials compared to trash disposal, were developed for each option based on application of the US EPA WARM model (v14). Those results are discussed in Section 10.

The primary difference between the GHG emission inventory and the lifecycle GHG emissions calculations is that the inventory looks at actual emissions on an annual basis from emission sources like trucks collecting and hauling waste, carbon dioxide and other emissions from incineration, and methane emissions from landfill; while the lifecycle GHG emissions also factor in the GHG emission reductions or offsets that come from reducing, reusing, recycling materials and recovering renewable energy. The GHG emission inventory indicates that there are direct emissions of GHG's to the environment associated with waste transportation and disposal, while the lifecycle GHG analysis indicates that these emissions can be more than offset by the avoidance and recovery of materials and energy through diversion.

9.1 Baseline GHG Emission Inventory

GHG emissions were estimated for the period from 2012 to 2016 for direct transportation of waste materials, indirect transportation of materials and emissions from waste

¹⁰ Greenhouse Gas Protocol, <https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities>.

¹¹ US EPA, <https://www.epa.gov/climateleadership/center-corporate-climate-leadership-ghg-emission-factors-hub>

¹² US EPA, <https://www.epa.gov/warm>

management facilities including anaerobic digestion, composting, landfill and waste to energy (WTE). As noted above, this inventory was developed based on guidance provided by the Protocol for Community-scale Greenhouse Gas Emissions Inventories for applicable waste subsectors. The outcome of the inventory is presented in the following table.

Table 9-1: GHG Emission Inventory 2012 to 2016 (metric tonnes CO₂e)

	2012	2013	2014	2015	2016
Direct Transportation (City Collection Fleet)	230	238	280	286	266
Indirect Transportation (Contracted Collection and Transfer)	419	546	552	550	549
Waste Management Facilities (Landfill, Organics Processing, WTE)	12,753	10,731	10,614	10,615	10,654
Total	13,402	11,515	11,446	11,451	11,469

9.2 Impact of Recommendations

The potential impact from implementing the recommended options on the GHG emission inventory was extrapolated over the period from 2017 to 2030, based on potential changes in tons managed in the waste management system. It was not possible to estimate potential changes in the direct and indirect transportation emissions over time, however it is not anticipated that there would be substantive changes in these emissions, and they only represent in the order of 7% of the current inventory.

Implementation of the recommended ZWMP options, is anticipated to reduce the inventory of emissions from waste management facilities that are part of the City's waste management system, by in the order of 6,000 MTCO₂e by 2030, a reduction of 58% compared to 2016, primarily as a result of the decrease in tons of waste disposed. An interim goal of 50% GHG emission reduction compared to 2016 levels would appear to be a reasonable and achievable target for the City.

These estimates do not account for all potential life cycle GHG emissions associated with the reduction, reuse and recycling of materials. The overall potential change in life cycle GHG emissions was calculated and is presented in Section 10 below.

10 Projected Diversion and GHG Performance

The trash disposal rate as of 2017 was approximately 17.5 lbs/HH/wk for residents on the City's trash collection route (residents with private trash collection likely have similar trash production rates). The expansion of the curbside organics program across the City, is expected to achieve significant progress towards the 2020 goal of 16 lbs/HH/wk. It is anticipated that once the curbside organics program is more mature, it should be able to reduce the trash disposal rate by 3 to 4 lbs/HH/week.

The next major program change, implementation of a standard trash container, is expected to lower this rate even further by approximately 3 lbs/HH/wk. Implementation of the rest of the reduction/reuse/recycling options as discussed in Section 5.3, are expected to result in more modest reductions in trash disposal. However, these options are estimated to produce the largest incremental GHG emission reductions¹³. Reduce and reuse yield a higher greenhouse gas emissions reduction because there is a reduction in greenhouse gas emissions at every step of the lifecycle of a product, including sourcing materials, production, transportation, and end of life management.

Figure 10-1 presents the estimated change in trash disposal rates with implementation of the recommended programs. Each recommended program contributes to an incremental reduction over time in the trash disposal rate. The general timeframe where the effect of each program would be most noticeable is indicated in this figure. Actual change will depend on participation in the diversion programs, and the capture rates for targeted materials for diversion.

This figure shows the 2020 and 2050 trash disposal goals as well as the impact on the trash disposal rate with implementing the identified options. The trash disposal rate is estimated to decrease from 17.5 lbs/HH/week in 2016/2017 to approximately 9.4 lbs/HH/week as of 2030 with implementation of all recommended options.

It is estimated that there would be an overall reduction in GHG emissions of approximately 5,000 metric tonnes of CO₂ (MTCO₂E) with the implementation of the organics program and standard trash container options and an estimated overall GHG reduction of approximately 20,000 MTCO₂E by 2030 with implementation of all recommended waste diversion options compared to landfilling/incineration. Figure 10-2 presents the changes in GHG emissions with the implementation of new programs. As with the trash disposal rates, each recommended program contributes to an incremental reduction over time in GHG emissions. The general timeframe where the effect of each program would be most noticeable is indicated in this figure.

Achieving these waste and GHG emission reduction estimates depends on participation and uptake of the recommended options by residents. Continued promotion and education will be crucial to encouraging participation to achieve the capture rates assumed for the development of the waste and GHG reduction estimates.

¹³ As modelled using the EPA's Waste Reduction Model (WARM v14)

Figure 10-1: Estimated Change in Trash Disposal Based on New Program Implementation

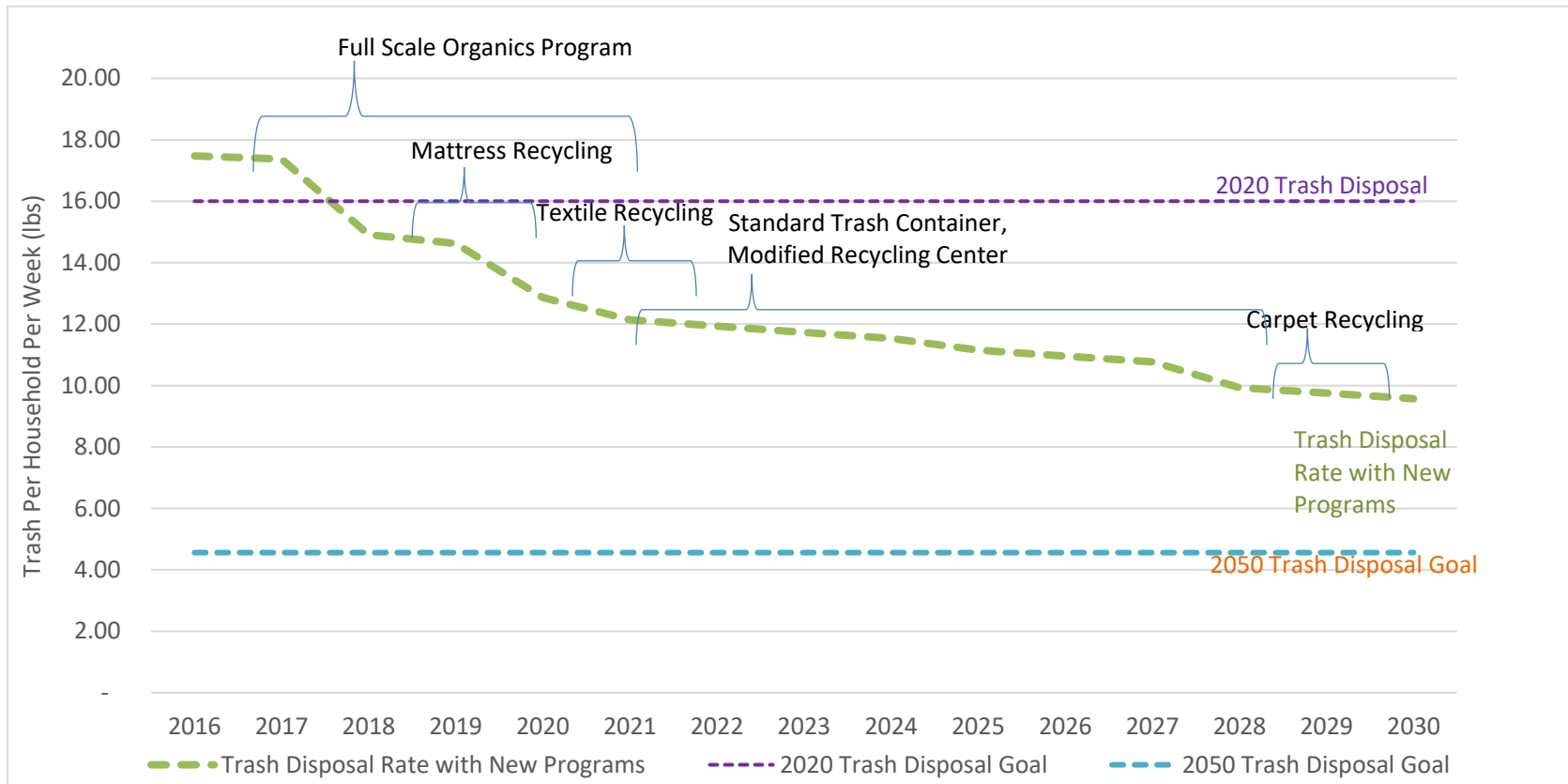
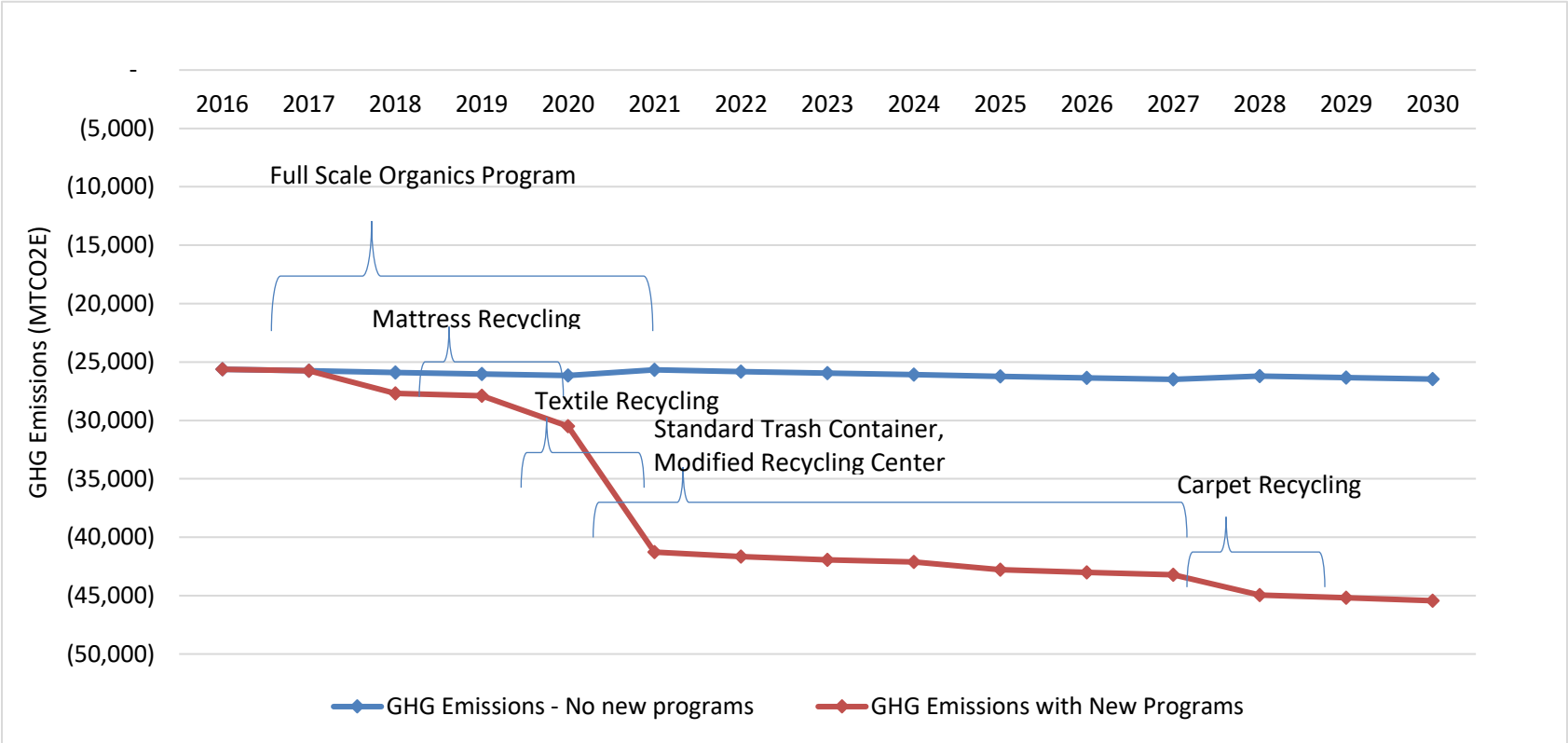


Figure 10-2: Estimated Change in GHG Emissions Based on New Program Implementation ¹⁴



¹⁴ As modelled using the EPA’s Waste Reduction Model (WARM v14)

11 Financial Summary

The following sections provide a high level overview of the financial impact to the City with implementation of the recommended options.

11.1 Program Costing for Recommended Options

The following table summarizes the potential costs and savings associated with the recommended options.

Table 11-1: Summary of Potential Costs

Recommendation	Potential Cost Increases	Potential Cost Savings
Standard Trash Container	<ul style="list-style-type: none"> Promotion and education (P&E) campaign. Cost to the City to purchase and distribute containers in the order of \$40-45 per household, or around \$1.2 - \$1.5 million. 	<ul style="list-style-type: none"> Potential decrease in waste management fees from more diversion which costs less per ton.
Reduction/Reuse Activities	<ul style="list-style-type: none"> One new shared staff position with other additional recycling initiatives. Additional P&E costs anticipated in the order of \$2 to \$3/HH (\$100,000-150,000) shared with other recycling initiatives. 	<ul style="list-style-type: none"> Potential for small decrease in diversion processing and/or trash disposal costs.
Mattress Recycling	<ul style="list-style-type: none"> Shared staff and P&E costs. City will receive grant for up \$160,000 over two years to recycle mattresses but collecting mattresses for removal will be an additional cost. 	<ul style="list-style-type: none"> Potential decrease in trash disposal costs and \$25/mattress surcharge from trash disposal contractor.
Carpet Recycling	<ul style="list-style-type: none"> Shared staff and P&E costs. It is unknown at this time if grants/funding for recycling would be available. 	<ul style="list-style-type: none"> Potential decrease in trash disposal costs.
Enhanced Recycling Program and/or Recycling Center	<ul style="list-style-type: none"> P&E campaign. Some staff time required to implement changes to Recycling Center. The capital costs to change the Recycling Center. The potential operating costs for a new or mobile recycling depot will depend on the frequency of operation. 	<ul style="list-style-type: none"> Potential decrease in trash due to more accessible and welcoming Recycling Center.

11.2 Impacts to MSW Tipping Fees

The trend towards decreasing landfill capacity in Massachusetts is anticipated to result in increased MSW tipping fees as demand outstrips supply. Already, tip fees in northeastern U.S. are higher than in other parts of the country and are expected to continue to increase as capacity decreases. Concurrently, hauling fees are also expected to increase as waste needs to be transported longer distances to landfills located farther away. It is expected that tipping fees at WTE facilities will increase as their capacity replaces landfill capacity. The City has estimated that disposal fees could escalate by approximately 20% with future contracts.

At present, tipping fees for diversion programs are significantly less than trash tipping fees. As of June 2019, recycling and organics tip fees are approximately \$35/ton (\$70 per ton for loads with excess contamination) and \$60/ton, respectively. The trash tipping fee is approximately \$100/ton. It is anticipated that tipping fees for trash will continue to increase in the near future. Recycling tip fees have the potential to increase with the next recycling contract, as the net cost of recycling is increasing due to material market issues (see below). Compost tipping fees don't appear to be changing much in the immediate future. However, it is anticipated in the foreseeable future that the tipping fees for recycling and composting will remain less than trash tipping fees.

11.3 Market Revenue Potential

As this plan was developed, the global economy with respect to recycling markets has had significant changes, as the Chinese government implemented new policies under the “National Sword” program which restricts imports of various grades of recycled paper and plastic unless very high-quality standards (0.5 % contamination rates) are met. It is difficult to know what the long-term implications of this program will be on the U.S. recycling market and potential revenue. However, it is possible at least in the near term that shifts in the recycled material market could result in the City paying a higher price for recycling. The City is likely to continue to see significant price differentials for loads that meet or exceed contamination rates, emphasizing the need for promotion and education and recycling collection system performance as discussed previously.

In regard to other programs identified in the ZWMP, minimal other revenue potential has been identified.

11.4 Funding Options/Mechanisms

MassDEP provides funding for municipalities through a Recycling Dividends Program (RDP). RDP allocates funds to municipalities for meeting certain criteria for recycling,

composting, reduce/reuse, and other waste reduction activities that the City implements. The more the City does to reduce waste, the more grant money MassDEP will provide.

In FY18, the City received the highest amount of RDP funds of all qualifying communities in Massachusetts. There is potential for additional funding if additional qualifying programs were put in place. The City should continue to seek more money from the RDP program each year.

Grants are available for transportation and recycling of mattresses for up to two years. Additionally, MassDEP may pay for rental of a mattress storage container to store mattresses so they can be aggregated for collection.

It appears that funding may be available for a standard trash container, recycling carts for small businesses and curbside food waste collection containers.

11.5 Other Revenue Potential

There is potential for some revenue sharing from textile recovery, depending on how the program is implemented and with whom. Some organizations offer a rebate to municipalities for curbside collection programs.

12 Implementation Plan

The figure below presents an approximate high-level timeline for implementing the options in the ZWMP between 2018 and 2028. Some options will take longer to implement than others, depending on the level of effort, whether supplies or equipment need to be procured, and the staff and resources available to the City.

Figure 12-1: Implementation Timeline



13 Measuring Performance in the Future

Monitoring the performance of the current waste system, as well as new system options that have been recommended is vital to ensure its success and effectiveness. Understanding the performance of the overall waste system, as well as each component of the system, provides for a better understanding of the potential areas for improvement, future trends to watch for, and return on investment as new programs or facilities are implemented.

The metrics identified below should be considered for future reporting and have been specifically identified to:

- Reflect the performance of the current integrated waste management system.
- Measure the impact of the new ZWMP.
- Monitor trends associated with waste reduction and reuse activities.
- Provide for transparency on aspects of solid waste management including customer service, enforcement actions, safety performance, etc.

Table 13-1: Recommended Performance Metrics

Category	Metric	Measurement
ZWMP Related		
Trash Disposal Rate Residential	Change in Trash Disposal rate	Waste Audits conducted before and after major program changes, and/or on regular intervals.
	Pounds per household per week	Estimated based on tonnage records and household count and/or through regular container fullness / visual survey including weighing containers.
Recycling Rate Commercial and/or Residential	Average disposal volume used	Regular container fullness / visual survey.
	Change in Recycling rate	Waste audits and/or through information provided by the City's recycling processor.
	Pounds per customer per week	Estimated based on tonnage records and household count.
	Recycling capacity used	Regular container fullness / visual survey.

Category	Metric	Measurement
Contamination Rate	Change in Contamination Rate	Waste audits and/or through information provided by the City's recycling processor.
Reduction - Food Waste	Change in organics generated (placed in compost and/or trash)	Waste Audits and/or information provided by the City's processor
Reuse Textile/Electronics Reuse or Recycling	Change in quantities of textiles/electronics in trash at the curb	Waste Audits and/or information provided by the City's collector or processor
Greenhouse Gas Emissions Related to the System	Annual tonnes of CO2 equivalents reduced	Calculated using the WARM model
Operations Related		
Safety Performance	Annual Measures (e.g. Worker's Compensation Claims)	Operational information
Total Tonnage Managed	Tons	Totals reported by the City's processors.

14 Zero Waste Master Plan Updates

This ZWMP is intended to be a 'living document' to be used by the City as guidance for waste management system changes. It is not intended to be static, as opportunities and issues related to waste management can change rapidly, requiring adaptation. The adoption and implementation of the ZWMP recommendations will and should be subject to regular adjustments based on direction by Council, the City Manager and Staff.

It is recommended that the City undertake a review of the ZWMP at regular intervals. Typically plans like these are reviewed every five years to consider changes in population, demographics, new technologies, changes in laws/regulations, shifts in waste generation and materials markets. Waste management planning is a continuous process, which involves reviewing and revising plans or strategies at regular intervals. Aside from providing a formal mechanism to incorporate lessons learned and new information obtained over the previous implementation period, having a regular review process allows

adjustments to be made to ensure progress towards the ZWMP's long-term objectives.

A biennial report should be prepared to present an ongoing update of progress of the ZWMP. The biennial report should also identify any specific achievements or issues that arose during the last two years and how they were addressed. Implementation plans for options in the following years should also be identified.

The following sections provide an overview of the processes involved in updating and reviewing the ZWMP and annual system monitoring and reporting.

14.1 Updates and Revisions to the ZWMP

It is recommended that the first formal review of the ZWMP be completed in five years or during 2023, with subsequent updates being completed every five years. Formal review points, and as required interim review points, provide an opportunity for any adjustments to the ZWMP as required. It is recommended that the initial review include a comprehensive assessment of the performance of each ZWMP option implemented over the next five years to determine if the anticipated objectives have been met, and to identify any issues that may have affected their implementation and performance. The review should consider the annual performance metrics data recorded (e.g. waste reduction, worker injuries) to confirm any trends that may need to be investigated further. Reasons for success or under performance should be explored and documented. The ZWMP can be updated to reflect the results of the review, identify any changes required to achieve the targets, or any changes in the implementation timeline for the planning period.

The following are some key factors that should be considered and may necessitate the need for revision of the ZWMP:

- A significant change in customer base.
- Changes in waste composition and generation.
- A change in legislation as it relates to program and/or service delivery.
- Financial impacts/opportunities such as new sources of funding or decreased material markets, customers and commodity prices.
- Advancements in new technologies that could benefit the City.

The review process should be formally documented for presentation to the City Manager and to the broader community (including City Council and the Recycling Advisory Committee). This would take the form of an update report on the ZWMP.

14.2 Annual System Monitoring and Reporting

Annual reporting, both internally and externally, beyond the data collected and reported formally to other parties, is an excellent means of demonstrating the progress achieved by both the municipality and the non-municipal partners and participants.

An annual report card presents the opportunity to report on the current year, highlight accomplishments, and present minor adjustments. It is recommended that an annual report card documenting the performance of the ZWMP be prepared in the spring of each year.

In addition to the performance of the subject year, a comparison to the baseline should be provided with commentary where appropriate to address items such as:

- Programmatic or facility changes that were implemented that could have impacted quantities managed, tonnes diverted, etc.
- Waste generation anomalies (e.g. severe weather events).
- Changes to external influences such as changes to State or Federal legislation.
- Any other internal or external factors that impacted the ZWMP implementation.
- Contract changes with City contracted service providers.
- Identification of potential trends, such as a year over year decrease in waste disposal that should be monitored to assess the potential for future system impacts.

14.3 Keys to Success

The ZWMP has been developed to enhance the City's existing waste management programs and with several elements which will contribute to its success. However, there are several risk factors that need to be considered which could affect the implementation of the ZWMP, some of which are currently beyond the City's control.

14.3.1 Success Factors

The ZWMP is a robust, forward-looking plan that builds on the City's historic waste diversion success and leadership and lays the foundation for achieving an ambitious waste reduction target going forward. The anticipated successful implementation of the plan is based on a variety of key factors:

- **Customer participation** – Although the ZWMP outlines several new and innovative waste management options (e.g. food waste, textiles and waste

electronics reduction and reuse strategies; mobile drop-off depots, etc.), a central focus of this plan is to further improve participation and proper utilization of the City's existing programs and services by, for example, expanding services to the small commercial sector and expanding promotion and education. The success of the ZWMP is very dependent on the participation of the customers of the City of Cambridge.

- **Expanded public engagement** – In a city with a population that is diverse and located predominantly in multi-family residences, there are significant challenges associated with engaging residents in waste management initiatives, but also tremendous opportunities. Meaningful and effective public engagement is a cornerstone to the successful implementation of this ZWMP.

14.3.2 Barriers and Risks

As in any other planning process, there are risk factors that could result in the ZWMP not producing the expected results. These could include both internal factors (e.g. failure to engage City residents) and external factors (e.g. changes in waste composition, consumer patterns, and/or governing legislation). It is important that the ZWMP is flexible so that it can respond to risks and barriers that have been identified throughout the implementation and operating periods. The first five-year review is intended to allow for a mid-course correction if some of the assumptions built into the ZWMP are found to not occur as anticipated over time.

Barriers and related risks that may influence the success of the ZWMP include the following:

- Changes in State waste legislation, regulations, policies have the potential to significantly impact the City's ability to achieve lower rates of waste disposal.
- Waste reduction estimates may not be reached - The diversion estimates presented in the ZWMP may not be reached either because:
 - Waste composition changes over time in ways which are not predictable today; and/or,
 - Residents may not participate, or do not participate properly in the waste reduction and diversion programs, thereby resulting in lower capture rates for targeted materials.
- Changes in the composition of waste that will be generated by City households and businesses through the ZWMP timeline present a risk to success, as waste reduction estimates have been based on the current waste composition. Some of the most significant changes in the waste stream that have been anticipated to continue throughout the planning process include:

- A continued decline in the generation of newsprint.
- An increase in plastics packaging (especially hard-to-recycle films, stand-up pouches and plastic laminates).
- An increase in old corrugated cardboard in both households and businesses due to growing internet sales.
- An increase in the quantity and types of waste electronics and electrical equipment in both households and businesses.
- The ZWMP depends on successful partnerships - Elements of the ZWMP require partnerships with non-profits for programs. The food waste reduction strategy could be strengthened by collaborating or working with local municipalities and various food related organizations, as well as universities and colleges interested in the topic. Operating textile and drop-off facilities should ensure that non-profits currently collecting these materials are not negatively impacted by the City program, and partnerships with the existing non-profits may be considered to expand the service. Partnerships require a significant investment of time to establish and maintain, and unless they are executed effectively, they may not be successful.

15 Conclusion

The recommendations contained in this report represent actions that are aligned with the DPW's guiding principles and will contribute to reaching the City's waste and GHG emission reduction goals in a fiscally responsible manner. As markets evolve, policies change, and cultures shift there will be changes to the waste diversion programs. The City should continue to evaluate programs and new opportunities while continuing to support the needs of the community. An analysis of the Zero Waste Master Plan should be carried out every 5 years. This analysis will help make the Zero Waste Master Plan evolve and grow as things change.