City of Baltimore

RECYCLING AND SOLID WASTE MANAGEMENT MASTER PLAN

Final Master Plan

Task 9 Report

28 July 2020

Prepared for:

Baltimore City Department of Public Works

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Columbia, Maryland

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Table of Contents

ABBREVIATIONS AND ACRONYMS

Formal names for offices, agencies, institutions, and programs are capitalized; technical terms are in lower case.

AD	anaerobic digestion; anaerobic digestor
BCCA	Baltimore Clean Air Act
BCPS	Baltimore City Public Schools
BCRP	Baltimore City Department of Recreation and Parks
BFDPZW	Baltimore Fair Development Plan for Zero Waste
BFWRS	Baltimore Food Waste and Recovery Strategy
BOS	Baltimore City Office of Sustainability
BRESCO	Baltimore Refuse Energy Systems Co. (now Wheelabrator)
BSP	Baltimore Sustainability Plan
C&D	construction and demolition
CAP	Baltimore City Climate Action Plan
CAPEX	capital expenditure
CASP	covered aerated static pile (composting technique)
CCR	Curtis Creek Recovery Transfer Station (Waste Management)
CDL	container deposit law; bottle bill
CY	cubic yards
DDFCM	Disaster Debris/Facility Closure Management Plan (future)
DHCD	Baltimore City Department of Housing and Community Development
DOC	drop-off center (operated by DPW)
DP3	Baltimore City Disaster Preparedness and Planning Project
DPW	Baltimore City Department of Public Works
DGS	Baltimore City Department of General Services
EPR	extended producer responsibility
EPS	expanded polystyrene; Styrofoam
FTE	full-time equivalent (employee)
GHG	greenhouse gas
GROW	Green Resources and Outreach for Watersheds (Centers)
HDPE	high-density polyethylene; no. 2 plastic
HHW	household hazardous waste
ILSR	Institute for Local Self Reliance
LWBB	Less Waste, Better Baltimore (Plan)
L&J	L&J Waste Recycling, LLC
MDP	maximum diversion potential
MES	Maryland Environmental Service
MFB	multi-family building
MRC	mandated recycled content
MRF	materials recovery facility
MSW	municipal solid waste
MTCO2E	metric tons (tonnes) of carbon dioxide equivalent
MWP	mixed waste processing
NMWDA	Northeast Maryland Waste Disposal Authority

NWTS	Northwest Transfer Station
NTR	non-traditional recyclables
OPEX	operating expenditure
O&M	operation and maintenance
PAYT	pay as you throw
PET/PETE	polyethylene terephthalate; no. 1 plastic
PPP/P3	public-private partnership
QRL	Quarantine Road Landfill
RMDZ	recycling market development zone
RNG	renewable natural gas
RORO	roll-on, roll-off container
RTS	new rail transfer station in Baltimore (proposed in LWBB Plan)
SAYT	save as you throw
SFH	single-family home
SM3	Sustainable Materials Management Maryland (P3 Program)
SRF	solid recovered fuels
SSR	single-stream recycling; single-stream recyclables
SSO	source-separated organics
SWMP	Baltimore City Solid Waste Management Plan
TS2	new truck transfer station in Baltimore (proposed in LWBB Plan)
USDA	United States Department of Agriculture
U.S. EPA	United States Environmental Protection Agency
W2W	Baltimore City Waste to Wealth Initiative
WAF	Western Acceptance Facility (Baltimore County)
WARM	Waste Reduction Model (U.S. EPA)
WMRA	Waste Management Recycle America
WTE	waste-to-energy
ZWA	Zero Waste Associates

1. INTRODUCTION

1.1 Overview and Approach

This Final Master Plan (Task 9 Report) was prepared by Geosyntec Consultants, Inc. of Columbia, MD for the City of Baltimore Department of Public Works (DPW) as culmination of the planning effort titled the "Less Waste, Better Baltimore" (LWBB) Master Plan. The LWBB Plan is intended to:

1. Outline a clear and achievable vision for improving Baltimore City's solid waste and recycling system over both the near- and long-term, with the goal of maximizing waste reduction, reuse/repair, recycling, and sustainable management of materials;
2. Develop actionable strategies to achieve this goal; and
3. Identify potential impacts on existing solid waste management systems, including programmatic and infrastructure needs, investment challenges, and associated policy or regulatory initiatives.

In this Report, the capitalized term "City" is used specifically to refer to Baltimore City Government, which includes DPW and other departments and offices (e.g., Planning, Sustainability, and Health) but does not include Baltimore City Public Schools (BCPS). "Baltimore" or the lower case term "city" refers to Baltimore City as a whole. The terms "mixed refuse" and "trash" are used interchangeably with the industry term "municipal solid waste (MSW)" to mean everyday items thrown away by the public, such as product packaging, food and kitchen waste, paper, plastic bags, bottles, cups, and grass clippings. MSW thus includes materials that may ultimately be recycled or composted.

Vision Statement

> ***"We are committed to providing the most efficient and equitable solid waste management system using industry best practices and leading technology to ensure, in a collaborative manner, a safe, viable, and healthy environment for ALL residents through our long-term Less Waste, Better Baltimore Master Plan"***
>
> ***- Baltimore City Department of Public Works***

Guiding Principles and Goals

The LWBB Plan was developed in accordance with the following values and guiding principles:

1. Maximizing **waste reduction and diversion** while meeting the City's short- and long-term needs for solid waste disposal;
2. **Resource conservation**, including outreach efforts to inspire conscious decision making to reduce consumption and waste generation;

3. Meeting goals for accountability, transparency, and **equity**;
4. Aligning environmental, economic, and social needs to achieve **operational and financial sustainability**;
5. Creating **green jobs** in the recycling and reuse sectors; and
6. Seeking opportunities for **cooperation and collaboration**.

The primary goal of the LWBB Plan is to help the City achieve its vision for improving solid waste and recycling in Baltimore over both the short- and long-term by executing the scope outlined in Section 1.2. This needs to be achieved consistent with the City's existing Solid Waste Management Plan (SWMP), and in accordance with aspirations laid out in the City's existing source reduction and recycling plans, climate change adaptation and resilience plans, and legislative efforts as summarized in Section 1.3. In particular, the goals of the LWBB Plan are governed by the Baltimore Sustainability Plan.

While operationally focused, the LWBB Plan differs from the existing SWMP in that it is a strategic master plan aimed at enabling the City (and in particular DPW) to improve its systems and services in accordance with the aspirations outlined herein, whereas the SWMP is a tactical plan aimed at ensuring that DPW's systems and services meet the needs of city residents and businesses and comply with regulations. The LWBB Plan is also performance based rather than prescriptive; as such, the City may choose not to implement all options exactly as presented herein. The focus will be on achieving the goals for waste recycling and diversion within the timeframes indicated. If superior technologies become available or a new actor enters the market, for example, the City may decide to modify or eliminate specific options in their favor. Given this dynamic structure, it is recommended that DPW forms a LWBB Review Committee to report annually on progress made and decisions taken.

Equity Statement

"The LWBB Plan is consistent with DPW's commitment to equity and environmental justice, as set forth in our mission and vision statements and Equity Ordinance 18-160. In developing this plan, DPW recognizes the importance of internal review with our Equity Committee as well as external review with communities and stakeholders. Through the development and implementation of the LWBB Plan, DPW will apply an equity lens and commit to best practices that will advance our equity priorities and goals."

- Baltimore City Department of Public Works

1.2 Scope of this Report

Background

Several technical and strategic planning documents have been prepared as part of LWBB Plan development to inform and guide the development of the Final Master Plan in Task 9. Documents listed here have received

final approved by DPW and are available to the public in the document repository at the LWBB website. The following documents were prepared as part of the LWBB Plan:

1. Task 0 – Waste Sort: Geosyntec conducted a two-season waste sort (January and June 2019) to establish reliable and up-to-date data on waste characteristics and quantities generated by the residential and commercial sectors in Baltimore. Reports on the winter and summer waste sorts were published on 22 February and 26 September 2019, respectively.
2. Task 1 – Stakeholder Outreach: To involve residents and other stakeholders in developing the LWBB Plan, DPW solicited community input through four facilitated community meetings. The first two meetings were held on 28 February and 11 March 2019 and the second two meetings were held on 4 and 15 June 2019. Reports on the two sets of meetings were published on 29 March and 26 August 2019, respectively. DPW also solicited public input through email submittals to a dedicated email address established for the project, as well as via various online social media platforms. Parallel to the community meetings, DPW published an online survey to solicit input from stakeholders. Over 2,000 survey responses were received and summarized in a report published on 18 April 2019.
3. Task 2 – Public Communication: To provide regular updates on the status of the LWBB Plan, and to inform stakeholders of new developments, the project team maintained the LWBB website as the primary means of communication from project inception through development of the Final Master Plan. Updates were also posted to DPW's online social media accounts, including Facebook, Twitter, and Nextdoor.
4. Task 3 – Comprehensive Description of Existing Solid Waste Management System: Geosyntec reviewed the multifaceted solid waste and recycling programs, services, and facilities operated by DPW and other municipal and private actors as well as relevant regulations, population and housing projections, governance, finance, and contracts affecting solid waste management and recycling in Baltimore. The review of private actors included infrastructure and facilities in the local region, as defined by a 3-hour truck travel distance from the city. The Report also quantifies material flows from the residential and commercial sectors within the city's wasteshed. The final Task 3 report was published on 30 July 2019.
5. Task 4 – Benchmarking: This study compared the performance of Baltimore's current solid waste management systems and services with those in five other U.S. jurisdictions (Austin, TX; Boston, MA; Charleston, SC; Charlotte, NC; and Portland, OR) that have either enacted, or are in the process of enacting, meaningful improvements to their waste disposal and recycling rates. The experiences and data reported by these jurisdictions served to inform assessment of waste diversion and recycling options in the LWBB planning effort. The final Task 4 report was published on 26 September 2019.
6. Task 5 – Potential Improvements to the Current Diversion/ Recycling System: The Task 5 Report documented potential options for the City to consider which, if implemented, would improve waste diversion and recycling rates within the residential and commercial sectors. These included:

- Options for reducing and diverting food scraps and other organic waste, traditional recyclables, C&D debris, and non-traditional recyclables;
- Options for developing integrated recycling facilities that target multiple material classes in combination;
- Broader strategies and policies for encouraging waste reduction and diversion in Baltimore; and
- Other service and administrative changes, including improvements in the City's 311 service, street sweeping, and waste collection and recycling in public areas.

The final Task 5 Report was published on 15 April 2020.

7. Task 6 – Summary of Previous Tasks: Between October and December 2019, the project team provided status updates and presented preliminary findings on the LWBB Plan to various entities, including the Baltimore Commission on Sustainability, the City Council, and representatives from the Mayor's office.
8. Task 7 – Managing What's Left: The Task 7 Report outlined options for environmentally and fiscally responsible management of "what's left," or the waste that cannot realistically be prevented from being generated or diverted from disposal under one or more options assessed in the Task 5 Report. These included:
    - Maximizing the use of DPW's Quarantine Road Landfill (QRL);
    - Continued use of Wheelabrator Baltimore, the waste-to-energy (WTE) incinerator previously known as BRESCO;
    - Constructing new/expanded waste transfer stations as long-haul transfer options for disposal out of the City; and
    - Other waste processing technologies such as mixed waste processing, mechanical-biological treatment, or gasification.

    The Task 7 Report also identified specific facilities and programs that could assist with budgetary planning for future waste disposal needs and outlined a decentralized approach to provide contingencies for unexpected interruption to the City's main recycling or transfer/disposal locations. The final Task 7 Report was published on 15 April 2020.
9. Task 8 – Draft Master Plan: The Task 8 Report, which was the tenth in the series of reports prepared for the LWBB Plan, drew on the Task 5 and 7 Reports to develop a set of draft recommendations for implementation by the City. After internal review, the Draft Master Plan was published for public review on 6 June 2020. The Draft Master Plan was also presented at a 2½-hour community meeting on 19 June 2020, which was held as a live event on CharmTV rather than an in-person meeting due to the City's social distancing restrictions in response to the COVID-19 pandemic. Questions submitted on the Draft Master Plan were addressed at the event.

Basis for Final Master Plan Development and Content

This Task 9 Report, which is the final in the series of reports prepared for the LWBB Plan, represents finalization of the draft recommendations presented in the Task 8 Report. Internal and public feedback on the Draft Master Plan was evaluated for incorporation into the Final Master Plan for adoption by DPW and presentation to the Mayor and City Council.

Consistent with the scope of work for Task 9, the specific purpose of this Task 9 Report is to:

1. Present a recommended hierarchy of options for the City to pursue, based on:
   A. Projected outcomes;
   B. Timeframe for implementation;
   C. Estimated costs;
   D. Potential funding sources, including grants and options for private investment such as public-private partnerships (PPPs or P3s); and
   E. Site availability;
   F. The potential roles of various actors within the private and public sectors, including City departments and agencies, elected officials, residents, nonprofits, and universities.
2. Address changes in systems, programs, and costs.
3. Identify major events and their expected outcomes that could trigger the need for contingency operations under a comprehensive Disaster Debris/Facility Closure Management (DDFCM) Plan, which is to be developed separately outside the scope of the LWBB Plan.

Additional details are provided in Chapter 4. The above hierarchy applies primarily to "hard" infrastructure options, which comprise facilities and systems that would need to be implemented by the City and/or the private sector to increase diversion of specific material classes from the current disposal waste stream. However, enactment of policies and strategies (i.e., "soft" infrastructure) by the City will also be critical to promote waste reduction, thoughtful consumption, and reuse across multiple material classes and stakeholder sectors. Soft infrastructure options cannot be directly assessed using a hierarchical methodology, because waste that is not generated in the first place does not enter the waste stream and thus cannot be measured and does not incur a management cost. Nevertheless, encouraging waste reduction and reuse through key policy changes and strategic initiatives are important goals of the LWBB Plan. Soft infrastructure options recommended for consideration by the City are presented in Chapter 5.

Integration with Disaster Management Planning

With regard to future development of a DDFCM Plan, in review of potential diversion and recycling options in Task 5 and processing, transfer, or disposal options in Task 7, the LWBB Plan considered contingency planning for unexpected events that could temporarily or permanently interrupt use of an existing or planned operation in the City. As outlined in the Task 5 and 7 Reports, the risk of future disruption to waste management and recycling services is best mitigated by:

1. Adopting a decentralized approach that provides redundancy by developing multiple smaller facilities in phases rather than relying on one centralized facility for any particular operation (e.g., composting).
2. Ensuring the total capacity of decentralized facilities exceeds the total capacity requirement (e.g., if three facilities are developed, each should offer more capacity than simply a third of the total required). In general, each facility proposed for development in the LWBB Plan is sized at 120% of its maximum expected capacity.

3. Maintaining adequate contingency disposal airspace at QRL to handle potential debris from major storms or other disasters. As discussed in Section 8.2, it is recommended that 4M cubic yards of airspace at QRL is reserved for disaster debris management, which is equivalent to about 7 years of waste filling under current operations.
4. Avoiding low-lying and other potentially vulnerable areas for siting new facilities.

These risk mitigation measures should be reflected in the DDFCM Plan to reduce the City's reliance on its current centralized disposal and recycling infrastructure and thus build resilience to future disruptions due to climate change or other factors.

In terms of assessing capacity requirements for waste transfer operations (the ultimate contingency measure), it was assumed that temporary or permanent disruption to recycling or processing facilities means that materials typically entering these facilities would instead need to be transferred for disposal. Therefore, assumptions for disposal tonnages and the sizing of all processing and transfer facilities in Task 7 were based on handling total waste quantities (i.e., assuming that additional diversion rates achieved from implementing Task 5 options may be temporarily or permanently lost).

1.3 Governing Plans and Legislative Efforts

Source Reduction and Recycling Plans

The City has multiple planned source reduction, recycling, and waste diversion plans, which were prepared by the Baltimore Office of Sustainability (BOS).

Baltimore Sustainability Plan (BSP)

The Baltimore Sustainability Plan was developed by the Baltimore Office of Sustainability (BOS) and adopted by the City Council in 2019. The BSP presents three major strategies for improving waste management and recycling in the City with associated action items:

1. Increase the amount of trash that is diverted from the landfill and incinerator to recycling programs. Specific action items include providing free recycling bins to all City residents and increasing commercial recycling; launching an anti-litter, pro-recycling campaign; and **creating a plan to achieve zero waste, meaning the City "are working toward or diverting over 90% of our discards from landfilling or incineration."**
2. Expand the City's Waste to Wealth Initiative. Specific action items include implementing the Baltimore Food Waste and Recovery Strategy (BFWRS), siting a local compost facility, and revising building codes and/or creating ordinances to eliminate waste and encourage reuse of deconstructed building materials.
3. Pursue legislative and policy changes to reduce the waste stream. Specific action items include imposing a fee for plastic bags, creating a procurement committee to incentivize source reduction, and developing a "save as you throw" (SAYT) program.

Meeting the above goals will require funding to be approved by the City Council as well as deviation from DPW's current funding mechanisms in which provision of collection and disposal services is funded from the City's general fund.

Options that fall within the BSP's three main action items and options that could help the City work toward achieving zero waste goals are

emphasized in the LWBB Plan and were assessed in detail in Task 5. The Task 5 Report was written in the context of assessing the City's ability to meet the waste reduction/diversion goals established in the BSP and BFWRS. Although the Task 5 Report focused on programs that could be directly implemented or managed by DPW (i.e., programs that primarily impact the residential sector), it also assessed reduction/diversion measures in the commercial sector. **Altogether, it is estimated that an overall waste diversion rate of 83% could be achieved by 2040** if the City were to implement the full combination of Task 5 options resulting in the maximum diversion potential. This compares to the overall diversion rate of about 45% achieved in 2017.

The estimated maximum diversion rate of 83% calculated in Task 5 is below the 90% goal of the BSP; however, the Task 5 analyses mainly focused on quantifying the expected performance of new/modified facilities, systems, and programs (i.e., "hard" infrastructure) rather than results from waste reduction measures (i.e., "soft" infrastructure), which are much harder to quantify. Relying on hard infrastructure alone to achieve a waste diversion rate of 90% would require improved efficiencies in existing technologies coupled with maturation of advanced chemical recycling technologies and other innovations to process materials that cannot currently be recycled. Promising technologies and suggestions for City engagement in this regard were discussed in Section 6.3 of the Task 5 Report.

Successful implementation of soft infrastructure options to reduce waste generation – especially of non-recyclable and hard-to-recycle materials – will be critical for the City and the private sector to achieve an overall diversion rate above 83%. These options will require support for initiatives at the federal and state level, the engagement of the City Council to pass necessary ordinances at the local level, the commitment of City Government to implement and enforce new rules, and the involvement and buy-in of Baltimore residents and businesses. Simply put, the analyses in Task 5 showed that the City cannot just engineer its way to 90% diversion but must also receive the support of all stakeholders to achieve this goal.

Baltimore Food Waste and Recovery Strategy (BFWRS)

The Baltimore Food Waste and Recovery Strategy was developed in 2018 in partnership with the Institute for Local Self-Reliance (ILSR), a non-profit organization based in Washington DC. The BFWRS sets specific goals and outlines strategies for achieving multi-sectorial reductions in food waste, with a target date of 2040 in each case:

1. Commercial: 50% reduction in food waste.
2. Higher Education Institutions: eliminate all food waste.
3. City Government: 90% diversion of food and organic waste from landfill or incineration.
4. Public Education: 90% food and recyclable waste diversion in K-12 schools.
5. Residential: 80% reduction in residential food waste; 100% access to organic waste collection for residents; 80% diversion of residential food and organic waste from landfill or incineration.

In support of these goals, the BFWRS recommends creation of composting and anaerobic digestion (AD) capacity for processing 100% of the City's organic waste stream, support for the food waste diversion market by ensuring an adequate supply of organic waste is being diverted

to compost and AD facilities, and creating a supportive culture for food waste reduction and diversion within City Government.

To meet the above goals, BFWRS outlines over 60 short-, medium-, and long-term strategies to be implemented by the City, many of which would require significant additional funding to be approved. Support from the City Council will be critical to their success, as well as supporting legislation to help "move the needle" on new initiatives. Community support for these initiatives will also be critical. Options that could contribute towards meeting the goals of the BFWRS are emphasized in the LWBB Plan. However, it should be recognized that implementing the BFWRS requires initiatives that are much broader than those under the City's direct jurisdiction.

Waste to Wealth Initiative (W2W)

The Waste-To-Wealth Initiative was developed to help grow City businesses while reducing overall waste generation. W2W seeks ways to support local businesses that are using waste (secondary materials) to make products rather than primary (virgin) materials. The vision is for these businesses to support the creation of stable middle-class jobs.

W2W acknowledges that while several businesses in Baltimore have already engaged in innovative reuse and repurposing strategies for a wide variety of secondary materials, particularly C&D debris, they need support from the City to achieve greater success. By fostering businesses that seek to capture value from secondary materials before they enter the waste stream, it is hoped the City can stimulate job creation, combat blight, and encourage resident-led greening efforts to revitalize City neighborhoods. W2W specifically targets three high-value, primarily non-residential wastes that comprise a significant portion of waste generated in the City. These are food waste, C&D debris, and wood waste. Options that could contribute towards reducing these targeted wastes are emphasized in the LWBB Plan.

Climate Change Adaptation and Resilience

To mitigate the severity of future impacts due to climate change and adapt to known risks facing a low-lying coastal region, the City is working to instill resilience into vulnerable systems and infrastructure. In addition to a multitude of ongoing projects and initiatives, two plans have been created that focus on mitigation and adaptation strategies.

Climate Action Plan (CAP)

The Climate Action Plan was developed in November 2012 to reduce Baltimore's greenhouse gas (GHG) emissions by 15% below 2010 levels by 2020 through a range of strategies targeted at reducing consumption of fossil fuels. In the BSP, the GHG emission reduction goal was updated to 25% reduction by 2020 and 30% by 2025 (relative to 2007). Transportation and disposal of waste were identified as significant contributors to overall GHG emissions.

Public services such as solid waste management are vulnerable to changing climate patterns, but also offer solutions to reduce GHG emissions and improve resilience. Implementing programs to locally process and reuse components of the waste stream could significantly reduce GHG emissions, which complements the City's goals to promote composting and compost use under the BFWRS as well as recycling of C&D debris and wood waste in accordance with W2W. Waste reduction and reuse are central tenets in the BSP's goal to increase diversion, recycling, and composting to move Baltimore further towards zero waste. Sustainably managing materials, including recycling and disposal of

materials as close as possible to the point of generation, would help the City achieve its GHG emissions reduction goals.

Disaster Preparedness and Planning Project (DP3)

The Disaster Preparedness and Planning Project was created in an effort to address existing hazards while simultaneously preparing for predicted hazards due to climate change. An update to the DP3 was adopted by the City in December 2018. With regard to public services, disaster preparedness and distribution of resources, information, and response plans are identified as being key to ensuring public safety and mitigating hazards. A primary goal of the DP3 is to enhance the city's resilience and adaptive capacity and build institutional structures that can cope with future conditions that are beyond past experience.

The key impacts of climate change in Baltimore are likely to manifest as increased flooding and storm damage, potentially inundating low-lying properties and disrupting transportation routes. Therefore, as previously discussed in Section 1.2, the options reviewed in Tasks 5 and 7 generally steer towards recommending decentralized systems (i.e., a network of small facilities and programs) rather than one centralized system as decentralized systems are more resilient to catastrophic disruption. Smaller impacted facilities can also usually recover more quickly than larger ones.

City Regulations and Ordinances

Baltimore Clean Air Act (BCAA)

The Baltimore Clean Air Act (BCAA), introduced as Council Bill 18-0306, was approved by the City Council on 11 February 2019 and signed by then Mayor Pugh on 7 March 2019. The BCAA requires commercial solid waste incinerators in Baltimore to conduct continuous monitoring of multiple pollutants, including dioxins, furans, nitrogen oxides (NOx), sulfur dioxides (SOx), particulate matter, polycyclic aromatic hydrocarbons, and several heavy metals. It also establishes significantly stricter emission limits for mercury, NOx, SOx, and dioxins/furans than are required under Maryland regulations. As currently written, compliance with the BCAA would be required starting in September 2020 or January 2022, depending on the specific emission control and/or monitoring system in question.

Consideration of the BCAA had significant impact on the analyses performed in Tasks 5 and 7. If BRESCO could not economically comply with some measures of the BCAA by September 2020, it would be forced to close, adding urgency to the City's need to achieve significant diversion of waste from disposal. In the short term, additional disposal at QRL and/or contingency transfer of waste to other disposal facilities would be needed until longer-term options were developed.

The status of the BCAA has been extremely fluid during development of the LWBB Plan. When the project commenced in September 2018, the BCAA had not yet been introduced by the City Council. On 30 April 2019, Wheelabrator in conjunction with other plaintiffs sued the City in Federal Court over the legality of the BCAA. On 29 January 2020, at the request of the Court, the City agreed to stay implementation of the BCAA pending resolution of the motions. Soon thereafter, on 27 March 2020 the Court found that the BCAA conflicts with federal and state law, is preempted by such laws, and therefore is invalid. This effectively ruled in Wheelabrator's favor for their continued operation of BRESCO. At the time of completing this Final Master Plan, the City has announced it will appeal the Court's ruling although the timing of the appeal is uncertain.

In addition, it is not known whether the City will renew its contract for disposal at BRESCO after December 2021. For the purposes of this Final Master Plan, therefore, and to remain consistent with the analyses of options for disposal of what's left in Task 7, it is assumed that BRESCO may not be available for waste disposal starting in 2022.

Zero Waste Resolution

The Judiciary and Legislative Investigations Committee approved 17-022R, a resolution calling for City agencies and experts to meet and begin discussing "the development of a Zero Waste plan for Baltimore that will advance sustainability, public health, and job creation." The resolution was adopted in June 2017. A follow-up resolution 18-0086R was adopted in May 2018. In April 2019, an advocacy group led by United Workers, a nonprofit organization based in Baltimore, hired Zero Waste Associates (ZWA) and the ILSR to "assist the City of Baltimore to develop a zero waste scenario for the city's long-range recycling and solid waste management master plan." ZWA and ILSR have worked on a Baltimore Fair Development Plan for Zero Waste (BFDPZW) under contract to United Workers, independent of this LWBB Plan. The key goal of the effort is to permanently shutter BRESCO. The BFDPZW aims to make zero waste a key priority to mitigate climate change, reduce climate emissions and other environmental and public health impacts, save money, support economic mobility, create good jobs and small businesses in all sectors of Baltimore, and sustain this work through a culture change. The BFDPZW was released on 29 February 2020 and on 6 April 2020 the City Council passed Resolution 20-0202R calling on the Mayor and affected agencies to implement certain priorities of the document.

In agreement with DPW, ZWA and Geosyntec have collaborated and shared ideas during development of the LWBB Plan. Where appropriate, for example, the potential role of the BFDPZW in helping achieve necessary programmatic or policy changes was highlighted in several sections in the Task 5 Report. This has been carried forward into this Final Master Plan. The BFDPZW was reviewed by the LWBB project team prior to preparation of this Final Master Plan; however, the BFDPZW has not been directly shared or discussed with the LWBB project team.

Expanded Polystyrene Foam Ban

Preceding a statewide ban, Baltimore City Council passed ordinance 18-0125 in April 2018 banning expanded polystyrene (EPS) foam food containers. The law prohibits the use of EPS (or Styrofoam) as disposable food serviceware or packaging. Items such as foam cups, clamshells, bowls, and plates are no longer allowed in Baltimore. The ban went into effect on 19 October 2019 and applies to all foodservice facilities, including restaurants, grocery stores, hospital cafeterias, mobile food carts, bars/taverns, market stalls, public and private schools, caterers, special event food vendors, summer camps, bakeries, and congregation kitchens.

Single-Use Plastic Bag Bill

The City Council passed ordinance 19-0401 on 18 November 2019 (signed 13 January 2020) to ban the distribution of single-use plastic bags at the point of sale, and place a fee of a nickel for other types of single-use bags, including paper and compostable bags. The program goes into effect one year after the ordinance is enacted (i.e., 13 January 2021). For the planning period covered by this Final Master Plan, therefore, it is effectively assumed the plastic bag bill is already in effect.

2. STAKEHOLDER OUTREACH

2.1 Community Meetings

To involve Baltimore City stakeholders in developing the strategy for the LWBB Plan, in Task 1 of the project DPW solicited broad public input through a series of four facilitated community meetings. The first round of community meetings was held early in the master planning process on 28 February and 11 March 2019 at Edmondson-Westside High School and the Shake and Bake Community Center, respectively, with the second round of meetings held on 4 and 15 June 2019 at Mergenthaler High School and Highlandtown branch of the Enoch Pratt Library, respectively. The community meetings provided Baltimore City residents, organizations, businesses, and other stakeholders an opportunity to identify challenges to improving waste management and diversion and to suggest solid waste management and diversion options for consideration in the master plan. During open discussions, attendees at the community meetings were invited to address these two main issues and ask questions on the project's goals, scope, and progress. The two June meetings also allowed the project team to provide feedback on how previously submitted ideas were being addressed in Tasks 5 and 7.

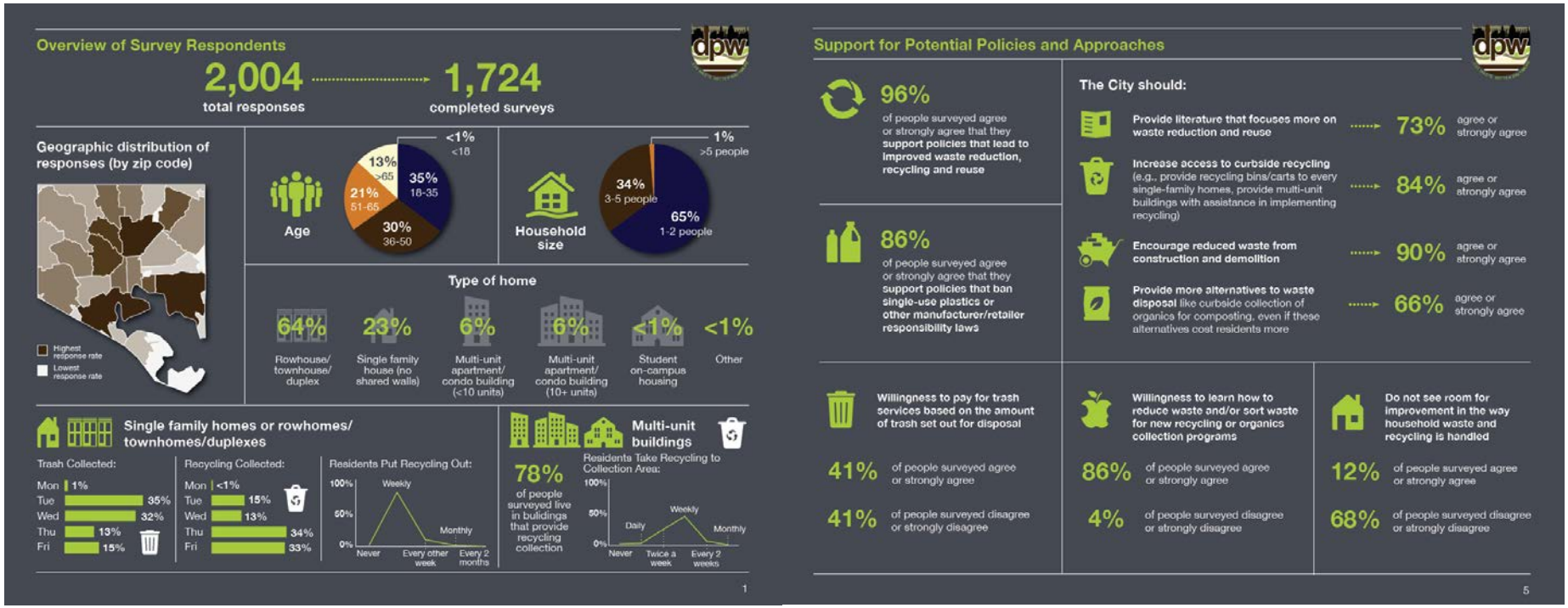
Ideas shared at the community meetings were collated around central themes of source reduction, waste collection, recycling, composting, reuse, managing what's left, education, health and environment, and enforcement. These ideas were summarized in two Task 1 reports available on the LWBB website.

Community Outreach Meeting at Edmondson-Westside High School

2.2 Online Survey and Other Outreach Efforts

In addition to attending community meetings in person, stakeholders were invited to submit questions and feedback via a dedicated email address as well as via various online social media platforms, including Facebook, Twitter, and Nextdoor.

Parallel to the community meetings, DPW published an online survey to solicit input from stakeholders. Over 2,000 survey responses were received and compiled into a graphical summary report to capture participants' current waste management and diversion practices and their ratings of potential future waste and recycling collection and drop-off services. A snapshot from the report, which was published in April 2019, is provided overleaf; the full report is available at the LWBB website.

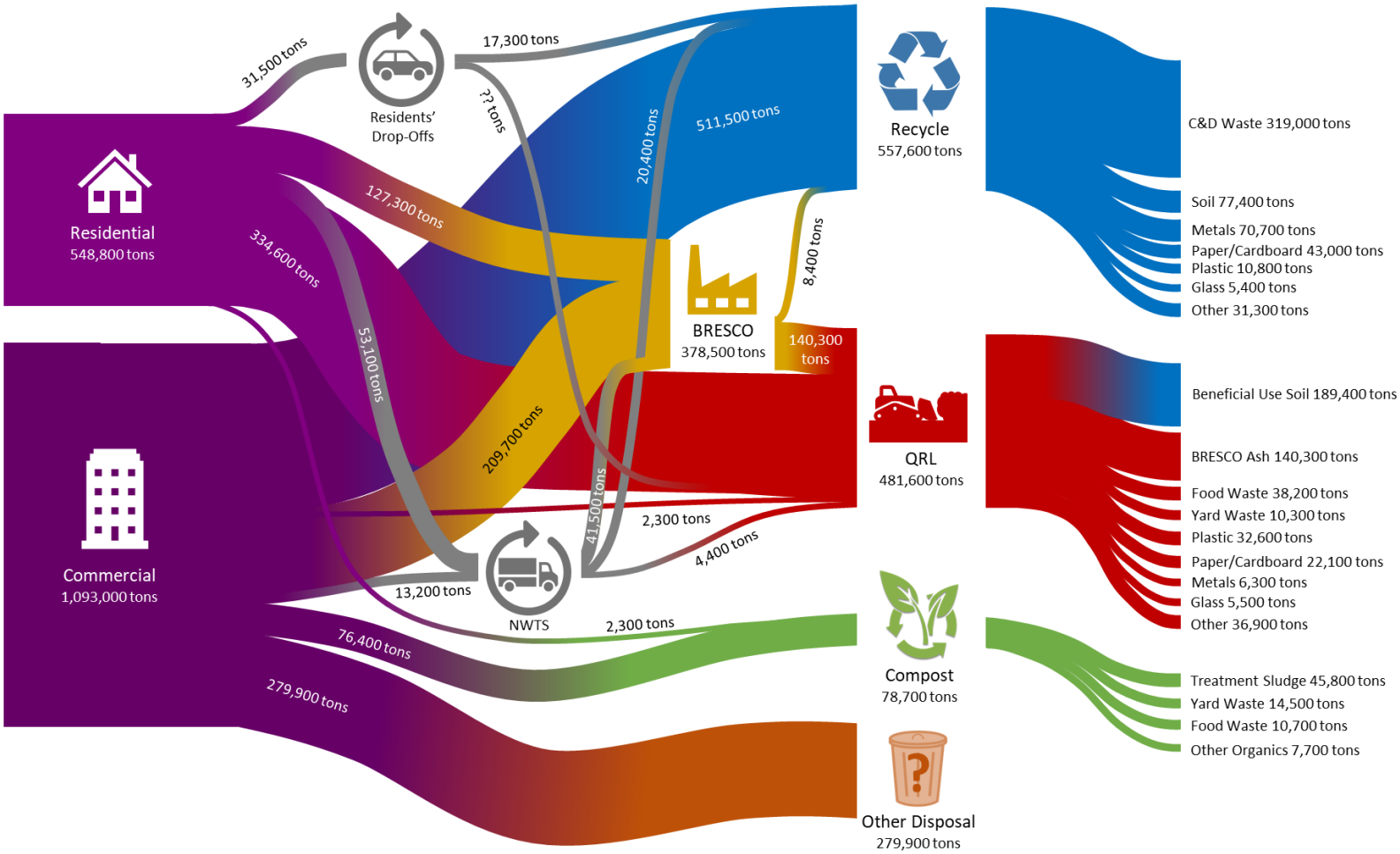


Excerpts from the Task 1 Survey Report indicating Participant Demographics and Main Priorities for the Master Plan

(Original report available at: https://publicworks.baltimorecity.gov/lwbb-docs)

3. ASSESSMENT OF EXISTING SYSTEM, OPTIONS, AND NEEDS

A simplified graphical summary of the existing solid waste stream used as the baseline for analysis is depicted in the flow diagram below, based on 2017 data. Assumptions and data sources are listed in the Task 3 Report.



Quantities and Composition of Waste Streams in Baltimore City under the Existing System

3.1 Existing Waste and Recycling System

The baseline solid waste management system in Baltimore is a mix of public and private systems serving the residential and commercial sectors. DPW is responsible for collecting residential trash and recyclables from public housing, single-family homes (SFHs), and government buildings. DPW also provides limited trash and recycling services to some private multi-family buildings (MFBs) and small businesses, although most waste from MFBs and the commercial sector is collected by private haulers. DPW provides recycling services to public schools at no cost, although not all schools take advantage of this service. Public schools contract with private haulers for trash collection.

As shown on the graphic on the previous page, in 2017 approximately 548,800 tons of residential waste and 1,093,000 tons of commercial waste were generated in the City (1,641,800 tons in total). Of the total waste generated, approximately 747,000 tons (45%) was recycled (this value includes the roughly 8,400 tons of backend scrap metal recovered from BRESCO, included in the commercial recycled scrap metal category, and the 189,400 tons of recycled soil used as daily and intermediate cover material at QRL). Composting accounted for 78,700 tons, 229,800 tons were incinerated at BRESCO (this value does not include the approximately 8,400 tons of recovered backed scrap or the 140,300 tons of ash landfilled at QRL), 292,200 tons was landfilled at QRL (including the 140,300 tons of ash from BRESCO), and 279,900 tons was disposed in the private system (presumed to be primarily C&D waste).

Primary Recycling/Disposal Facilities in the City

Under the City's current contract with BRESCO, which runs through December 2021, DPW disposes no less than 150,000 tons of mixed waste annually at BRESCO. Mixed waste collected by DPW but not sent to BRESCO is sent to QRL for disposal. QRL also accepts waste from other City departments and agencies, private haulers, and the City's Small Hauler Program. Grit screenings from the City's wastewater treatment plants (WWTPs) and incinerator ash from BRESCO are also accepted. QRL recovers soil for use as daily and intermediate cover at the landfill. A residents' drop-off facility is also sited at QRL, which provides free disposal and recycling services to Baltimore residents.

DPW operates the Northwest Transfer Station (NWTS) for consolidation and transfer of residential mixed refuse and single-stream recyclables. Mixed refuse is sent to BRESCO or QRL while recyclables are sent to the private materials recovery facility (MRF) in Elkridge, MD, which is operated by Waste Management Recycle America (WMRA). NWTS also serves as a residents' drop-off location and a disposal facility for licensed small haulers, accepting mixed waste, C&D waste, and other recyclables.

Including QRL and NWTS, DPW operates a total of five residents' drop-off centers (DOCs) where residents may dispose of various materials, including bulk trash, mixed recycling, rigid plastics, scrap metal, scrap tires, household appliances, waste oil and antifreeze, electronics, and oyster shells. Household hazardous waste (HHW) is accepted only on specified dates at one DOC (Sisson Street). The Department of General Services (DGS) also operates three recycling-only convenience centers.

Composition of the Existing Disposal Waste Stream

The overall composition of the disposal waste stream (ignoring WWTP grit screenings) is shown in the table overleaf. Values in the table were determined using a combination of data from the Task 0 waste sorts and published sources. Details are provided in the Task 3 and 5 Reports.

Summary of Disposed Waste Composition in Baltimore in 2017 (tons)

Category	Sub-Category	Residential Waste	Commercial Waste	Total
Organics (163,200)	Food Waste	65,450	44,050	109,500
	Yard Waste	36,250	15,150	51,400
	Mixed Organics	0	2,300	2,300
Traditional Recyclables (240,700)	Cardboard	24,600	32,350	56,950
	Mixed Paper	18,700	17,600	36,300
	HDPE/PET	12,700	7,550	20,250
	Mixed Plastic	55,150	29,800	84,950
	Aluminum Cans	4,000	2,500	6,500
	Steel Cans	7,650	9,000	16,650
	Mixed Metals	250	300	550
	Glass	9,350	9,200	18,550
C&D (288,700)	Lumber	2,400	22,000	24,400
	Clay Bricks	0	6,350	6,350
	Concrete	2,050	199,300	201,350
	Asphalt Concrete	0	40,200	40,200
	Asphalt Shingles	0	7,150	7,150
	Soil	150	150	300
	Drywall	900	8,050	8,950
Non-Traditional Recyclables (5,600)	Bulk Waste	2,500	2,500	5,000
	Textiles/Carpet	250	250	500
	Other	50	50	100
Unclassified (117,900)	-	77,050	40,850	117,900
TOTAL	-	319,450	496,650	816,100

The unclassified category shown in the table comprises non-recyclable and hard-to-recycle material (including non-compostable organics, medical waste, composite materials, diapers, etc.).

3.2 Assessment of Diversion Potential

As previously introduced in reference to achieving the goals of the BSP, there is a combination of mutually exclusive waste reduction and diversion options from Task 5 that would result in the Maximum Diversion Potential (MDP) and thus minimize residual waste volumes for disposal. As shown in the table below, the MDP is 552,900 tons per year.

Expected Maximum Diversion Potential and Performance Timeframes for Task 5 Diversion/Recycling Options

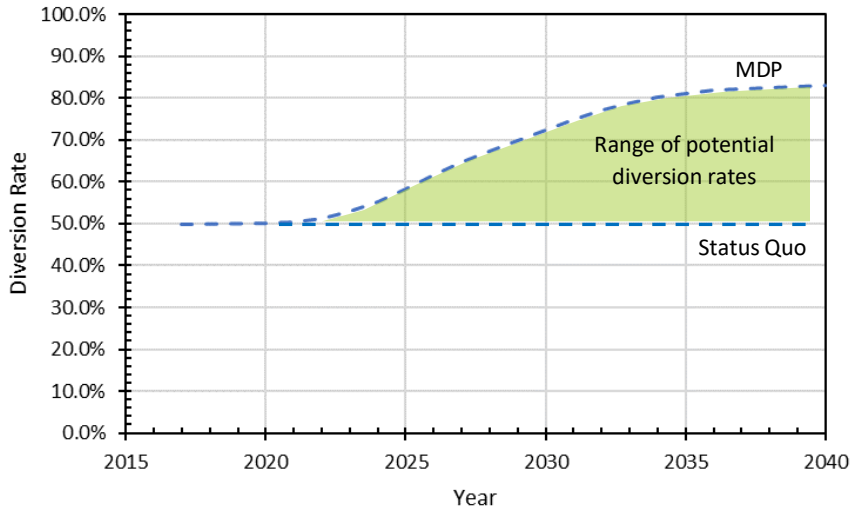
Diversion/Recycling Option (Details provided in Task 5 Report)	Maximum Diversion Potential (tons)	Expected Performance Timeframe (years)
Food Waste Reduction	72,400	20
Residential Organics Diversion	42,800	20
Commercial Organics Diversion	35,500	20
Improved Recycling Collection	84,200	10
Expanded Recycling Collection	69,300	10
C&D Reuse and Reduction	28,400	10
C&D Diversion	200,100	20
Bulk Waste Diversion	4,100	10
Drop-Off Center Improvements	16,100	5
TOTAL	**552,900**	-

When considered relative to the current diversion rate (747,000 tons currently recycled including soil at QRL, plus a further 78,600 tons currently composted), achieving the MDP would increase the overall diversion rate for all waste in Baltimore from 45% to about 83%.

Expected Performance Timeframes

To estimate the changing composition of the waste stream over time as waste diversion increases, it is necessary to assign an expected performance timeframe to each of the nine sets of options comprising the MDP. The performance timeframe for each option was summarized in the table on the previous page. This timeframe represents the total time expected after implementation of an option for diversion to achieve maximum performance levels in accordance with an S-curve (as described in the Task 5 Report). Larger, more complex options have longer performance timeframes; however, all timeframes are conservative estimates, which is appropriate for long-term master planning. The City could aim to decrease any performance timeframe by phasing in options faster than assumed herein and/or by increasing funding to education, outreach, and other efforts to stimulate participation. It is also important to emphasize that the timeframes shown in the table are end-points. For example, a 20-year performance timeframe means that it is expected that 50% of the MDP will be achieved in 10 years, 90% of the MDP will be achieved in 15 years, and 100% of the MDP will be achieved within 20 years.

The figure opposite shows the overall expected diversion rate over time assuming full implementation of all recycling/diversion options to achieve the MDP. It is expected that the overall diversion rate achieved may vary between the status quo (i.e., maintaining a 50% diversion rate consistent with performance in 2017) and implementing the MDP options to their utmost extent to result in 83% diversion by 2040. The actual diversion rate achieved will be dependent on multiple factors, including when each option is implemented, the level of funding provided to each option, and the level of response and participation by residents and businesses.



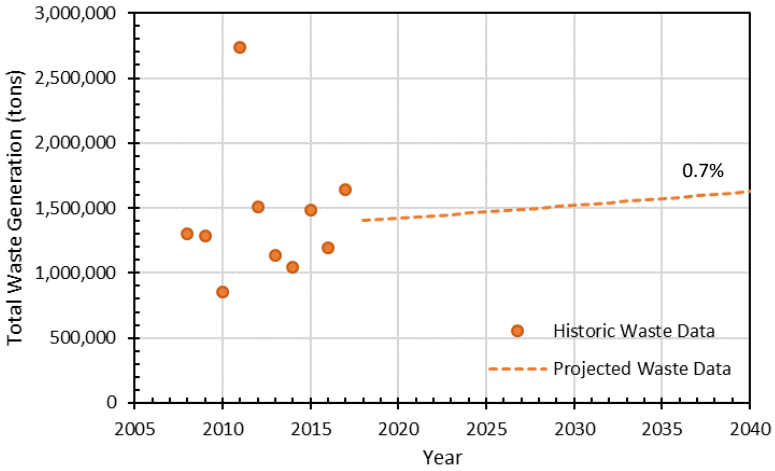
Range of Diversion Rates over Time between the Status Quo or after Implementing the MDP Options

3.3 Assessment of Future Disposal Needs

Waste Growth Projections

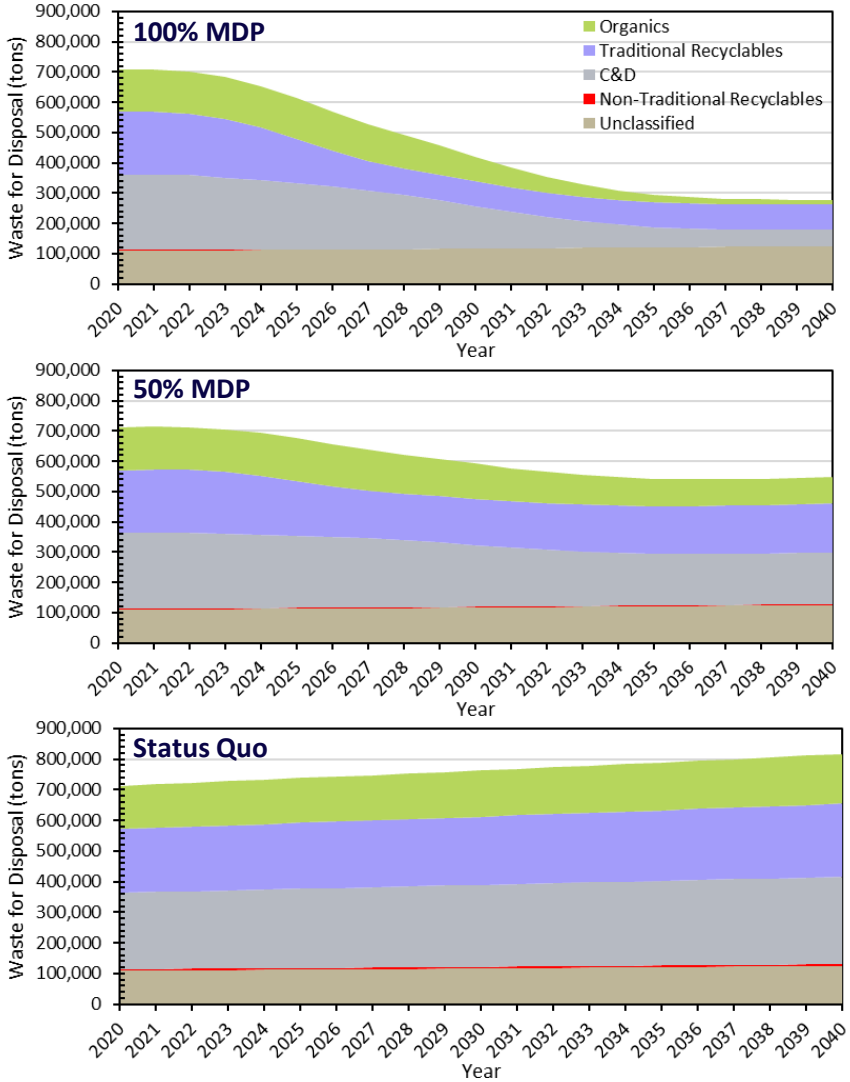
To project the tonnages of waste for disposal over time, it is necessary to model the overall growth in waste generation. As described in the Task 3 Report, it is anticipated that the City's total waste stream will grow at an average annualized rate of 0.7% per year, based on historical waste

generation data from 2007 to 2017 and projected population growth in the city. This assumption was used to estimate the total amount of waste generated in Baltimore through 2040. The estimated total waste generation in the City through 2040 is indicated in the figure below.



Historical and Projected Waste Generation Rate in Baltimore

Combining waste growth projections with the overall waste diversion rates provided by the MDP, the characteristics of the citywide "what's left" waste stream can be estimated. The figures opposite illustrate the expected tonnage and composition of the total disposed waste stream, assuming that the City achieves the full MDP, 50% of the MDP, or 0% of the MDP (i.e. the status quo). Details are provided in the Task 7 Report, which includes separate analysis of residential and commercial waste streams because different disposal options apply to each waste type (e.g., incineration is a feasible disposal option for MSW but not for C&D waste).



Expected Change in Mass and Composition of Citywide Disposed Waste over Time after Implementing the MDP Options

Expected Residential Waste Stream for Disposal

The residential waste stream comprises all waste managed by DPW, which mainly includes waste collected from SFHs and public housing, government offices, some Downtown businesses, and residents' drop-off centers. The diversion rate for residential waste was approximately 42% in 2017.

The table below shows the expected mass (in tons) of disposed residential MSW between 2020 and 2040 assuming that the City achieves different fractions of the MDP (i.e., 0% represents the status quo).

Expected Residential MSW Disposal as a Percentage of the MDP

MDP	2020	2025	2030	2035	2040
0%	271,700	281,000	290,700	300,700	311,000
50%	270,900	257,000	229,400	219,000	222,800
100%	270,100	233,000	168,100	137,200	134,600

The table below shows the expected mass (in tons) of residential C&D waste over time assuming different fractions of the MDP. The amount of residential C&D waste generated in Baltimore is expected to be *de minimis*, regardless of the fraction of the MDP that is attained. It is assumed this material will continue going to current disposal facilities, mainly QRL. As such, alternative disposal options for residential C&D waste are not addressed further.

Expected Residential C&D Disposal as a Percentage of the MDP

MDP	2020	2025	2030	2035	2040
0%	4,700	4,900	5,100	5,200	5,400
50%	4,700	2,700	2,800	2,900	3,000
100%	4,700	500	500	500	500

Expected Commercial Waste Stream for Disposal

The commercial waste stream comprises all waste managed by the private sector and includes waste collected from City businesses, industries, and multi-family dwellings not served by DPW's curbside collection program. The commercial diversion rate was approximately 54% in 2017.

The table below shows the expected mass (in tons) of disposed commercial MSW between 2020 and 2040 assuming that the City achieves different fractions of the MDP.

Expected Commercial MSW Disposal as a Percentage of the MDP

MDP	2020	2025	2030	2035	2040
0%	191,500	198,000	204,900	211,900	219,200
50%	190,900	178,600	157,800	151,300	154,200
100%	190,300	159,200	110,800	90,800	89,200

The table below shows the expected mass (in tons) of disposed commercial C&D waste over time assuming that the City achieves different fractions of the MDP. It is expected that the overall size of the C&D waste stream will decrease over time as various reuse/diversion options are implemented, with the remaining C&D waste stream for disposal continuing to find its way to local C&D landfills. Therefore, commercial C&D waste disposal is not addressed further.

Expected Commercial C&D Disposal as a Percentage of the MDP

MDP	2020	2025	2030	2035	2040
0%	245,100	253,500	262,200	271,200	280,500
50%	244,000	236,700	201,400	169,100	166,900
100%	243,000	220,000	140,700	67,200	53,400

4. METHODOLOGY FOR PRIORITIZING OPTIONS

This chapter summarizes the methodology used to recommend options for increasing diversion of specific material classes from the current disposal waste stream, focusing on facilities and programs (i.e., "hard" infrastructure). However, as previously introduced in Section 1.3, a number of important policies and strategies (i.e., "soft" infrastructure) are also recommended for consideration by the City to promote and increase waste reduction and reuse across multiple material classes and stakeholder sectors, which will be critical to achieving the goals of the BSP. The true reduction potential and costs of soft infrastructure options are difficult to quantify using an objective methodology, as waste that is not generated in the first place does not enter the waste stream and thus cannot be measured and does not incur a processing or disposal cost. As a result, this chapter does not provide a methodology for quantitative estimates of performance for soft infrastructure options.

4.1 Metrics for Objective Assessment

Six metrics were used to objectively compare and prioritize each potential waste recycling and diversion option from Task 5 and each processing, transfer, and disposal option from Task 7 for consideration in the Final Master Plan. These metrics are used to assess options relative to existing/needed solid waste infrastructure, projected characteristics of the city's waste stream (i.e., quantities and composition), achieving the maximum diversion potential (MDP) for each waste class, and ensuring adequate disposal capacity. Estimates of performance and cost are based on the baseline solid waste system in Baltimore (2017 data, see Chapter 3) coupled with best estimates for participation rates, capture rates, performance levels, etc. for each particular option based on relevant case studies, technology/program reviews in technical and industry publications, online research, and Geosyntec's professional experience. Additional details on calculation methodologies, sources of input data, assumptions, etc. are provided in the Task 5 and 7 Reports.

Reduction/Diversion Potential and Airspace Savings

Reduction/diversion potential is an estimate of the quantity of waste that could potentially be prevented from being generated or, if it is generated, diverted from disposal if an option were to be implemented. Reduction/diversion potential is measured in terms of an option's expected contribution to meeting the City's waste reduction/diversion goals for a particular component of the waste stream (per the BSP and BFWRS, as summarized in Section 1.5). Reduction/diversion potential was calculated for diversion/recycling options from the Task 5 Report and processing options in the Task 7 Report. All calculated tonnages are rounded to the nearest 50 tons.

Reduction/diversion potential is also calculated as airspace savings at QRL (which preserves airspace for contingency disposal in response to a disaster and for DPW to use as leverage in negotiating disposal contracts) for all options. These values represent the amount of waste that would be diverted from final disposal either through increased waste diversion practices or through alternative disposal options. Options with greater diversion potential and airspace savings are considered more desirable. Although airspace is strictly a volumetric measure, for simplicity all airspace savings are quoted in this Task 9 Report on a mass rather than volume basis. This is because material diversion potentials and disposal needs are calculated in tons,

which can be directly correlated to costs such as tip fees, which are also assessed in tons. There are also a lot of assumptions related to calculating an in-place volume, which are material specific (i.e., the volume occupied by a ton of lumber is different to that of a ton of plastic bottles). Converting airspace savings from tons to cubic yards would thus introduce an unnecessary level of uncertainty.

Timeframe

The timeframe associated with each option was assessed in terms of the short term (within the next 1-3 years), medium term (the next 5 years), long term (the next 10 years), or very long term (up to 20 years). Estimated timeframes consider two factors:

1. Implementation timeframe, which is mostly affected by the time needed to identify/acquire a site; raise funds; design, permit, and construct new facilities; procure necessary equipment; and/or allocate resources to operate a new facility or program; and
2. Performance timeframe, which account for the expected time lag between facility/program implementation and seeing noticeable improvements as a result of the affected population/businesses responding and adapting to it. As discussed in Section 3.2, performance timeframes are expected to follow an S-curve uptake pattern.

Timeframes for each option were developed in the Task 5 and Task 7 Reports. Options were considered more desirable if they had a shorter overall timeframe. Timeframes were allocated based on benchmarking studies performed on similar programs in other U.S. jurisdictions (see Task 4 Report); however, the City could accelerate implementation of some programs to achieve results in a shorter timeframe.

Costs

Total expected costs were calculated in the Task 5 and Task 7 reports. For each option, total capital costs (CAPEX), average annual operating costs (OPEX), and, where appropriate, average annual revenues and cost offsets were calculated. Labor contributions to OPEX were calculated as fully-burdened costs (i.e., salary plus benefits) for full-time equivalent (FTE) employees. Each option was compared using normalized CAPEX and OPEX (i.e., costs/ton), with lower costs being more desirable when prioritizing each option.

Funding and Contracting Mechanisms

Both funding sources and project delivery mechanisms were considered for each option. Potential funding sources were considered based on DPW's past experience with any given option as well as the potential cost of the option. Delivery mechanisms considered included private, public, or a public-private partnership (PPP or P3). Options were considered more desirable if they could realistically be funded through grants, PPP contracts, or directly by the private sector, as these options would ease the financial burden placed on the City.

Where the selected project delivery mechanism is public sector funding or a PPP, the City could consider a wide range of funding sources and mechanisms to cover its share of CAPEX and/or OPEX. Public funding sources and mechanisms are not specified in detail in this Task 9 Report, as they would require legislative and/or administrative scrutiny before adoption. The Final Master Plan also aims to provide flexibility to the City rather than specificity in their future consideration of options. However, funding options that could be considered include:

1. Allocation of funds from the City's general fund.
2. Establishing an enterprise fund, which could be leveraged to issue bonds for capital projects.
3. Direct billing for waste management services. This would enable the City to increase billings to cover new programs as they are introduced, which would provide a high level of transparency over program costs. This mechanism also enables the City to leverage its considerable billing experience and existing billing infrastructure for municipal water and wastewater services.
4. Billing for waste management services as a line item on property tax bills. As with (3) above, this would enable the City to increase billings to cover new programs as they are introduced, which would provide a high level of transparency over program costs.

With regard to (3) and (4) above, it should be noted that this Final Master Plan does not recommend usage-based models – commonly termed "pay-as-you-throw (PAYT)" – for any solid waste management or recycling programs, at least until the current issues surrounding illegal dumping and littering have be addressed. Therefore, it is recommended that any consideration of direct billing should be on a flat fee basis only.

Site Availability

Land use needs and site availability within Baltimore or surrounding counties were considered for each option based on consultation with DPW. Options were considered more desirable if they would not require large tracts of land to develop or if they could be easily sited on existing City-owned properties.

Roles and Actors

The potential actors for each option include companies and organizations that have reached out to DPW or the City with proposals for participating in future waste reduction or diversion measures, as well as existing entities within the City that could potentially participate in each option moving forward. Options were considered more desirable if there are many entities in or outside the City with whom the City could partner.

Benefits

The benefits associated with any waste management and disposal option include revenues (e.g. from sale of recovered recyclables or from sale of energy), environmental benefits such as reductions in greenhouse gas (GHG) emissions, and potential job creation. Expected benefits for each option were reported in the Task 5 and 7 Reports. It is noted that all benefits and drawbacks are conceptual level estimates only and that additional data collection and research is required to obtain more accurate estimates.

As reductions in GHG emissions are key goals of the BSP and CAP, changes in GHG emissions serve as the primary surrogate measure of environmental performance associated with each option in this Final Master Plan. Expected GHG emissions were calculated in terms of metric tons of carbon dioxide equivalents (MTCO2E) using the U.S. EPA Waste Reduction Model (WARM). In some cases, benefits are negative (i.e., drawbacks). For example, changes in GHG emissions are reported relative to the 2017 baseline, meaning that negative values represent expected emission reductions relative to that baseline while positive values represent expected increases in GHG emissions.

4.2 Process for Recommending Options

The next four chapters of the Final Master Plan briefly summarize options recommended for inclusion in the Final Master Plan using the established metrics and baseline conditions. These are as follows:

- Chapter 5 – Strategies and policies for encouraging waste reduction and diversion in Baltimore;
- Chapter 6 – Options for reducing and diverting food scraps and other organic waste, traditional recyclables, C&D debris, and non-traditional recyclables;
- Chapter 7 – Options for mixed waste processing; and
- Chapter 8 – Options for providing final disposal of what's left, conservatively based on the full baseline disposal practices in the city and assumed growth in waste generation; and

A final summary of recommended options is provided in Chapter 9, including a broad schedule for phased implementation of various components of different options.

With regard to the recommendation of options in Chapter 9, it should be noted that a business case cannot be made for most of the options that the private sector will be expected to provide. That is, current market conditions and pricing expectations for recovered recyclables do not support these programs (hence, they are not currently provided by for-profit enterprises). The City can help stimulate the market by enacting ordinances requiring that recycling services are provided; however, the costs for complying with these ordinances may be passed on to city businesses and residents.

Finally, although included in Task 5 and of high public interest, immediate changes to DPW's services and administration (e.g., improvements in the City's 311 service, street sweeping, control of illegal dumping, litter issues, etc.) are the subject of ongoing independent studies by DPW and are thus not included in this Final Master Plan.

5. STRATEGIES FOR ENCOURAGING WASTE REDUCTION AND REUSE

Chapters 6 and 7 of this Report will present recommended options to increase diversion of specific material classes from the current disposal waste stream, focusing on facilities and programs (i.e., "hard" infrastructure) that would need to be implemented by the City and/or the private sector in order to achieve the waste reduction and diversion goals of the BSP. Prior to that, Chapter 5 recommends policies and strategies (i.e., "soft" infrastructure) for enactment by the City to promote and increase waste reduction and reuse across multiple material classes and stakeholder sectors.

As outlined here, many "soft" infrastructure options require the engagement of City Council legislators to pass the ordinances needed and the commitment of City Government to implement and enforce new rules. Their success is also dependent on effecting behavioral changes across all socioeconomic sectors in Baltimore to reduce waste from consumers, manufacturers, restaurants and bars, grocery stores, online vendors, and other businesses. Leadership by example from all branches of City government will be essential.

5.1 Legislative Initiatives

A number of legislative initiatives could be enacted by the City Council, or supported at the State Legislature, as a means of helping the City meet the goals of the BSP. These legislative initiatives should focus on reducing waste generation and banning/restricting the use of low value, hard-to-recycle materials. The LWBB Plan makes no attempt to quantify the waste diversion tonnage that could be achieved through full or partial implementation of any legislative initiative, or the costs that would be incurred by the public and private sectors. In the overall context of the LWBB Plan, no single legislative action was assumed to have a significant impact on the quantity of recycling and waste diversion achieved in the city, but could significantly improve the quality (i.e., reduce contamination) of residential curbside and other recycling and composting streams or increase the quantity of material diverted in conjunction with other actions.

Legislative efforts recommended for consideration are listed below. DPW, BOS, and other City department/offices would have no direct control over these initiatives, but could lobby internally for their enactment and help provide data or cost estimates in support of legislators.

1. Bans/restrictions on single-use plastics. A ban on single-use plastic bags has already been passed by the City Council and will take effect in January 2021. Additional efforts to limit the use of plastic utensils and plastic straws could also be considered.

2. Bans/restrictions on expanded polystyrene (EPS), also known as Styrofoam. EPS bans on food serviceware are already in place at both the City and State level. Bans on the use of EPS could be extended to other non-durable EPS products such as coolers; trays used for raw meat, seafood, mushrooms, and other produce; and packing foam and peanuts used in boxes for shipping.

3. Extended producer responsibility (EPR) mandates. EPR is a product stewardship mandate that shifts financial and/or

management responsibility for waste management upstream to the manufacturer of a product and away from the public sector, while incentivizing manufacturers to incorporate environmental considerations into the design of their products and packaging. Applied effectively, EPR can be valuable in helping communities manage and fund the reduction/recycling/diversion of non-recyclable and hard-to-recycle materials. It is noted that these bills would be most effective if passed at the federal or state level, with local governments lending support. Examples of EPR-like initiatives to fund recycling that are already in effect in Maryland include manufacturer fees for certain electronics as well as consumer fees for tires, which are paid to the state. However, the effectiveness of recycling programs funded from these particular fees should be researched further.

4. Product take-back programs. Similar to EPR programs, product take-back programs are a form of product stewardship for hard-to-recycle items and packaging. These initiatives are typically organized by a manufacturer or retailer to collect used products or materials from consumers and reintroduce them to the original processing and manufacturing cycle. It is noted that these bills would be most effective if passed at the federal or state level, with local governments lending support.

5. Mandated recycled content (MRC) laws. MRC laws require that a minimum percentage of post-consumer recycled material be included in certain new products and packaging.

6. Container deposit law (CDL) or "bottle bill." CDLs seek to increase rates of beverage container recovery by implementing a refund program. CDLs are a proven, sustainable method of capturing beverage bottles and cans for recycling. The refund value of the container (usually 5 or 10 cents) provides a monetary incentive to return the container for recycling. This can help provide low income people with an additional source of revenue.

7. Right-to-repair bill. These bills, which typically focus on electronic devices and appliances, refer to government legislation that is intended to allow consumers the ability to access manufacturer product data and spare parts to repair and modify their own consumer products. It is noted that right-to-repair bills would be most effective if passed at the federal or state level, with local governments lending support.

8. Disposal bans or surcharge fees. Defined broadly, these refer to policies that restrict or penalize disposal of certain materials in landfills or WTE incinerators. Common materials considered for disposal bans include food scrap and organic waste (which is outlined as an option for the LWBB Plan in Section 6.1) and clothing and textiles.

Further details and examples are provided in Section 8.6 of the Task 5 Report.

5.2 Other Initiatives and Strategies

Education and Outreach

Educating residents and businesses on the importance of waste reduction, reuse, recycling, and composting is a key factor for achieving the goals of the BSP. The role of education and outreach in the LWBB Plan is detailed in Section 8.1 of the Task 5 Report. Specific education and outreach efforts needed to improve the level of participation in and

effectiveness of recommended waste diversion programs are described in Chapter 6 of this Report.

On 15 May 2020, Mayor Jack Young announced that DPW had received a $250,000 grant from the Recycling Partnership to implement a campaign to help educate residents about items accepted in curbside recycling. The campaign is designed to encourage residents to "recycle right" with the aim of reducing the level of contamination. A main focal point of the effort will be a "Feet on the Street" program designed as an education and outreach strategy, which will have recycling crews and supervisors providing feedback on reducing contamination rates in residential recycling.

Incentive Programs

Incentives for waste reduction and recycling can take many forms. At a commercial level, incentives include the development of a recycling market development zone (RMDZ) to provide loans, technical assistance, and product marketing to businesses that use recyclable materials to manufacture their products within the RMDZ, rewarding recycling efforts by larger waste generators and haulers by offering reduced disposal fees at landfills, and/or offering annual recycling rebates or credits. At a community or household level, incentives include offering grants for community recycling initiatives or providing discounts on property taxes or other City fees for proper and consistent use of recycling bins.

The LWBB Plan focuses on simple incentives that could be offered at a community or household level. Two options entailing relatively modest costs are recommended for consideration by the City:

1. Cash or other rewards for recycling. These serve as direct financial incentives to encourage residents and businesses to reduce waste generation and recycle. The City could consider developing their own program; however, it would be simpler and more cost effective to sign up with an existing national recycling rewards program such as Verde or Recyclebank.
2. Payment for City services using recyclables such as plastic bottles and cans. Reverse vending machines could be set up and used to reward recycling by, for example, offering credit for parking meters or vouchers for public transportation.

These options would most likely be administered by DPW or BOS in coordination with the Dept. of Finance. Some federal, state, or other grant monies may be available to support specific programs. Further details and case histories are provided in Section 8.4 of the Task 5 Report.

Reverse Vending Machine in Sydney, Australia
(Source: envirobank)

Sharing and Reuse Opportunities

Opportunities for sharing items that are used infrequently are becoming more prevalent in many communities. The City could partner with charitable and nonprofit organizations to provide opportunities for the public to borrow items such as shop tools, kitchen appliances, musical instruments, audio/visual media equipment, community farming and food processing equipment, or bikes. Items can be donated, or libraries can purchase items and cover expenses through user fees. Two successful examples already exist in the city (the Baltimore Community Tool Bank and Station North Tool Library), which could serve as a template for developing new initiatives. Other options include fix-it/repair clinics (see Section 6.4 in content of bulky waste reuse) and swap (freecycling) events. Further details and examples are provided in Section 8.5 of the Task 5 Report.

By eliminating duplicate purchases of infrequently used items, sharing/reuse programs provide a low-cost mechanism for reducing waste generation and raising awareness about unnecessary purchases. Depending on the City's level of engagement in these initiatives, some staff time and effort would be expected for promotion and support, with responsibility most likely falling on BOS or DPW, depending on how and where an event was staged. DPW's DOCs or Green Resources and Outreach for Watersheds (GROW) Centers could be suitable forums.

Other Options

Other options that are recommended for consideration by the City are:

1. Inter-judicial partnerships. In keeping with the guiding principles for the LWBB Plan, the City should consider partnering with neighboring counties to facilitate knowledge sharing and exchange of ideas, exploring joint procurement opportunities, sharing of critical infrastructure for new waste diversion programs, and harmonization of programs so that residents who work and live in the region all have access to similar levels of service. As examples, the City has previously coordinated anti-litter campaigns with Baltimore County and has coordinated a number of stormwater projects with surrounding counties.
2. Green procurement, which is purchasing products and services that minimize adverse human health and environmental impacts. This provides the City with an opportunity to lead by example.
3. Supporting innovation and research by providing grants or hosting incubators for universities, start-ups, and other entities investigating new ways to reduce and reuse waste.

Fix-It/Repair Clinic in Hennepin County, MN
(Source: hennepin.us)

6. RECYCLING AND DIVERSION OPTIONS

This chapter presents recommended options for increasing waste reduction, diversion, and recycling. Where applicable, policies aimed at mandating participation in waste diversion and recycling programs, and education and outreach efforts to improve the level of participation in and effectiveness of programs, are also reviewed. These efforts are intended to make it easier and more meaningful for residents and businesses to participate in new programs.

6.1 Organic Waste Reduction and Diversion

With approximately 163,200 tons disposed in Baltimore in 2017, organic waste represents the third largest component of the disposal stream (behind C&D waste and traditional recyclables). Very little organic waste is currently diverted (the residential diversion rate for organic waste is roughly 2%); therefore, there is a lot of room for growth in the City's efforts to reduce, reuse, and divert organic waste.

Food Waste Reduction and Recovery

Food waste reduction targets and specific strategies for reducing food wastage from different sectors in the city are laid out in the BFWRS. As detailed in Section 3.1 of the Task 5 Report, it is assumed that food waste reduction targets will be met through a combination of food rescue and donation (e.g., via food banks) and true source reduction (e.g., educating consumers to purchase only the amount of food they need and hence generate less food waste). This will require a coordinated effort between the City, local food generators (businesses, universities, and residents), and local food rescue/donation organizations such as the Maryland Food Bank. The BOS rather than DPW is expected to lead these efforts.

If the goals of the BFWRS are met in full, the total reduction potential for this program is estimated to be 72,400 tons of food waste per year (11% of the BSP's diversion target).

Costs were separated into operational costs (i.e., for constructing and operating food rescue infrastructure and programs) and administrative costs (i.e., for education and outreach, tracking, enforcement, and health monitoring). A summary of maximum expected costs after full program implementation is provided in the table below, with costs directly allocated to the City highlighted in orange. No cost offsets in the form of revenues are expected.

Expected Costs and Revenues for Food Waste Reduction and Recovery

Item	CAPEX	Annual OPEX	Annual Revenue
Food Rescue Programs[1]	$50M	$63M	-
Education and Outreach[2]	-	$3.1M	-
Program Management[3]	-	$0.5M	-
Health and Safety Monitoring[4]	-	$1.1M	-
TOTAL	**$50M**	**$67.7M**	**-**

Notes:

1. Based on 2018 Annual Report from Maryland Food Bank. The equivalent value of food (in-kind donations) is not included.
2. Based on studies from Minnesota, this assumes 47 lbs. of food reduction per dollar spent on education and outreach.
3. Based on DPW's spending on administration of the recycling program.
4. Based on DPW's spending on the rat abatement program.

As indicated in the table on the previous page, the most likely delivery mechanisms for food waste reduction and recovery programs are for the City to cover administrative costs (i.e., education and outreach, program management, and health and safety monitoring) with the nonprofit and/or private sectors covering the costs of developing food rescue infrastructure and programs. It is assumed these programs would be voluntary with food provided as in-kind donations and no fines assessed for non-participation (i.e., no costs are allocated to enforcement). Although the City could enact ordinances requiring large food waste generators (e.g., supermarkets, restaurants, etc.) to cover some/all of the costs of food rescue, this would significantly increase administration and enforcement costs and is not recommended.

The main components of this option may be funded in different ways depending on the delivery mechanism that the City chooses. The nonprofit sector may be able to cover/offset the cost of food rescue programs through grant income and/or reduce operating costs through monetary donations and volunteering. A PPP contract is unlikely to be feasible as there is no revenue stream to offer to the private sector as an incentive. The City could choose to fund operation and administration of these programs in the following ways:

1. Public funds: The City could allocate funds from the general fund or recover costs as a line item on propery tax bills.
2. Grants (federal, state, or other): The City could apply for grants to help cover some administrative costs, in particular education and outreach.

The BFWRS calls for food waste reduction targets to be met by 2040. It is assumed that the BFWRS would be implemented in four roughly equal phases, with expansion every five years or so. As a way to "lead from the front," it is assumed that the City would implement food waste reduction targets for government offices and public schools as part of the first phase. Assuming that the City is able to meet the food waste reduction goals by 2040, the expected timeframe for the program to achieve its maximum potential is estimated as 20 years.

Site availability was not considered for this program, as food rescue infrastructure is already in place in Baltimore (through nonprofits such as the Maryland Food Bank). It is likely that existing facilities will expand as necessary to accommodate increased food rescue capacity. Establishing new food rescue operations also does not require specialized site preparation/construction or a long lead time for design and permit approval. Several unused or underutilized buildings are available in Baltimore that could be rapidly refitted to serve this purpose.

The primary actors for this option are BOS and food rescue organizations such as the Maryland Food Bank, Food Rescue Baltimore, the Food Recovery Network, Helping Up Mission, Paul's Place, the Franciscan Center, and Hungry Harvest. Universities and other higher education institutes in the city can also play a role.

The primary benefit is feeding hungry people in the city. If the BFWRS targets are met in full, the estimated GHG emission reductions achieved would be about 305,000 MTCO2E annually. Jobs creation would be focused at food rescue organizations, although much of this could comprise volunteer labor.

Residential Organics Collection and Processing

Currently, there is no centralized program for diversion of organics from residential solid waste in Baltimore, although small-scale composting is available only through local community collectives, farm-based initiatives, small-scale privately contracted collection services, and personal backyard compost systems. The BOS has also implemented a food scrap drop-off service through the "Food Matters" program at the weekly Jones Falls and Waverly farmers' markets. Collected food scraps are used by a tenant farmer to feed pigs. In addition, the Department of Recreation and Parks (BCRP) operates Camp Small, a 5-acre wood waste collection and recycling yard located in the Jones Falls valley just north of Coldspring Lane at I-83. However, there is limited scope for expanding this facility to offer a residential yard waste or food waste composting program.

Expanding the use of small-scale organics processing capacity is a straightforward way to increase participation in residential organics diversion. The BFWRS lays out a series of recommendations to expand existing capacity in Baltimore (e.g., improving residents' access to backyard composting bins, establishing school gardens at public schools to encourage on-site gardening and composting, and launching urban farming, community garden, or "adopt a lot" programs to turn empty lots into parks and gardens). The City may choose to encourage these programs by providing grants, interest-free loans, or subsidies to local community composting initiatives or having set-aside provisions for local small businesses and nonprofits in future composting procurements and contracts.

Notwithstanding the positive role of small-scale operations, the City will need a wholesale approach to achieve the goal of the BFWRS of providing all residents with access to composting by 2040 and meeting food waste diversion targets for the residential sector of 80-90% as detailed in Section 3.2 of the Task 5 Report. To meet these goals, and to maximize organics diversion, it is recommended that separate collection and processing of organic waste would be offered to the over 200,000 households in the City currently served by DPW for trash and recycling collection as well as to City government buildings and public schools. This entails establishing a three-bin program for trash, recycling, and organics, with new collection bins for source separated organics (SSO) provided to each property served by the program. SSO collection would be added to existing weekly collection services. It is assumed that SSO would also be collected at the residents' drop-off centers operated by DPW.

Three-Bin Collection, Left to Right: Recycling, Composting, and Trash
(Source: San Francisco Strategic Plan)

Although many processing methods could be combined to achieve the diversion goals for residential organics, a phased-in decentralized

approach is recommended in which 20,000 ton/year composting facilities would be developed sequentially in the city (assumed annual throughput capacity of 20,000 tons includes bulking materials, which may be supplied by BCRP). It is assumed these would operate as covered aerated static piles (CASPs), the dominant technology used for organics processing in the U.S.; however, other composting or anaerobic digestion (AD) technologies may be employed if at comparable performance and costs. As such, use of the term "composting facility" in this section is for simplicity only and does not imply an endorsement of CASPs over any other technology.

CASP Operation at the Organics Composting Facility in Prince George's County, MD

(Source: sustainable-generation.com)

It is noted that implementing the food waste reduction targets outlined in the BFWRS would reduce the availability of residential organics; therefore, the recommendations presented here assume that the reduction goals outlined in the BFWRS are implemented and met in full.

It is also noted that constructing a mixed waste processing (MWP) facility, which would include an AD and/or gasification process as reviewed in Section 7 of this Report, would compete for organics as feedstock. The City would thus need to decide on one course of action for resident organics management and not develop competing programs.

Assuming the food waste reduction goals of the BFWRS are met, the additional organics diversion potential for a residential organics composting program is estimated to be 42,800 tons per year (6.5% of the BSP's diversion target).

To estimate costs, it was assumed that additional trucks would be required (i.e., DPW could not realistically use its existing fleet to provide additional collection). A summary of maximum expected costs after full program implementation is provided in the table below, with direct costs allocated to the City highlighted in orange.

Expected Costs and Revenues for Residential Organics Diversion

Item	CAPEX	Annual OPEX	Annual Revenue
Curbside Bins (Households)[1]	$7M	-	-
Bins and Dumpsters (Schools)[2]	$220k	-	-
Bins and Dumpsters (City Govt.)[2]	$190k	-	-
Additional Trucks[3]	$12.6M	-	-
Collection Services[4]	-	$12.5M	-
Composting Facilities[5]	$10.8M	$4.4M	$2M
Administration and Outreach[6]	-	$600k	-
TOTAL	**$30.8M**	**$17.5M**	**$2M**

Notes for table on previous page:

1. Assumes 35-gallon bins supplied to 200,000 serviced locations at unit cost of $35 per bin.
2. Assumes 10-gallon bins supplied at rate of one bin per 25 students/employees and unit cost of $20 per bin for collection in classrooms/offices; 65-gallon bins supplied at a rate of one bin per 100 students/employees and unit cost of $45 per bin for collection from communal dining areas; and 2-CY dumpsters provided at a rate of one dumpster per 500 students/employees and unit cost of $800 per dumpster for bulk consolidation of collected organics.
3. Assumes addition of 70 new 20-CY load packers at unit cost of $180,000 per truck.
4. Assumes 50% of DPW's 2018 budget for trash and recycling collection services ($25,064,000). It is assumed this includes labor, depreciation on assets, truck maintenance, and fuel costs.
5. Assumes four CASP composting facilities, with unit CAPEX of $2.7M (incl. land acquisition, site preparation and engineering, compost system, and equipment); unit annual OPEX at $1.1M (incl. cost of labor, benefits, repair and maintenance, utilities and fuel, and disposal of residuals); and unit revenue of $30 per CY of high-quality compost generated.
6. Assumes $3 per household per year.

The three main components of this option (i.e., collection, processing, and education and outreach) may be funded in different ways depending on the contract mechanism for service delivery that the City chooses to use. As indicated in the table above, it is assumed that DPW would be responsible for education and outreach; however, workable contract mechanisms for the other two components include:

1. Public: DPW could provide organics collection to residents and construct its own organics processing capacity.
2. Private: DPW could contract out organics collection and/or processing to a private third party.
3. PPP: DPW could develop organics processing capacity as part of a PPP contract where DPW provides a land lease and a guaranteed waste stream with a private third party constructing and operating the facilities.

The City could choose to fund operation and administration of the residential organics diversion program in the following ways:

1. Public funds: To cover program costs, the City could allocate money from the general fund, establish an enterprise fund, direct bill for services, or add costs as a line item on property tax bills.
2. Grants (federal, state, or other): The City could apply for grants to cover some program costs. This option could be used to cover specific costs, such as education/outreach or the costs of providing organics bins to residents, schools, or City government buildings.

Other funding options such as pay-as-you-throw (PAYT), a usage-based billing system (similar to water billing), reducing trash or recycling collection frequency to cover the cost of adding a weekly organics collection, or charging fines for non-participation were considered but are not recommended as they could result to high administration and enforcement costs, low participation rates, compromised recycling habits, and/or increased illegal dumping.

The BFWRS calls for food waste reduction targets to be met by 2040. The timeframe to achieve the full diversion potential from this program was estimated to be 20 years, with the program implemented over two phases. Phase I (one facility) would involve collection from public schools and city government offices, with a small residential pilot program. Phase II would involve a step-by-step

expansion of the program to remaining neighborhoods with phased construction of three additional composting facilities. It is expected Phase II would begin implementation about 5-7 years after Phase I.

It is estimated that each composting facility would require a property with at least four acres of usable space to process 20,000 tons of organics per year. There are a number of City-owned sites that potentially meet this requirement, including the closed Monument St. Landfill or land adjacent to Eastern Sanitation Yard (Bowleys Lane) and Western Sanitation Yard (Reedbird Avenue).

The primary actors for this option are DPW and/or private companies that could provide collection services and/or organics processing. These include Veterans Compost, Acme Biomass Reduction, Mundea, Compost Cab, BioEnergy Development Company, Veolia, and Organix Solutions. State agencies Maryland Environmental Service (MES) and the Northeast Maryland Waste Disposal Authority (NMWDA) have deep experience with facility financing and operation on behalf of public owners. For example, MES operates the Prince George's County composting facility. The Baltimore City Composting Facility, which composts sewage sludge at the Back River Wastewater Treatment Plant, is operated under a PPP between the City, NMWDA, and Veolia.

Beyond circular economy benefits of converting organic waste into reusable compost product, if the BFWRS targets are met in full the additional GHG emission reductions achieved are estimated to range from 4,500 to 8,950 MTCO2E annually. Total job creation between collection and processing is estimated at 176 full-time equivalent (FTE) employees.

Commercial Organics Collection and Processing

In 2017, approximately 30,600 tons out of 92,000 tons (33%) of commercially generated organics were diverted from disposal. This number includes approximately 12,200 tons of yard waste, 7,700 tons of wood waste (diverted to Camp Small), and 10,700 tons of food waste. Commercial waste collection, including from public schools and universities, is currently handled by private haulers in Baltimore. As such, exact destinations for currently diverted organics are not reported in detail; however, the likely destination is private composting facilities (e.g., Veteran Compost).

The City has no direct control over commercial organics diversion but can influence diversion rates by implementing a combination of incentives and mandates and/or by supporting legislation at the state level. It is noted that state legislation enacted under HB 510 in 2019 will prohibit the owner/operator of a disposal facility from accepting loads of separately collected organic waste for final disposal unless they provide for organics recycling. Further mandates on organics diversion may also be enacted in upcoming legislative sessions.

The BFWRS lays out goals for a 50% reduction in commercial food waste generation in Baltimore by 2040 but does not provide any goals for food waste diversion. As such, various policy options that the City could enact are recommended in this section and an estimate of the achievable diversion potential provided for each policy option without reference to any set goals or targets. It is assumed that increasing organics diversion in the commercial sector would be achieved through selective policy implementation and enforcement rather than by DPW stepping in to collect commercial organics and operate additional processing capacity. This requires action on the part of the City Council to pass regulations and

by DPW for subsequent administration and enforcement. Separate collection and processing of organic waste would be required of the City's commercial sector (i.e., all those not currently served by DPW) with waste collection and processing services provided by the private sector. Specific policy options in increasing order of stringency are:

1. A subsidy or credit for voluntary organics diversion;
2. Surcharge pricing for organics disposal;
3. Organics disposal ban on very large generators (> 2 tons/week);
4. Organics disposal ban on large generators (> 1 ton/week); and
5. A blanket ban on organics disposal across the commercial sector.

It is assumed that requirements for commercial organics composting would be phased in, starting with Option 1 above and gradually moving to Option 5. Details are provided in Section 3.3 of the Task 5 Report. Similar to increasing residential composting, for this analysis it is assumed that all organics would be composted at decentralized, 20,000 tons/year CASP composting facilities (again, this is for simplicity only and does not imply an endorsement of CASPs over any other technology). It is assumed that these facilities would operate independently of those proposed for the residential organics program; however, co-processing of commercial and residential organics could serve to lower costs in both programs by providing greater efficiencies and economies of scale.

Assuming the food waste reduction goals of the BFWRS are met, the maximum additional organics diversion potential for a commercial organics composting program is estimated to be 35,500 tons per year once a blanket ban is enacted (5.5% of the BSP's diversion target).

The expected costs for this program include administrative costs (i.e., education and outreach, enforcement, and coordination), subsidies and surcharges, collection costs, and organics processing costs. A summary of the costs expected for each implementation option is given in the table below, with direct costs allocated to the City highlighted in orange. A sum total cannot be provided since each option is sequentially replaced by the next and thus costs and revenues are not necessarily realized concurrently.

Expected Costs and Revenues for Commercial Organics Diversion

Item	Option	CAPEX	Annual OPEX	Annual Revenue
Education and Outreach	All	-	$100k	-
Coordination/Enforcement[1]	1-2	-	$60k	-
	3	-	$180k	$75k
	4	-	$180k	$195k
	5	-	$180k	$390k
Subsidy[2]	1	-	$300k	-
Surcharge[3]	2	-	-	$2.5M
Collection ($/ton)[4]	All	$154	$75	-
Composting[5]	1-4	$2.7M	$1.1M	$500k
	5	$8.0M	$3.1M	$1.5M

Notes:

1. For Options 1-2, OPEX assumes one FTE analyst at a cost of $60,000 for program coordination. For Options 3-5, OPEX assumes three FTE inspectors at a unit cost of $60,000 for program coordination and enforcement. Revenues are obtained in the form of fines and assume each inspector can perform 15 inspections per day with a citation issued at $500 per violation. Violations are assumed to result for 2% of inspections under Option 3, 5% of inspections under Option 4, and 10% of inspections under Option 5.

Notes continued for table on previous page:

2. OPEX assumes subsidies to be paid to participating businesses as 20% of organics disposal costs.
3. Revenue assumes surcharge collection equivalent to 20% of a typical landfill tipping fee ($67.50/ton at QRL).
4. Total CAPEX and OPEX varies by option. Unit CAPEX assumes 2-CY dumpsters at a unit cost of $800/dumpster and 20-CY collection trucks at a unit cost of $180,000 per truck (see photograph below). Unit OPEX is based on DPW's current collection costs.
5. Based on unit costs for a 20,000 tons/day CASP composting facility. CAPEX includes cost of land acquisition, site preparation and engineering, compost system, and equipment. OPEX assumes cost of labor, benefits, repair and maintenance, utilities and fuel, and disposal of residuals. Revenue assumes $30 per CY of high-quality compost generated. Options 1-4 assume one facility is built. Option 5 assumes three facilities are built.

Enclosed Compactor Container Suitable for Collecting Food Waste from Large-Capacity Customers

As indicated in the table on the previous page, the City is expected to be responsible for administrative costs (education, outreach, coordination, and enforcement) as well as the handling of subsidies and surcharges, while the private sector would be responsible for collection and processing. The private sector would recover its costs through service fees charged to customers. In general, there are three main ways in which the City could fund its responsibilities, including soliciting money from the general fund, applying for grants, and self-funding through revenue from citations and the proposed surcharge on organics disposal (this is not applicable to all options). Although the handling of subsidies and surcharges could be transferred to the private sector via a PPP contract, this is not recommended as it could be difficult and costly to track.

If co-processing of commercial and residential organics is selected, then processing of commercial organics could be provided by operators of residential organics processing facilities (if sufficient spare capacity exists). However, a better option would be for DPW to contract out residential organics processing to a private company as part of a commercial organics processing service. This could be contracted directly or through a PPP where DPW provides a land lease and a guaranteed waste stream with a private third party constructing and operating the facilities. A PPP would also allow DPW's administration costs to be wrapped into the contract.

The timeframe to achieve the full diversion potential from this program was estimated to be 20 years, with the program implemented over four phases. Phase I would be a combination of Options 1 and 2, while Phases II through IV would be a stepwise implementation of Options 3 through 5. It is anticipated that Phase I would last approximately seven years, followed by two years for Phase II, a further two years for Phase III, and then nine years for Phase IV to achieve the full diversion potential.

Site availability was not considered for this program, as it is assumed the private sector will be responsible for providing commercial composting services. However, siting needs will be similar to those previously discussed for residential composting services. If co-processing of commercial and residential organics is selected, previous siting suggestions for residential composting facilities could apply. Other potential sites include the former Pulaski Incinerator property, City-owned land at Wagners Point, unused areas at Port of Baltimore properties in Dundalk or Locust Point, or unused areas at Sparrows Point.

The primary actors for this option are DPW for program administration and the private sector for program execution. Private companies who could provide collection services and/or organics processing include Veterans Compost, Acme Biomass Reduction, Mundea, Compost Cab, BioEnergy Development Company, Waste Management, Republic Services, Veolia, and Organix Solutions, and Trilogy Finance Group.

Beyond circular economy benefits of converting organic waste into reusable compost product, if the BFWRS targets are met in full the annual GHG emission reductions achieved from commercial organics composting are estimated to range from 1,700 MTCO2E for Option 1 to 14,150 MTCO2E for Option 5. Job creation is estimated at up to 3 FTE City employees and a further 71 FTE employees in the private sector.

6.2 Improvement/Expansion of Recycling

This section focuses on "traditional" recyclables, that is materials that are widely accepted in single-stream curbside collection programs across the U.S. These include mixed paper, cardboard, plastic no. 1 or polyester (PET/PETE), plastic no. 2 or high density polyethylene (HDPE), other mixed plastics, aluminum cans, steel cans, and glass bottles and jars. Because these items are accepted as single-stream recyclables (SSR), the shorthand term SSR is often used to describe mixed traditional recyclables. SSR are defined as secondary materials in recycling markets. SSR is estimated to comprise about 240,700 tons of the approximately 816,000 tons in the disposed waste stream in Baltimore annually, or about 30% of total disposed tonnage. Recovery of additional SSR could thus significantly contribute to working toward the BSP's goal of 90% waste diversion.

Recycling services recommended in this section are derived from analysis in Task 5, with options divided into improving existing services and expanding recycling services to currently unserved or underserved sectors in the city. Section 4.1 of the Task 5 Report provided a cautionary review of the status of the recycling industry, in particular the impacts of China's "National Sword" policy which has severely limited imports of mixed recyclables since 2018, and other issues regarding the unpredictable global secondary materials market. Many jurisdictions, including the City, that were previously receiving revenues from SSR collection are now paying significant fees to haulers or MRFs to take it. Therefore, it is important to realize that options outlined in this section may not be financially viable unless new technologies are developed, global recycling markets stabilize, and/or new domestic demand is stimulated. This may include chemical recycling to handle hard-to-

recycle materials such as mixed plastics (as discussed in Section 6.3 of the Task 5 Report). Predicting the evolution of recycling markets and technologies over the next several years is not possible, and the City is cautioned to carefully examine up-to-date industry trends and technologies, as well the potential for securing direct or indirect agreements with end users for secondary materials before making any meaningful investments in additional SSR collection and processing.

More impactful and valuable than goals for increasing recycling are source reduction goals, that is preventing these materials from entering the waste stream in the first place or developing true closed-loop systems for material reuse. This requires changes in the design, manufacture, purchase, and use of products; eliminating excessive layers of packaging; and laws/incentives for consumers to have the option to choose reusable rather than single-use products and guide behavioral changes (e.g., eating in at restaurants using washable cups, plates, and utensils rather than buying take-out in single-use containers and bags, or allowing consumers to bring their own reusable containers for food take-out service or leftovers).

Source reduction goals are generally best achieved by implementing extended producer responsibility (EPR) programs, product take-back programs, and bans or restrictions on the use of single-use products, especially in the retail and food service sectors. This must be coupled with offering realistic alternatives to banned items; educational programs to educate consumers on why programs/bans have been implemented and what is expected from individuals for these programs/bans to succeed; and a willingness on the part of the City to pass regulations, inspect, and enforce. Chapter 5 dealt with options related to reduction and reuse measures. Although not quantified here, when looking at long-term SSR tonnages and expectations for recovery rates, it is important to recognize the impact that successful source reduction measures would have on decreasing the SSR stream.

Improved Residential Curbside Recycling

This category of options assumes that DPW would make changes to their existing curbside SSR collection program to improve diversion of traditional recyclables from the residential waste stream to help meet the 90% diversion goal of the BSP. DPW currently provides weekly curbside SSR collection to single family residences in Baltimore as well as public housing and some public schools and small businesses. Currently, participation in recycling is optional. Participating residents must supply their own recycling containers, although bins can be purchased from DPW at a subsidized cost. Currently, bins/carts are not required for recycling. Residents can use any container, even a paper bag or cardboard box, although plastic bags are not allowed.

The option recommended for improving the existing curbside program is providing free recycling carts with secure covers to residents to increase participation in curbside recycling. It is recommended that participation in curbside recycling remains voluntary and that residents may continue to supply their own containers; however, to control litter issues associated with the current curbside recycling program, the City should enact an ordinance requiring residents to use containers with secure covers.

Other options evaluated but not recommended include implementing dual or multi-stream recycling to provide separate collection containers for SSR loads containing fiber (i.e., paper and cardboard) and glass, or revising bin sizes and allocations to provide a larger recycling bin and a

smaller trash bin. These options are considered to provide negligible benefit while entailing more complex, higher cost operations. Options to reduce trash collection frequency to cover the cost of recycling; direct billing for trash collection (e.g., implementing a PAYT policy in which residents would pay for trash collection based on the size and number of trash bins used but would not be directly charged for recycling); or making recycling mandatory and charging fines for non-participation were also considered but are not recommended. These options are not considered workable, at least in the short to medium term, as they could result in high administration and enforcement costs, low participation rates, compromised recycling habits (i.e., higher contamination rates and lower value SSR loads), and/or increased illegal dumping.

Two potential mechanisms are recommended for processing collected SSR material, with DPW initially continuing to contract with WMRA's MRF in Elkridge, MD while constructing a series of decentralized mini-MRFs around the city. The mini-MFR option is preferred as it gives the City more control over recycling. Mini-MRFs also have the advantage that they can be housed in moderately sized unused industrial properties in the city. As such, it is expected that all processing will gradually transition to mini-MRFs. An option for DPW to stop contracting with WMRA in lieu of constructing a new centralized MRF to handle all SSR collected in the city was considered, but is not recommended due to its high capital costs.

A target diversion rate of 90% is applied to all residential SSR except mixed paper and mixed plastic, for which a lower diversion target of 50% is applied to reflect current recycling challenges for these materials. Based on this, a maximum diversion potential of 84,200 tons per year was estimated for residential SSR (13% of the BSP's diversion target).

Workers at a Simple Mini-MRF Sorting System
(Source: Revolution Systems)

Expected costs include education and outreach, collection, and processing. Currently, it costs DPW about $24.6M annually to provide residential trash collection and recycling. As an extension of existing services with voluntary participation, no additional collection or administrative costs are assumed for improving recycling services. This is reasonable given that DPW already provides weekly collection of both trash and recycling, and the improved recycling program would lead to more materials moving from the trash stream to the recycling stream (i.e., the total quantity of materials collected would remain the same). A summary of expected costs is given in the table overleaf, including costs for processing additional recycling either by WMRA or developing mini-MRFs in the city. Direct costs allocated to the City are highlighted in orange. A total cannot be provided as the two processing options are mutually exclusive.

Expected Costs and Revenues for Improved Residential Recycling

Item	CAPEX	Annual OPEX	Annual Revenue
Education and Outreach	-	$50k	-
Provide Free Recycling Carts[1]	$9M	-	-
Contract with WMRA[2]	-	$5.1M	-
Develop Mini-MRFs[3]	$17.6M	$10.4M	$3.8M

Notes:

1. Assumes new 65-gal. recycling carts will be supplied to 200,000 serviced locations at unit cost of $45 per cart.
2. Includes processing additional SSR collected from improved residential programs (84,200 tons per year). OPEX assumes a WMRA tip fee of $61/ton, the effective tip fee paid by the City in 2018.
3. Assumes processing all SSR collected in the city, which includes collection from improved residential programs (84,200 tons per year) as well as current SSR collection (20,200 tons per year) and expected SSR collection from expanded recycling programs (69,300 tons per year, see next section). CAPEX assumes a total of 16 mini-MRFs will be developed with a unit capacity of 5.5 tons/hour at a unit cost of $1.1M. OPEX includes estimated labor and maintenance costs. CAPEX and OPEX data is from Revolution Systems, Inc. Revenues assume 85% recovery of saleable recyclables (i.e., a 15% rejection rate) at bulk value of $26 per ton.

The three main components of improved recycling (i.e., education and outreach, collection, and processing) may be funded in different ways depending on the contract mechanism for service delivery that the City chooses to use. As indicated in the table above, it is assumed that DPW would be responsible for education and outreach, providing free recycling carts to SFHs, and contracting with WMRA until processing of SSR can fully transition to mini-MRFs. To cover program costs, the City could allocate money from the general fund, establish an enterprise fund, direct bill for services, or recover costs as a line item on property tax bills. Although residential curbside recycling services could be privatized through a franchising scheme, continuation of existing services by DPW is recommended.

Several workable contract mechanisms exist for developing a mini-MRF program, including DPW owning and operating the mini-MRFs, DPW contracting out mini-MRF development to a private third party, or a PPP contract where DPW provides a property lease and guaranteed SSR feedstock with a private third party constructing and operating the facilities. Contract mechanisms involving the private sector are preferred.

It is assumed that supply of recycling carts could be implemented within one year. An educational outreach program to alert residents to the program would be required. With respect to SSR processing, contracting with WMRA represents a short-term option, while permitting and constructing new mini-MRFs would take 2-5 years to commence and up to 10 years to complete.

At full buildout of the mini-MRF program, a total of 16 facilities is anticipated. It is estimated that each mini-MRF can fit in buildings as small as 5,000 square feet. As such, mini-MRFs could be located throughout the city at unused industrial properties. Specific locations have not been identified at this stage.

The primary actors for this option are DPW and WMRA (until mini-MRF capacity is available), as well as the private companies and project funders with whom DPW could contract to provide mini-MRFs for SSR processing. These include Revolution Systems and the Closed Loop Fund.

If recycling targets are met in full, the additional GHG emission reductions achieved are estimated at up to 195,000 MTCO2E annually. Job creation is estimated at 10 FTE employees per mini-MFR, for a total 160 FTE employees. These jobs are most likely to be created in the private sector.

Expanded Access to Recycling

Collection of single-stream recyclables from the commercial sector (which includes most MFBs and businesses in Baltimore) is currently provided by private haulers. In 2017, about 34,850 tons of SSR were diverted from disposal in the private system for an average recycling rate of 24%. This category of options assumes that the City would expand access to recycling in an effort to improve diversion of traditional recyclables from the commercial sector. Based on evaluation of options in Section 4.3 of the Task 5 Report, recommendations for expanding the recycling network and increasing the overall recycling rate in the city include:

1. Expand SSR collection services to include all MFBs that do not currently have access to recycling;
2. Expand recycling services to the entire commercial sector (i.e., require all privately-owned properties to provide recycling services);
3. Provide mobile collection units (i.e., modified trailers or trucks) to provide access to recycling for residents without vehicles or means to travel to residents' drop-off locations; and
4. Improve access to recycling in public spaces by providing additional "smart cans" with separate recycling and compacting trash receptacles, which improve collection efficiency).

With regard to Options 1 and 2, the City currently has no direct control over commercial recycling but can influence recycling rates by enacting ordinances and supporting legislation at the state level. It is thus assumed that increasing SSR collection in the commercial sector would be achieved through selective policy implementation and enforcement rather than by DPW stepping in to perform collections.

While DPW provides SSR collection to some MFBs (predominantly public housing and smaller private buildings such as subdivided houses), most residents in MFBs rely on private haulers contracted by landlords for trash and recycling services. Reportedly, private haulers periodically reject recycling loads from MFBs and/or stop services altogether due to contamination issues (generally, because they may be fined or have their loads rejected at receiving MRFs if contamination is too high). This leads to inconsistent collection and contributes to low participation in recycling programs among MFB residents. By ensuring recycling services are provided at all MFBs, DPW could help create a more stable recycling environment. The state has mandated recycling at MFBs with more than ten units; therefore, the most cost-effective and direct way to ensure SSR collection at these MFBs is through enforcement of the state mandate. Expanding access to recycling at MFBs with less than 10 units would require issuance of a City ordinance mandating that landlords of such MFBs provide recycling services, with enforcement by DPW or DHCD. As managing contamination levels will be critical to the success of expanded SSR collection programs, a high level of education and outreach will be necessary.

To expand recycling services to the entire commercial sector, the City would need to require all businesses to provide recycling services. The state has recently mandated recycling at office buildings with greater than 150,000 square feet. Therefore, this option would involve DPW's enforcement of the state mandate at larger commercial properties. Expanding access to recycling at smaller commercial properties would require issuance of a City ordinance mandating that property owners/managers provide recycling services, with enforcement by DPW.

Options 3 and 4 would require direct action by DPW. While DPW currently accepts SSR at residents' drop-off centers, residents must have the means to transport these materials. Provision of a more convenient way to accept these materials may encourage additional recycling. Offering mobile collection also provides an opportunity for DPW to have one-on-one outreach with residents who use the mobile service and to provide education on improving recycling habits.

Mobile Recycling Service Provided by Polk County, NC
(Source: PolkNC.info)

DPW has already deployed several smart can combinations (recycling can plus solar-powered compacting trash can) in Downtown and South Baltimore locations. These wirelessly communicate their real-time status and notify collection crews when they are full and ready to be emptied. Compacting models increase a can's effective capacity by up to five times, which helps streamline collection operations and increase productivity. Although expensive, deploying smart cans should have a positive effect on reducing litter, thereby reducing DPW's costs for litter cleanups.

A target diversion rate of 90% is applied to all SSR from the commercial sector except mixed paper and mixed plastic, for which a lower diversion target of 50% is applied to reflect current recycling challenges for these materials. From this, a maximum diversion potential of 69,300 tons/year was estimated (10.5% of the BSP's diversion target).

Smart Can Unit (Combined Recycling and Trash) in South Baltimore

In addition to the recommended options for expanding SSR collection, mechanisms for processing additional collected SSR material need to be considered. It is assumed that all additional SSR will initially continue to be sent to WMRA's MRF in Elkridge, MD (or other private MRFs) while a series of decentralized mini-MRFs is constructed around the city. As such, the total capacity estimate for mini-MRFs provided in the previous section includes the maximum expected quantity of SSR collected from expanded services to MFBs and the commercial sector in the city. Processing costs are thus not included in the estimates in the table below.

The expected costs for this program include administrative costs (i.e., education and outreach, enforcement, and coordination) as well as the cost of additional collection and recycling units. A summary of expected costs for each option is given in the table below, with direct costs allocated to the City highlighted in orange. A total cannot be provided as some options are mutually exclusive.

Expected Costs and Revenues for Expanded Recycling Services

Item	Option	CAPEX	Annual OPEX	Annual Revenue
Education and Outreach	All	-	$50k	-
Coordination/Enforcement[1]	1-2	-	$180k	$175k
	3-4	-	$30k	-
Expand Recycling to MFBs[2]	1	$1M	$450k	-
Exp. Recycl. to Com. Sect.[3]	2	$10.8M	$5.2M	-
Mobile Recycling Units[4]	3	$150k	$150k	-
Improve Public Recycl.[5]	4	$8.2M	-	-

Notes for table opposite:

1. For Options 1 and 2, OPEX assumes three FTE inspectors at a unit cost of $60,000 for program coordination and enforcement. Revenues are obtained in the form of fines and assume each inspector can perform 15 inspections per day with a citation issued at $500 per violation. Violations are assumed to result for 3% of inspections. For Options 3 and 4, OPEX assumes one half-time analyst at a cost of $25/hour for program coordination.
2. CAPEX assumes cost of 20-CY collection trucks ($180,000 each) and 2-CY dumpsters ($800 each) to provide collection to approximately 59,500 MFBs not currently served by DPW. OPEX assumes unit collection cost of $75.30 per ton based on current DPW collection costs (i.e., assuming private haulers have similar cost structures to DPW). Revenues are realized by processor and thus not included here.
3. CAPEX assumes cost of 20-CY collection trucks ($180,000 each) and 2-CY dumpsters ($800 each) to collect 69,300 tons of recyclables per year. OPEX assumes unit collection cost of $75.30 per ton based on current DPW collection costs (i.e., assuming private haulers have similar cost structures to DPW). Revenues are realized by processor and thus not included here.
4. CAPEX assumes purchase of three small trucks with trailers. OPEX assumes one FTE driver/laborer per truck at a cost of $50,000 each. Additional costs for processing and revenues from sale of recovered recyclables are assumed negligible.
5. CAPEX assumes purchase of 2,000 smart cans at a cost of $4,100 each. OPEX is assumed to be captured as part of DPW's existing services in public spaces. Additional costs for processing and revenues from sale of recyclables are assumed negligible.

The various components of expanded recycling are expected to be delivered and funded in relatively straightforward ways with little scope for imaginative contracting mechanisms. As indicated in the table opposite, it is assumed that DPW would be responsible for program administration (education, outreach, coordination, and enforcement) as well as providing mobile recycling units (Option 3) and smart cans for public spaces (Option 4). DPW's

responsibilities could be partially funded through the City's general fund or grant applications. It is expected that DPW's enforcement activities could be self-funded through fines levied for violations. A private or PPP contract for Options 3 and 4 is unlikely to be feasible as there is no revenue stream to offer as an incentive. Options 1 and 2 would be provided by the private sector, who would recover costs through service fees charged to customers.

As it is assumed that all SSR processing will transition to mini-MRF developed by or in cooperation with DPW (see previous section), the City may need to encourage private haulers to deliver to a mini-MRF location. As haul distances will be shorter than going to an out-of-city MRF, this should not require much incentive.

It is assumed that Options 3 and 4 could be implemented relatively quickly, likely within 2-5 years, as these options would require little change in recycling behavior (i.e., they would simply provide greater opportunity for recycling to occur). Options 1 and 2, however, would require additional planning and educational outreach prior to implementation as these options require changes in behavior and habits to achieve full diversion potential. It is assumed private haulers could quickly map out additional collection routes and purchase/allocate equipment. It is expected that the City would start with enforcing existing state mandates before enacting ordinances to mandate wider participation. Similarly, starting with Option 1 and then transitioning to Option 2 would be optimal for phasing in wholesale recycling services to the commercial sector. Overall, it is assumed that Options 1 and 2 could begin in 2-5 years and would take up to 10 years to achieve their full diversion potential. With respect to SSR processing, contracting with WMRA or other private MRFs represents a short-term option for haulers while waiting for new mini-MRFs to be available. As discussed in the previous section, this is expected to take 2-5 years to commence and up to 10 years to complete.

Site availability was not considered for this program. Processing of recyclables recovered from these options would be co-processed with residential recyclables as discussed in the previous section.

The primary actors for this option are DPW as well as private hauling companies such as Cockey's Enterprises, Waste Management, L&J Waste Recycling, Goode, Gerber's, TMS Hauling, Waste Connections, or Republic Services.

If recycling targets are met in full, the additional GHG emission reductions achieved are estimated to be about 155,000 MTCO2E annually. Job creation is estimated at up to 7 FTE City employees and a further 14 or 86 FTE employees in the private sector for Options 1 or 2, respectively.

6.3 C&D Waste Reuse and Diversion

C&D waste represents the single largest component of the waste stream for disposal, comprising about 288,700 tons (35% of the total disposal waste stream in Baltimore) in 2017. Although the C&D waste stream is highly diverse, major material categories tracked for potential reduction and diversion only include lumber, clay bricks, concrete, asphalt, shingles, soil, and drywall. Concrete dominates the C&D disposal stream, accounting for about 200,000 tons (69%), followed by asphalt at about

40,000 tons (14%). C&D waste from commercial sources dwarfs that from residential sources, accounting for about 283,000 tons (98%); therefore, only options for reduction and diversion of C&D waste from commercial sources are considered in this section. C&D waste from the residential sector primarily enters the waste steam via the small hauler programs at QRL and NWTS. Recovery of some of this material could be achieved in conjunction with recommended upgrades to DPW's drop-off centers (see discussion in Section 6.5).

C&D Recycling Facility in New York City
(Source: cdrecycler.com)

Recovery of additional C&D waste could significantly contribute to meeting the BSP's overall goal of 90% waste diversion. Currently, however, the City lacks specific guidance on reduction or diversion targets for C&D waste although recovery of C&D waste and wood are key components of the W2W Initiative. While the data suggests that the potential for reducing and diverting C&D waste is high, it is noted that the recycling rate for C&D waste in Baltimore is already high at about 48%, indicating that much of the easily recoverable C&D waste is already being diverted. Additional recovery would thus need to target harder-to-recycle materials (e.g., bulky composites that are difficult to separate into base components, asbestos-containing items, or materials contaminated with grease, lead paint, etc.).

This category of options assumes that the City will enact ordinances to promote the reuse and recovery of C&D waste from demolition and construction sites and mandate the diversion of C&D waste that is not salvageable for reuse. The City already has a fairly robust C&D reuse and diversion system in place; however, the options listed below seek to improve the existing system to meet the 90% diversion goal of the BSP:

1. C&D Reuse Program:
   A. Implementing a mandated deconstruction policy. It is assumed this this policy would target lumber and clay bricks as the most valuable reusable components of C&D waste.
   B. Implementing an architectural salvage program. This program would match potential buyers and sellers of deconstructed materials.
2. C&D Diversion Program:
   A. Implementing a mandatory diversion ordinance. This could require a stepwise increase in diversion from construction and demolition sites (e.g., beginning at 50% and stepping up to 90% over time).
   B. Expanding C&D recycling capacity in the city by constructing a large C&D recycling facility in the Baltimore area.

Both options will require the engagement of City Council legislators to pass the ordinances needed and the commitment of City Government to implement and enforce new rules. With regard to Option 2, it is noted that several C&D management facilities already exist in the Baltimore area. These would be expected to upgrade their operations to provide additional recycling capacity if the City were to mandate that their customers (i.e., local contractors) demonstrate higher rates of waste diversion on construction projects. However, given the scope and ambition of the C&D diversion goal, it is assumed that a new high-capacity C&D MRF will be needed. Additional details on evaluation of options for increasing C&D reuse and diversion are provided in Chapter 5 of the Task 5 Report.

It was estimated that nearly all currently disposed lumber and clay bricks could be reused if a well-managed deconstruction and architectural salvage program were in place. As such, the expected reuse potential from this option is 28,400 tons per year (5% of the BSP's diversion target). An overall diversion rate of 90% was assumed for all remaining C&D waste, which represents a further diversion potential of 200,100 tons per year (36% of the BSP's diversion target).

The expected costs for this program include administrative costs for both options and the direct costs of constructing and operating a C&D recycling facility for Option 2. No direct costs are assessed for C&D reuse; however, contractors will face higher costs for deconstruction rather than demolition. A summary of expected costs for the C&D reuse and diversion programs is given in the table opposite, with direct costs allocated to the City highlighted in orange.

Expected Costs and Revenues for C&D Waste Reuse and Diversion

Item	Option	CAPEX	Annual OPEX	Annual Revenue
Administration/Enforcement[1]	1-2	-	$130k	$105k
C&D Recycling Facility[2]	2	$20.5M	$17.9M	$22.1M

Notes:

1. OPEX assumes the cost of one FTE inspector ($60,000 per year), one FTE analyst ($60,000 per year), and education and outreach ($10,000 per year). Revenues are obtained in the form of fines and assume the inspector can perform 4 inspections per day with a citation issued at $2,000 per violation. Violations are assumed to result for 5% of inspections.
2. CAPEX assumes a unit cost of $55 per annual ton of capacity, acquisition of 15 acres of land, and access/transportation improvements to accommodate increased truck traffic. OPEX includes labor costs, O&M costs of $50 per ton of annual throughput, and disposal costs for residual material at QRL. Revenue assumes a tip fee of $75 per ton and the sale of recycled C&D waste at $15 per ton.

As indicated in the table above, it is assumed that the costs for program administration (education, outreach, coordination, inspection, and enforcement) would be borne by the City, with responsibility falling to DPW, DHCD, or BCRP (through their Baltimore Wood Project). These activities could be partially funded through the City's general fund or grant applications. It is expected that enforcement activities could be self-funded through fines levied for violations. A private or PPP contract for Option 1 is not feasible as there is no revenue stream to offer as an incentive. Option 2 would be provided by the private sector in response to the mandate for C&D diversion from the City. The C&D recycling facility owner/operator would recover costs through service fees charged to customers (as shown, it is expected that a fee of about $75/ton would be sufficient). As DPW does not handle

collection or disposal of commercial C&D waste, establishing a PPP contract is not recommended as this would put the City at risk of guaranteeing an incoming waste stream it does not have control over.

It is expected that the City will be able to achieve C&D waste reuse targets relatively quickly (i.e., within 5-10 years) because only two material types are targeted (lumber and clay bricks) and Baltimore already has a fairly robust deconstruction and salvage system in place. However, the expected performance of such a program is difficult to gauge because it is not easy to measure waste that is not generated or directly managed by the City. Implementation of a C&D diversion program could take several years to complete (the estimated timeframe is approximately 20 years to reach full diversion potential) and would likely be enforced in phases. Initial phases in the first 5 years may involve slowly increasing the C&D waste diversion target (e.g., begin by mandating 50% diversion and then work up to 90%) and/or imposing size-based criteria for compliance with the program (e.g., begin by imposing diversion targets on projects valued at over $1M and then gradually expand the program to include smaller projects).

Siting the C&D recycling facility would likely require a minimum 15-acre lot. Potential options for locating the facility include the closed Monument St. Landfill, the former Pulaski Incinerator property, Wagners Point, Port of Baltimore properties in Dundalk or Locust Point, or Sparrows Point. Existing C&D recycling facilities in the city (e.g., the Baltimore Recycling Center or L&J Waste Recycling) could also be expanded, although the availability of land at/adjacent to these facilities has not been investigated. Transfer of materials recovered at the C&D recycling facility could be via long-haul trucking or intra-city truck transfer to a rail loading facility (if integrated rail transfer at the facility is not possible). A vacant property at 1900 Neiman Ave. adjacent to CSX tracks in Lakeland has been suggested.

The primary City actors are DPW and/or DHCD. Members of the private sector who would be subject to C&D reuse and diversion mandates include local construction and demolition contractors as well as existing deconstruction and salvage organizations such as the Loading Dock, Second Chance, and Habitat for Humanity of the Chesapeake. The Baltimore Wood Project, a collaboration between BCRP, USDA, and private partners that seeks to reuse wood waste from deconstruction, could play a leading role. Existing private C&D recycling facilities in the City include the Baltimore Recycling Center and L&J Waste Recycling.

If C&D reuse targets are met in full, the additional GHG emission reductions achieved are estimated to be about 25,000 MTCO2E annually. Direct job creation is limited to 2 FTE City employees; however, several secondary jobs requiring skilled building deconstruction workers would also be created.

If C&D diversion targets are met in full, the additional GHG emission reductions achieved are estimated to be about 32,700 MTCO2E annually. Direct job creation would include 30 FTE employees at the C&D recycling facility.

6.4 Bulk Waste Recycling and Reuse

This section covers remaining classes of recyclable and potentially recyclable materials that do not comprise the traditional recycling streams described in previous chapters. The non-traditional recyclables (NTR) stream is highly diverse, comprising bulk trash (e.g., furniture,

homewares, appliances, electronics, etc.) as well as mattresses, carpet, textiles, porcelain/ceramics, batteries, and other materials that are currently not recycled widely. DPW already provides recycling of some NTR materials, including scrap metal and appliances, scrap tires, and electronics and electrical equipment, which are sent to local recyclers. In 2017, DPW recycled about 86 tons of these items. This Final Master Plan assumes this recycling will continue.

The NTR stream comprises a very small component of the waste disposal stream in Baltimore, contributing only about 5,600 tons annually (<1% of the total waste stream for disposal). By far the largest NTR component is bulk waste at over 5,000 tons/year. For this reason, recommended options for NTR diversion focuses mainly on bulk waste reduction, reuse, and recycling measures. Implementing such measures would have a negligible impact on waste diversion tonnages or achievement of the BSP 90% overall waste diversion goal; nonetheless, bulk waste reuse and recycling is an important component of the LWBB master planning effort for several reasons:

- Bulk waste recovery programs driven by small businesses and community organizations are key opportunities identified in the W2W Initiative.
- While bulk waste represents a small proportion of the total waste stream by mass, many items (e.g., broken furniture and mattresses) are difficult to handle and occupy a lot of space in waste trucks and landfills.
- Bulk trash is highly visible in the community and comprises items found in illegal dumping incidents, so offering alternatives that the community are invested in may help reduce illegal dumping.
- Improving recycling and reuse of bulk trash is important in changing the public's mindset toward waste diversion and reduction generally.

It is assumed that DPW, BOS, and/or DHCD would lead community initiatives to reuse and recycle bulk waste and other NTR items. A detailed evaluation of bulk waste and NTR recycling and diversion is provided in Chapters 6 and 8.5 of the Task 5 Report. From this, four options are recommended:

1. Fix-it/repair clinics. By funding/providing clinics at existing facilities such as GROW Centers, the City can help residents learn how to repair broken electronics, appliances, bikes, etc. rather than throwing them away. This should also encourage residents to be more thoughtful about consumption and reduce their waste generation.
2. Develop recycling capacity for bulk waste. Constructing a new recycling center for bulk waste would be expensive, so expanding existing residents' drop-off centers (DOCs) to handle bulk waste for donation or recycling is recommended as a more affordable option. This would require working with local recyclers to take delivery of bulk waste items targeted for collection.
3. Support donation of bulk waste. The City could partner with charitable and nonprofit organizations to donate bulk waste items collected curbside and at DOCs.
4. Waste-to-art initiative. By donating bulk waste material to local artists, the City could help raise awareness of bulk waste recycling opportunities in the community.

Mattress Recycling Facility in California
(Source: Mattress Recycling Council)

Options to offset/reduce the costs of bulk waste collection and recycling were also investigated, including charging for collection or reducing the limit on the number of free monthly pickups that DPW will allow as a stimulus for residents to donate items. However, these are not recommended since they are likely to result in increased illegal dumping.

Assuming a waste reduction/reuse goal of 50% and a waste diversion goal of 60%, the total bulk waste and NTR diversion potential is calculated to be 4,100 tons diverted from disposal each year.

Expected costs include education and outreach and funding for reuse and donation programs. A summary of expected costs is given in the table below. Direct costs allocated to the City are highlighted in orange.

Expected Costs and Revenues for Bulk Waste Reuse and Recycling

Item	Option	CAPEX	Annual OPEX	Annual Revenue
Administration and Outreach	1-4	-	$50k	-
Fix-It/Repair Clinics	1	-	$20k	-
Bulk Waste Recycl. Center[1]	2	N/A	N/A	N/A
Supporting Donations[2]	3	-	-	-
Waste-to-Art Initiative	4	-	$50k	-
TOTAL		**-**	**$120k**	**-**

Notes:

1. The costs associated with upgrading DOCs to serve as bulk waste recycling centers are included in the costs to upgrade DOCs (see Section 6.5) and are not included in this section.
2. The additional direct costs associated with supporting donations of bulk waste items are considered negligible and could be handled under the budget for administration and outreach.

As indicated in the table above, it is expected the City would cover the administrative and outreach costs for delivering bulk waste reuse and recycling initiatives, partnering with community and nonprofit organizations in Baltimore. Responsibility for different initiatives could fall to DPW, BOS, and/or DHCD. Initiatives could be funded through the City's general fund, as an added line item on property tax bills, grant applications, and/or charitable donations. A better approach for increasing collection of bulk waste (Options 2 and 3) may be to expand the range of materials accepted at existing residents' drop-off centers (DOCs), which is addressed in Section 6.5.

For Option 2, the City could partner with the state's Sustainable Materials Management Maryland (SM3) P3 Program to support local bulk waste recycling vendors and stimulate markets. Otherwise, a private or PPP contract for bulk waste reuse and recycling is not really feasible for any option as there would be negligible revenues to offer as an incentive.

Most options outlined in this section have few timing constraints and could be implemented at the City's discretion within the next 1-2 years. Upgrading DOCs to accept bulk waste for recycling is discussed in Section 6.5. The major limitation on the implementation timeframe is the time needed for a local bulk waste recycling industry and market to develop, something the City can support but not control. It is estimated this could take up to 10 years.

Siting requirements and site availability were not considered for these options. With the exception of upgrading DOCs to accept bulk waste for recycling, which is discussed in Section 6.5, establishing the initiatives described here does not require specialized site preparation/construction or a long lead time for design and permit approval. Fix-it/repair clinics could be organized similar to the Baltimore GROW centers as pop-up centers hosted in City-owned spaces and public schools. Several unused or underutilized buildings are also available in Baltimore that could be rapidly made ready to serve purpose.

If bulk waste reuse and recycling targets are met, annual GHG emission reductions achieved are estimated at 11,400 MTCO2E. Direct job creation is limited; however, several secondary jobs in the recycling industry would be supported.

The primary City actors are DPW, BOS, and/or DHCD. Charitable organizations and nonprofits with whom the City could partner for donations or to host reuse events and clinics include the Salvation Army, Goodwill, Loading Dock, Second Chance, Habitat for Humanity ReStores, Vietnam Veterans of America, Baltimore Community Tool Bank, and Station North Tool Library. The SM3 P3 Program could play a leading role in developing recycling capacity and markets. The City could partner with NMWDA to issue RFPs for new services. Montgomery County's annual GreenFest is a potential local public sector partner.

6.5 Upgrading Residents' Drop-Off Centers

This option assumes that DPW would upgrade five existing DOCs to accept additional recyclable and donatable materials (e.g., mattresses, carpet, furniture, homewares, textiles, ceramics, and porcelain) as well as items that are currently accepted but are not separated (e.g., C&D waste, bulky waste, food scraps and other organics, appliances with large amounts of rigid plastic, and yard waste). This option could include a materials exchange network/partnership that would allow drop-off facilities to partner with nonprofits to expand donation of items such as bicycles, musical instruments, books, clothes, etc.

An option to develop new DOCs was considered but is not recommended as the option to upgrade existing DOCs is more practical and cost-effective as a starting assumption. However, it is recognized that some existing DOCs may not be expandable to the full extent envisioned here. In such cases, a more limited expansion to suit site-specific conditions should be considered.

Of the material currently disposed at DOCs, it is estimated that 17,900 tons (68.5%) is potentially divertible. Assuming a 90% diversion goal in accordance with the BSP, it is estimated that an additional 16,100 tons could be diverted annually.

CAPEX requirements are expected to be minimal, mainly consisting of purchasing additional dumpsters and roll-on/roll-off containers (ROROs) to store additional divertible material. Annual OPEX is expected to reflect program administration (i.e., managing the DOC recycling program and keeping track of additional collected material) and additional staff to meet increased labor demands for handling more materials at each DOC (i.e., directing residents and small haulers to the correct areas for tipping, keeping DOCs well organized, coordinating with recyclers and nonprofits for collections, etc.). Modest education and outreach costs are also expected. Costs are summarized in the table opposite, with direct costs allocated to the City indicated in orange. Potential revenues from sale of recovered recyclables are assumed to be low relative to operational costs and are ignored in the analysis.

It is important to note that the costs shown in the table do not include transfer or processing of recovered items. Where items are recyclable, transfer and processing costs are expected to be borne by the local bulk waste recycling industry although, in some cases, a portion of these costs may be passed on to DPW (as is the case with existing items such as electronics and HHW). However, these additional costs are too uncertain to estimate here. Where items are in good enough condition to be donated, local nonprofits are expected to bear the cost of transferring these items. The City can help stimulate donations and/or the market for bulk waste recycling (as discussed previously in Section 6.4). In summary, DPW's primary role would be to provide convenient drop-off locations and temporary storage of recyclable/donatable items, but not to be a direct actor in the market.

Expected Costs and Revenues for Upgrading Drop-Off Centers

Item	CAPEX	Annual OPEX	Annual Revenue
Education and Outreach[1]	-	$50k	-
Adminstration and Staffing[2]	-	$310k	-
Equipment[3]	$325k	-	-
TOTAL	**$325k**	**$360k**	**-**

Notes:

1. Assumed at $10,000/location for a total of five DOCs.
2. It is anticipated that one additional FTE employee would be required at each facility with wages and fringe benefits of $50,000/year. Additionally, one FTE program administrator would be required with wages and fringe benefits of $60,000/year.
3. It is assumed that six additional dumpsters and ROROs would be required for each of the five DOCs at nominal unit cost of $800 per dumpster and $10,000 per RORO.

It is expected that DPW would cover the costs for upgrading DOCs as these operations fall within the remit of existing operations. Upgrades and recycling operations could be funded through the City's general fund, as an added line item on property tax bills, and/or grant applications. Outreach efforts would be needed to change the usage habits of residents and small haulers.

As previously discussed in Section 6.4, the City could partner with local charitable and nonprofit organizations to accept bulk waste and other NTR accepted at the DOCs, as well as the state's Sustainable Materials

Management Maryland (SM3) P3 Program to support local bulk waste recycling businesses. Other opportunities to engage the private sector would likely be limited.

Time constraints on upgrading DOCs are expected to be minor, mainly related to addressing land-use issues and potential permitting delays. As such, it is estimated that this option could be fully implemented within five years. The major limitation on achieving a 90% recycling goal for bulk waste is the need for a local bulk waste recycling industry and market to develop, something the City can support but not control.

This option will likely require expanding the footprint area of the existing DOCs to be upgraded. However, space restrictions at some locations (e.g., Sisson Street and NWTS) will make lateral expansion difficult if not impossible. At these locations, it may not be possible to fully reconfigure the DOC to allow for collection of all classes of additional materials listed for this option. The DOCs with available adjacent land for potential expansion are Eastern Sanitation Yard (Bowley's Lane), Western Sanitation Yard (Reedbird Avenue), and QRL.

The primary City actor is DPW. Charitable organizations and nonprofits with whom the City could partner for donation of recovered bulk waste and recyclables include the Salvation Army, Goodwill, Loading Dock, Second Chance, Habitat for Humanity ReStores, and Vietnam Veterans of America. The SM3 P3 Program could play a leading role in developing local recycling capacity. The City could partner with NMWDA to issue RFPs for new services.

If bulk waste reuse and recycling goals for materials targeted at DOCs are met in full, the additional GHG emission reductions achieved are estimated to be about 25,800 MTCO2E annually. Direct job creation at DPW would include 6 FTE employees; however, several secondary jobs in the recycling industry would also be supported.

7. MIXED WASTE PROCESSING OPTIONS

7.1 Technology Overview

To reduce future disposal needs, the City may consider constructing a mixed waste processing (MWP) facility. The main goals of MWP are to generate energy, recover recyclables, create reusable products, and reduce the final quantity of waste that requires disposal. MWP facilities are highly complex and automated operations that employ a multi-stage approach to sort and process the incoming mixed waste stream.

State-of-the-Art Mixed Waste Processing Facility in Norway
(Source: wastetodaymagazine.com)

The first stage of MWP involves constructing a materials recovery facility (MRF) to recover recyclables and separate out undesirable materials prior to processing. However, unlike the MRFs discussed in Section 6.2, which process source separated recyclables and are thus often referred to as "clean MRFs," a MRF at a MWP facility is used to pre-sort the full mixed waste stream. As such, MRFs operated as a component of a MWP facility are often referred to as "dirty MRFs." After the separation stage, the remaining components of the waste stream are sent for processing. Organics, plastics, and other high calorific materials can be converted to energy and base products using gasification or pyrolysis technology or converted to solid recovered fuels (SRF). Although organics can be composted, they are more commonly processed at anaerobic digestion (AD) plants with biogas conversion to electricity or renewable natural gas (RNG). Solid residues from the AD process are typically aerobically cured to generate usable compost. It is noted that MWP facility design is tailored to specific waste stream characteristics and may not include all of these components or may employ different components in alternative configurations.

Although MWP is an option recommended for consideration by the City to divert waste from disposal, this recommendation comes with a number of important cautions and qualifications:

1. High costs and potential financial risks. MWP options are the most expensive of the options considered in the LWBB Plan, both in terms of CAPEX and OPEX. This means that developing MWP facilities can represent significant capital risk. The City has been approached by some potential partners to develop MWP technology in Baltimore under risk-sharing strategies where, for example, the developer would self-finance the project if the City provides the land for siting a facility, a guaranteed supply of MSW for at least 15 years, and cost-free disposal of all unsalable products generated at the facility. While attractive in many ways, these proposals may place the burden on underperformance

largely on the City. The financial viability of a MWP facility is also generally dependent on securing commitments to purchase energy at preferential pricing to meet a buyer's renewable energy goals; however, such pricing may not be sustainable over the long term.

2. MWP technologies are largely unproven in the U.S., although they are popular in Europe. Based on historical performance data from U.S.-based facilities, mixed waste MRFs tend to be very inefficient at separating and removing recyclables and organics. Processing of MRF-separated organics can thus be problematic because high levels of inorganic contaminants can affect the AD process and glass shards and plastic residues in the finished compost can prevent it from being marketable. However, new generation technologies in Europe have seemingly overcome these issues. AD facilities in the U.S. have typically been used to process relatively clean, often single stream, organics. That is changing, with a number of U.S. technologies now offering mixed waste processing capabilities. Gasification is also an emerging and untested technology for waste processing in the U.S., which may make it may be difficult to permit and build such a facility.
3. MWP generally operates counter to many of the waste recycling and diversion measures outlined in Chapter 6. As more upstream diversion efforts are implemented, the remaining quantities of recyclables and organics in the disposed waste stream is expected to diminish over time. This could lead to overdesign and underperformance issues, and also cause MWP to become progressively more expensive on a per-ton basis. As MWP technologies effectively compete for feedstock with many recycling/diversion options, the City would realistically need to choose MWP or increased recycling/diversion programs, not both (e.g., it would not be realistic to implement a source separated organics collection and composting program if a MWP facility that includes AD is planned).
4. Public perception and opposition. MWP facilities are generally not well received by environmentalists and zero waste advocacy groups. It is likely that the City would face significant public opposition if it chose to develop a MWP facility.
5. Risk of encouraging public antipathy toward recycling. Developing MWP capacity does not encourage consumers to think about recycling, waste reduction, or composting. This could have negative impacts on the City's overall waste reduction and diversion efforts under the LWBB Plan.

Based on the above, MWP is only recommended for consideration by the City as an alternative to other options, not in combination with other options.

7.2 Options for Consideration

Two MWP options are presented for consideration: one with a mixed waste MRF followed by AD for processing organics, and one with the MRF followed by gasification. These are conceptual examples only to provide an indication of potential technology components, delivery mechanisms, and benefits. Costs are order-of-magnitude estimates only and do not include land acquisition, any necessary property or transport infrastructure upgrades, or disposal of residues.

If a MWP facility is constructed in the City, it is assumed it would be collocated with new transfer facility (see Chapter 8) to allow for easy transfer of residual material for disposal. Further, to reduce capital and

other risks, it is assumed a MWP facility would be sized to process only 50% of the residential waste stream rather than the entire waste stream (if this proves successful, a second MWP facility could be built in the future to process the remainder of the residential waste stream). If other waste reduction/diversion programs are successful, the size of the incoming waste stream to the MWP facility will reduce over time. This would result in the MWP facility having significant excess capacity in the medium to long term, in which case the City may elect to open the facility to commercial customers to utilize redundant capacity.

Mixed Waste Processing with Anaerobic Digestion

One potential MWP option is to construct a mixed waste MRF plus AD facility. Such a facility would receive residential trash only, with single-stream recyclables in the city's curbside collection program handled separately via existing/proposed systems (see Section 6.2). Recovered metals, plastics, and paper from the MRF would be sold on the secondary materials market, while the organic fraction of the waste would be processed at the AD facility. For this analysis, it is assumed that the AD biogas is used to generate electricity. Although AD digestate can be used beneficially in land applications if of high enough quality, for this analysis it is assumed that all residuals would require disposal. Additional details are provided in Section 4.1 of the Task 7 Report.

The expected annual throughput to the MRF is 155,000 tons (i.e., 50% of the residential waste stream). CAPEX for the MRF is estimated at $200 per annual ton of throughput capacity. The MRF is expected to have a design capacity of about 185,000 tons/year (i.e., 120% of expected throughput) and thus an estimated CAPEX of about $37M. CAPEX for the AD facility is estimated at $600 per annual ton of capacity. Based on MRF performance assumptions, the AD facility is expected to have a design capacity of 30,000 tons (i.e., 120% of expected throughput) and thus an estimated CAPEX of about $18M. This yields a total CAPEX for the MWP facility of about $55M.

Unit OPEX of $120 per ton of annual throughput is expected for the MRF with annual throughput of about 155,000 tons, yielding OPEX of about $19M per year. The AD facility is expected to have unit OPEX of $100 per ton and a maximum throughput of about 25,000 tons, yielding additional OPEX of about $2.5M per year.

OPEX would be offset by the sale of recyclables and electricity. It is estimated that about 28,000 tons of recyclables could be recovered from the MRF annually, generating $725,000 assuming a commodity price of $26/ton for mixed recyclables. It is estimated that 5.5M kWh of electricity could be generated at the AD facility per year, generating $220,000 assuming electricity sales at $0.04/kWh. This yields total cost offsets on the order of $900,000 per year and thus total net annual OPEX for the MWP facility of about $20.6M.

It is expected that the MRF would be capable of recovering 50% of the traditional recyclables and 50% of the organics from residential MSW. Contamination is expected to comprise 15% of the recovered recyclable stream and 20% of the recovered organics stream; this will be removed after the initial sort. It is further assumed that 30% of the organics stream will remain as residual digestate following AD. Based on these assumptions, the maximum diversion potential through 2040 is estimated at about 40,000 tons per year.

Given the high capital costs involved, the most realistic option is for a MWP facility to be constructed and operated through a

PPP with a private company. NMWDA could help secure funding. The contract would have to be carefully structured to minimize the City's burden of risk (see cautions in Section 7.1). Construction of MWP capacity would enable DPW to leverage existing disposal at BRESCO and minimize the use of QRL to preserve airspace in the case that other disposal options are not available or contingency disposal is required.

For this analysis, with a motivated private developer it was assumed that contract agreement, land acquisition, design, permitting, and construction could be fast-tracked such that the MWP facility could be operable within five years, although a longer timeframe is more likely. This could alleviate short-medium term disposal issues in the event that the City does not renew its contract with BRESCO after 2021.

A MWP facility would likely be co-located with a transfer station (see Section 8) to facilitate disposal of residual material. It is estimated that the facility would require up to 20 acres of land. It may be difficult to acquire a contiguous 20-acre parcel in or around Baltimore. Potential sites include the closed Monument St. Landfill, former Pulaski Incinerator property, City-owned land at Wagners Point, unused areas at Port of Baltimore properties in Dundalk or Locust Point, or unused areas at Sparrows Point. Expansion of QRL, Eastern Sanitation Yard (Bowleys Lane), or Western Sanitation Yard (Reedbird Avenue) may also be possible.

Developing a MWP facility with the capacity outlined here could generate up to 28 FTE jobs in the private sector, with average annual GHG emission reductions of about 85,000 MTCO2E annually.

The primary City actor would be DPW, partnering under a PPP contract with a private developer. Private equity would likely need to be secured to fund the project. Some private equity funds have already approached the City (incl. Trilogy Finance Group); however, specific MWP developers and technology vendors cannot be identified at this stage.

Mixed Waste Processing with Gasification

An alternative MWP option is to construct a mixed waste MRF plus gasifier. Again, the facility would receive residential trash only, with single-stream recyclables in the city's curbside collection program handled separately via existing/proposed systems (see Section 6.2). Metals plus plastics and paper/cardboard with recycle value recovered from the MRF would be sold on the secondary materials market, while the organic fraction of the waste plus mixed plastics and paper would be processed into syngas at the gasifier. For this analysis, it is assumed that syngas would be sold directly into the market. All residuals would require disposal. Additional details are provided in Section 4.1 of the Task 7 Report.

It is expected that the MRF would be capable of recovering 50% of the traditional recyclables and 50% of the organics from residential MSW. Contamination is expected to comprise 15% of the recovered recyclable stream and 20% of the recovered organics stream; this will be removed after the initial sort. It is further assumed that 2% of the gasification stream will remain as residual ash. Based on these assumptions, the maximum diversion potential through 2040 is estimated at about 45,000 tons per year.

Capacity and CAPEX estimates for the MRF are as assumed previously. CAPEX for the gasifier is estimated at $3,200 per annual ton of capacity. Based on MRF performance assumptions, the gasifier is expected to have a design capacity of about 50,000 tons/year (i.e., 120% of expected throughput) and thus an estimated CAPEX of about $160M. This yields total CAPEX for the MWP facility close to $200M.

Unit OPEX estimates for the MRF are as assumed previously. The gasifier is expected to have unit OPEX of $200 per ton and a maximum expected throughput of about 40,000 tons, yielding total OPEX of about $8M per year.

It is estimated that 12,000 tons of recyclables could be recovered from the MRF annually, generating over $300,000 in revenues assuming a commodity price of $26/ton for mixed recyclables. It is estimated that 10M gallons of liquified syngas (synfuel) could be generated, valued at $14M assuming a unit price of $1.40/gal. for synfuel. This yields total cost offsets of about $14.3M per year and thus total net annual OPEX for the MWP facility close to $13M.

Potential contracting mechanisms, contracting risk reduction measures, and benefits in terms of leveraging existing disposal options and helping the City minimize the use of QRL are described previously for a MWP facility with AD, and apply similarly here.

For this analysis, with a motivated private developer it was again assumed that contract agreement, land acquisition, design, permitting, and construction could be fast-tracked such that the MWP facility could be operable within five years, although a longer timeframe is more likely. This could alleviate short-medium term disposal issues in the event that the City does not renew its contract with BRESCO after 2021.

A MWP facility would likely be co-located with a transfer station (see Section 8) to facilitate disposal of residual material. It is estimated that the facility would require as much as 20 acres of land. Potential sites for the MWP facility are as previously described for a MWP facility with AD.

The primary City actor would be DPW, partnering under a PPP contract with a private developer. Specific MWP developers and technology vendors cannot be identified at this stage.

Developing a MWP facility with the capacity outlined here could generate up to 110 FTE jobs in the private sector, with average annual GHG emission reductions of about 85,000 MTCO2E annually.

Recommendation

Based on the very high capital costs for a MWP facility using gasification technology, and the fact that gasification is a largely untested technology for processing organics separated from a mixed waste stream, a MWP facility configuration with a gasifier is not recommended. If the City were to consider partnering with a third-party developer for MWP, it would be less risky to investigate development of a facility using AD technology. In either case, the City is reminded of the cautions and qualifications on MWP presented in Section 7.1.

8. TRANSFER AND DISPOSAL OPTIONS

8.1 Basis for Assessment

Chapter 8 focuses on options for managing "what's left" in the solid waste stream after waste reduction and diversion options from Chapters 5 and 6 have been implemented. Therefore, a foundational assumption in this chapter is that the materials remaining in the waste stream have little/no potential for recovery because the majority of materials with recovery value (e.g., cardboard, plastics, metals, compostable organics, etc.) have already been removed. The expected rate at which other options achieve their maximum diversion potential (MDP) has significant bearing on the quantity of waste requiring disposal in any given year. Based on analysis in Task 5, it was estimated that many of the options recommended in Chapters 5 and 6 will take several years to fully mature and reach their full diversion potential. Therefore, the quantity of residual waste for disposal is expected to decrease relatively slowly at first, but then accelerate significantly over time as the full impacts of waste reduction and diversion measures are realized. Over the same period, total waste generation in Baltimore would be expected to gradually increase under the status quo. Waste disposal needs assessed in this chapter, which are presented in detail in the Task 7 Report, thus reflect the dynamic nature of the evolving waste stream expected through 2040 and beyond. A summary of the expected magnitude and composition of the residential and commercial waste streams in Baltimore between 2020 and 2040 assuming waste diversion achievements varying from 0% of the MDP (i.e., status quo) and 100% of the MDP (i.e., recycling/diversion options implemented in full and performing to their maximum potential) was presented in Section 3.3.

Residential waste is managed by DPW while commercial waste is managed by private haulers. Both sectors are currently heavily dependent on BRESCO and, to a lesser extent, QRL. Future options for waste disposal in Baltimore include:

1. Continue disposal at BRESCO and QRL.
2. Develop a new MSW landfill in/near Baltimore.
3. Develop waste transfer facilities for out-of-city disposal at one of several privately-operated regional landfills or WTE facilities in Virginia, Pennsylvania, and New Jersey that are within a three-hour travel distance of Baltimore.

With regard to Option 1, BRESCO is the subject of intense opposition from some sectors of the public as well as certain environmental and zero waste advocacy groups. As such, City officials are under pressure to cease using BRESCO for waste disposal after the existing contract expires in December 2021 (see Section 1.3). An independent in-depth facility inspection performed in Task 7 reported that BRESCO could remain operable for at least another 20 years. However, it is an aging facility for which increasingly frequent and expensive maintenance and repair may cease to be cost effective at some point. If BRESCO was to close in the short-medium term, both DPW and commercial haulers would have to redirect their waste to QRL, which would rapidly consume permitted disposal capacity (even accounting for the fact that DPW is in the process of permitting a major landfill expansion). In keeping with the LWBB Plan's goal of maintaining adequate contingency disposal airspace at QRL to handle potential debris from major storms or other disasters, therefore, alternative disposal options are needed.

Option 2 is not considered practical for several reasons. First, the City's zoning code does not allow for new landfills. Second, even assuming the zoning code could be changed, DPW has not performed any preliminary siting work to identify a potential site. Siting, permitting, and construction of a new landfill in Maryland would take 10-12 years as a best case scenario and potentially much longer. Finally, constructing a new landfill in the Baltimore metro area would require an undeveloped or brownfield area of up to 1,000 acres, which would be hard to find.

Option 3 would require expansion or construction of truck, rail, or barge transfer facilities. After some consideration, barging was not investigated in detail as a transfer option. There would likely be a lot of pushback against using waterfront property for waste transfer. Also, a key requirement for options recommended under the LWBB Plan is to be robust to potential impacts of climate change and to provide a reliable means of waste management in the event of a natural disaster, whereas a waterfront facility would be vulnerable to storm impacts and flooding. There are also fewer unloading options for barging compared to road or rail.

Waste collection vehicles can reasonably travel about 15 miles one way from their route to discharge their loads. Longer distances are cost-prohibitive because of labor and equipment inefficiencies. Based on a practical 15-mile limit, there are four existing transfer facilities around Baltimore that could potentially accept waste from DPW and commercial collection vehicles: DPW's NWTS, Baltimore County's Western Acceptance Facility (WAF), and Waste Management's Curtis Creek Recovery (CCR) and Quad Avenue Transfer Stations. CCR and Quad Avenue have tight space restrictions and are currently operated at or near capacity to service commercial clients; therefore, it is unlikely these facilities could be expanded to meet DPW's transfer needs. NWTS also has little scope for lateral expansion, but could manage a larger portion of the residential waste stream if it were to be operated at full permitted capacity. However, this would disrupt the successful small hauler program and limit DPW's capacity to use NWTS for transfer of curbside recycling loads. As such, expansion of NWTS is not recommended. Baltimore County reports that WAF has some utilizable capacity that could potentially be made available to DPW. WAF could potentially also be expanded under a bilateral agreement between the County and City.

Of the three options for meeting long-term waste disposal needs, developing out-of-city waste transfer capacity (Option 3) is preferred. This avoids reliance on centralized, aging infrastructure and preserves permitted disposal capacity at QRL for contingencies such as disaster debris management. Recommended options for developing waste transfer operations are presented in Section 8.3. However, as it is expected to take 5-10 years to develop sufficient transfer capacity to fully meet the City's potential transfer needs, for planning purposes Section 8.2 presents a review of the expected costs and performance of continuing disposal at BRESCO and QRL under various contract scenarios.

8.2 Continued Disposal Within the City

BRESCO

As detailed in the Task 7 Report, Wheelabrator would need to invest about $95M in capital improvements at BRESCO to meet the proposed BCAA emission limits. In recommending that the City continues to contract with BRESCO for residential waste disposal while transfer capacity is developed, it is assumed that Wheelabrator will make this investment. Conditions under which BRESCO does not make this

investment are discussed in terms of their impact on operations at QRL in the next subsection.

It is assumed that Wheelabrator would pass on the $95M cost of capital improvements to the City and its other customers in its tip fee. For simplicity, it is assumed the fee increase to all customers would be amortized over the period of the contract extension signed by the City. This is reasonable given that the City is one of BRESCO's largest customers. As such, the annualized cost per ton for capital improvements would be expected to decrease over a longer contract term, ranging from $27/ton for a 5-year contract extension to $7/ton for a 20-year contract extension.

In 2017, BRESCO handled about 156,900 tons (49%) of the residential waste stream. The average effective tip fee between 2012 and 2017 was $47/ton. Under the existing contract between the City and BRESCO, the tip fee is expected to rise to $57/ton by 2021. Adding the annualized costs for the $95M capital improvements to this, the expected future tip fee is calculated in the table below for 5-year, 10-year, and 20-year contract periods.

The City's Expected Tip Fee at BRESCO in January 2022

Contract Period (years)	Expected Tip Fee ($/ton)
5	$84
10	$71
20	$64

Additional financial benefits to the City of continuing to contract with BRESCO include revenues, airspace savings at QRL, steam used to heat some Downtown businesses and City offices, and the potential for preferential electric supply rates (if negotiated by the City during the contract renewal process). Changes in GHG emissions were not quantified for this option because this option represents a continuation of the status quo for waste disposal. Direct revenues to the City include the tip fees for disposal of BRESCO ash at QRL (approximately $19/ton between 2012 and 2017, rising to $22/ton in 2020), as well as host fees paid by BRESCO (i.e., community fee and city surcharge, which totaled an average of $15/ton of waste disposed at BRESCO between 2012 and 2017). BRESCO also pays property taxes and site lease payments to the City, but these are not considered as revenue since an alternative land use would also realize these payments. In 2017, revenues totaled approximately $4.1M. Over the period 2012 through 2017, BRESCO payments to the City averaged $34/ton of residential waste disposed at the facility. If the City continues to contract with BRESCO, it is expected that these payments would continue at the same rate (i.e., the effective tip fee in the table opposite would be reduced by $34/ton).

Airspace savings were calculated as the cumulative waste disposed at BRESCO (assumed to be 150,000 tons per year per the City's current contract) over a 5-, 10-, or 20-year contract. This represents avoided disposal at QRL over the same period (minus a small portion that will be landfilled as ash). It is noted that the quantity of waste going to BRESCO will be dependent on the City's attainment of the MDP for recycling/diversion options.

QRL

In 2017, 149,600 tons (47%) of the residential waste stream and 140,300 tons of BRESCO ash were landfilled at QRL. Additionally, the City

beneficially reused roughly 189,400 tons of soil as approved cover material at QRL and recycled 3,500 tons of asphalt concrete.

The remaining permitted capacity at QRL as of January 2019 was 3.45M cubic yards (CY). Under a proposed lateral expansion over the adjacent Millennium Landfill, the capacity will increase to 8.9M CY. For future development of QRL, it is recommended that significant permitted capacity be maintained for two reasons: leverage when negotiating contracts with private disposal facilities, and contingency capacity for disaster debris management. Continued operation of QRL is assumed to include the additional capacity gained from the proposed lateral expansion, design and permitting of which is well advanced.

It is assumed that DPW will continue to operate QRL directly; however, a PPP contract in which a private company or a state agency such as MES takes over operation could be considered. Several other options for the future use of QRL were also considered, including a vertical expansion, full privatization of the landfill, landfill mining, and rapidly filling the landfill to gain revenue to pay for waste recycling/diversion measures. None of these is recommended, as discussed in Section 4.2 of the Task 7 Report.

Depending on operating scenarios, continued landfilling at QRL would involve accepting all residential waste not sent to BRESCO, ash from BRESCO, and some commercial waste until transfer operations are available. The landfill would be filled to final permitted grades. The size of the disposed waste mass at QRL has the potential to change depending on the future of BRESCO and the City's attainment of the MDP. Three scenarios are considered:

1. City renews contract with BRESCO. If BRESCO invests in BCAA-compliant emission controls, or makes other improvements to the satisfaction of the City, it is assumed the City will renew their contract to send residential MSW to BRESCO after December 2021. In this case, the current system does not change significantly beyond 2022, with QRL continuing to accept roughly half of the residential waste stream as well as ash from BRESCO and a negligible quantity of the City's commercial waste.
2. City does not renew contract with BRESCO. Under this outcome, it is assumed the City will initially send all residential MSW to QRL (commercial waste is expected to continue to go primarily to BRESCO). In this case, it is also assumed the City would not accept BRESCO ash or commercial waste at QRL.
3. BRESCO ceases operation. If BRESCO closes before the City can develop waste transfer capacity, the City will be forced to send all of its waste to QRL as an interim measure. In this case, the commercial sector will also need to find new disposal options and may turn to QRL for final disposal. As a worst-case scenario in terms of QRL airspace consumption, it is assumed that BRESCO shutters in 2022.

A summary of the implications on airspace savings and the remaining service life of QRL under these three potential scenarios is provided in the table overleaf. Calculation details are provided in Section 4.2 of the Task 7 Report. Note that waste transfer is not included in these scenarios; as such, the table provides an indication of how much time would be available to develop transfer capacity before exhausting airspace in QRL. However, maintaining redundant capacity at QRL is a key goal of the LWBB Plan to allow for contingency operations and provide leverage for bargaining future tip

fees with private disposal facilities once waste transfer facilities have been developed (because the City continues to have the option of sending all of its waste to QRL rather than to a private disposal facility). It is recommended that 4M CY of redundant capacity is maintained for disaster debris management, which is equivalent to about six years of operation based on 2017 data. Therefore, the dates in the table below allow for contingency capacity. As a worst-case example, if BRESCO were to shut down in 2022 per Scenario 3, and the City does not make rapid progress at achieving the MDP from waste diversion/recycling options, the City may only have until 2027 to develop full waste transfer capacity before starting to eat into contingency airspace at QRL.

Estimated Year in Which Expanded QRL Would Have Only Contingency Capacity Remaining

MDP Attainment	Scenario 1 City Renews BRESCO Contract	Scenario 2 City Does Not Renew BRESCO Contract	Scenario 3 BRESCO Shuts Down in 2022
100%	2100+	2049	2032
50%	2053	2039	2029
0%	2038	2034	2027

Note: Includes airspace in lateral expansion and account for six years of contingency capacity.

Another important consideration is that constructing the lateral expansion at QRL is a large capital expense. By developing waste transfer stations quickly, the City can keep much of the lateral expansion airspace as "in-hand" permitted capacity, leveraging it in negotiations for waste disposal at private landfills, but not incurring all the costs of construction (or incurring costs more slowly).

DPW's costs for operation of QRL (including payments to the closure/post-closure fund and routine expenditure on minor capital projects such as on-site access roads) are covered by the tipping fee of $67.50/ton. Additional CAPEX for full construction of the lateral expansion is estimated at about $85.5M (including a 30% contingency). Costs are assumed not to vary significantly between scenarios; however, operating costs will likely be higher under scenarios in which QRL is filled faster.

8.3 Recommended Waste Transfer Options

Given the limitations on existing transfer capacity, and the need to provide long-term disposal alternatives to BRESCO and QRL, options for developing transfer operations for residential waste consider siting new facilities as well as expanding existing facilities. Contingencies for disruption to transfer/disposal facilities are best addressed through adopting a decentralized approach that provides redundancy, that is developing multiple facilities rather than relying on one centralized facility; and ensuring the sum total capacity of decentralized facilities exceeds the total capacity requirement (e.g., if three facilities are developed, each should offer more capacity than simply a third of the total required). Adoption of the diversified options for waste diversion and recycling presented in Chapter 6 will also reduce the City's reliance on centralized disposal infrastructure and thus help build resilience to climate change or other disruptions.

Temporary or permanent disruption to Chapter 6 options (e.g., closure of composting facilities due to disease or contamination) essentially means materials that can no longer be diverted will need to be transferred for disposal. Therefore, disposal tonnages and the sizing of transfer facilities in this section are based on handling total waste quantities under status

quo assumptions (i.e., 0% of MDP). As the City's achievement of the MDP is expected to gradually increase, this is expected to result in the transfer facilities having excess capacity in the medium to long term except under contingency operating conditions. Therefore, the City may elect to open the facilities to commercial customers during normal operations to utilize redundant capacity.

DPW operates NWTS as an intra-city truck transfer facility where waste collected from Baltimore's northern neighborhoods can be transferred from smaller load-packer trucks to larger roll-off trucks for transportation to BRESCO or QRL. (It is noted that since 2019, NWTS has been used only as a drop-off facility for small haulers and residents and for transfer of curbside recyclables to WMRA, but this is mainly due to a current shortage of transfer truck drivers at DPW). If needed due to unavailability of BRESCO, NWTS could be used to start the transfer of waste to out-of-city disposal facilities, although the City would quickly need a second, larger transfer facility to move an appreciable fraction of the residential and commercial waste streams (which totaled 319,500 and 221,900 tons, respectively, in 2017). In the longer-term, the most sustainable and cost-effective transfer mechanism would be to develop a large transfer facility with rail loading capabilities. Based on this, the recommended options for developing waste transfer capacity are listed below. These options are intended to provide step-up increases in waste transfer capacity, starting with the simplest and lowest cost option and moving to the most complex and expensive option. As such, it is assumed these options would be implemented in the order listed. However, the City could adopt an alternative implementation sequence.

1. Begin long-haul truck transfer operations from NWTS;
2. Construct a long-haul truck transfer station in/near the city; and
3. Construct a large rail transfer station in/near the city.

Option 1, and to some extent Option 2, are expected to be utilized for long-haul waste transfer only in the event that BRESCO becomes unavailable before Option 3 is constructed and a decision is made to preserve airspace at QRL in the meantime. Options 1 and 2 may also be used for temporary waste transfer if Option 3 is inoperable due to major scheduled maintenance or damage from a natural disaster. Under normal operating conditions, however, it is expected these two facilities would serve mainly for consolidation and intra-city transfer of residential trash and recyclables.

An option considered but ultimately not recommended is upgrading NWTS to operate at its permitted capacity of 150,000 tons/year. To date, DPW reports that NWTS has only ever been operated at a maximum of 67,000 tons/year. Operating at 150,000 tons/year would require significant staffing and equipment upgrades, and would entail greatly increased truck traffic and longer working hours, which would be unpopular with neighbors. Increasing throughput to 150,000 tons/year would also mean the popular small hauler program and residents' access to the DOC at NWTS would have to be shut down until the DOC could be relocated. Given how successful the small hauler program has proven to be in recent years, not least in helping tackle illegal dumping, this would represent a major setback to DPW's services. Notwithstanding, upgrading NWTS to operate at 150,000 tons/year remains an option for DPW to "keep in their back pocket" as a relatively quick and cost-effective means of increasing waste transfer capacity if this is ever needed as a contingency.

Long-Haul Transfer from NWTS

For this option, it is assumed that DPW would operate NWTS at 70,000 tons/year, similar to its historical maximum throughput, but instead of sending loaded tractor trailers to BRESCO or QRL, tractor trailers would be sent to a private regional landfill. Once a large rail transfer station is developed, intra-city truck transfer from NWTS to the rail transfer station is expected to replace long-haul trucking.

The potential airspace savings at QRL for this option are 70,000 tons per year.

No major capital improvements or engineering works are required for this option. It is anticipated that necessary NWTS upgrades could be implemented in less than one year with NWTS available for long-haul waste transfer in 2022.

There are no major capital costs associated with this option. As detailed in Section 4.3 of the Task 7 Report, it is anticipated that this option could be implemented for an approximate OPEX of $75/ton, including the costs of transportation and disposal, yielding annual OPEX of about $5.3M per year. This cost would be partially offset by eliminating corresponding disposal costs at BRESCO or QRL.

This option does not require the construction of a new facility or expansion of an existing facility, so there is no need to consider site availability.

It is expected that DPW would cover the costs for upgrading NWTS as this operation falls within the remit of DPW's existing services. Upgrades would most likely be funded through the City's general fund. Some minor outreach efforts would be needed to inform residents and small haulers of changes to NWTS operation.

It is expected that DPW would continue to operate NWTS using money from the general fund. Privatization of NWTS is not recommended; however, DPW could choose to contract with a private company or public agency (e.g., MES) through a PPP for operations. A PPP contract would be most attractive for bundled operation of NWTS in conjunction with the other planned long-haul transfer operations.

The primary actors involved in this option are DPW and private landfill owners (e.g., Waste Management, Waste Connections, or Republic Services) with whom DPW would contract for out-of-city disposal. The same companies or state actors such as MES could potentially contract with DPW for operation of NWTS under a PPP contract.

No GHG emission benefits are expected; if NWTS is used to transfer 70,000 tons/year, GHG emissions would actually increase by about 35,000 MTCO2E annually relative to the baseline of BRESCO disposal. This is due to increased emissions of landfilling vs. WTE and from long distance trucking. Direct job creation at NWTS could include about 6 FTE employees.

Construct New Truck Transfer Facility

For this option, it is assumed that DPW would construct and operate a new truck transfer station (TS2), preferably in the eastern part of the city. It is assumed that TS2 would primarily service Baltimore's northern and eastern neighborhoods, but over time as residential waste

recycling/diversion measures take effect the facility could also serve commercial MSW haulers. TS2 is expected to include a large drop-off center for residents and small haulers and a materials reuse center.

As discussed in Section 4.3 of the Task 7 Report, TS2 was originally sized to handle the remainder of the residential waste stream under the status quo, assuming that NWTS would be utilized to its full capacity of 150,000 tons/year. This equated to a maximum expected throughput of about 165,000 tons/year at TS2, although the facility would be designed at 120% of this size to accommodate contingencies. The total design capacity of TS2 was thus estimated at 200,000 tons/year. It is now recommended that DPW only operate NWTS at 70,000 tons/year; however, increasing the capacity at TS2 to make up for the shortfall at NWTS is not recommended. NWTS and TS2 are mainly intended to serve as short-medium term long-haul options for waste transfer in the event that BRESCO is unavailable before a large rail transfer facility can be developed (see next subsection), at which point they would likely revert to intra-city transfer. If long-haul waste transfer is required before the large rail transfer facility is available, residential waste disposal in excess of the combined capacity of NWTS and TS2 can be directed to QRL.

The potential airspace savings at QRL for this option are 165,000 tons per year.

As a best-case scenario, it is assumed that the City could acquire land and design, permit, and construct a truck transfer facility within five years. As such, the transfer facility could be fully operable by 2025; however, a longer timeframe is more likely.

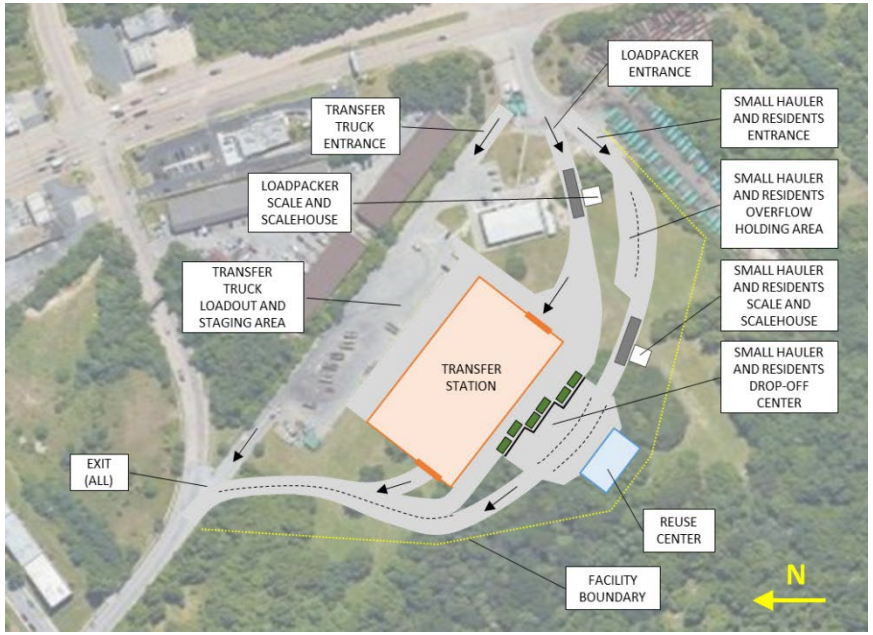
CAPEX for TS2 are estimated to be $80/ton of annual capacity, which is conservatively estimated at 200,000 tons (i.e., 120% of the maximum expected annual throughput of 165,000 tons). This equates to a total CAPEX of $16M.

OPEX is anticipated at $75/ton of annual throughput for a total expected annual OPEX of $12.4M, including the costs of out-of-city transfer and disposal. This cost would be partially offset by eliminating corresponding disposal costs at BRESCO or QRL. OPEX for out-of-city transfer and disposal were estimated based on current contracts in place in Maryland; however, if BRESCO were to close this would invariably have upward pressure on pricing.

It is estimated that TS2 would require at least 10 acres of land. Potential sites include the closed Monument St. Landfill, former Pulaski Incinerator property, City-owned land at Wagners Point, unused areas at Port of Baltimore properties in Dundalk or Locust Point, or unused areas at Sparrows Point. Development of TS2 at QRL, Eastern Sanitation Yard (Bowleys Lane), or Western Sanitation Yard (Reedbird Avenue) may also be possible. Of these existing sites, Bowleys Lane is considered optimal.

A conceptual layout of TS2 at Bowleys Lane is provided in the figure overleaf (a larger version is presented in Section 6 in the Task 7 Report). As shown, in addition to transfer operations, the TS2 facility developed by expanding Bowleys Lane would provide a drop-off area for residents and small haulers (with six bays for MSW, C&D, traditional recyclables, yard waste and other organics, and non-traditional recyclables) as well as a materials reuse center. Traffic flow is isolated between loadpackers, transfer trucks, and small haulers and residents.

Once a large rail transfer station is developed, intra-city truck transfer from TS2 to the rail transfer station would be expected to replace long-haul trucking. In the interim, intra-city waste transfer could also be to a separate rail loading facility. A vacant property at 1900 Neiman Ave. adjacent to CSX tracks in Lakeland has been suggested.



Conceptual Layout of New Truck Transfer Facility at Bowleys Lane

Workable contract mechanisms for developing TS2 include a public or PPP option. Private development of TS2 is not recommended as residential waste collection will remain a public service provided by DPW. Under the public option, DPW would self-develop and operate TS2, with costs covered by allocating money from the general fund, establishing an enterprise fund, direct billing, or adding a line item on property tax bills. Under a PPP option, the City could provide a land lease and a guaranteed waste stream with a third party (either a private company or a state agency such as MES) constructing and operating the facility. NMWDA could help secure funding. A PPP contract would be most attractive for bundled operation of TS2 in conjunction with the other planned long-haul transfer operations. Some minor outreach efforts by DPW would be needed to inform residents and small haulers of facility usage rules, especially if it involves redevelopment of an existing DOC such as Bowleys Lane.

The primary actors involved in this option are DPW and private landfill owners (e.g., Waste Management, Waste Connections, Republic Services) to contract for out-of-city disposal. The same companies or state actors (e.g., MES, NMWDA) could potentially contract with DPW for operation of TS2 under a PPP contract.

No GHG emission benefits are expected; if TS2 is used to transfer 165,000 tons/year, GHG emissions would actually increase by about 62,000 MTCO2E annually relative to the baseline of BRESCO disposal. This is due to increased emissions of landfilling vs. WTE and from long distance trucking. Direct job creation at TS2 could include up to 14 FTE employees.

Construct Large Rail Transfer Facility

In addition to constructing TS2 to complement NWTS, it is recommended that DPW constructs a large rail transfer station (RTS) where operations can be consolidated and provided more efficiently. RTS would be

constructed so that it could be operated as a truck transfer station, but would be built along a rail spur to allow for containerization and rail shipment of waste. Rail would be the primary method of transfer with trucking capabilities available as a contingency. Rail transfer from RTS would provide a more efficient, cost-effective, and environmentally friendly service than truck transfer from NWTS and TS2 and would allow waste to be sent to multiple regional landfills or even more distant facilities as needed.

Developing RTS would be a capital intensive project; therefore, it is assumed the facility will be sized to accept waste from the commercial as well as residential sectors in Baltimore (and potentially surrounding counties) to help make it economically viable. Following construction of RTS, NWTS and TS2 are expected to function as intra-city transfer stations sending residential waste to RTS for consolidation. As detailed in Section 4.3 of the Task 7 Report, the RTS would be sized to handle the city's maximum expected combined residential and commercial MSW waste streams under the status quo through 2040 (estimated at 311,000 tons and 219,000 tons, respectively, for a total of 530,000 tons/year).

The maximum expected airspace savings at QRL for this option would be 311,000 tons per year (representing avoided disposal of residential waste) plus whatever portion of the commercial waste stream would be landfilled at QRL in any given year (which depends on the status of BRESCO and other factors).

It is assumed that it would take ten years to acquire land and rights-of-way access; design, permit, and construct the transfer facility; and complete the associated rail spur. As such, it is anticipated that RTS could be fully operable by 2030 at the earliest.

CAPEX for RTS are estimated at $95/ton of annual capacity, which is conservatively estimated at 640,000 tons (i.e., 120% of the maximum expected annual throughput of 530,000 tons). This equates to a total CAPEX of $61M. OPEX is anticipated at about $50/ton of annual throughput, yielding maximum expected annual OPEX of $26.5M, including the costs of out-of-city transfer and disposal. OPEX for out-of-city transfer and disposal were estimated based on current contracts in Maryland for out-of-state waste disposal as well as estimated rail transfer costs; however, if BRESCO were to close this would invariably have upward pressure on disposal pricing.

Operating costs would be partially offset by eliminating corresponding disposal costs at BRESCO or QRL. RTS would also charge a tip fee for commercial waste accepted. Assuming that RTS would be capable of processing all of the commercial MSW generated in the City (a maximum of about 219,000 tons/year expected through 2040), and using an estimated tip fee of $67.50/ton (the current tip fee at QRL), this could generate revenues of up to $14.8M annually.

Workable project delivery mechanisms for RTS include public, private, or PPP options. Under the public option, DPW would self-develop and operate the facility with costs covered by allocating money from the general fund, establishing an enterprise fund, direct billing, and/or adding a line item on property tax bills. However, given the high capital costs, the public option is the least preferred. Private development would see the private sector develop the facility with DPW simply delivering residential waste as a customer. However, this option does not give the City any control over pricing or usage. The preferred delivery mechanism would be a PPP contract, with the City providing a land lease and a partially guaranteed waste stream with a

third party (likely a private company, although a state agency such as MES could be involved) serving to construct and operate the facility. NMWDA could help secure funding for a PPP option. A PPP contract would be particularly attractive for bundled operation of RTS in conjunction with TS2 and/or NWTS.

It is estimated that RTS would require at least 20 acres of land in a location suitable for installing a rail spur, similar to the example in the image below.

Screenshot of Waste Management's Annapolis Junction Transfer Station in Jessup, MD, showing Rail Spur Connection to Main Railroad
(Source: Google Earth)

Potential sites include WAF, which would require a collaborative agreement with Baltimore County. Adding a rail spur at WAF could be challenging, however. Other potential sites include the former Pulaski Incinerator property, City-owned land at Wagners Point, unused areas at Port of Baltimore properties in Dundalk or Locust Point, or unused areas at Sparrows Point. Most of these locations have good railroad access.

The primary actors involved in this option are DPW and private landfill owners (e.g., Waste Management, Waste Connections, Republic Services) to contract for out-of-city disposal. The same companies or state actors (e.g., MES, NMWDA) could potentially contract with DPW for operation of RTS under a PPP contract.

GHG emissions are expected to increase by about 30,000 MTCO2E for RTS relative to the baseline of BRESCO disposal. This accounts for transfer and landfill disposal of all residential waste but does not include emissions associated with any commercial waste transfer. The superior GHG performance of RTS compared to use of NWTS and TS2 for long-haul trucking is due to the significantly lower emissions of rail transportation vs. trucking. Direct job creation at RTS could include up to 42 FTE employees.

9. SUMMARY OF RECOMMENDATIONS

This chapter summarizes the main recommendations from the LWBB Final Master Plan, as outlined in previous Chapters 5 through 8 of this Task 9 Report. Where possible, a tabulated summary is provided, which includes the waste diversion potential, value of disposal airspace savings, expected costs (CAPEX and OPEX), implementation timeframe, and optimal project delivery mechanism.

9.1 Waste Reduction and Reuse Strategies

Chapter 5 recommends policies and strategies (i.e., "soft" infrastructure) to promote waste reduction and thoughtful consumption across multiple material classes and stakeholder sectors. These recommendations include legislative initiatives, increased education and outreach strategies, incentive programs, and sharing and reuse opportunities. Implementing these recommendations will likely require coordination with federal and state initiatives. Success will be dependent on effecting behavioral changes across all socioeconomic sectors in Baltimore. Leadership by example from City government will be essential.

Soft infrastructure options cannot be directly assessed using a hierarchical methodology, because waste that is not generated in the first place does not enter the waste stream and thus cannot be measured and does not incur a management cost. Therefore, costs for implementing the recommendations in Chapter 5 are not tabulated here as they will vary widely depending on what the City decides to implement and how. Significant grant funding opportunities exist to support these initiatives, as exemplified by DPW's recent receipt of a recycling outreach and education grant from the Recycling Partnership.

9.2 Waste Diversion and Recycling Options

Chapter 6 presents recommendations for "hard" infrastructure options for increasing waste diversion and recycling across several material classes, including food scraps and other organics, traditional recyclables, C&D waste, and bulk waste. The table overleaf provides a summary of hard infrastructure options recommended for implementation with the range of dates for the start of each phase of implementation (if applicable). Expected CAPEX and OPEX are shown for each option/phase, along with the estimated value of avoided waste disposal (calculated based on the current tip fee of $67.50/ton at QRL), which would partially offset OPEX. Costs shown in the table do not all occur at the same time (e.g., when an option moves from Phase I to Phase II, costs transition accordingly); therefore, summing the OPEX column does not provide an indication of total annual costs. Similarly, diversion tonnages are specific to phases/components and cannot be summed to provide a total.

Several options would be optimally developed by the private/nonprofit sectors or under a PPP effort. Costs shown in the table for developing and operating these options would not be borne by the City. Only the costs/savings highlighted in orange text are directly allocated to the City. These data should be used to help with budget planning when the City decides that individual options/phases should be implemented. In most cases, an implementation range is given rather than a specific start date, which allows the City the flexibility to determine which programs are highest priority and thus should be budgeted for first over a period deemed acceptable by decision makers. Finally, there are two sets of options (shaded yellow) that are mutually exclusive in which DPW will need to decide which option to pursue or when to transition from one option to the next. Details are provided in notes to the table.

Summary of Hard Infrastructure Options with Recommended Delivery Mechanism and Implementation Schedule

Option[1,2]	Phase	Maximum Diversion Potential (tons/year)	Schedule[3] (range of start years)	Component	Optimal Delivery Mechanism/ Sector	CAPEX	Annual OPEX (excl. revenues)	Annual Disposal Savings[5]
Food Waste Reduction Program (see Section 6.1)	I	6,600	2021-2025	Admin.	City	-	$1.8M	-
				Food Rescue	Nonprofit	$12.5M	$5.7M	$450k
	II	36,200	2026-2030	Admin.	City	-	$4.7M	-
				Food Rescue	Nonprofit	$12.5M	$31.5M	$2.4M
	III	65,800	2031-2035	Admin.	City	-	$4.7M	-
				Food Rescue	Nonprofit	$12.5M	$57.3M	$4.4M
	IV	72,400	2036-2040	Admin.	City	-	$4.7M	-
				Food Rescue	Nonprofit	$12.5M	$63M	$4.9M
Residential Organics Composting (see Section 6.1)	I	10,700	2021-2025	Admin.	City	-	$600k	-
				Collection	City	$5M	$3.1M	$725k
				Processing	PPP	$2.7M	$1.1M	incl. above
	II	42,800	2026-2040	Admin.	City	-	$600k	-
				Collection	City	$15M	$12.5M	$2.9M
				Processing	PPP	$8.1M	$4.4M	incl. above
Commercial Organics Composting[4] (see Section 6.1)	I – II	12,600	2021-2030	Admin.	City	-	$280k	-
				Collection	Private	$2.0M	$1.0M	$850k
				Processing	Private	$2.7M	$1.1M	incl. above.
	III – VI	35,500	2031-2040	Admin.	City	-	$280k	-
				Collection	Private	$5.5M	$2.7M	$2.4M
				Processing	Private	$8M	$3.1M	incl. above

Summary of Hard Infrastructure Options with Recommended Delivery Mechanism and Implementation Schedule (cont.)

Option[1,2]	Phase	Maximum Diversion Potential (tons/year)	Schedule[3] (range of start years)	Component	Optimal Delivery Mechanism/ Sector	CAPEX	Annual OPEX (excl. revenues)	Annual Disposal Savings[5]
Improve Residential Recycling (see Section 6.2)	-	84,200	2021-2036	Admin.	City	-	$50k	-
				New Carts	City	$9M	incl. below	$5.7M
Expand Access to Recycling (see Section 6.2)	-	-	2021-2026	Admin	City	-	$230k	-
		6,100	2021-2026	MFBs	Private	$1M	$450k	$415k
		69,300	2026-2036	Com. Sector	Private	$10.8M	$5.2M	$4.7M
		not calculated	2021-2023	Mobile Units	City	$150k	$150k	-
			2023-2030	Public Spaces	City	$8.2M	-	-
Processing of Recycling (see Section 6.2)	-	incl. above	2021-2036	WMRA	City	-	$5.1M	incl. above
			2023-2036	Mini-MRFs	PPP	$17.6M	$10.4M	incl. above
C&D Reuse and Recycling (see Section 6.3)	-	228,500	2021-2035	Admin.	City	-	$130k	-
				Recycl. Fac.	Private	$20.5M	$17.9M	$15.4M
Bulky Waste Recycling[6] (see Section 6.4)	-	4,100	2021-2031	-	City	-	$120k	$275k
Expand Drop-Off Centers[6] (see Section 6.5)	-	16,100	2021-2026	-	City	$325k	$360k	$1M

Notes:

1. Orange text indicates actions and direct costs/savings allocated to City. These costs would be difficult to transfer to other sectors. A large portion of costs incurred under a PPP would also be borne indirectly by the City, as the facility operator would pass these costs on to its customers in the form of tip fees.
2. Adjacent rows with yellow shading are mutually exclusive; the City should elect to implement/mandate only one option or transition/expand from one to the other over time (e.g., the City would initially extend its recycling contract with WMRA until transitioning to processing recyclables at newly-built mini-MRFs).
3. Where the schedule is shown as a range, this indicates the available time horizon before the next phase of implementation is expected. Schedules were assessed based on the expected performance or implementation timeframes for the various options. The implementation schedule was also chosen such that costs do not all occur at once.
4. Costs shown do not account for subsidies or surcharges during Phase I.
5. Savings apply relative to disposal at QRL at a tip fee of $67.50/ton. Note that avoided disposal of diverted residential and commercial organics assumes 24% of incoming feedstock to processing facilities is rejected. Note also that avoided disposal of C&D waste would mostly affect local C&D landfills and not QRL; however, tip fees are similar.
6. Costs include DPW's program administration and provision of drop-off/storage capacity only. Transfer and processing costs, which will be incurred by others, are not included.

9.3 Mixed Waste Processing Options

To reduce future disposal needs, the City may consider constructing a MWP facility as discussed in Chapter 7. MWP is the most expensive of the options evaluated in the LWBB Plan, both in terms of CAPEX and OPEX. This means that developing MWP facilities can represent significant capital and operational risk. Notwithstanding, the City has been approached by some potential partners with proposals to develop MWP facilities under creative risk-sharing contracts where the developer would self-finance a project under certain conditions (e.g., the City provides the land for siting a facility, a guaranteed supply of MSW over a fixed term, and/or cost-free disposal of all unsalable products generated at the facility). While attractive in many ways, these proposals may place an undue burden of underperformance on DPW (i.e., lead to higher-than-expected disposal requirements at QRL or BRESCO). Overall, while it is recommended that the City considers proposals from well-qualified and motivated partners, MWP is not an option recommended outright for implementation. As such, the tabulated summaries of recommended options in this chapter do not include MWP.

Another important consideration is that MWP generally operates counter to many of the waste recycling and diversion measures summarized in Section 9.2. In other words, MWP technologies compete for feedstock with many recycling/diversion options. Therefore, the City would realistically need to choose MWP or increased recycling/diversion programs, not both (e.g., it would not be realistic to implement a source separated organics collection and composting program if a MWP facility that includes AD is planned). Based on this, MWP may be considered as an alternative to other options, but may not work effectively in combination with other options.

9.4 Waste Transfer and Disposal Options

Chapter 8 presents options for managing "what's left" for disposal after waste reduction and diversion options have been implemented. Options assessed include continued disposal at BRESCO, continued disposal at QRL, or development of transfer stations to send waste to out-of-city landfills. The table overleaf provides a summary of these options, of which developing multiple out-of-city waste transfer stations with redundant capacity is generally preferred as the long-term strategy. This avoids reliance on centralized, aging infrastructure and preserves disposal capacity at QRL for contingencies such as disaster debris management. DPW is currently finalizing a lateral expansion permit to increase the disposal capacity at QRL; however, this represents a large capital expense. By developing waste transfer capabilities, DPW can keep much of the lateral expansion airspace as "in-hand" permitted capacity, leveraging it in negotiations with out-of-city landfills but not incurring all the costs of construction (or incurring costs more slowly). Avoided costs may be redirected at diversion/recycling efforts.

Although it is assumed that waste volumes will decline over time to reflect improving diversion rates, temporary or permanent disruptions to diversion/recycling systems may require materials to be transferred for disposal. To provide suitable redundancy, the total transfer capacity is sized to handle waste volumes under the status quo (i.e., 0% of the MDP).

It is recommended that BRESCO and, to a lesser extent, QRL continue to be utilized for disposal of declining waste volumes until the rail transfer station is operational. Long-haul truck transfer from the other two transfer stations (NWTS and TS2) is a contingency operation only if BRESCO service is eliminated in the short-medium term, as this is a cost prohibitive and environmentally degrading option.

Summary of Waste Transfer and Disposal Options with Recommended Delivery Mechanism and Implementation Schedule

Option[1]	Max. Diversion Potential from QRL (tons/year)	Schedule[4] (earliest year available)	Optimal Delivery Mechanism/ Sector	CAPEX	OPEX[5]	Annual Disposal Savings Relative to QRL[7]
Continue Disposal at QRL[2] (see Section 8.2)	-	2022	City	$85.5M (expansion)	$67.50/ton	-
Continued Disposal at BRESCO[3] (see Section 8.2)	150,000	2022	Private	$95M (BCAA upgrades)	$37 - $50/ton (effective)[6]	$2.6M - $4.6M
Truck Transfer from NWTS[8] (see Section 8.3)	70,000	2022	City	-	$75/ton	$(525k)
Truck Transfer from TS2[8] (see Section 8.3)	165,000	2025	City	$16M	$75/ton	$(1.2M)
Rail Transfer from RTS (see Section 8.3)	315,000	2030	PPP	$61M	$50/ton	$5.4M

Notes:

1. Orange text indicates direct costs/savings allocated to the City. These costs may be difficult to transfer to other sectors. A large portion of costs incurred under a PPP would also be borne indirectly by the City, as the facility operator would pass these costs on to its customers in the form of tip fees.
2. Continued disposal at QRL includes CAPEX for construction of the lateral expansion (value shown is current estimate including a 30% contingency). For fair comparison to other options, OPEX at QRL is assumed as the current posted tip fee of $67.50/ton.
3. Continued disposal at BRESCO assumes BCAA emissions control upgrades are made to the satisfaction of the City such that a contract extension is signed starting January 2022. The range of OPEX shown represents the variability in the expected tip fee based on whether a 5 or 10 year extension is signed (CAPEX for BCAA upgrades is assumed to be amortized over the contract term, with a shorter term thus producing a higher tip fee).
4. The first year for consideration of alternative disposal options is 2022, which is when the City's current contract with BRESCO expires (i.e., status quo disposal continues through December 2021). The year shown in this column represents the first year an alternative facility may reasonably be available, subject to successful completion of siting, design, permitting, and construction (where applicable). Actual availability may be delayed, which is an important factor to consider in long-term decision making.
5. OPEX is presented on a per-ton basis to allow easier comparison between options.
6. OPEX shown for BRESCO is net effective tip fee after allowing for rebates in the form of community fee, city surcharge, and disposal of ash. These totaled an average of $34/ton between 2012 and 2017. It is assumed similar rebates will apply after 2022.
7. Annual savings relative to disposal at QRL are calculated based on the difference in OPEX between QRL and other options. Negative values indicate relative cost increases.
8. Long-haul truck transfer from NWTS and TS2 is a contingency operation to be considered only if BRESCO service is eliminated in the short-medium term.

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