Montgomery County Department of Environmental Protection

Recycling and Resource Management Division

Municipal Solid Waste Management System

Alternatives Analysis

May 2025

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1. IDENTIFICATION OF MSW MANAGEMENT SYSTEM ALTERNATIVES

The County continues to implement a combination of source reduction and recycling programs to reduce waste generation and divert materials from future disposal while moving toward a 'zero-waste' model. Even so, approximately 52 percent of materials delivered to the County's waste processing facility and transfer station (TFS) tipping floor are still comprised of either comingled recyclables, recyclable paper, or compostable organics, which represent a significant opportunity for enhanced waste diversion [**Ref. 1**]. In addition, the County's current municipal solid waste (MSW) management system relies upon a Resource Recovery Facility (RRF) to combust approximately 600,000 tons per year of processible waste materials; and although the facility operates in compliance with its Permit requirements as well as applicable Federal and State regulations, it has been recognized as a significant source of air emissions (primarily carbon dioxide and other compounds).

The County retained Arcadis in November 2023 to evaluate and compare multiple alternative MSW management systems including the following:

- Alternative 1 Materials Recovery and Biological Treatment (MRBT) to enhance recovery of valuable materials from the TFS tipping floor.
- Alternative 2 Long-Haul MSW to an Out-of-County MSW Landfill (MSWLF).
- Baseline for Comparison – Retrofit/Repair and/or Rehabilitation of the County's existing RRF.

Based upon the results of that evaluation, the County's Department of Environmental Protection (DEP) is proposing development of an innovative MRBT facility, which represents a significant opportunity to enhance diversion of MSW and reduce future GHG emissions.

1.1 Existing MSW Management System

MSW materials collected from within the County's jurisdictional boundaries are delivered to the TFS located in Derwood, MD. Four (4) compactors at the transfer building load MSW into 40-foot length intermodal containers (ITCs) with a target weight of 27 tons of waste, which are then hauled by a small 'terminal tractor' unit to an adjacent 1.2-mile length access track within the adjacent TFS railyard.

From there, containers are lifted by gantry crane and stacked two-high on special purpose rail cars which are pulled by locomotive engine approximately 18 miles by rail after close of daily TFS operations to the County's existing RRF located in Dickerson, MD. CSX Transportation, Inc. provides rail service.

The RRF, also referred to as a Waste-to-Energy facility, incinerates the MSW and creates high pressure steam which is input to a turbine engine. The turbine generator is capable of producing up to 52 MW of electricity, 24 hours per day, 7 days per week, which is sold and exported to the local power grid. Resulting revenues from the sale of electricity and renewable energy certificates (RECs) are used to offset operating expenses (OPEX) charged to the County from the facility operator.

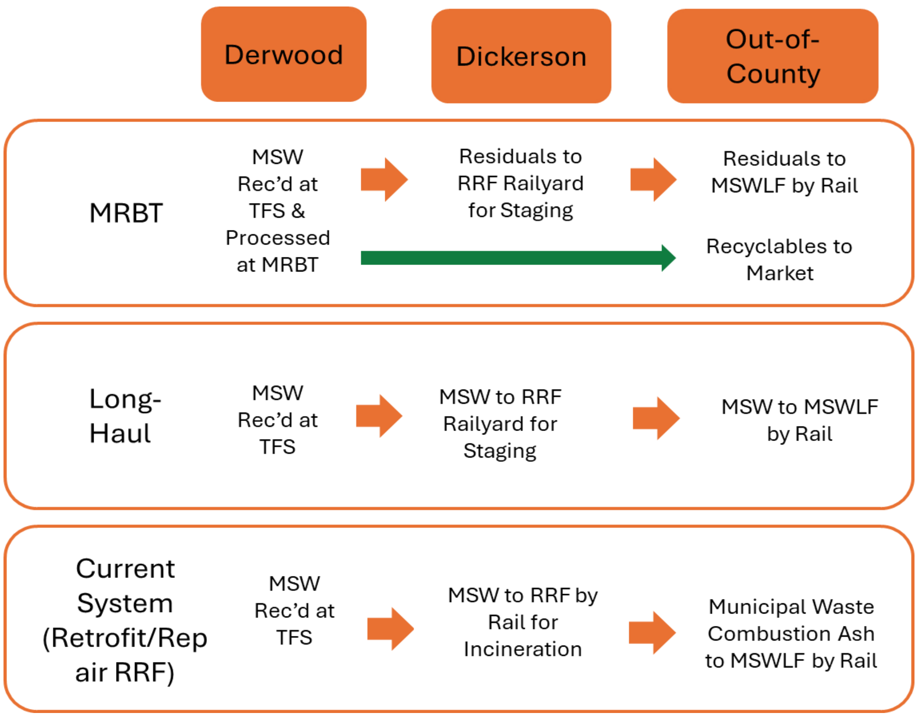
Following incineration, the resulting residual material, sometimes referred to as Municipal Waste Combustion (MWC) Ash, is again loaded into ITCs and onto railcars within the RRF railyard. After staging off-site at a local CSX junction, a length of approximately 120 rail cars is sent by locomotive every 3 days, approximately 160 rail-miles for disposal at the Old Dominion Landfill owned and operated by Republic Services, Inc., located in Henrico County, VA (in proximity to Richmond, VA). Given the relatively large distance, the journey from the RRF to the landfill and back to the RRF requires several days to complete. Republic Services utilizes the MWC Ash as an

Alternate Daily Cover (ADC) pursuant to Virginia Solid Waste Management Regulations, avoids the cost of importing other fill materials for use as daily cover, and receives credit for beneficial re-use.

1.2 Alternative MSW Management Systems

Multiple alternative MSW management systems were evaluated and are summarized in **Figure 1-1.**

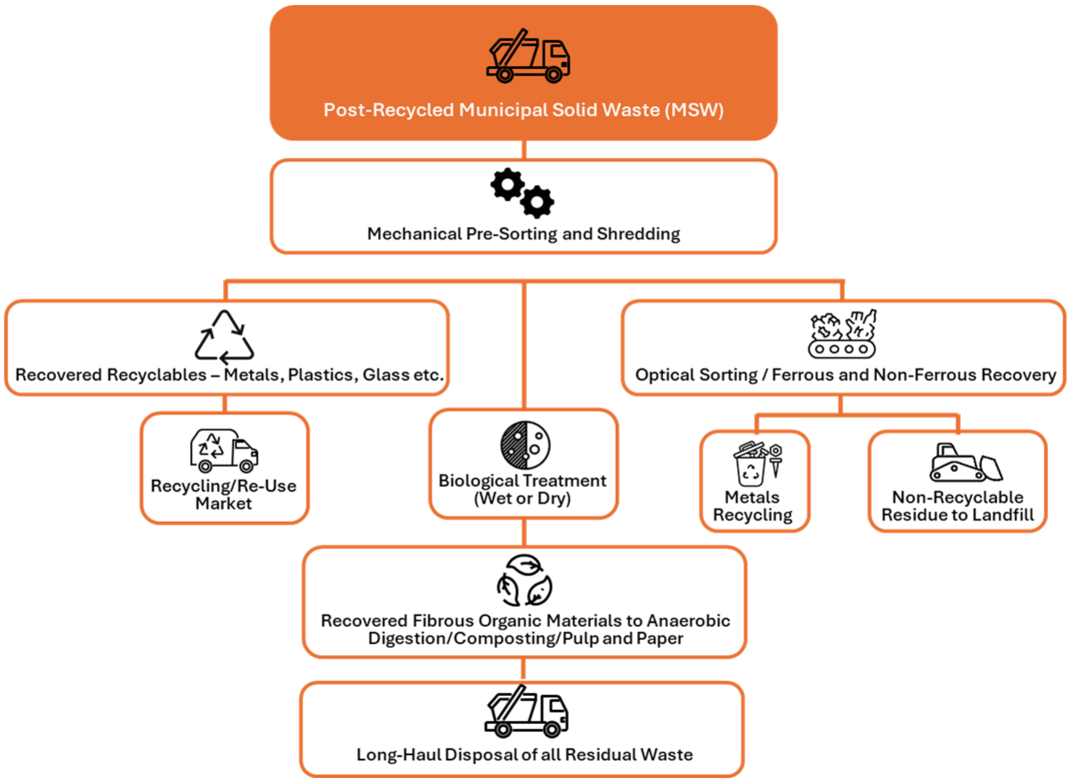
Figure 1-1: Summary of Alternatives Evaluated



A more complete discussion of the alternative MSW management technologies can be found in **Appendix A**.

Alternative 1 - MRBT - This alternative would adapt the TFS (or other potential site) to accommodate development of a MRBT facility and increase waste diversion. Basic components of an MRBT facility are shown in **Figure 1-2**.

Figure 1-2: Typical MRBT Facility Configuration



It is noteworthy that the MRBT facility is intended to supplement (not replace) on-going diversion efforts within the County and would be used to manage materials remaining in the MSW stream which arrive at the TFS tipping floor after recycling and other source reduction efforts.

MRBT utilizes mechanical equipment separation technologies to sort residential or commercial-generated MSW by size, shape, weight, conductivity, or other parameters into recoverable recyclable materials for market sale and recoverable organic waste fractions for possible beneficial use, along with residual waste that require disposal at a RCRA Subtitle D-compliant MSWLF. Recovered recyclable commodities (e.g., plastics, ferrous and non-ferrous metals, cardboard, etc.) will vary in quality and may require a washing process to optimize pricing for market sales. The recoverable organic waste fraction (e.g., food scraps, yard trim, non-recyclable paper) will undergo biological stabilization, most likely through anaerobic digestion (AD) that uses microorganisms to break down organic matter in the absence of oxygen and produce biogas that can be upgraded to an energy source such as renewable natural gas (RNG).

AD facilities produce solid digestate that will require disposal at a permitted landfill or may potentially be used for land application as a soil amendment; as well as liquid digestate which may require both pre-treatment (typically on-site) before final treatment at a wastewater treatment facility prior to discharge

The MRBT residue would require disposal and would follow a sequence of transfer and hauling processes similar to that described previously for the County's existing MSW management system. Residue would be compacted within the transfer building into ITCs and transferred at the end of each operating day by CSX rail from the TFS to the RRF railyard for temporary storage and staging. After staging into longer train-lengths, again, as required by CSX, the ITCs would be hauled via rail from the RRF railyard to an Out-of-County MSWLF.

There are no MRBT facilities of the projected size required for management of Montgomery County's MSW stream operating in the United States. However, the City of San Jose, CA relies upon an MRBT facility (Greenwaste) with nameplate capacity of approximately 90 tons/hour (or about 900 tons/day), or approximately one-half the capacity required by Montgomery County. It is our understanding the Greenwaste facility was constructed on behalf of a private sector vendor (Athen's Services) and operated pursuant to an agreement with the City. It sits on a property comprising an approximate 10-acre footprint (which is similar in size to the footprint available at the County's TFS and/or RRF footprint following decommissioning).

With regard to the potential location of the MRBT facility, a formal feasibility study has not been carried out but one of the Offerors deemed responsive to a preceding Request for Expression of Interest (REOI) included a preliminary site plan with their submittal which showed locating the proposed MRBT facility at the TFS. This may require relocation of other activities which are currently co-located with the Transfer Building and future MRBT facility. If the County chooses to proceed with procurement for an MRBT facility, the selected project developer would be required to identify the proposed facility location and plan the facility design and construction to abate or minimize disruption of activities at the TFS (which may include temporary or permanent relocation of some existing supporting activities).

Alternative 2 - Long Haul of MSW to an Out-of-County MSWLF - This alternative would transport the entire MSW stream of materials from the TFS tipping floor to an Out-of-County MSWLF. Multiple scenarios (labeled 2A through 2E) were evaluated utilizing either rail or tractor-trailer for hauling MSW. Facility adaptation, rolling stock requirements to transport waste materials, as well as resulting cost of service varied significantly when compared to other alternatives.

The implications of hauling MSW as opposed to MWC Ash relate directly to their physical properties which are changed by the incineration process and have a significant impact on long haul operations and disposal. In each of these scenarios the impact of change from hauling and disposal of MWC Ash to that of hauling and disposal of unsorted MSW has been considered. These included evaluation of public safety, cost (including facility adaptation and rolling stock requirements), potential nuisance impacts on the immediate surrounding community) and other factors such as complexity of operations as well as proximity and availability of disposal capacity from landfills.

More specifically depending upon whether rail or tractor-trailer is used for hauling:

- **Rail Haul** - Long haul via rail would continue to rely upon dedicated rolling stock specifically designed to accommodate between 2 to 4 ITCs per rail car depending upon whether the containers are single- or double-stacked. Two scenarios were evaluated:
    - **2A Long Haul MSW by Rail from the RRF to an Out-of-County MSWLF** – Hauling and disposal of waste materials in this scenario is similar in many ways to the process used for the County's existing MSW management system as well as the previously described MRBT alternative. This alternative includes compaction of waste into ITCs at the transfer building; daily transfer of waste by CSX rail from the TFS to the RRF railyard in Dickerson; temporary storage and staging of waste-filled ITCs on rail cars to enable formation of longer train lengths in accordance with CSX requirements; followed by transport by CSX rail to an Out-of-County MSWLF for final disposal.

  - **2B Long Haul by Rail from the TFS to an Out-of-County MSWLF** – Direct hauling of MSW from the TFS railyard omits utilizing the RRF railyard as an intermediate staging area. In other respects, it is similar to Alternative 2A. Although staging of ITCs on railcars is still required to satisfy CSX requirements, these efforts would be performed within the TFS railyard and then transported by CSX rail to an Out-of-County MSWLF for final disposal. There are significant constraints and limitations associated with this alternative, relating to cost of necessary railyard adaptation and rolling stock, regulatory requirements, and potential nuisance impacts on the surrounding community associated with overnight storage of MSW within ITCs.

- **Tractor-Trailer** – MSW transport by tractor-trailer would require utilization of walking-floor trailers in lieu of ITCs. Unlike ITCs, walking-floor trailers cannot be 'double-stacked' on railcars. The corresponding reduction in payload has significant implications on the cost of railyard adaptation and rolling stock requirements:
  - **2C Long Haul Tractor-Trailer from the TFS to an Out-of-County MSWLF** – Direct hauling of MSW from the TFS to an Out-of-County MSWLF using tractor-trailer appears to be the simplest operation, however, there are significant constraints and limitations relating to potential public and worker safety as well as potential nuisance impacts (largely traffic related) on the surrounding community.
  - **Hybrid Utilizing both Rail and Tractor-Trailer:**
    - **2D Long Haul by Rail from the RRF (65%) and Long Haul by Tractor -Trailer from the TFS (35%) to an Out-of-County MSWLF** – This represents a 'hybrid' approach which attempts to relieve pressure on the TFS facility caused by increased rolling stock and 'heavy' tractor-trailer traffic by hauling from both the RRF and TFS locations. To avoid overly complex operations all MSW materials would be compacted into walking floor trailers (no utilization of ITCs). Approximately 65 percent of the MSW would be transported to the RRF railyard and the remaining 35 percent via direct haul from the TFS.

      The fraction of MSW managed via the RRF railyard would utilize a process similar to that described previously for Scenario 2A following compaction of waste into walking-floor trailers at the transfer building (including daily transfer of waste by CSX rail from the TFS to the RRF railyard in Dickerson; temporary storage and staging on rail cars to enable formation of longer train lengths in accordance with CSX requirements; followed by transport by CSX rail to an Out-of-County MSWLF for final disposal).

      The fraction of MSW managed via the TFS would utilize a process similar to that described previously for Scenario 2C. MSW would be direct hauled from the TFS to an Out-of-County MSWLF. Constraints and limitations relating to potential public and worker safety as well as nuisance impacts (largely traffic related) on the surrounding community would be reduced but not abated.
    - **2E Long Haul by Tractor-Trailer from the RRF (100%) to an Out-of-County MSWLF** – This scenario represents a variation of the previously described 'hybrid approach' and was suggested by external stakeholders as a way to expedite transition to another technology and avoid extension of the RRF operations agreement. All MSW arriving at the TFS tipping floor would first be transported by rail to the RRF railyard, similar to the previously described Scenario 2A. and

then subject to additional handling and transferred for long-hauling via tractor-trailer from the RRF to an Out-of-County MSWLF.

Constraints/Limitations and potential impacts on the TFS railyard and rolling stock requirements are unchanged, while potential nuisance impacts on the community surrounding the TFS are shifted to the community surrounding the RRF. In addition, significant potential impacts are associated with adding between 110-115 outbound and 110-115 inbound tractor-trailers daily on local roadways between the RRF and Routes 28 and/or 109 through Beallsville and Barnesville (while heading toward or coming from I-270); as well as potential significant roadway/intersection improvements within both towns. Remedying these potential impacts are anticipated to be costly and time-consuming, which would preclude immediate implementation of this alternative.

Alternative 2E was shown to be the most expensive, least practical, and most time-consuming of the various alternatives and dismissed from further consideration.

Results of the separate evaluation of these various Long Haul to an Out-of-County MSWLF scenarios indicated Alternative 2A Long Haul MSW by Rail from the RRF should be used for comparison to Alternative 1 and the base case because Alternative 2A minimized cost and avoided traffic impacts around the already-busy TFS site.

<u>Current System for Comparison: Retrofit/Repair and/or Rehabilitation of the County's Existing RRF</u> - This system is described for comparison purposes only, understanding the County Executive's intent to decommission the RRF following transition to another MSW management system utilizing a different primary technology for MSW processing.

The analysis assumes retrofit/repair and/or rehabilitation of the existing RRF suitable for a 30-year planning horizon. The scope of these efforts is deemed sufficient and necessary to facilitate long-term operations and include significant modifications to the facility's major components. These modifications include full boiler replacement, an upgraded air pollution control system including selective catalytic reduction (SCR) system components, as well as upgrades to the Municipal Waste Combustion (MWC) ash process and handling system and improvements to enhance recovery of ferrous and non-ferrous metals.

2. EVALUATION OF ALTERNATIVE SYSTEMS

A multi-variable evaluation model was developed to enable comparison of the alternative MSW management systems defined above. Detailed methodology is provided in **Appendix B**. Technologies were compared on the basis of the following evaluation criteria identified by the County:

- **Waste Diversion (Percent Diversion from Disposal)** – Estimates were made of anticipated diversion using reasonable assumptions based on past performance of similar facilities.
- **Carbon Footprint/Greenhouse Gas (GHG) Emissions (eCO2/ton)** - USEPA Waste Reduction Model (WARM) was utilized to estimate resulting emissions based upon waste composition obtained from previous County studies.
- **Cost-of-Service (Net Present Value ($/Ton))** – The model utilized estimated cost of developing the various technology-based alternative systems using data collected from local, regional and national sources.

Each of the evaluation criteria were equally weighted pursuant to the County's policy objectives. Results of the evaluation using the model and comparison of alternatives are summarized in **Table 2-1:**

- **Alternative 1 MRBT** represents the top-ranked alternative. Highest scores for individual criteria were associated with waste diversion and carbon footprint.
- **Alternative 2A Long Haul of MSW by Rail from the RRF to an Out-of-County MSWLF** was the lowest ranked alternative.
- For comparison purposes the **Current System including Retrofit/Repair and/or Rehabilitation of the County's Existing RRF** was ranked second. It received the highest rank score for cost-of-service.

Table 2-1: Summary of Evaluation Model Ranking of Alternatives

Alternative	Rank	Diversion	Carbon Footprint	Cost
1 – MRBT (with Long-Haul)	1			
2 – Long Haul to Out-of-County MSWLF from RRF (Options 2A or 2C)	3			
Current System for Comparison (Retrofit/Repair RRF)	2			

Legend: Top | Middle | Low

Notes:
1. Diversion Reflects Rate of Avoided Disposal off TFS Tipping Floor. Top Rank Equals High Diversion.
2. Carbon Footprint is the Difference in MTCO2e/Ton MSW Processed when Compared to Current County System. Top Rank Equals Small/Reduced Footprint.
3. Cost-of-Service includes Preliminary Estimate of Potential Health & Environmental Impacts. Top Rank Equals Low Cost.

In addition, the USEPA Environmental Justice Screening and Mapping Tool (EJ Screen) was utilized to identify and compare socioeconomic, health and environmental data for a range of indices and indicator parameters in an effort to identify the extent to which any community that may host a waste processing facility is already disadvantaged.

2.1. Waste Diversion

Waste diversion was evaluated as the percentage of MSW arriving at the TFS tipping floor that could be diverted from disposal. Results of analyses showing estimated percent diversion of waste materials from disposal are summarized in **Table 2-2**.

Table 2-2: Summary of Waste Diversion from Disposal

MSW Management System Alternatives	Est. Percent Diversion from Disposal
1 – MRBT (with Long-Haul)	45
2 – Long Haul MSW to Out-of-County MSWLF by Rail from RRF (Option 2A or 2C)	0
Current System for Comparison (Retrofit/Repair of RRF)	3 to 4

Notes:

1. Percent diversion expressed as fraction of MSW delivered to the TFS Tipping Floor and does not include up-front programmatic efforts to prevent recoverable materials such as recyclables or compostable organics from entering the TFS.
2. Alternative 1 MRBT subject to confirmation by collaborative design with System Developer. A diversion rate of 45% is assumed and reflects average of data provided by two Offerors in response to the County's recent REOI, as well as typical diversion rates independently confirmed with a provider of existing MRBT systems.

Results of these analyses indicate the following:

- **Alternative 1 MRBT** - Development and operation of an MRBT facility may result in approximately 45 percent diversion depending upon the efficiency and effectiveness of the System Developer's proprietary process. The assumed percent diversion was based upon responses to a previous County REOI and conversations with other similar facilities operating or planned in the U.S.
- **Alternative 2A Long Haul of MSW by Rail from the RRF to an Out-of-County MSWLF** – Disposal of MSW at a typical MSWLF obviously results in no supplemental waste diversion.
- **Current System for Comparison Including Retrofit/Repair and/or Rehabilitation of the County's RRF** - For comparison purposes the RRF with upgraded metals recovery from the MWC Ash may be expected to result in approximately 3 to 4 percent diversion of materials from landfill disposal.

While the exact diversion rate that can be accomplished by MRBT would be determined through the facility design process, it is clear MRBT represents the alternative with the greatest potential for waste diversion.

2.2. Carbon Footprint/Greenhouse Gas (GHG) Emissions

Modeling was performed using USEPA Waste Reduction Model (WARM), which is a tool for comparing life cycle greenhouse gas emissions for different material management strategies or practices. WARM was used to compare GHG emissions of the various alternatives to a baseline which corresponds with upgrade of the County's RRF. The County's waste composition, as determined by the 2023 waste composition study (previous **Ref.1**), was used to develop WARM inputs.

WARM was first introduced in 1998 and has been periodically updated to incorporate new data and waste management strategies. The current Version 16 was published by USEPA in December 2023 and includes updates to landfill emissions factors for organic fractions of MSW such as food waste and other wood products. Professional peer review was completed using a team of independent researchers with no conflict of interest who collectively had specialized expertise relating to life cycle assessment modeling, solid waste management modeling, modeling GHG emissions and other environmental impacts, as well as experience in modelling carbon storage (in landfills and other natural environmental systems).

The model treats biogenic carbon sources as carbon neutral since potential GHG emissions from biogenic carbon do not interrupt the natural carbon cycle within the timeframe of the model assumptions. This is consistent with the International Panel on Climate Change (IPCC). As such, WARM makes a distinction between biogenic and non-biogenic carbon sources and how those impact lifecycle emissions:

- **Biogenic Carbon** - If the source of carbon is biogenic, the material in its original condition prior to being disposed would still produce carbon dioxide (CO2) if it were to degrade naturally:
    - CO2 emissions from biogenic carbon sources are considered carbon neutral regardless of the disposal technology. Biogenic CO2 emissions resulting from any of the MSW management alternatives, which utilize incineration, anerobic digestion, or landfill disposal as their primary technology, are all considered carbon neutral.
    - Emission of GHGs other than CO2, which are anthropogenic in nature and caused and/or influenced by the waste processing technology, and which would otherwise not occur under natural conditions, are not carbon neutral and considered in the analyses.
- **Non-Biogenic Carbon Sources (sometimes referred to as 'fossil carbon sources')** – If the source of carbon within the MSW stream of materials is derived from non-biogenic sources, such as plastics (which are anthropogenic in nature given they are derived from extracted fossil-based fuel), WARM will assume that component of the waste stream may result in discharge of GHG emissions, but only to the extent to which the processing technology is able to convert non-biogenic carbon to other gases.

Examples of how the source of carbon (whether it be biogenic or non-biogenic) and waste processing technology affect the formation of CO_2 and other climate-relevant GHGs include the following:

- **Landfill Disposal** results in the decomposition of biogenic carbon and formation of methane (CH_4), CO_2 and N_2O during anaerobic decomposition in the presence of methanogens (bacteria) within the waste mass, as well as CO_2 which occurs during aerobic decomposition at the landfill surface either prior to burial of the waste, or as fugitive CH_4 molecules produced within the waste mass migrate to the landfill surface and are oxidized by methanotrophs (which consume the CH_4 as a food source). The CO_2 component is deemed 'carbon neutral' inasmuch as it would have formed in absence of the landfill process, whereas the CH_4 which is caused specifically by burial of the carbon source within the landfill waste mass is not. However, it is important to note these compounds are only formed from degradation of biogenic carbon, and not non-biogenic or fossil carbon sources (such as plastics embedded within the MSW). It is also noteworthy that the model appears to over-estimate the collection efficiency of Landfill Gas Collection and Control System (LFGCCS) thus likely under-reporting fugitive emissions of methane.
- **Anaerobic Digestion** (which can be used on the 'back end' of an enhanced MRBT facility) creates both methane (CH_4) and N_2O from biogenic carbon embedded within the MSW. Although the resulting biogas is ultimately combusted, both compounds are deemed climate-relevant inasmuch as they are caused directly by the waste processing technology which is anthropogenic. It is equally important to note that

Anerobic Digestion is not able to synthesize plastics derived from non-biogenic carbon sources embedded within MSW.

- **Incineration of MSW** on the other hand, can emit CO_2, as well as other GHGs such as nitrous oxide (N_2O), oxides of nitrogen (NOX) and ammonia (NH_3), from both biogenic and non-biogenic carbon sources. Thus, inasmuch as CO_2 derived from biogenic carbon is deemed 'carbon-neutral', the 'climate-relevant' CO_2 emissions from MSW incineration are determined by the proportion of waste whose carbon compounds are assumed to be of 'fossil origin'; and the allocation of percentages of the MSW stream of materials to biogenic or fossil carbon sources has a significant influence on the calculated amounts of climate-relevant CO_2 emissions. It is also noteworthy that WARM does not take credit for carbon offsets associated with recovery of nonferrous metals (such as copper and aluminum) which would have a large impact on calculated net GHG emissions and energy use footprints.

Results of analyses comparing the estimated GHG emissions are summarized in **Table 2-3**.

Table 2-3: Summary of GHG Emissions Reductions Relative to RRF

Alternative[1] Systems	GHG Emissions Per Ton MSW (MTCO2E/ton)[2]	Annual GHG Emissions (MTCO2E)[2]	Annual Avoided Emissions (Passenger Vehicles)[3]
1 – MRBT (with Long-Haul)	(0.70)	(418,560)	97,524
2 – Long Haul MSW to Out-of-County MSWLF by Rail from RRF (Option 2A)	(0.03)	(20,537)	4,785

Notes:
1. Alternatives were compared to Baseline (MCRRF Upgrade with Long-Haul MWC Ash by Rail to Out-of-County Landfill.
2. Assumes 600,000 tons MSW per year.
3. Greenhouse Gas (GHG) Emissions performed by WARM pursuant to USEPA passenger vehicle emissions assumptions. MTCO2E refers to metric tonnes of carbon dioxide equivalent.
4. Alternative 1, MRBT, assumed approximately 45% diversion off of TFS tipping floor.

The Table shows the reduction in GHG emissions for each option relative to continuation of the RRF. Results of these analyses indicate the following:

- **Alternative 1 MRBT -** Development and operation of an MRBT facility represents a potential reduction in GHG emissions equivalent to approximately 0.70 metric tonnes eCO2 per short ton of MSW processed.

- **Alternative 2A Long Haul of MSW by Rail from the RRF to an Out-of-County MSWLF** – This alternative represents a reduction in GHG emissions equivalent to approximately 0.03 metric tonnes eCO2 per short ton of MSW processed.

Development and operation of an MRBT facility represents the alternative with the greatest potential for reduction in GHG emissions and associated carbon footprint.

Carbon footprint and GHG emissions are affected by the MSW composition and processing technology. MRBT represents a potential significant reduction in carbon footprint by removing and recycling materials from the waste stream (plastics, paper and other organics) which would otherwise be combusted in the County's RRF (the baseline system used for comparison). This results in both avoided emissions from the RRF and avoided emissions from the use of recycled commodities in making new products. Long Haul of MSW by Rail to an Out-of-County MSWLF reduces the carbon footprint less due to potential 'fugitive' air emissions at the landfill tipping face during early stages of aerobic decomposition, incomplete collection of methane from the facility's Landfill Gas Collection and Control System (LFGCCS) during later anaerobic decomposition, and diesel emissions associated with rail haul operations.

A full explanation of the inputs and results of the WARM analysis are included in **Appendix C**.

2.3. Cost of Service

A financial model has been developed to enable estimation of capital and operating expenditures (CAPEX and OPEX, respectively), off-setting revenue and resulting expenditure schedules for the alternatives, including variations of MRBT, Long-Haul of MSW to an Out-of-County MSWLF, and the existing system as a baseline for comparison.

The analysis considers a 30-year planning horizon. Input variables include the following:

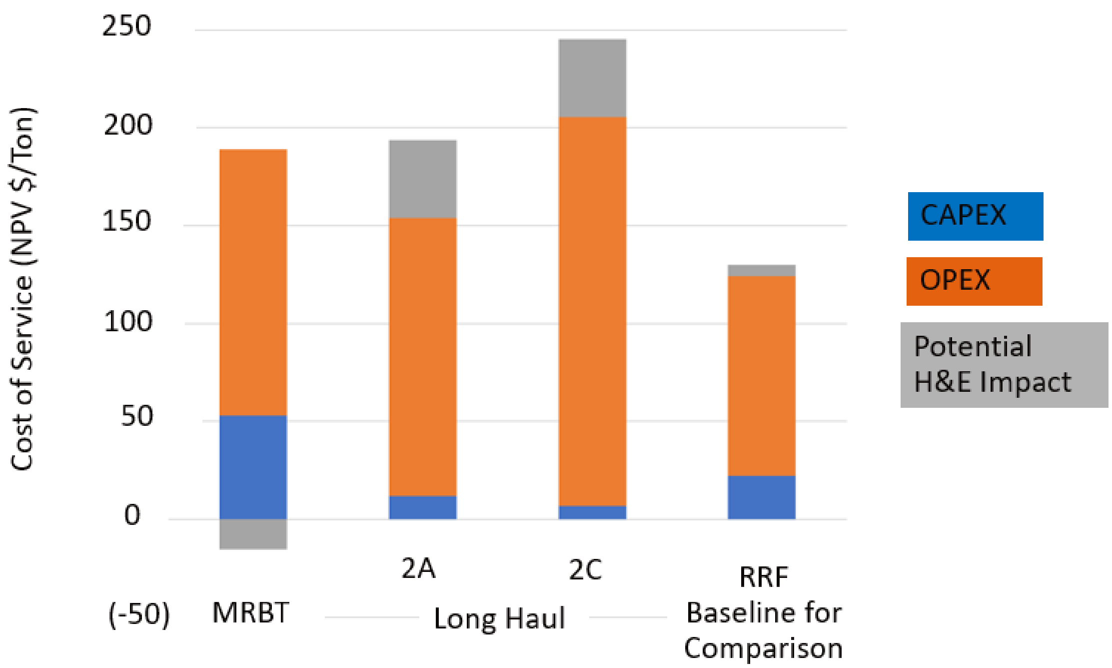
- MSW system mass balance and waste stream characteristics including tonnage, anticipated growth rate, and composition. The analysis did not consider implications of potential future waste reduction efforts on the various alternative MSW management systems and focused on existing waste stream characteristics. For instance, if less food waste is included in the MSW stream, the diversion rate from MRBT would likely be reduced, but the overall diversion rate for the County (including diversion from MSW and source-separated composting) would likely still be higher than if food waste was not captured in advance of the TFS tipping floor.
- Waste processing technology efficiency in recovering materials from the TFS tipping floor.
- Cost and revenue inputs including CAPEX, OPEX including but not limited to TFS and railyards; Residue Transport via truck and/or rails as well as MSWLF tipping fees.
- Other project development costs include fees paid to project developers and/or the County's professional services A/E contractor team.
- Financing costs.
- Scheduling details, including project startup and duration of phased build-out and development.

The financial model reports cost of the various alternatives in terms of Net Present Value (NPV). Future CAPEX, OPEX and offsetting revenue line-items are projected forward and backward using assumed inflation and discount rates, respectively, to create a 'net' cost estimate expressed in terms of 2025 dollars on a $/ton basis over the planning horizon.

Detailed analyses provided by the financial model are included in **Appendix D.**

Results of financial modeling showing the estimated cost of service for the alternative MSW management systems over a 30-year planning horizon are summarized in **Figure 2-1,** including the relative contribution of CAPEX and OPEX**.** The figure indicates that annual recurring operating expenses have a significantly larger impact on the resulting lifecycle cost than the up-front capital expenditure required to construct the various facilities and associated infrastructure.

Figure 2-1: Summary of Estimated Cost of Service Including Contributions of CAPEX and OPEX Components



OPEX has been shown as a net operating expense and includes the contribution of off-setting revenues for the various alternatives:

- MRBT offsetting revenues may be derived from the sale of recovered recyclable materials and biogas.
- RRF offsetting revenues include the sale of energy as well as recovered ferrous and non-ferrous metals from RRF MWC Ash recycling. Off-setting revenue from potential sales of Renewable Energy Credits (RECs) has been ignored. Pursuant to HB 1035 of 2025, waste-to-energy has been removed from Tier 1 of the State's Renewable Portfolio Standard. The change becomes effective for Montgomery County's RRF on July 1, 2026. After that date the market for RECs from the facility is expected to be eliminated or severely limited.
- Long-Haul of MSW to an Out-of-County MSWLF does not generate any off-setting revenue.

Future decommissioning of the approximate 10-acre RRF footprint in the MRBT or Long-Haul scenarios may allow development of alternative 'secondary' revenue-generating technologies which may or may not result in net revenue generation.

More detailed results of the financial analyses are summarized in **Table 2-4.** The Table indicates the following system costs for each alternative, which do not include estimated monetized cost of potential public health and environment impacts to the surrounding area. Such potential costs are calculated separately and subsequently added to the system cost to estimate the approximate total cost of service:

- **Alternative 1 MRBT** - The estimated cost-of-service for development and operation of an MRBT facility with long-haul of residual wastes by rail is approximately $189/ton. The unit cost of the alternative may be expected to increase if the County chooses to send residual waste materials to an Out-of-County MSWLF located at greater distance than the Republic Services Old Dominion Landfill located in Henrico County, VA (in proximity to Richmond, VA).
- **Alternative 2A Long Haul of MSW by Rail from the RRF to an Out-of-County MSWLF** - The estimated cost of service for long-haul using the RRF railyard as a staging area is approximately $154/ton. Again, the unit cost of long-haul may be expected to increase if the County chooses to send MSW to an Out-of-County landfill located at greater distance than the Republic Services Old Dominion Landfill in Henrico County, VA (in proximity to Richmond, VA).
- **Current System for Comparison Including Retrofit/Repair and/or Rehabilitation of the County's RRF** - For comparison purposes, the estimated cost of service for upgrading the RRF is approximately $124/ton.

Not including upgrade of the RRF (current system for comparison), Alternative 2A Long Haul of MSW by rail from the RRF to an Out-of-County MSWLF represents the lowest system base cost.

Table 2-4: Summary of Estimated MSW Management System Cost of Service

Alternative Systems	30-year System Costs (NPV$ billion)	System Cost ($/ton)[1]	Health and Environment (H&E) Impact ($/ton)[2]	Total with H&E ($/ton)
1 – MRBT[3] (with Long-Haul)	3.8	189	-16	173
2A – Long-Haul MSW to Out-of-County MSWLF by Rail from RRF	3.0	154	+40	194
2C – Long Haul MSW to Out-of-County MSWLF by Tractor-Trailer from TFS	4.0	205	+40	245
Current System for Comparison (Retrofit/Repair of RRF)	2.4	124	+6	130

Notes:

1. System Cost $/Ton is the Net Present Value (NPV) for a 30-Year Planning Horizon accounting for future inflation including all anticipated capital/operating expenses and off-setting revenue.
2. Potential H&EI Impacts have been assigned a preliminary monetary value based upon Morris et. al., 2013.
3. MRBT assumes 45% recovery rate from TFS tipping floor and corresponds with the average of data provided by two Offerors in response to the County's recent REOI. 5

An external source [**Ref. 2**] has estimated the relative monetized cost of potential human health and environmental impacts associated with various MSW processing technologies. For the purpose of comparison, we have included values for the differential monetized cost of potential health and environmental impacts derived from that external technical source. Monetized costs of potential impacts estimated from this source have been increased to account for simple inflation since the time of its publication (2013). The monetized costs presented are only intended to represent the variance in approximate cost of potential health and environmental impacts relative to the other alternatives. Our independent review of the referenced document, and other references provided by the same author, have been unable to replicate the potential cost of impact for several categories of potential health and environmental impacts. Although more recent cost estimates presented by external stakeholders indicate significantly greater monetized cost of potential impacts, insufficient supporting documentation has been provided to enable review or confirmation of those separate analyses. The 2013 publication was thus used in absence of more detailed data available for technical peer review.

The estimates of monetized cost of potential health and environmental impact include the contribution of the following categories of impacts:

- Climate change – eCO2
- Acidification - eSO2
- Eutrophication - eNitrogen
- Respiratory PM2.5 emissions - ePM2.5
- Non-Cancer Toxicity - eToluene
- Cancer (Human Disease and Carcinogen) - eBenzene
- Ecosystem Toxicity - e2,4-D

The values for the estimated differential cost of potential health and environmental impacts include the following:

- **Alternative 1 MRBT** - Enhanced diversion and capture of co-mingled recyclables, recyclable paper and compostable organics is estimated to result in an approximate $16/ton reduction in cost of service when compared to the other alternatives. This represents a preliminary estimate and is subject to confirmation once updated estimates are obtained of potential air emissions associated with the MRBT process, which can be proprietary.
- **Alternative 2A Long Haul of MSW by Rail from the RRF to an Out-of-County MSWLF** – Utilization of a MSWLF with anticipated Landfill Gas to Energy plant is anticipated to result in an approximately $40/ton increase in cost of service.
- **Current System for Comparison Including Retrofit/Repair and/or Rehabilitation of the County's RRF –** On-going utilization of the RRF is estimated to result in an approximate $6/ton increase in cost of service.

Adding these potential incremental costs to those indicated in the previously referenced table indicates the following' total' cost of service including the estimated difference in monetized cost of potential health and environmental impacts:

- **Alternative 1 MRBT** - $173/ton.
- **Alternative 2A Long Haul of MSW by Rail from the RFF to an Out-of-County MSWLF** - $194/ton.
- **Current System for Comparison Including Retrofit/Repair and/or Rehabilitation of the County's RRF** – $130/ton

Not including the current system used for comparison, the estimated cost of service for Alternative 1 represents the low-cost alternative after accounting for the monetized cost of potential health and environmental impacts. However, for comparison purposes the existing system, including retrofit/repair and/or rehabilitation of the County's existing RRF is approximately $43/ton less cost than MRBT.

2.4. Environmental Justice (EJ) Screening

EJ Screening was developed for a range of environmental indexes as well as socioeconomic and public health indicators at three communities which may potentially host one of the necessary MSW system components for waste processing (waste processing and transfer (TFS in Derwood, MD), staging of waste prior to transport (RRF railyard in Dickerson, MD) and final disposal at an Out-of-County MSWLF (location to be determined). EJ Screening was not included in the previously described Evaluation Model used for comparison of alternatives because each alternative anticipates some form of waste management activity at the same three (3) previously referenced geographic locations.

Eleven (11) screening criteria were deemed relevant to the analysis associated with locating and development of a waste management processing facility:

- Environmental Indexes:
    - Particulate Matter 2.5
    - Ozone
    - Diesel Particulate Matter
    - Toxic Releases to Air
    - RMP Facility Proximity
- Public Health Indicators:
    - Cancer
    - Asthma
    - Low Life Expectancy
- Socioeconomic Indicators:
    - Low Income
    - People of Color
    - Limited English-Speaking Households

Other factors may also influence the potential health and environmental impacts of the alternatives on host communities, such as the specific waste processing technology used at any given location and its associated air emissions, the type of waste material managed (such as MWC ash, MSW or MRBT residual), as well as the quantity of materials managed at the location.

Results of EJ Screening analyses for various infrastructure host communities are summarized in **Table 2-5.**

Table 2-5: Summary of Environmental Justice Screening Analyses for Potential Host Communities

EJ Screen Indicators	RRF, Dickerson, MD	TFS, Derwood, MD	Republic Old Dominion, Henrico County, VA
PM 2.5			X
Ozone		X	
Diesel Particulate Matter		X	X
Toxic Releases to Air			X
RMP Facility Proximity			X
Cancer			
Asthma			X
Low Life Expectancy			X
Low Income			X
People of Color		X	X
Limited English-Speaking Households		X	X

Notes: 1. X Indicates Surrounding Host Community Area Exceeds National 50th percentile.

The community surrounding the Republic Services Old Dominion Landfill in Henrico County, VA, the landfill currently used for MWC ash disposal, exceeds national 50 percentile data for nine (9) of the eleven (11) EJ Screening indicators:

- Particulate Matter 2.5 - 56 percentile
- Diesel Particulate Matter – 82 percentile
- Toxic Releases to Air – 97 percentile
- RMP Facility Proximity – 94 percentile
- Asthma – 91 percentile
- Low Life Expectancy – 64 percentile
- Low Income – 81 percentile
- People of color – 84 percentile
- Limited English-Speaking Households – 58 percentile

Conversely, communities within the County surrounding the TFS and RRF indicate relatively favorable characteristics. The community surrounding the TFS (and TFS Railyard) as well as the potential future MRBT facility exceeds the 50th percentile data in four (4) of the eleven (11) criteria:

- Limited English-Speaking Households – 78.1 percentile
- Diesel Particulate Matter – 73.5 percentile
- People of Color – 73.2 percentile
- Ozone – 51.3 percentile

The community surrounding the location of the RRF (and RRF Railyard), the latter of which may be used as a staging area for waste containers prior to shipment to an Out-of-County MSWLF, has no indicator parameters exceeding the national 50 percentile.

Changing the location of the Out-of-County MSWLF for final disposition of waste materials could reduce potential impact on a disadvantaged community. EJ Screening Criteria were identified for communities surrounding ten (9) additional Out-of-County MSWLF located in either Virginia or Pennsylvania:

- Virginia:
  - Waste Management Maplewood Landfill, Jetersville, VA.
  - Shoosmith Sanitary Landfill, Chester, VA.
- Pennsylvania:
  - Republic Services
    - Modern Landfill, York, PA.
    - Imperial Landfill, Imperial PA.
  - Waste Management Inc.:
    - Laurel Highlands Landfill Johnstown, PA.
    - Evergreen Landfill, Blairsville, PA.
    - Mostoller Landfill, Somerset, PA.
  - Noble Environmental (formerly GFL)
    - Sandy Run Landfill, Hopewell, PA
    - Southern Alleghenies Landfill, Davidsville, PA.

These facilities would require confirmation of compatibility with waste by rail (presuming long-haul via tractor-trailer from either the Derwood TFS or Dickerson RRF railyards was not acceptable). Review of screening criteria for these various facilities is summarized in **Table 2-6** and indicates the following:

- Each of the host communities surrounding the referenced MSWLF facilities exceeded the national 50 percentile data for at least two (2) and as many as seven (7) of the screening criteria.
- All of the potential host communities exceeded the national 50 percentile for fewer criteria than the community around the Old Dominion Landfill currently used for disposal of MWC Ash produced from the County's current MSW management system.

Elevated frequency or incidence rate of public health indicators exceeding the national 50 percentile data do not indicate the MSWLF is the cause of increased incidence.

It is noteworthy that the facilities identified in the previously referenced table are not intended as an exhaustive list of alternative MSWLFs. This list was compiled for the purpose of comparing environmental justice screening results for alternative landfills, with the intent of determining whether a change in MSWLF for final disposal of waste materials could potentially reduce the impact of the County's MSW management on disadvantaged or overburdened communities. Other landfill options may exist. The ultimate choice of landfill would be determined by the MRBT developer or long-haul contractor and informed by additional considerations such as cost, distance, rail compatibility, etc. (Changes in OPEX associated with the various potential out-of-County MSWLF were not considered and are not anticipated to change the identification of a preferred alternative given the selection criteria.)

Table 2-6: Summary of Environmental Justice Screening Analyses for Alternate MSWLF Host Communities

EJ Screen Indicators	Republic Old Dominion, Henrico County, VA	GFLSandy Run, Hopewell PA	GFL Southern Alleghenies Landfill, Davidsville PA	Republic Services Imperial Landfill, Imperial PA	WM Maplewood Landfill, Jetersville VA	WM Laurel Highlands Landfill Johnstown, PA	WM Evergreen Landfill, Blairsville, PA	WM Mostoller Landfill, Somerset, PA	Shoosmith Sanitary Landfill, Chester, VA	Republic Modern Landfill, York PA
PM 2.5	x			x						x
Ozone				x		x	x			
Diesel Particulate Matter	x									
Toxic Releases to Air	x	x	x	x		x	x	x	x	x
RMP Facility Proximity	x			x					x	
Cancer		x	x	x	x	x	x	x	x	x
Asthma	x	x	x	x	x	x	x	x		
Low Life Expectancy	x				x	x		x	x	
Low Income	x	x		x	x		x	x		
People of Color	x								x	
Limited English-Speaking Households	x									

Notes: 1. **X** Indicates Surrounding Host Community Area Exceeds National 50th percentile.
2. Availability of each alternative landfill would need to be confirmed prior to use. Maplewood and Modern Landfill are the only two known to have current rail access. 7

2.5. Uncertainties and Risks in Analyses

It is important to recognize there are several elements of risk and/or uncertainty associated with these various analyses.

One risk is greater-than-anticipated CAPEX and OPEX. All alternatives carry some risk of actual costs exceeding the estimate cost of service. Because there are no domestic examples of MRBT at the scale required for Montgomery County's MSW there may be more significant uncertainty of variance in anticipated CAPEX for MRBT than for the other options. However, this risk would be limited contractually before the County must make the final decision to construct the MRBT. In the phased procurement approach envisioned for MRBT (see Section 3 of this report), a small percentage of the investment would be made during the pre-construction phase. Prior to deciding to initiate construction, the County would receive a Guaranteed Maximum Price (GMP), which could be incorporated into the contract for construction services, shifting the risk of cost overages to the project developer.

Another risk is reliance on external disposal facilities. All alternatives rely on an Out-of-County MSWLF for disposal of MSW, MRBT residual or MWC Ash. Long-term, there are both financial and operational risks associated with increased tipping fees or reduced availability at Out-of-County MSWLFs. Development of new MSWLFs in the mid-Atlantic is significantly constrained by space, land use, and political factors. Consequently, there is finite capacity in the region and there may be increasing incentives to conserve capacity for locally generated waste materials. The greater an option's reliance on Out-of-County MSWLF the greater the exposure to this element of risk.

Finally, there is some uncertainty about system performance. Across existing MRBT systems, there is some variation and limited transparency of actual diversion rates, which raises a potential risk of lower-than-anticipated system performance. In addition, the MRBT system contemplated in Montgomery County would be the largest of its kind. Although the diversion rate assumed for this analysis was conservative to account for this it still indicated significantly greater diversion and GHG emissions reductions than the other alternatives. Performance risk will also be mitigated through utilization of a phased procurement process. Performance standards can be refined during the design phase and incorporated in the construction contract and any operating contracts to limit risk to the County. Long haul and continuation of the RRF promise less in terms of diversion and greenhouse gas emission avoidance, so there is less risk of mismatch between anticipated and actual performance in these areas. However, because these options fail to address environmental concerns raised with the current MSW management system, they pose their own risk in terms of long-term public acceptance and ability for the County to reach its climate and other commitments.

3. PROCUREMENT AND SOLICITATION OF QUALIFIED PROJECT DEVELOPERS

The preceding analysis of alternatives resulted in a top ranking for MRBT. If the County proceeds with developing a MRBT facility, a phased approach would be used to procure a preferred project developer to design, build and operate an MRBT waste processing facility.

The first step in this process was to issue a REOI. This initial phase was completed in parallel with the alternatives analysis presented in this report and results of the REOI informed the analysis. The REOI solicited interest from a range of technology vendors and/or system integrators capable of implementing various waste processing technologies. Recipients of the REOI were required to include information relating to both their qualifications, experience and capabilities to enhance recovery and diversion of materials from the County's MSW stream of materials. Efforts included extensive vendor outreach which resulted in identification of seven (7) Offerors deemed qualified for further consideration and inclusion in a subsequent Request for Proposal (RFP). Those seven (7) offerors included the following:

- Freepoint Ecosystems (with BHS)
- AMP Robotics Corporation
- Juno
- Stadler American

- Machinex
- Republic
- Sparta Manufacturing

The next component of the procurement process is the RFP which is anticipated to utilize a Progressive Design-Build-Operate (PDBO) method of project delivery in order to foster collaboration between the County and the selected project developer.

The RFP itself reflects a phased approach to procurement. The selected project developer would originally be retained to provide Phase 1 Pre-Construction Services (PCS) on a Time and Material basis up to an agreed Not-To-Exceed amount. The County would work in a collaborative manner with the project developer in the design of the MRBT facility through approximately 80 percent completion and lock-in a GMP for the completed project. This enables the County to participate in the conceptual design of the facility while seeking to balance cost-of-service with performance objectives, as well as allowing multiple opportunities to terminate the process if the County is unable to achieve its performance objectives at an agreeable cost.

Once the GMP is agreed upon, the County then has the opportunity to confirm whether or not to award a Phase 2 contract to complete detailed design and build the proposed facility for the agreed upon amount.

Upon completion of Phase 2 services, the County may, in its discretion, award a Phase 3 contract for future operations of the completed facility.

The estimated total cost of Phase 1 PCS is approximately $36 million and is comprised of the following:

- PCS Developers Fee – this budget-level planning estimate is based on 3% of the estimated up front capital cost of $701M for the proposed MRBT facility. This results in an estimated cost of approximately $21.3M over 3 years (FY26-FY28) that will be allocated to the Developer of the proposed MRBT facility to facilitate detailed design and lock-in of a GMP as part of the Phase 1 collaborative design process. Funding will be allocated over multiple project development milestones to manage performance risk to the County. This approach will provide the County with opportunities to review and verify the work of each project development milestone independently for items such as operational capability and effectiveness, risks, costs, and other pertinent factors of performance prior to providing approval to proceed to the next project development milestone. The PCS funding amount will be confirmed during the RFP but will include all of the Developer's resources to complete Phase 1. Project developer personnel and specialty subcontractors may include the following: administrative staff, planners, engineers (architectural, structural, mechanical, electrical, plumbing, fire, safety, site civil), utility expects, business and financial analysts, bonding agents, attorneys, land and property assessment experts, equipment manufacturers (with suppliers and distributors), construction contractors, solid waste management companies and material management facilities, and other entities to support the delivery of the project.
- County Owner's Representative/Agent Professional Fee – this budget-level planning estimate is based on 2% of the estimated up front capital cost of $701M for the proposed MRBT facility. This results in an estimated cost of approximately $14.2M over 3 years (FY26-FY28) that will be allocated to the Owner's Representative/Agent to support the County during the Phase 1 collaborative design process. This includes staff of the County Owner's Representative/Agent, their team of technical sub-consultants, and other potential staffing resources such as new dedicated positions in County DEP through completion of the Phase 1 PCS contract.

4. CONCLUSIONS

Development of an MRBT facility in lieu of long-term utilization of the County's existing RRF represents a significant opportunity to enhance diversion of MSW from disposal and reduce future GHG emissions. This alternative represents a preferred MSW Management System alternative when compared to long-haul of MSW to an Out-of-County MSWLF, or the retrofit/rehabilitation and/or repair of the County's RRF, when using the evaluation model and criteria identified by the County for this project-specific analysis.

Regardless of which alternative MSW management system is selected for future operations, an acceptable Out-of-County MSWLF capable of receiving MSW or residual MRBT materials will need to be identified. Selecting a landfill other than the Old Dominion Landfill, currently used for MWC ash, could result in shifting landfill-related impacts of the County's MSW management system to a community that is less disadvantaged.

The short-term extension of existing RRF operations is necessary to ensure continuity of service. Utilization of an innovative Progressive Design-Build-Operate (PDBO) project delivery method in the intervening period will help mitigate risk associated with project cost- and level-of-service.

5. REFERENCES

1. SCS Engineers, 2022/23 Montgomery County Waste Composition Study, https://www.montgomerycountymd.gov/DEP/Resources/Files/trash-recycling/waste-composition-study.pdf, April 2023.
2. Morris, Favoino, Lombardi and Baily, What is the Best Disposal Option for the "Leftovers" on the Way to Zero Waste, www.ecocycle.org/specialreports/leftovers, May 2013.

Appendix A: Technical Memorandum

TECHNICAL MEMORANDUM

To:

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From:

Steve R. Nesbitt, Arcadis

Date:

May 13, 2025

Arcadis Project No.:

30164537

Subject:

Municipal Solid Waste Management System Analysis

Solid Waste Processing Technology Assessment

INTRODUCTION

We have completed our evaluation of commercially available technologies to enhance recovery of resources and/or energy from the County's municipal solid waste (MSW) stream as input to future procurement efforts associated with adaptation and/or re-use of the County's Derwood and Dickerson facilities. A web-based technical literature search confirmed identification of the following short-list of relevant technologies which may be adaptable to Montgomery County:

- Mixed Waste Processing (MWP)
- Material Recovery and Biological Treatment (MRBT)
- Composting
- Anaerobic Digestion (AD)
- Construction & Demolition Debris (CDD) Recycling
- Glass Pulverization

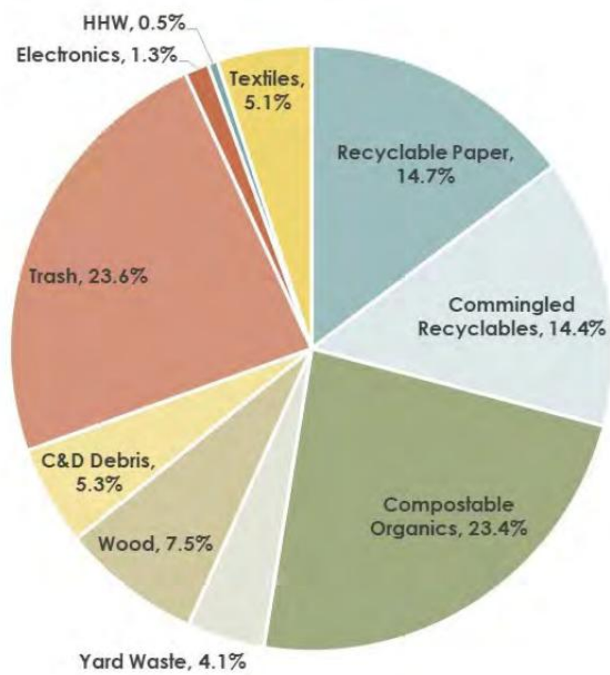
Based upon our previous conversations with the County our review did **not** include technologies characterized as 'emerging' and specifically excluded pyrolysis, gasification, plasma arc or any sort of waste-to-fuels technology. In addition, enhanced materials and/or resource recovery from the County's existing Material Recovery Facility (MRF) was not addressed because it is the subject of other on-going retrofit efforts by the County.

The following information is provided for each of these screened technologies:

- A general description of the technology.
- Site considerations, including compatibility with Montgomery County Derwood Transfer Station (TFS) and/or Dickerson Resource Recovery Facility (RRF) locations. The TFS can accommodate approximately 15- to 20-acre footprint with some re-location of existing secondary waste management processes; whereas the RRF can accommodate only an approximate 10-acre footprint if and when the facility is demolished and properly decommissioned.
- Rough order of magnitude cost for development and operations.

An annotated bibliography of reference materials used in sourcing information related to these technologies is provided in **Appendix A**.

MSW COMPOSITION



A process flow diagram for the County's TFS is provided in **Appendix B** (which relies upon 2021 data). Extrapolating for incremental growth in population and waste generation since that time, we estimate approximately 777,000 tons of MSW crossed the TFS tipping floor in 2024 (ranging from approximately 2,000 tons to 3,000 tons per day assuming 6 days per week operations). Results of the County's recent Waste Composition Study [**Ref. 1**] indicate approximately 23 percent compostable organics, 14.7 percent recyclable paper, and 14.4 percent of comingled recyclables remain with the MSW stream of materials delivered to the TFS tipping floor.

Their combined 52.5 percent equates to approximately 400,000 tons per year of material – and post-consumer food waste (approximately 16.6 percent or about 125,000 tons per year) represents the single-largest component of that waste fraction which is potentially recoverable. To maintain perspective the County's existing MRF processes approximately 37,500 tons per year of co-mingled recyclables. This suggests any supplemental facility to extract the combined quantity of compostable organics, recyclable paper and comingled recyclables from the MSW waste stream, would need to be several times larger than the existing MRF.

SUMMARY/PRELIMINARY ASSESSMENT

In all cases, adaptation of both the TFS and RRF to accommodate supplemental waste processing technologies to advance waste diversion goals represents significant constraints and limitations.

Adaptation of the TFS represents significant constraints and limitations with regard to potential health, nuisance and/or aesthetic impacts associated with supplemental processing of plastics (and associated fossil carbon) or organic waste materials within its urban setting and limited available footprint while maintaining uninterrupted MSW transfer operations. This includes but is not limited to the following:

- The facility is located within an urban area with already surrounding residential and commercial development, adjacent Metro Station, and future planned residential housing.
- The site itself is already congested with limited available footprint outside of the transfer building unless portions of the existing railyard can also be captured and adapted.
- In the absence of source-separated collection of organics, managing significant quantities of organic materials extracted from the MSW stream represents specific challenges related to both limited available footprint for managing the materials (either within or exterior to the transfer building), interim storage requirements during ‘batch’ processing, as well as odor and vector control once it is extracted.
- Depending upon the nature of the waste processing system, such as MRBT, potential air emissions including but not limited to potentially harmful Volatile Organic Compounds (VOCs), which may be associated with either thermal hydrolysis and/or anaerobic digestion, must be carefully addressed and managed.
- Neither Aerobic Composting nor Anaerobic Digestion of any organic fraction of the waste extracted from the TFS tipping floor appear compatible with the TFS location.

Facility adaptation must consider on-going MSW transfer operations. This is separate and apart from consideration of interim operations until programs are in place to replace current RRF operations and relate to the logistics of adapting the transfer building while maintaining flow of materials through the TFS. Other interim operations may be necessary while the transfer building is being retrofitted and adapted.

The RRF facility represents an even more limited 10-acre footprint which would only become available after future decommissioning, presumably no sooner than mid-2031, and is not suitable for adaptation to accommodate the alternative primary technologies required to process between 2,000 to 3,000 tons per day of processible MSW. The RRF is better suited for the adaptation of secondary technologies which may be capable of generating offsetting revenue.

Rough Order of Magnitude (ROM) cost estimates provided in the following discussion of alternative technologies reflect 2024-dollar amounts. The cost estimates vary widely based on multiple factors:

- Facility capacity.
- Economies of scale.
- Required land acreage.
- Degree of automation and utilization of low-or high-technology equipment.
- Price of utilities such as energy and water.

- Recovery rate and distance to markets of recovered materials.
- Hours of operation and contract terms.

The estimated cost for each technology is summarized in **Table 1** with supporting details provided in **Appendix C.** Cost details are based on limited available public sources and represent a range of financing options for capital and operating expenses (CAPEX and OPEX).

1. Mixed Waste Processing (MWP)

Mixed Waste Processing (MWP) facilities utilize a combination of mechanical and manual systems to receive, separate and process collected MSW to recover materials for recycling or beneficial use. Typical processes include the following:

Athens Sun Valley MRF located in Sun Valley, CA (courtesy Athens Services)

- Preparation – removal of large items (i.e., metal, concrete, non-recyclable items [carpeting, etc.]).
- Separation into different fractions based on material properties via one or more of the following:
    - Trommels and screens
    - Manual separation
    - Magnetic removal of ferrous metals.
    - Eddy current separation of non-ferrous metals.
    - Wet separation
    - Air trommel to separate heavier (i.e., concrete, glass, ceramics, etc.) and lighter (i.e., cardboard, wood, insulation, etc.) materials.
    - Ballistic separation
    - Optical separation

A 2022 Greenpeace survey [**Ref. 2**] showed seven (7) MWP facilities operating at the time in the US, which appears to be consistent with recent industry reports (SWANA reported less than 20 in operation as of 2019). Although these facilities can be designed to accept both MSW and recyclables they are better used in combination with source separation of organics and a Material Recovery Facility (MRF) with either single and/or dual stream collection of recyclable materials to enhance recovery of higher value metals and plastics/resins. However, contamination of lower value paper and fiber is often observed within MWP facilities based on collection and processing methods. Organic materials extracted from the waste stream have historically also been observed to be contaminated with fats, oil, grease, and glass with corresponding small residual commercial value.

Reported diversion rates range from approximately 10 to 50 percent [**Ref. 3**], depending upon the extent of source-separated collection of organics and other recycling efforts. Implementation requires no supplemental consumer participation, education, or sorting behavior.

It is noteworthy that odors and vector control associated with treatment of the organic fraction extracted from the MSW stream are significant issues that, in absence of supplemental biological treatment, must be addressed by careful facility design.

Siting Considerations/Compatibility

MWP facilities are trending to larger footprint to accommodate complicated automated sorting equipment and typically situated upon land parcels ranging in size from 20 to 60 acres. However, footprint requirements are much smaller if co-located with other MSW management facilities/activities. Retrofit of the TFS is not ruled out but complicated by previously described site constraints/limitations.

Costs

Source	Project Year	Capacity (tons/yr)	Rough Order of Magnitured Adjusted Inflation @3%
Monro County, IN	2018	130,000	$ 47,507,452
San Leandro, CA	2020	150,000	$ 133,046,145
Sant Barbara, CA	2021	180,000	$ 139,259,250

Development and operation of MWP facilities are both capital and labor intensive. Recently completed facilities across the country range in capital cost of construction from approximately $50 to $140 Million for facilities with operating capacity ranging from only 130,000 to 180,000 tons per year [**Ref. 4**], whereas the County's TFS processes about 3 to 4 times that quantity. On a unit cost basis, CAPEX and OPEX range from approximately $15 to $45 per ton **[Ref. 5 and 6]** and $90 to $210 per ton, respectively **[Ref. 7 and 8]**. The OPEX is similar to those of MRFs due to similar operations and the wide range is dependent on the number of shifts per day. Total combined CAPEX and OPEX, not including other lifecycle costs, ranges from approximately $105 to $255 per ton of waste processed. Anticipated revenue from sale of recovered materials should be discounted given the recovered product quality is typically less than similar material recovered from the County's MRF which relies upon dual-stream collection (incremental diversion with limited off-setting revenue).

2. Mechanical Biological Treatment (MBT) and/or Material Recovery and Biological Treatment (MRBT)

These facilities range in capacity from approximately 55,000 to 336,000 tons per year (again, significantly less than the quantity of MSW passing across the Derwood Transfer Station tipping floor) and are typically designed to operate for 15 to 25 years. Although there are more than 300 MBT and/or MRBT facilities operating in Europe there are only a few here in the United States.

MRBT facilities integrate mechanical processes found in either a Materials Recovery Facility (MRF) or Mixed Waste Processing (MWP) facility with supplemental capture and processing of organic material via various biological processes. Some modern facilities incorporate thermal hydrolysis at the front end of the facility to enhance recovery of the organic fraction of waste (OFW) and accelerate its decomposition, as well as improve separation from components of the waste stream, decrease contamination, and increase effective diversion. The goal of such facilities is to augment, not replace, source separated removal and recycling, capture remaining recyclables as well as stabilize the residual organic fraction to minimize potential greenhouse gas emissions.

Biological treatment of the organic waste fraction can take place prior to or after mechanical sorting of the waste to achieve different objectives depending upon the nature of the waste stream.

It is noteworthy that the same constraints and limitations which relate to the quality of lower value recyclables described for MWP applies to MRBT facilities as well. Unless supplemental efforts are performed, recyclables are typically of a lesser quality than those derived from a separate household recycling collection system, and contamination of lower value paper and fiber cannot be undone.

Consequently, many MRBT facilities only recover high value metals or plastics/resins and, although low value materials (such as glass, plastics, and paper) can be recovered, their cost of recovery is high, and the materials have limited residual value and utility.

With regard to the organic fraction of MSW passing through the facilities, depending on facility design basis, the biological treatment of mechanically separated organics produces either partially/fully stabilized compost-like outputs (CLO) or partially stabilized digestate material:

- CLO is produced by facilities that employ an aerobic process such as bio-drying, in-vessel composting, and agitated bed.
- Digestate material is produced from anaerobic digestion.

Again, these materials are often contaminated with little residual commercial value and typically require extensive post-treatment processing. The goal is not so much as to create a saleable product as much as it is to stabilize the remaining organic fraction and reduce potential future greenhouse gas emissions.

Odor, vector, and noise control is required and are important design considerations. Mitigation/abatement of potential health and environmental impacts associated with potential discharge of compounds associated with air discharge (if any) must be carefully considered and managed.

Siting Considerations/Compatibility

Site location and footprint requirements depend on their individual design basis and performance requirements, but most operational facilities range in size from 7 to 40 acres. Again, similar to expressed concerns of siting an MWP facility, these facilities are trending to larger footprint requirements but are much smaller if co-located with other MSW management facilities/activities. Retrofit of the TFS is not ruled out but again, is complicated by previously described site constraints/limitations. Re-use of the RRF footprint following future potential demolition and decommissioning of the site does not appear viable given the limited footprint.

Veolia Southwark MBT Facility, Southwark, England (photo courtesy Veolia Southwark)

Costs

MRBT facilities are both capital and labor intensive:

- Aerobic Facilities - Capital as well as O&M costs were found to range from approximately 65 to 490 $/ton/year processing capacity and $40 to $150 per ton, respectively [**Ref. 9 and 10**].
- Anaerobic Facilities – Capital as well as O&M costs were found to range from approximately 370 to 1,570 $/ton/year processing capacity and $132 to 175 per ton, respectively [**Ref. 9 and 10** and other data sources].

Revenue from the sale of recovered materials (and electricity if so equipped) may help offset some of the costs but are highly dependent upon localized markets.

Case Studies

Here is a brief sample of US facilities:

GreenWaste
San Jose Material Recovery Facility
San Jose, CA

The facility was developed by Bulk Handling Systems (BHS) on behalf of Athens Services and is a high diversion organic waste processing facility designed to maximize recovery of compostable and other recyclable materials. It operates at approximately 75 to 90 tons per hour and recovers approximately 75 percent of the material processed.

https://www.greenwaste.com/facilities/greenwaste-san-jose-material-recovery-facility/https://bulkhandlingsystems.com/solutions/municipal-solid-waste-msw/

Renovare Environmental
Berkeley County
Martinsburg, WV

Approximately 100,000 ton per year facility opened in 2019 and suspended operations in 2023:

https://www.wastedive.com/news/renovare-traqiq-aerobic-digester-entsorga/640053/
https://www.wastedive.com/news/entsorga-west-virginia-renovare-us-bank-apple-valley/652083/

There are some reports that the facility never truly exited start-up testing and may have failed prematurely due to financial stability of the private sector owner/operator.

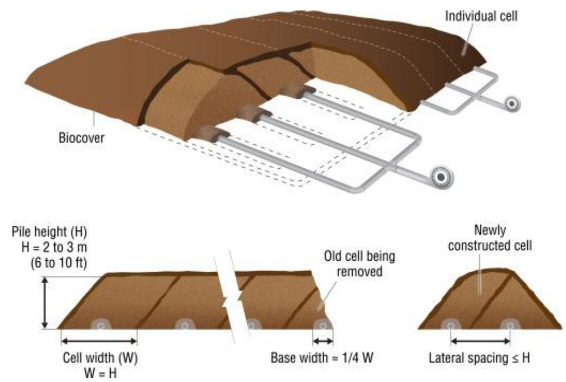
3. Composting

Methods presented are considered suitable for composting food and/or horticultural waste considering the volume of material expected to be received, available land area and level of operational difficulty. Most stakeholders recognize the constraints/limitations and potential health effects associated with conventional active windrow composting. Concerns include but are not limited to airborne dispersion of Aspergillus Fumigatus (recognized health hazard), large pad area, extensive equipment, and labor-intensive methods with associated investment in equipment as well as operations and maintenance.

Open Methods with Forced Aeration

Forced aeration uses a blower to introduce and control the flow of air through a pile of organic waste, providing a constant supply of oxygen while removing heat, moisture, and carbon dioxide. This reduces the need for both mechanical turning of the pile (windrows) along with corresponding reduction in overall site footprint and fugitive airborne emissions (particularly if air supply is via negative pressure). Forced air can be supplied via either positive or negative pressure.

- Aerated Static Pile (ASP) – Organic waste formed into freestanding piles approximately 6 to 12-feet high are aerated using blowers providing negative (or positive) air pressure through perforated pipes. During initial pile construction a 'biocover', typically consisting of compost or wood chips, is added to protect from drying, reduce heat loss and vector attraction; as well as filter odors, ammonia and other compounds which may be released.

  Aerated Static Pile Diagram (courtesy Compost Research & Education Foundation)

  It is noteworthy this technology is:
  - Well proven and reliable
  - Requires smaller footprint than windrow composting
  - Scalable to large capacity
  - Susceptible to operational difficulties (over-drying of piles and difficult to add water)
  - Suitable for feedstock mixes that require documented pathogen and vector reduction (i.e., food waste, manure, etc.)
  - Can be outdoors or enclosed in a building but are usually built on a concrete pad.
  - Efficient with regard to processing of material – hot compost is generally produced in 4 to 8 weeks, which is then cured for another 4 to 8 weeks to produce finished compost.

- Aerated Static Pile with Microporous Cover – Essentially the same operation as ASP described above but replaces the 'biocover' with a semipermeable microporous fabric membrane which discourages birds and other vectors that may be attracted to feedstocks like food waste.

Aerated Static Pile with Microporous Cover (courtesy Prince George's County, MD)

In-Vessel Composting - Rotating Drums

These systems use a slightly inclined horizontal steel cylinder to agitate, aerate, and move compost through to the discharge end of the cylinder. Feedstocks are loaded on one end through a hopper or infeed conveyor. The drum is slowly rotated on bearings typically by a simple electric motor-driven gear system with minimal moving parts. A fan or the hopper opening provides continuous air to the cylinder, while warmer air exits the end, allowing for some measure of temperature control while maintaining aerobic conditions. These systems are designed to handle virtually any materials, including animal mortalities, and the decomposition process occurs rapidly (typical retention time is 3 to 5 days). Once processed through the rotating drum, compost is moved to windrows for another 30 to 60 days of curing and stabilization.

Rotaposter® Rotating Drum Composter – (courtesy Rotary Composters, LLC)

The following is noteworthy:

- Commercially engineered systems are available for direct purchase.
- Batch system – not continuous feed, although initial retention time is short (3-5 days), followed by a second stage of composting, limits application for continuous feedstock. Would require purchase of multiple ‘train’ to accommodate lag in batch mode and require additional footprint.
- Works well for highly degradable feedstocks (i.e., food waste, meats, etc.) and quickly converts organic feedstock which would otherwise attract pets/vectors into a compostable material.
- Built-in materials handling and aeration.
- Closed vessel aerobic process reduces odor, prevents pests, reduces heat loss with added ability to operate in enclosed building or open environment.

Agitated Bed

This method uses forced aeration like ASP and in vessel compositing. Organic material is placed in a large bed that is mechanically turned every 1 to 3 days to allows an even aeration of the waste. As an auger moves down the pile of organic waste in the bed, stable compost is discharged onto the bed floor or conveyor for further processing. This opens up space for new material to be loaded by front end loaders upstream. The active composting phase is typically 3 to 4 weeks and the total processing time to produce compost is 2 to 4 months **[Ref. 11]**.

The following is noteworthy:

- This process is highly automated and has high capital costs.
- Suitable for food scraps and yard trim material.
- Typical facility sizes range from 50,000 to 100,000 tons per year capacity.
- Land requirement is low compared to other open composting methods.
- Odor is better controlled and can be implemented in buildings.

Siting Considerations/Compatibility

The siting requirements for composting operations vary depending on their design and technology selection:

- No conflict with Dickerson facility and relatively remote location, distant from residential and commercial neighbors, schools, hospitals, and sensitive populations.
- Not suitable for adaptation of the Derwood Transfer Station due to previously described site constraints/limitations:
    - Batch System – Not continuous feed. Although initial retention time is short (3 to 5 days) there is a necessary 2nd stage of composting/curing which limits applications for continuous feedstock. Alternatively, would require purchase of multiple treatment 'trains' at cost of added capital, O&M, and footprint.
    - Applicability is limited to processing capacity – in vessel systems in particular typically manage only a few tons per day and do not compare well with the volume of organic material which may be extracted from the County's MSW stream.

Costs

Cost data was not uniformly available for each of the various types of composting processes. Composting facilities are generally not as capital and labor intensive as other solid waste management systems, but their capital and operating costs vary depending on the site design, capacity, and technology selected. Based on nationwide average data, larger ASP, CASP, or in-vessel composting facilities that can process up to 40,000 tons per year are expected to cost $5 to $9 million in up-front capital and $17 to $28 per incoming ton to operate based on national averages [**Ref. 12**]. Revenue from the sale of finished compost helps to offset some of the costs.

4. Anaerobic Digestion (AD)


BTS anaerobic digestion system at the Maryland Food Center in Jessup, Maryland. – (courtesy BioCycle)

Anaerobic digestion is a process through which bacteria decompose (digest) organic matter (i.e., animal manure, wastewater biosolids, food wastes, etc.) in the absence of oxygen within a sealed reactor vessel.

The digestion process produces biogas (primarily methane) that can be flared or recovered for energy production, solid digestate that can be land applied as a soil amendment, and liquid digestate that can be used for fertilizer. The digestate can also be bio-stabilized when processed in combination with other aerobic composting efforts. A 2021 EPA report addressing 209 AD facilities shows the top feedstock sources as Fats, Oils and Greases (FOG), as well as some digesters designed to process specific types of organic waste found in MSW [**Ref. 13**].

There are a few basic approaches that may be used depending upon the nature of the organic feedstock:

- Wet low solids for dilute feedstock with very little to no contamination and is not compatible with MSW. These are typically large tank-based systems with mixing used at Wastewater Treatment Plants and used in co-digestion systems which process both biosolids and other dilute putrescible materials.
- Wet high solids for thick but pumpable materials that contain some contamination. These systems use a plug flow or similar process, which does not include mixing. The system can be configured in either vertical or horizontal orientations. Materials advance through the digester when new feedstock is added.

  Anaerobic digestion of MSW requires 'organic' feedstock (food and yard waste) be collected separately, mixed with water to form a wet 'slurry' and then conveyed via conveyors, pumps, and mechanized agitation to a digester. Insoluble inorganics (glass, plastics, and metals otherwise not recovered from the waste stream) are discharged for separate processing or disposal. The remaining slurry stream is processed by a series of sealed chambers/digesters designed to remain at the optimum conditions for anaerobic digestion by specific bacteria for a determined residence time to optimize the production of biogas, which is composed primarily of methane, carbon dioxide, hydrogen sulfide, and water vapor.

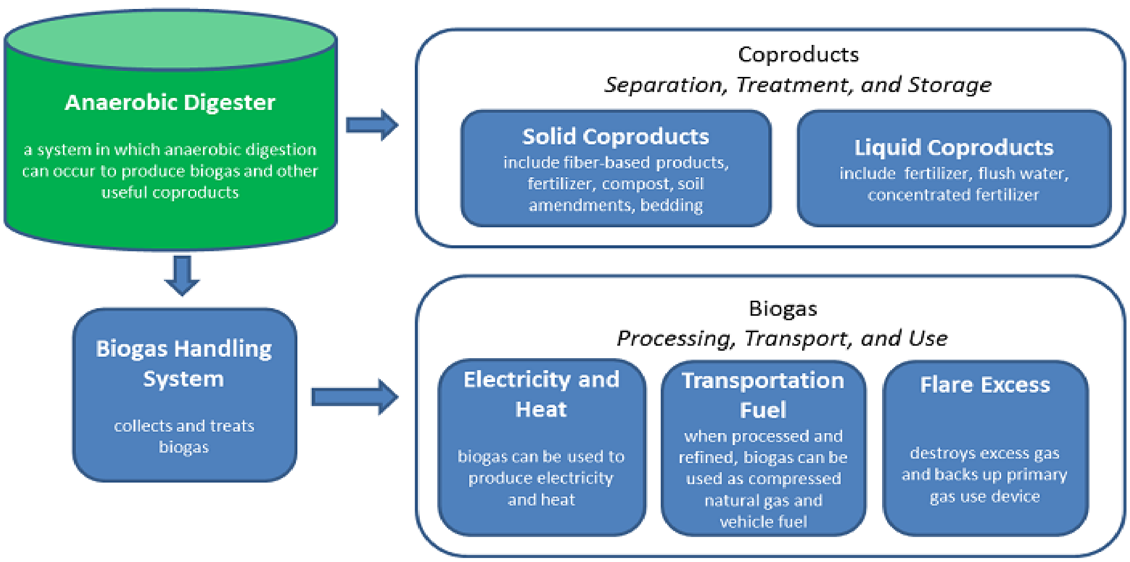
The resulting biogas can be used for one of the following purposes:

- Electricity generation via reciprocating internal combustion and conversion to electrical energy for sale to a host generator.
- Further refined to remove contaminants (hydrogen sulfide, particulates, moisture, etc.), carbon dioxide, oxygen, and/or nitrogen to produce renewable natural gas (RNG) for sale to a local

natural gas utility or other end-user as transportation fuel or capture as Renewable Energy Credit (REC) tax credits.

Anaerobic digesters have been increasingly used to combat the emissions issue of food waste or other residuals by diverting organic carbon from landfills, where it decomposes and creates methane, a greenhouse gas with significantly greater global warming potential than carbon dioxide. Biogas production can also create additional income and can reduce the overall costs of operating waste handling facilities, particularly if organics can be presorted and separated from MSW (source separated organics).

The figure below depicts a United States Environmental Protection Agency (USEPA) process diagram of anaerobic digestion [**Ref. 14**]. The organic feedstock becomes processed and creates the two co-products of solid compost and a liquid concentrate fertilizer which may be sold for agricultural purposes. It is critical that the presorting is efficient at removing non-organic waste to prevent contamination and ensure quality co-products that can be sold.



Anaerobic Digestion Process Flow Diagram (courtesy USEPA)

It is noteworthy that AD plants capture most emissions primarily related to combustion of resulting biogas via either baghouses for particulates, scrubbers for SO_2, oxidation catalysts and/or selective catalytic reduction for various other air pollutants. A flare may also be required to burn any excess produced biogas. In addition, because the AD process is biologically driven, time is required for microorganisms to start up and complete the digestion process. Consequently, AD facilities require relatively large storage and processing vessels with corresponding capital investment and land area.

Other significant technical constraints and limitations relate to contamination of the organic feedstock from inorganic and/or hazardous materials, which if not prevented from entering the organic feedstock, can have a significant detrimental inhibition on the digestion process or biogas production. Rigorous source separation is critical.

Siting Considerations

According to the American Biogas Council there are currently 473 anaerobic digesters on farms, 1,269 water resource recovery facilities using an anaerobic digester, and 102 stand-alone systems that digest food waste, which are operating in the United States.

The site characteristics for anaerobic digestion vary depending on the facility design and capacity. Locating AD is compatible with the Dickerson facility but not Derwood due to previously expressed concerns regarding limited available footprint and aesthetic/nuisance impacts (largely odor related).

Costs

Capital costs for facilities with capacity between 25,000 to 100,000 tons per year range from approximately $15 to $30 per ton, and O&M costs average around $40 per ton [**Ref. 15**]. Total combined capital plus O&M costs, not including other lifecycle cost costs, can be expected to range from approximately $55 to $70 per ton of waste processed.

5. Construction & Demolition Debris Recycling

Processing of CDD waste is typically performed using mechanical and manual sorting systems. Smaller materials may be handled using systems not too dissimilar to those found in a Material Recovery Facility. The size, equipment, labor needs and layout depend on its complexity and capacity.

There are two waste CDD waste streams to consider:

- Type 1 - soil, broken asphalt and concrete, stone, brick, and block from road and structure demolition projects that may also have large pieces of pipe and other heavy materials, often mixed with soil and fines.
- Type 2 - mixed construction materials which may include drywall, dimensioned lumber, metal pipe, electrical wire, and a range of other materials found in buildings during demolition such as different flooring materials, insulation, and lighting and plumbing fixtures.

For heavy Type 1 materials, separation of bulky oversize items and then screening enables the soils and finer grained materials to be shipped out as clean fill material. To the extent loads can be sorted while coming in based on origin and purity of materials, separate piles of broken concrete, broken asphalt, and other inert materials can be established to make them more suitable for reuse or further processing.

For Type 2 mixed construction and demolition materials, conveyor systems are often used with the following processes:

- Initial sorting – removal of large items (metal, concrete, non-recyclable items [carpeting, etc.]) This is usually done on a tip floor or concrete pad prior to loading other materials onto conveyors.
- Shredding
- Separation of materials into basic sizes (>5”, <5”)
- Magnetic removal of ferrous metals, eddy current separation of non-ferrous metals.
- Trommel screening to further separate materials by size and remove fines.
- Air trommel to separate heavier (concrete, glass, ceramics, etc.) and lighter (cardboard, wood, insulation, etc.) materials.
- Manual sorting to remove plastics, non-recyclables, and other materials.
- Bunker storage of sorted materials.

Many materials are recovered and either reused or recycled into other products such as:

- Crushed concrete and brick used in road construction, drainage projects.
- Concrete, block, masonry, and other clean debris used as clean fill.
- Reusable building supplies such as lumber and whole bricks.
- Remanufacture of wood chips into engineered wood.
- Wood fuels used in co-generation plants and industrial boilers.
- Horticultural mulches made from natural woody material.
- Dyed, decorative mulches made from construction debris wood.
- Wood chips used as a bulking agent in biosolids, compost, and animal bedding.
- Planks and other dimensional lumber sawn from whole trees.
- Corrugated cardboard containers.
- Metals (steel, aluminum other non-ferrous)
- Recovered screened material (RSM) for soil amendments and other approved uses.
- Processed CDD used as daily landfill cover material.

It is noteworthy that CDD recycling facilities, depending on their design and operation, can divert up to 70 percent or more of the materials they receive [**Ref. 16**] and can be designed to process between approximately 500 to 1,200 tpd, exceeding any short- and/or long-term demands by the County.

Siting Considerations

The size, equipment, labor needs and layout of a CDD recycling facility depends on its complexity and capacity. Most facilities only require an area of approximately 5 to 10 acres, but they generate high levels of noise, dust, and traffic. This technology is not suitable for Derwood given the previously described site constraints and limitations.

Costs

Depending on the layout and complexity, capital costs for CDD recycling facilities range from $13 to $16 million, and annual O&M costs are generally in the range of $2.2 to $ 2.7 million for a 135,000 to 160,000 tons per year capacity facility [**Ref. 17**].

6. Glass Pulverization

Glass is a particularly difficult material for the recycling industry, as its bulk weight makes it expensive to transport. In addition, glass ‘remelt’ facilities are usually not locally available, and broken glass contaminates cardboard and other recyclables, presents hazards to workers, and causes significant wear and tear on sorting and processing equipment. For these reasons, many communities simply crush collected glass and use it as landfill road or cover material.

One way to move glass toward a more circular economy is to pulverize the material and create both glass sand and glass gravel, which can then be used as fill material, pipe bedding, cement additives, beach renourishment, or other potential uses. Glass pulverizers use hammermills to reduce the glass to a set size gradation, and remove bottle caps, labels, and other contaminants during the process.

Figure 6. Glass Crushed to Sand (Courtesy Aqua Tools)

Readily available commercial glass pulverizer systems can process up to 20 tons of glass per hour. Larger capacity pulverizers can be custom designed and fabricated to meet the specific glass processing demands of a municipality.

Many municipalities around the country have begun investigating glass pulverizing operations in recent years, mostly as a measure to reduce glass hauling and disposal costs. Most notably, as of March 1, 2023, Walt Disney World in Orlando, Florida was conducting a pilot program to pulverize collected glass and use it to fill holes on roads and trails.

Siting Considerations

The size, equipment, labor needs and layout of a glass pulverizing facility depends on its complexity and capacity. Most facilities are co-located with MRFs, transfer stations, or other solid waste facilities, and usually occupy less than an acre of area. However, they generate high levels of noise. Glass pulverizer facilities should have good truck access with short travel times to major roads, and electrical utilities available at the property.

Costs

Capital as well as O&M costs for commercial scale pulverizers vary by capacity and throughput but are generally not cost-intensive operations. Estimated capital costs derived from multiple sources ranged from approximately $10 to $13 per ton, and O&M costs were found to range from approximately $10 to $15 per ton [**Ref. 18**]. Resulting total costs typically range from approximately $20 to $28 per ton of processed material.

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TABLES

Montgomery County, MD

Department of Environmental Protection

Municipal Solid Waste Management System Alternatives Analysis

ARCADIS

Table 1

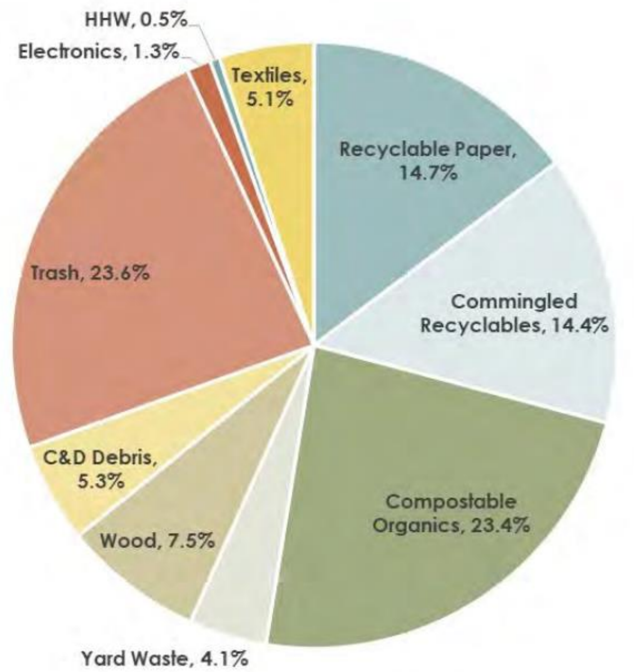
Summary of CAPEX and OPEX for MSW Processing Technologies

Technology	Cost Component					
	Capital ($/Ton or $/Ton/Year (MRBT))		O & M		Total	
	Low	High	Low	High	Low	High
Mixed Waste Processing	15	45	90	210	105	255
MRBT - Aerobic	65	490	40	150	Not Available - Capital Cost Varies per $/Ton/Year and Financing Scenarios. Information is mostly proprietary. See Tables 2 and 3 for Details.	
MRBT Anaerobic	370	1570	50	175		
Composting	6	11	17	28	23	39
Anaerobic Digestion of Source Separated Organics	15	30	40		55	70
Construction & Demolition Debris Recycling	4	5	15	18	19	23
Glass Pulverization	10	13	10	15	20	28

APPENDIX A

1. **SCS Engineers, 2022/23 Montgomery County Waste Composition Study, Ref. No. 02222013.0000, April 18, 2023.**

SCS Engineers conducted a waste composition study for the waste received at the Montgomery County Transfer Station for the period between Spring 2022 to Winter 2023. Some of the key results are:



- The pie chart above shows the weighted overall waste composition by material. It indicates approximately 23 percent combined compostable organics and approximately 14 percent of comingled recyclables remain with the MSW stream.
- Overall, the three largest subcomponents by weight of the waste stream are Food Waste (16.6 percent), Film Plastic - Other (7.3 percent), and Non-Recyclable Paper (6.9 percent).
  - The three largest recyclable subcomponents are Corrugated Cardboard (4.9 percent), Other Recyclable Paper (3.3 percent), and Paperboard (2.1 percent).
- Waste Composition of Single-Family Subdistrict A waste stream are Food Waste (19.3 percent), Non-Recyclable Paper (7.7 percent), and Film Plastic - Other (7.4 percent).
  - The three largest recyclable subcomponents are Other Recyclable Paper (3.3 percent), Corrugated Cardboard (2.5 percent), and Other Plastic Containers/Tubs (2.1 percent).
- Waste Composition of Single-Family Municipal waste stream are Food Waste (16.4 percent), Non-Recyclable Paper (8.1 percent), and Miscellaneous Organics (7.8 percent).
  - The three largest recyclable subcomponents are Corrugated Cardboard (3.4 percent), Other Recyclable Paper (2.7 percent), and Other Plastic Container/Tubs (2.3 percent)
- Waste Composition of Multi-Family waste stream are Food Waste (15.9 percent), Non-Recyclable Paper (7.5 percent), and Film Plastic - Other (7.3 percent).
  - The three largest recyclable subcomponents are Corrugated Cardboard (4.3 percent), Other Recyclable Mixed Paper (3.9 percent), and Office Paper (1.9 percent).
- Waste Composition of Non-Residential waste stream are Food Waste (14.8 percent), Film Plastic - Other (7.4 percent), and Non-Recyclable Paper (6.1 percent).

  - The three largest recyclable subcomponents are Corrugated Cardboard (6.7 percent), Other Recyclable Paper (3.4 percent), and Paperboard (2.5 percent).
- Materials such as yard waste and wood were more prevalent in the Spring, Summer, and Fall seasons.

2. Greenpeace 2022 US MRF Survey. https://www.greenpeace.org/usa/wp-content/uploads/2022/10/2022-MRF-Survey-August-15-2022-Final.pdf

Presents a summary table of the results of the survey of U.S. Residential Material Recovery Facilities - Acceptance of Post-Consumer Plastic Products published on August 15, 2022.

Five out of 7 of the active MWP Facilities in the US that process all trash are located in California as listed below:

- Advance Disposal Hesperia located in Hesperia, CA.
- Athens Services Sun Valley MRF located in Sun Valley, CA.
- LA County Sanitation: Puente Hills MRF located in Whittier, CA
- Nortech Waste MRF located in Roseville, CA.
- South Tahoe Refuse and Recycling Services located in South Tahoe, CA.

The other two active MWP Facilities in the US are operated by RePower:

- RePower South Montgomery, AL
- RePower South Berkeley County, SC

3. Long Term Disposal Alternatives Analysis for Cumberland County, NC Department of Solid Waste, HDR, Jan 2022

HDR provided a summary of the technical viability and commercial readiness of waste reduction technologies to Cumberland County. A summary of Mixed Waste Processing findings include:

- Traditional dirty MRFs (Mixed Waste Processing Facility (MWPF)) typically recover from 10 to 25 percent of the recyclable waste stream.
- Some advanced MWPF can achieve up to 50 percent recovery rate if the owner diverts both recyclable and other organic from the waste stream prior to reaching the facility.
- Typical capacity is between 200 tons per day (TPD) and 1,500 TPD.
- Useful operating life of 20 to 30 years with proper maintenance.
- Job creation of approximately 20 to 60 permanent jobs.
- A 1,500 TPD MWPF has an estimated capital cost of $50 million or approximately $33,000 per ton of daily design capacity.
  - Capital cost per ton over an assumed lifetime of 20 years is $5/ton
- Average processing cost (O&M only) is approximately $112/ton
- Average processing cost (O&M only) for recyclables via MRF is approximately $60/ton
- Total cost (not including source separated organics) is approximately $177/ton
- MWPF Revenue is approximately $42/ton
- Source separated MRF revenue is approximately $53/ton
- Total revenue is approximately $95/ton
- Net cost is approximately $82/ton

4. **King County Government, Re+ Action Overview, Mixed Waste Processing of Municipal Solid Waste**

King County Seattle reviewed the feasibility of Mixed Waste Processing Facility as one of the ways to achieve their diversion goals set by the Re+ programs.

- MWP operations can divert up to 75 percent of municipal waste.
- Priority materials for recovery may include fiber for paper production, organics for anaerobic digestion and/or composting, metals and high-quality plastics for recycling, and various low-value materials for energy production.
- MWP facilities work best in communities with effective curbside recycling programs.
- Cost ranges from $120 million to 130 million for a MWP processing capacity of 150,000 tpy to 180,000 tpy respectively.
    - Cost per ton over an assumed lifetime of 20 years ranges from $36/ton to $40/ton.
- Existing MWPs in California have capacity ranging from 120,000 tpy to 180,000 tpy
- Implementation of MWP may impact and change hauler routes.
- MWPs are relatively easy to integrate and requires no behavior change from residents or workers.
- Employees in a MWP facility are sorting mixed waste, so they are exposed to typical dangers associated with working around municipal solid waste.

5. **Details on WM's $75 million MRF in South Florida, Resource Recycling, https://resource-recycling.com/recycling/2023/03/20/the-details-on-wms-75-million-mrf-in-south-florida/**

Article summarizing details of the new Waste Management's MRF in South Florida. Details include:

- Facility located in Pembroke Pines, Broward County, Florida.
- Facility can process between 750 to 825 tons per day.
- Capital Cost: $75 million
- Land footprint: 127,000 square feet
- Projected to recover up to 95% material.
- Under the contract, the tipping fee for County material is $143.99 per ton.

6. **Details on Oregon's $150 million trash-sorting MRF, Resource Recycling, https://resource-recycling.com/recycling/2024/02/06/details-on-oregons-150m-trash-sorting-mrf/**

Article summarizing details of the new Waste Management's MRF in Lane County, Oregon. Details include:

- Facility capacity: 160,000 tpy
- Projected to boost County diversion by 20% more.
- Recycling system supplied by Bulk Handling Systems and included an anaerobic digester.
- Capital cost: $150 million.
- Targeted start of operation is 2025.
- Facility will be constructed on a 26-acre site.

7. **Northeast Recycling Council (NERC) Recycling Market Report, September 2023**

NERC publishes quarterly reports starting in April 2019 aimed at assessing regional market trends to inform decisions of recyclers, MRFS and municipalities. The most recent report was published in September 2023 and covers the periods between April to September 2023.

The blended market value of commodities recovered from a MRF for the last two quarters are reported in the table below.

All Reporting MRFs	Blended Value April - June 2023	Percentage Change from Previous Quarter
Without residuals	$85.63	10%
With residuals	$76.99	13%

All Reporting MRFs	Blended Value July - September 2023	Percentage Change from Previous Quarter
Without residuals	$72.77	-15%
With residuals	$63.95	-17%

The average processing cost per was $87.54/ton and $87.78/ton, respectively.

8. **Material Recovery Facility Evaluation, Isabelle County, Michigan, January 2023. Recycle.com**
   Recycle.com (RRS) assessed Isabella County recycling program, operation, staffing, costs and improvements. Details on MRF capital and O&M costs include:
   - Capital costs (includes building, processing line and system infrastructure) is approximately $12 million to $19 million for a 7tph and 10 tph facility respectively.
   - O&M costs include sorting, equipment O&M, admin, staff, utilities, hauling and disposal.
   - Gross O&M cost per ton ranges from approximately $178 to $205 per ton for a 10tph and 7 tph facility respectively.
   - Net O&M cost per ton ranges from approximately $142 to $169 per ton for a 10 tph and 7 tph facility respectively. Net cost includes potential revenue from disposal.

9. **Mechanical Biological Treatment of Municipal Solid Waste. UK Department for Environment, Food and Rural Affairs, February 2013.**

   Provides an overview of Mechanical Biological Treatment (MBT) of MSW as a reference for decision makers.

- Different mechanical separation technologies use varying properties of the materials such as shape, size, weight, conductivity to separate the MSW and are listed in the report.
- Biological treatment can take place before or after mechanical separation. There are three main ways to biologically treat the waste that include Aerobic- Bio drying, Aerobic in Vessel Composting and Anaerobic Digestion.
- Segregating glass would require material specific sorting technique for high value products.
- Textiles, paper and plastics are unlikely to receive an income.
- A common product of the MBT process is compost like outputs and can be used to improve low quality soil, restore brown field sites and landfill cap restoration.
- There are over 330 MBT facilities in operation throughout Europe.
- Capital costs for MBT facilities are relatively high. Recent example estimates and actual costs for the construction of MBT plants fall in the range of (2013 dollars):

  - £50m ($64m) – £125m ($159m) for MBT facilities in the capacity range 80,000 – 225,000 tpy.
- Footprint required varies on type of facility but can range from 7.4 acres to 42 acres for a 110,000 tpy to 305,00 tpy capacity plant.

10. Waste Conversion Mechanical Biological Treatment (MBT) Concept for Material and Energy Recovery from Mixed MSW. Waste Advantage Magazine, April 2015

https://wasteadvantagemag.com/waste-conversion-mechanical-biological-treatment-mbt-concept-for-material-and-energy-recovery-from-mixed-msw/

- According to the USEPA food waste comprises up to 21 percent of the MSW currently landfilled in the U.S.
- The growing demand for high-grade refuse derived fuel (RDF) around Europe additionally motivated the development of the MBT plants as one major by-product of these plants is RDF (~40 percent by weight).
- The leading MBT markets in Europe are Germany, Austria, Italy and Spain.
- The MBT plants accept for processing the mixed MSW as collected after source separation of recyclables and organics has been completed.
- The MBT plants with major landfilling fraction have a landfill diversion rate of around 60 percent, and the MBT plants dedicated to RDF production reduce the amount of waste being landfilled to 90 percent.
- Actual costs for the construction of MBT plants in the UK fall in the range of $150 per annual ton of capacity of MBT plant with aerobic composting (2015 dollars).
- Operational costs at the German MBT plants have been reported in the range of $45 to $103 per ton of MSW processed (2015 dollars).
- One of the issues these plants are facing is the quality of the recovered recyclables and the produced compost.

11. Organics Management Plan, Montgomery County, Maryland. EA 2023.

This organics siting study plan evaluates the siting, technology, and capacity planning for a County-owned organics processing facility in Montgomery County to meet the food scrap, non-recyclable paper, and yard trim diversion needs of the County for the next 20 years. Includes costs for different aerobic and anaerobic processing technologies.

Technology	Capital Cost	O&M Cost
Aerated Static Pile	$31,325,000	$11,050,000
In-Vessel Tunnel Reactor	$62,811,000	$13,770,000
Agitated Bed	$89,632,000	$12,260,000
Dry fermentation Anaerobic Digestion w/tunnel reactor composting	$139,460,000	$17,950,000
Dry fermentation Anaerobic Digestion	$105,041,000	$15,450,000

The alternatives presented considered a phased processing facility development, with adequate capacity to process up to 97,400 tons (273,500 CY) of yard trim and food scrap in Phase I, and to meet the future processing capacity needs identified in the mandatory program and some high capture scenarios in Phase II.

12. ReFed.com at https://insights-engine.refed.org/solution-database/centralized-composting

Summarizes the financial cost and benefits of composting and impacts to relevant stakeholders.

- In rural areas, windrow composting is more common, while aerated static pile compositing is found in urban areas.
- There are over 5,000 composting facilities nationwide, with only 500 facilities accepting food scraps.
- Larger facilities that can process up to 40,000 tons per year are expected to cost $5 to $9 million in upfront capital and $17 to $28 per incoming ton to operate.
- National average of processing capacity of the facilities is approximately 5,000 tons per year.
- Can achieve up to 16.2 M tons nationwide of annual food waste diversion.
- Results in an annual emission reduction of 8.75 M MTCO2e or (0.54 MTCO2e)

13. Anaerobic Digestion Facilities Processing Food Waste in the United States (2017 & 2018). USEPA Survey Results, January 2021.

EPA surveyed 209 AD facilities that accept food waste to identify the facilities, learn about their operations and develop a database. A summary of the major findings are listed:

- California has the greatest number of operating digesters (23) followed by Wisconsin (10). Ohio and New York both have nine digesters, Massachusetts has eight digesters and Pennsylvania has six digesters.
- Top Five feedstock sources for ADs in 2019: Food/beverage processors, restaurants, grocery stores, industrial sources, biodiesel production.
- Top five feedstocks accepted by ADs in 2019: Fats, oils and greases, food processing industry waste, beverage processing industry waste, fruit/vegetative waste and food service waste.
- Top uses of biogas were to produce electricity and fuel boiler and furnaces.
- Top uses of solid and liquid digestate include land applications, animal bedding, reusable and sellable product.

14. United States Environmental Protection Agency at https://www.epa.gov/agstar/anaerobic-system-design-and-technology

- Depending on the type of feedstock and the type of digester, pretreatment may be required.
- Digested solids may be used as animal bedding, as a soil amendment, a primary constituent in potting soils, or bio-based products (e.g., bioplastics).
- The liquid effluent from a digester can be used as a fertilizer, reducing the purchase of commercial fertilizers.

15. National Renewable Energy Laboratory (NREL) Comparison of Select Food Waste Utilization Options (2021).

NREL conducted a study to compare different food waste utilization options including landfill gas capture, anaerobic digestion and composting. Costs (in 2020 $) related to anaerobic digestion include:

Capacity (tpy)	Capital Cost (million USD)	O&M Cost (thousand USD)
2,500	3.0	85
5,000	4.7	171
25,000	12.3	854
50,000	18.6	1,707
100,000	28.2	3,415
200,000	42.7	6,830

Net GHG emissions (MTCO2e/ton) based on different final product applications:

- Dry AD with digestate curing: -0.04
- Dry AD with direct land application: -0.10
- Wet AD with digestate curing: -0.06
- Wet AD with direct land application: -0.14

Land area required: 3 to 6 acres

16. Zanker Material Processing Facility (ZMPF) Advanced C&D Processing System - Protocol Evaluation Report. Recycling Certification Institute, June 2020.

Presents the results of an evaluation of the process train for the Advanced C&D Recycling System operated at the Zanker Materials Processing Facility.

- In 2018 this operation processed 185,000 tons of material with a 70% diversion rate, approximately 41,000 tons more than its design capacity.

- The Advanced C&D Processing System is planned to operate 6 days per week and process an average of 500 tons per day, or 155,000 tons per year. Based on a preliminary acceptance test the operation achieved an 84.95% diversion rate with alternative daily cover (ADC) and a 64.68% diversion rate without ADC.

- *The following residue is disposed by:*
    - ***ADC** is sent to landfill*
    - ***Concrete*** is made into Base Rock
    - ***Metal*** (Tin, Steel, Aluminum, Copper) is delivered to a recycler for metal products.
    - ***Plastic (Beverage Containers, PET, HDPE)*** is delivered to other facilities for recycling.
    - ***Wood*** is processed into Biomass Fuel, Mulch, and Soil Amendments.
    - ***Trash*** is delivered to other landfills for disposal or disposed at the onsite landfill.

- Employee training should include hazardous materials recognition and screening and heavy equipment, operations, with emphasis on safety, health, environmental controls, and emergency procedures.

17. Consulting Services in Support of Resource Recovery Planning and Implementation, City of Dallas Sanitation Services, May 2014.

City of Dallas conducted a study on their Resource Recovery Planning and Implementation in an effort to meet their zero waste goals. The study provides an alternatives analysis of available technologies including C&D facilities. Cost information include:

- Capital cost range from $10 to $12 million in total.
  - Building and site construction - $7 to $8 million;
  - Processing equipment - $2 to $2.5 million; and
  - Rolling stock - $1 to $1.5 million.
- O&M costs range from $1.7 to $2.1 million annually.
  - Personnel - $1.3 to $1.5 million;
  - Rolling stock O&M - $175,000 to $250,000;
  - Processing equipment O&M - $80,000 to $90,000; and
  - Other operating expenses (utilities, fuel, supplies, training, etc.) - $225,000 to $260,000.
- The conceptual facility was sized to process 135,000 tons of C&D debris (including residuals) and increasing to 160,000 tons over ten years. Other assumptions include a debt issuance of 20 years for the facility/site development and a 5.0 percent interest rate on debt.

18. WIH Resource Group, City of Walla Walla, Washington, Glass Recycling Alternatives Analysis Report, October 2022.

The WIH Resource Group conducted a study for the City of Walla Walla in 2022 to analyze available alternative for glass recycling.

- Recycled glass can substitute for up to 95% of raw materials and extend manufacturing equipment's life.
- The estimated additional cost to collect and recycle glass from residential customers is $0.89 per month (2022 dollars).
- Because the glass will be source separated by the customers at the time of collection, SMI will pay the City of Walla Walla $15 per ton for the clean glass material stream.
- In 2018, 39.6% of beer and soft drink bottles were recovered for recycling, according to the U.S. EPA - 39.8% of wine and liquor bottles and 15.0% of food and other glass jars were recycled. In total, 33.1% of all glass food and beverage containers were recycled. Energy costs drop about 2-3% for every 10% cullet used in the manufacturing process.
- States with container deposit legislation have an average glass container recycling rate of just over 63%, while non-deposit states only reach about 24%, according to the Container Recycling Institute.
- Refillable bottles can be used about 25 times. Sterilizing and refilling a bottle use about 93% less energy and 47% to 82% less water than making a new bottle.
- The cost of the machine plus the setup costs is $277,000. It has an expected ten-year life and has a run cost of $2.96 per ton.
- Glass storage cost is $85,000. If this cost is depreciated over a ten-year life, the annual $8,500 cost has a monthly rate impact to each recycle customer of $0.07 ($8,500 / 10,335 customers/ 12 months).
- Reusing wine bottles has the highest net GHG impact compared to landfilling by reducing emissions by 5129 MT CO_2 e throughout its lifetime assuming it is reused 25 times before landfilling.
- Added glass collection routes and transport lead to an increase in GHG emissions by +255.61 MT CO_2e.
- Pulverize glass can reduce GHG emissions by 61 MT CO_2e.
- Andela glass pulverization system unit annual cost of operating ranges from $36 to $56 per ton.
- Cost per ton of glass depot (way to collect glass) is $0.64 per ton.

APPENDIX B

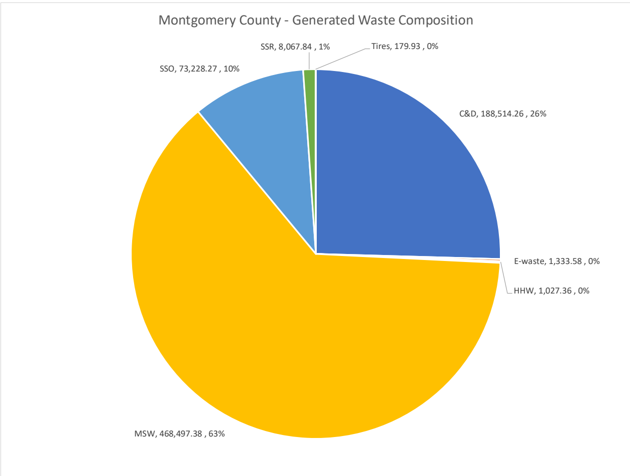
2021 Mass Balance

Montgomery County

Source: Solid Waste Tonnage Reports for Calendar Year 2021 for the Shady Grove TS and MCRRF

Mass Balance Status	OK

Waste Generation 740,849 tons | **Collections** 740,849 tons | **Processing & Transport** 740,849 tons | **Diversion and Disposal** 740,849 tons



Source	Material	Tons
Private Collection	MSW	257,706
	Recycling	0
	Scrap Metal	0
	Yard Trim	0
	C&D	0
	Leaves & Grass	0
Customer Dropoff	Mixed	0
	C&D	0
	Reserved	0
County Collections	C&D	188,514
	E-waste	1,334
	HHW	1,027
	MSW	210,791
	SSO	73,228
	SSR	8,068
	Tires	180
	Total Tons	740,849

Shady Grove TS	
Max Capacity	821,500
Material	Tons
C&D	188,514
E-waste	1,334
HHW	1,027
MSW	468,497
SSO	73,228
SSR	8,068
Tires	180
Reserved	0
Reserved	0
Reserved	0
Reserved	0
Total Tons	740,849

Legend
Bypass material which goes direct to receiving facilities.
Per conversation with County, materials do not cross the tipping floor.

Materials Routing			
Material	Transport	Destination	Tons
MSW - Mixed	Rail Haul	MCRRF	466,783
C&D - Mixed	Rail Haul	MCRRF	114,600
MSW - Mixed	Truck Haul	Covanta Fairfax - VA	419
MSW - Mixed	Truck Haul	King George - VA	443
MSW - Mixed	Truck Haul	Mountain View - PA	852
C&D - Mixed	Truck Haul	Mountain View - PA	47,300
C&D - Mixed	Truck Haul	Skinquarter - VA	4,593
Tires	Truck Haul	Emmanuel Tire - MD	180
E-waste	Truck Haul	Vintage Tech - PA	636
HHW - CRTs	Truck Haul	Vintage Tech - PA	697
SSR - Scrap Metal	Truck Haul	Joseph Smith & Sons - MD	7,566
C&D - Concrete	Truck Haul	Sandyfill Landfill - VA	8,797
C&D - Dirt/Rubble/Asphalt	Truck Haul	Sandyfill Landfill - VA	13,217
HHW - Paint	Truck Haul	MCRRF	521
HHW - Paint	Truck Haul	Zero Waste - MD	46
HHW - Mixed	Truck Haul	Clean Harbors - MD	148
SSR - Batteries	Truck Haul	Interstate - MD	106
SSR - Textiles	Truck Haul	Goodwill of Greater DC - MD	88
HHW - Paint	Truck Haul	Bresco - MD	80
SSR - Plastics 1-5,7	Truck Haul	MC MRF	245
SSR - Propane Tanks	Truck Haul	Pro Tank - DC	45
SSR - Books	Truck Haul	Goodwill of Greater DC - MD	7
SSR - Bikes	Truck Haul	Goodwill of Greater DC - MD	11
SSO - Vegetable Oil	Truck Haul	Not So Big Oil - MD	25
HHW - Oil	Truck Haul	FCC Environmental - MD	233
SSO - Leaves	Truck Haul	MCYTCF	3,067
SSO - Yard Trim	Truck Haul	MCYTCF	70,137
C&D - Wood		Storage	7
		Totals	740,849

Direct to Receiving Facilities	
Tons	85,490

MCRRF	
Max Capacity	624,150
Material	Tons
MSW	462,855
C&D	113,752
HHW-Paint	521
MSW Stored	(6,703)
MSW Storage Combusted	7,154
Moisture/Transport Losses	4,325
Net Total Tons	581,904
Total Tons Combusted	577,579
Estimated % Ash	26.1%
Ash Tons Generated	150,748
Ash Tons Out	150,370
Ash Tons Stored	378

MCYTCF	
Max Capacity	77,000
Material	Tons
SSO - Leaves	3,067
SSO - Yard Trim	70,137
Total Tons	73,204

MC MRF	
Max Capacity	24,960
Material	Tons
SSR- Plastics 1-7	245
Reserved	0
Reserved	0
Reserved	0
Bypass	0
Total Tons	245

Storage	
Material	Tons
Pallets	7
Reserved	0
Total Tons	7
Total Tons	740,849

MCRRF Materials Routing (Truck Haul)		
Material	Destination	Tons
Ash Residue	Old Dominion Landfill, VA	120,732
Recovered Metals	Recycle Management LLC	13,728
Recycled Ash	Old Dominion Landfill, VA	29,638
Total Tons		164,098

MCRRF Process Losses	
Combustion Losses	413,103
Total Tons	413,103

MCYTCF Materials Routing (Truck Haul)		
Material	Destination	Tons
Compost	End User Markets	73,204
Residue	Old Dominion Landfill, VA	0
Reserved		0
Total Tons		73,204

MC MRF Materials Routing (Truck Haul)		
Material	Destination	Tons
SSR- Plastics 1-7	Recycle One	245
Residue	Old Dominion Landfill, VA	0
Reserved		0
Total Tons		245

Materials Routing Summary	
Material Routing	**Tons**
MCRRF Process (Combustion) Losses	413,103
MCRRF Ash Tons Stored	378
TS Storage	7
Receiving Facilities Total Tons	323,036
Moisture/Transport Losses	4,325
Totals	740,849

Receiving Facilities	
Facility	Tons
Acme Biomass	0
Alexandria WTE	0
Ameriwaste	0
Annapolis Junction	0
Benning Rd (DC) Transfer Station	0
Bresco - MD	80
C&D Recovery LLC	0
Clean Harbors - MD	148
Covanta Fairfax - VA	419
Curtis Bay	0
Emmanuel Tire - MD	180
End User Markets	73,204
FCC Environmental - MD	233
Federal IPC	0
Fort Totten (DC)	0
Goodwill of Greater DC - MD	107
Interstate - MD	106
Joseph Smith & Sons - MD	7,566
King George - VA	443
Mountain View - PA	48,153
MRF - York County, PA	0
Not So Big Oil - MD	25
Old Dominion Landfill, VA	150,370
Pro Tank - DC	45
Recycle America Alliance	0
Recycle Management LLC	13,728
Recycle One	245
Rolloff Express	0
Rubble Landfill, MD	0
Sandyfill Landfill - VA	22,015
Skinquarter - VA	4,593
Vintage Tech - PA	1,334
WM (Northeast Transfer Station)	0
WMX Manassas Transfer Station	0
Zero Waste - MD	46
Totals	323,036

ARCADIS

APPENDIX C

Montgomery County, MD
Department of Environmental Protection
Municipal Solid Waste Management System Alternatives Analysis

ARCADIS

Mixed Waste Processing Facility Cost Detail

Sources	Facility Name and Location	Capacity (tpy)	Capital	Capital dollars in year	ENR CCI % Time Adjustem ent Factor	Capital ($ 2024) adjusted for location	Capital Costs ($/tpy) 2024	O&M	O&M Year in dollars	ENR CCI % Time Adjustemen t Factor2	O&M costs ($/ton)	Notes
https://nerc.org/documents/conferences/Spring%202015%20Conference/Eileen%20Berenyi_Mixed%20Waste%20Processing_The%20Good,%20the%20Bad,%20and%20the%20Ugly.pdf https://sunnyvaleca.legistar.com/LegislationDetail.aspx?ID=1820584&GUID=E6A6F02A-3988-477E-8FDC-C26246DD22E3&FullText=1	Sunnyvale Materials Recovery and Transfer Station (SMaRT)	142,780	$ 23,600,000	$ 1,993	1.53	$ 45,261,595	$ 418	$ 17,662,000	$ 2,023	0.00	$ 94	$59.29 per ton OPEX $17,662,000 in 2023 OPEX $21,300,000 in 2013 (offset by revenues)
City of Dallas - Consulting services in support of resource recovery planning and implementation (May 2014)	N/A	250,000	$ 36,955,000	$ 2,014	0.52	N/A	$ 224	$ 7,427,580	$ 2,014	0.52	$ 45	2 nine hour shifts, 5 days a week
Broward Report (Arcadis)	N/A	60tph (~600tpd)	$ 193,200,000	$ 2,020	0.03	N/A	N/A	N/A	N/A	N/A	N/A	Assumes 1 shift and 7 operating lines.
MRF Yearbook (2016-17)	Vieste, Glendale, AZ (6, 19)	22,500	$ 6,500,000	$ 1,999	1.31	$ 19,937,470	$ 668	$ 1,764,461	$ 2,014	0.52	$ 157.90	Single stream. 4 day operation, 1 shift per day. 260 days per year.
	Placer County/Western Regional Materials Recovery Facility, Lincoln, CA (19)	205,283	$ 22,000,000	$ 1,994	1.51	$ 41,919,694	$ 269	$ 11,418,618	$ 2,014	0.52	$ 64.01	Dual stream. 5 day operation, 1 shift per day. 260 days per year.
	Monterey Regional Waste Management District, Marina, CA (10, 19)	100,000	$ 21,000,000	$ 2,015	0.52	$ 24,239,867	$ 320	N/A	N/A	N/A	N/A	Dual stream. 5 day operation, 1 shift per day. 260 days per year.
	Newby Island Recyclery, Milpitas, CA (9, 19)	208,000	$ 4,500,000	$ 1,994	1.51	$ 8,574,483	$ 54	N/A	N/A	N/A	N/A	Dual stream. 5 day operation, 2 shift per day. 260 days per year.
	Athens Services Sun Valley MRF and Transfer Station, Sun Valley, CA (6, 19)	216,000	$ 50,000,000	$ 2,013	0.52	$ 57,678,561	$ 352	N/A	N/A	N/A	N/A	Single stream. 5 day operation, 1.5 shift per day. 260 days per year.
	Eastern Regional MRF, Truckee, CA (19)	53,000	$ 4,500,000	$ 1,994	1.51	$ 8,574,483	$ 213	N/A	N/A	N/A	N/A	Dual stream. 5 day operation, 1 shift per day. 260 days per year.
	Michiana Recycling and Disposal, Niles, MI (19)	28,050	$ 4,500,000	$ 2,007	0.95	$ 7,775,677	$ 312	N/A	N/A	N/A	N/A	Single Stream. 5 day operation, 2 shift per day. 260 days per year.
	Recycle City - Central Materials Processing Facility, St. Peters, MO (19)	57,116	$ 4,500,000	$ 1,995	1.44	$ 9,941,863	$ 192	$ 1,902,082	$ 2,015	0.52	$ 45.91	Dual stream. 5 day operation, 1 shift per day. 260 days per year.
	Van der Linde Recycling, Troy VA (19)	156,000	$ 11,000,000	$ 2,009	0.79	$ 19,647,765	$ 126	N/A	N/A	N/A	N/A	Single stream. 6 day operation, 1 shift per day.

*tpy to tpd conversion factor = 364 (from MWPF Assumptions tab)

Summary of Analysis

Capital Costs ($/tpy) 2024				**O&M costs ($/ton)**	
Low	$ 54			Low	$ 46
Average	$ 292			Average	$ 91
Average (excluding Low)	$ 319			Average (excluding Low)	$ 105
High	$ 668			High	$ 158

Montgomery County, MD
Department of Environmental Protection
Municipal Solid Waste Management System Alternatives Analysis

MRBT Facility Cost Detail

Sources	Facility Name and Location	Capacity (tpy)	Capital	Year in dollars	ENR CCI % change	Capital $2024	Capital Costs ($/tpy) 2024	O&M ($/year)	O&M ($/ton) 2024	Total	Notes
https://zerowasteeurope.eu/press-release/new-report-proves-cost-competitiveness-of-material-recovery-and-biological-treatment-based-approaches-for-mixed-waste-treatment/	Index Value/ Not facility Specific Value*	100,000	$ 37,050,000	2023	0.4%	$ 37,211,946	$ 372	$ 10,197,500	$ 102	E97-123 per ton $106-135 per ton	E296-377 per tpy $326-415 per tpy
https://zerowasteeurope.eu/press-release/new-report-proves-cost-competitiveness-of-material-recovery-and-biological-treatment-based-approaches-for-mixed-waste-treatment/	Index Value/ Not facility Specific Value*	200,000	$ 280,000,000	2023	0.4%	$ 281,223,885	$ 1,406	$ 4,800,000	$ 24	E76-96 per ton $83-105 per ton	E242-304 per tpy $226-334 per tpy
Mechanical Biological Treatment of Municipal Solid Waste. UK Department for Environment, Food and Rural Affairs, February 2013.	Index Value/ Not facility Specific Value*	80,000	$ 78,550,000	2012	59.6%	$ 125,346,566	$ 1,567	N/A	N/A	N/A	N/A
Mechanical Biological Treatment of Municipal Solid Waste. UK Department for Environment, Food and Rural Affairs, February 2013.	Index Value/ Not facility Specific Value*	225,000	$ 196,375,000	2012	59.6%	$ 313,366,415	$ 1,393	N/A	N/A	N/A	N/A
https://resource-recycling.com/recycling/2017/04/18/rr-exclusive-waste-management-builds-trash-sorting-mrf-near-oakland/	WM "O-MRF", San Leandro, California	150000	$ 120,000,000	2017	34.3%	$ 161,113,258	$ 1,074	None available	N/A	2017 dollars. Davis Street Transfer Station in San Leandro, California	100 tph
King County Re+ Plan	Tajiguas Resource Recovery Project. Santa Barbara, California	250,000	$ 140,600,000	2021	6.2%	$ 149,344,583	$ 597	N/A	N/A	N/A	In FY 2018/19 a COP for $149 million was issued to finance the Tajiguas Resource Recovery Project. MRF Operations occurs 24 hours/day up to 311 days per year, 6 days per week. The MRF is staffed in three 8-hour shifts: with primary processing occurring during the early morning and late afternoon shifts and only maintenance and cleaning occurring during the third evening shift. The ADF operates continuously and is staffed during daytime hours but is un-manned at night https://www.fws.gov/sites/default/files/documents/Tajiguas%20Draft%20HCP_040722.pdf
https://cdnsm5-hosted.civiclive.com/UserFiles/Servers/Server_3585797/File/Government/County%20Departments/Public%20Works/Waste%20Management/IMERF/IMERF_PDF_Nov_2023.pdf	Lane County, Oregon	160000	$ 155,000,000	2025	-3.7%	$ 149,325,626	$ 933	N/A	N/A	Construction planned to end 2025. Includes building and equipment for an integrated MRF with AD.	

*Reported estimates from industry experts not referencing a particular facility

Summary of Analysis

US Facilities (Excludes Europe)	Low	$ 597	**None Available**	
	Average	$ 868		
	High	$ 1,074		
All Facilities (Includes Europe)	Low	$ 372	Low	$ 24
	Average	$ 1,068	Average	$ 63
	Average Excluding Low	$ 1,068	Average Excluding Low	$ 102
	High	$ 1,567	High	$ 102
In absence of significant US operation data use US Based MWP + AD			MWP x 1.25	$ 132
			AD	$ 43
			MWP + AD	$ 175

Montgomery County, MD
Department of Environmental Protection
Municipal Solid Waste Management System Alternatives Analysis

Anaerobic Digestion Facility Cost Detail

Sources	Technology	Capacity (tpy)	Capital	Year in dollars	ENR CCI % change	Capital ($ 2024)	Capital Costs ($/tpy) 2024	O&M ($/year)	O&M Costs ($/ton) 2024	Total	Notes	Notes2	Notes3
City of Tucson Zero waste road map (HDR, May 2023)	Anaerobic Digestion	70600	$ 50,100,000	2030	-20.1%	$ 40,053,130	$ 567	$ 4,100,000	$ 46	$ 7,800,000	Assumes 23,300 tons of food waste, 42,400 tons of yard waste, 5,000 tons of industrial food waste. Low Estimate.	Annualized capital cost (4%, 20 years) 3,700,000. Total cost is annualized.	$110/ ton processed
City of Tucson Zero waste road map (HDR, May 2023)	Anaerobic Digestion	70600	$ 69,600,000	2030	-20.1%	$ 55,642,671	$ 788	$ 5,700,000	$ 65	$ 10,800,000	High estimate	Annualized capital cost (4%, 20 years) 5,100,000. Total cost is annualized	$153/ton processed
HDR - Harford WTE Facility Reuse study - Nov 2012	Anaerobic Digestion		$ 11,000,000	2019	18.7%	$ 13,058,644					Low cost estimate assuming source separated manue and bedding and food waste.		
HDR - Harford WTE Facility Reuse study - Nov 2012	Anaerobic Digestion		$ 31,000,000	2019	18.7%	$ 36,801,634					Facility receives MSW in addition to source separated organic material.		
EA Organics Study - Montgomery County 2023	Dry fermentation Anaerobic Digestion w/ product finishing via tunnel reactor composting	97,400	$ 73,089,000	2023	0.4%	$ 73,408,473	$ 754	$ 6,310,000	$ 65		Includes 30% contingency		
EA Organics Study - Montgomery County 2023	Dry fermentation Anaerobic Digestion w/ product finishing	97,400	$ 56,348,000	2023	0.4%	$ 56,594,298	$ 581	$ 5,270,000	$ 54		Includes 30% contingency		
NREL- Comparison of select food waste utilization options	Anaerobic Digestion w/biogas	2,500	$ 3,000,000	2020	15.3%	$ 3,457,758	$ 1,383	$ 85,000	$ 39				
NREL- Comparison of select food waste utilization options	Anaerobic Digestion w/biogas	5,000	$ 4,700,000	2020	15.3%	$ 5,417,154	$ 1,083	$ 171,000	$ 39				
NREL- Comparison of select food waste utilization options	Anaerobic Digestion w/biogas	25,000	$ 12,300,000	2020	15.3%	$ 14,176,807	$ 567	$ 854,000	$ 39				
NREL- Comparison of select food waste utilization options	Anaerobic Digestion w/biogas	50,000	$ 18,600,000	2020	15.3%	$ 21,438,098	$ 429	$ 1,707,000	$ 39				
NREL- Comparison of select food waste utilization options	Anaerobic Digestion w/biogas	100,000	$ 28,200,000	2020	15.3%	$ 32,502,923	$ 325	$ 3,415,000	$ 39				
NREL- Comparison of select food waste utilization options	Anaerobic Digestion w/biogas	200,000	$ 42,700,000	2020	15.3%	$ 49,215,418	$ 246	$ 6,830,000	$ 39				

* All facilities in this table are based on industry expert reports

Summary of Analyses

Capital Costs ($/tpy) 2024		O&M Costs ($/ton) 2024	
Low	$ 246.08	Low	$ 39.19
Average	$ 673.62	Average	$ 43.38
Average Excluding High Outlier	$ 572.26	Average Excluding High Outlier	$ 40.35
High	$ 1,383.10	High	$ 65.07

Montgomery County, MD
Department of Environmental Protection
Municipal Solid Waste Management System Alternatives Analysis

Construction & Demolition Debris Recycling Facility Cost Detail

Sources	Capacity (tpy)	Capital	Year in dollars	ENR CCI % change	Capital ($ 2024)	Capital Costs ($/tpy) 2024	O&M ($/year)	O&M Costs ($/ton) 2024	Total (annual cost)	Notes	Notes2	Notes3	Notes4
City of Tucson Zero waste road map (HDR, May 2023)	33,600	$ 1,300,000	2030	-20.1%	$ 1,039,303	$ 31	$ 800,000	$ 19	$ 900,000	C&D Low tech - includes pad and bunkers Low estimate		$27-37/ton processed	Capital cost annualized (4%, 20 years)
	33,600	$ 1,900,000	2030	-20.1%	$ 1,518,981	$ 45	$ 1,100,000	$ 26	$ 1,200,000	High estimate		$27-37/ton processed	Capital cost annualized (4%, 20 years)
	47,000	$ 4,800,000	2030	-20.1%	$ 3,837,426	$ 82	$ 1,500,000	$ 26	$ 1,800,000	C&D Medium tech - recycling system sort line Low estimate		$39-55/ton processed	Capital cost annualized (4%, 20 years)
	47,000	$ 6,700,000	2030	-20.1%	$ 5,356,407	$ 114	$ 2,100,000	$ 36	$ 2,600,000	High estimate		$39-55/ton processed	Capital cost annualized (4%, 20 years)
	67,100	$ 27,400,000	2030	-20.1%	$ 21,905,304	$ 326	$ 3,100,000	$ 37	$ 5,100,000	C&D High tech - MRF Low Estimate	26 tph /line/shift	$76-106/ton processed	Capital cost annualized (4%, 20 years)
	67,100	$ 38,100,000	2030	-20.1%	$ 30,459,566	$ 454	$ 4,300,000	$ 51	$ 7,100,000	High estimate	26 tph /line/shift	$76-106/ton processed	Capital cost annualized (4%, 20 years)
City of Dallas - Consulting services in support of resource recovery planning and implementation (May 2014)	135000 - 160000	$ 11,000,000	2009	78.6%	$ 19,647,765	$ 133	$ 1,900,000	$ 23		Capital cost includes building and site construction, processing equipment, rolling stock.	$1.7 -2.1 million. O&M costs includes personnel, equipment O&M, utilities, supplies, training, misc.	Includes debt issuance for 20 years and 5% interest rate on debt.	$10-12 million

Summary of Analysis

Capital Costs ($/tpy) 2024		O&M Costs ($/ton) 2024	
Low	$ 31	Low	$ 19
Average	$ 169	Average	$ 31
High	$ 454	High	$ 51

Montgomery County, MD
Department of Environmental Protection
Municipal Solid Waste Management System Alternatives Analysis

Composting Facility Cost Detail

Sources	Technology	Capacity (tpy)	Capital	Year in dollars	ENR CCI % change	Capital ($ 2024)	Capital Costs ($/tpd) 2024	Capital Costs ($/tpy) 2024	O&M ($/year)	O&M Costs ($/ton) 2024	Total	Notes	Notes2	Notes3
City of Tucson Zero waste road map (HDR, May 2023)	Composting - ASP	150,600	$ 30,000,000	2030	-20.05%	$ 23,983,910	$ 57,969	$ 159	$ 2,700,000	$ 14		Assumes 127,300 tons of yard waste and 23,300 tons of food waste. Capital costs include site preparation, utilities, equipment and construction. It includes contingency, engineering and design, QA/QC and permitting costs. O&M costs include labor, utilities, maintenance, repairs, fuel, ongoing consulting services, insurance, compost lab testing.	Total $32/ton processed	Annualized capital cost (4%, 20 years) $2,200,000
City of Tucson Zero waste road map (HDR, May 2023)	Composting - ASP	150,600	$ 41,600,000	2030	-20.05%	$ 33,257,688	$ 80,384	$ 221	$ 3,700,000	$ 20		Assumes 127,300 tons of yard waste and 23,300 tons of food waste. Capital costs include site preparation, utilities, equipment and construction. It includes contingency, engineering and design, QA/QC and permitting costs. O&M costs include labor, utilities, maintenance, repairs, fuel, ongoing consulting services, insurance, compost lab testing.	Total $45/ton processed	Annualized capital cost (4%, 20 years) $3,100,000
City of Tucson Zero waste road map (HDR, May 2023)	Composting - Windrow	132,000	$ 12,900,000	2030	-20.05%	$ 10,313,081	$ 28,439	$ 78	$ 1,900,000	$ 12		Assumes 4,700 tons of food waste and 127,300 tons of yard waste.	Total $21/ton processed	Annualized capital cost (4%, 20 years) $900,000
City of Tucson Zero waste road map (HDR, May 2023)	Composting - Windrow	132,000	$ 17,900,000	2030	-20.05%	$ 14,310,400	$ 39,462	$ 108	$ 2,600,000	$ 16		Assumes 4,700 tons of food waste and 127,300 tons of yard waste.	Total $30/ton processed	Annualized capital cost (4%, 20 years) $1,300,000
EA Organics Study - Montgomery County 2023	Composting - ASP	97,400	$ 16,318,000	2023	0.44%	$ 16,389,326	$ 61,250	$ 168	$ 3,470,000	$ 36		Includes 30% contingency		
EA Organics Study - Montgomery County 2023	In vessel tunnel reactor composting	97,400	$ 42,315,000	2023	0.44%	$ 42,499,960	$ 158,829	$ 436	$ 4,640,000	$ 48		Includes 30% contingency		
EA Organics Study - Montgomery County 2023	Agitated Bed Composting	97,400	$ 71,315,000	2023	0.44%	$ 71,626,719	$ 267,681	$ 735	$ 3,830,000	$ 39		Includes 30% contingency		
https://insights-engine.refed.org/solution-database/centralized-composting	All	40,000	$5-9 million	2023	0.44%				$ 900,000	$ 23	$203/ton	$17-28/ton		
NREL- Comparison of select food waste utilization options	Composting - ASP	1,800	$ 1,700,000	2020	15.26%	$ 1,959,396	$ 396,233	$ 1,089	$ 247,000	$ 158				
	Composting - ASP	40,000	$ 8,900,000	2020	15.26%	$ 10,258,015	$ 93,348	$ 256	$ 1,000,000	$ 29				
	Composting - ASP	180,000	$ 25,000,000	2020	15.26%	$ 28,814,648	$ 58,270	$ 160						
	Composting - Windrow	30,000	$ 4,300,000	2020	15.26%	$ 4,956,119	$ 60,134	$ 165	$ 601,000	$ 23		$437,000-765,000		
	Composting - Windrow	25,000		2020	15.26%				$ 362,000	$ 17				

Summary of Analysis

Organics Composting Expansion (Static Aerated Windrow w Membrane Cover)

Capital Costs ($/tpy) 2024		O&M Costs ($/ton) 2024	
Low	$ 160	Low	$ 20
Average	$ 379	Average	$ 61
Average Excluding High Outlier	$ 201	Average Excluding High Outlier	$ 28
High	$ 256	High	$ 36

Appendix B: Additional Detail on Evaluation Model

ARCADIS

Montgomery County MSW Management System Alternatives Analysis

Summary of Ranked Alternatives

Alternative	Rank	Points	Cost-of-Service		Carbon Footprint	Diversion
			NPV ($/Ton)	CAPEX ($MM)		
Alternative 1B MRBT-Medium	1	91.6	189	810	-0.72	45
Alternative 2A Long Haul MSW to Out-of-County MSWLF from RRF	3	59.9	154	216	-0.03	0
Baseline for Comparison - Retrofit/Repair and/or Rehabilitation of County RRF	2	63.5	124	356	0.00	4

NOTES:

1. NPV ($/Ton) Includes Preliminary Estimated Cost of Potential Health & Environmental Impacts which are Subject to On-Going E
2. Carbon Footprint Expressed as Difference in MTCO2e/Ton MSW Processed when Compared to Baseline
3. Diversion of Waste from Disposal is Represented as Percentage of Tipping Floor and/or MSW Delivered to RRF.

Montgomery County Municipal Solid Waste Management System Alternatives Analysis

Evaluation Model
Updated Weighted Ranking

Differential	10%

Legend

Copied from Data Results
Input Parameter
Model Output

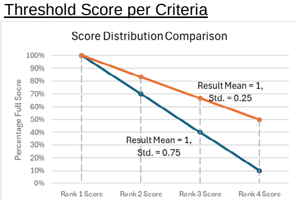
Evaluation Criteria		Performance Metric			Threshold Score per Criteria	Weighting Criteria	Maximum Score	MSW Management System Alternatives								
								Alternative 1B MRBT-Medium			Alternative 2A Long Haul MSW to Out-of-County MSWLF from RRF			Baseline for Comparison - Retrofit/Repair and/or Rehabilitation of County RRF		
No.	Description	Measurement	Rank	Unit				Result	Rank	Score	Result	Rank	Score	Result	Rank	Score
1	Lifecycle Cost of Service (30 Years) Including Monetized Cost of Potential H&E Impacts	Net Present Value	1 (Least Expensive)	$/Ton of MSW Processed	33	0.33	33	189	3	25	154	2	29	124	1	33
			2		29											
			3 (Most Expensive)		25											
2	Waste Diversion	Diversion of MSW from Disposal	1 (Most Diversion)	Percentage	33	0.33	33	45	1	33	0	3	9	4	2	21
			2		21											
			3 (Least Diversion)		9											
3	GHG Emissions	Difference in MTCO2e/Ton MSW Processed when Compared to Baseline	1 (Least Emission)	MTCO2e/Ton	34	0.34	34	-0.72	1	34	-0.03	2	22	0	3	9
			2		22											
			3 (Most Emission)		9											
					Total Points		100			91.6			59.9			63.5
							Rank	1			3			2		

NOTES:

1. Lifecycle Cost of Service: How expensive is this technology? Does the cost change based on contract terms? What drives the cost of the technology?
2. Waste Diversion: How does this technology contribute to Montgomery County's Zero Waste Goals? Diversion is calculated as total tonnage divertable based on the technology added to the current diversion of the County.
3. GHG Emissions: How does this technology contribute to Montgomery County's GHG emission reducgtion goals?

The County has a stated commitment to reducing GHG emissions with a goal of reducing GHG emissions by 80 percent by 2027 and 100 percent by 2035.
The EPA WARM Tool is suggested to calculation the Metric Ton of CO2 Equivalency per Ton of MSW Processed.

Threshold Score per Criteria



For each criterion, the threshold score distribution aligns with the result distribution (as shown in Column K).
The spacing of score intervals depends on the spread of the results:
Wider result distributions (e.g., results with a larger standard deviation) lead to larger score intervals. This is illustrated in the graphic: the blue line, representing results with a larger standard deviation, has wider score intervals.
Key scoring principles:
The top-ranked proposal always receives the maximum score.
Proposals with results significantly below the average receive a score of 0.
The score distribution method employed here ensures that both the ranking and the quality of the results are accurately and fairly represented in the final scores.
When the proposals are of relatively similar quality, this is reflected by closer scores across the board, creating a relatively even playing field. Conversely, when there is greater variability in the quality of the proposals, the score distribution reflects this by assigning wider gaps between scores. This method provides a balanced approach to scoring, rewarding both relative performance and absolute quality.

Results Differential (Cell D7)

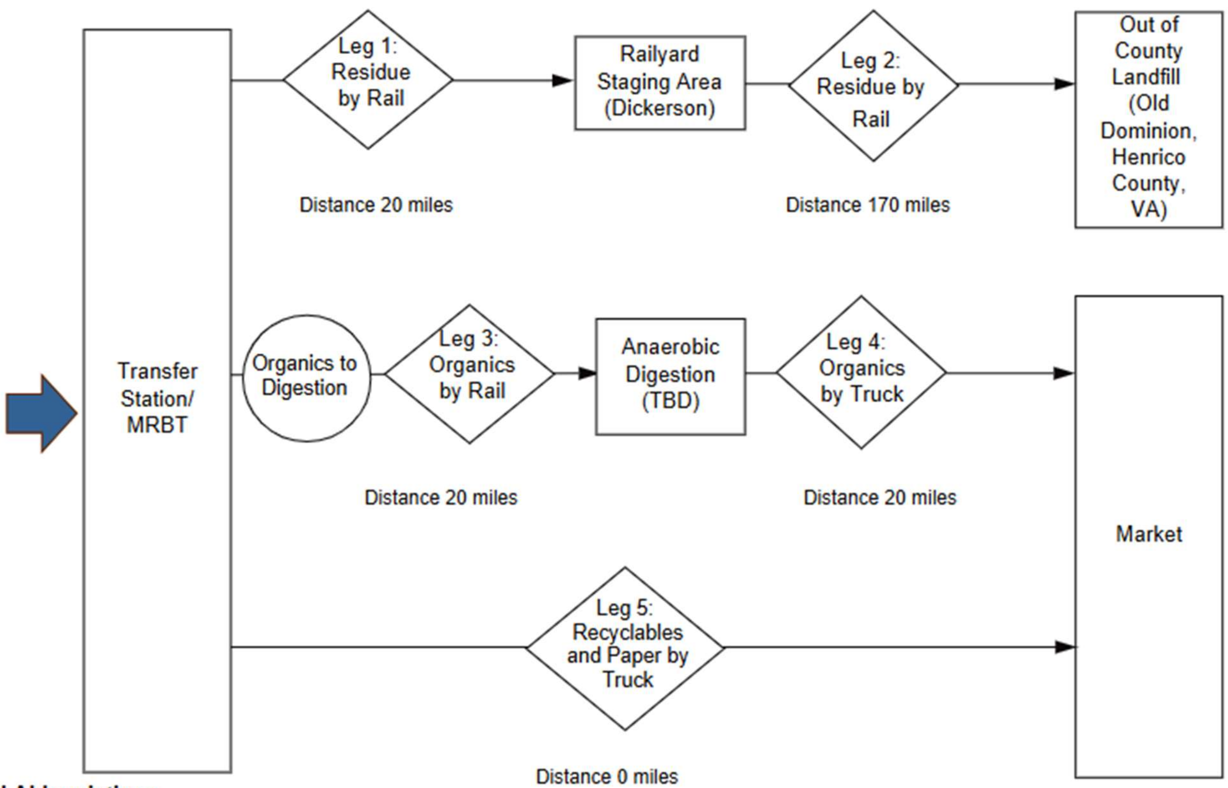
The differential in Cell D7 represents the percentage difference between proposals' results that the ranking model considers acceptable. Proposal results that differ by less than the differential are treated as similar.
The formula evaluates the original results by comparing them against one another.
For proposals with similar original results (i.e., differences below the differential threshold), the formula assigns the average of the two results to both proposals. This effectively gives them the same rank, ensuring that minor differences in results do not disproportionately impact the rankings.
This approach promotes fairness by recognizing and grouping proposals with comparable performance.

Appendix C: Additional Detail on WARM Analysis

Alternative[1]	GHG Emissions per Ton MSW (MTCO2E/ton)[2]	Annual GHG Emissions (MTCO2E)[2]	Annual Avoided Emissions, Passenger Vehicles Eliminated[3]
Alternative 1 (Original) - MRBT 52% Diversion[4]	(0.78)	(469,389)	109,368
Alternative 1A - 30% Diversion[4]	(0.49)	(294,037)	68,511
Alternative 1B - 60% Diversion[4]	(0.92)	(550,851)	128,348
Alternative 1C - 45% Diversion[4]	(0.70)	(418,560)	97,524
Alternative - 2A/B Long-Haul by Rail	(0.03)	(15,027)	3,501
Alternative 2C - Long-Haul Tractor-Trailer	(0.005)	(3,273)	763
Alternative 2D - Hybrid Transportation (65% Rail/35% Truck)	(0.02)	(10,953)	2,552

1. Alternatives were compared to Alternative 1 (MCRRF Upgrade Long Haul MWC Ash by Rail to Out-of County Landfill) in WARM.
2. Assumes 600,000 tons MSW per year.
3. This calculation is performed by WARM according to USEPA passenger vehicle emissions assumptions (https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator#results (Accessed February 2025)).
4. Assumes that anerobic digestate is cured and used for land application.
5. Alternative 1C (MRBT 45% Diversion) was interpolated from a curve fit using the 30%, 52%, and 60% scenarios.

Figure 1. Calculation of the effective WARM mileage to account for rail transport was performed for Legs 1 and 2 (underlined in red). This example is for Alternative 1C - MRBT with 45% Diversion, though other alternatives used the same approach.



Notes and Abbreviations
D = Distance (miles)
T = Tonnage
NA = Not Applicable
VTM = Vehicle Ton-Mile
MSW = Municipal Solid Waste
CF = Transportation Emissions Factor (Rail or Truck); 0.13524 for rail, 1 for diesel truck

Accounting for Rail Transportation in WARM: Corrected Mileage Methodology

WARM allows users to enter transport distances for different waste management endpoints. However, WARM assumes that all transportation is conducted via diesel trucking. Because the alternatives described above utilize a combination of diesel trucking and rail to transport MSW, a correction factor approach was used to account for the different emissions between these two hauling approaches. The correction factor was calculated by comparing the ratio of the average GHG emissions per vehicle type (e.g. diesel truck and rail) per ton per mile from several academic, industry, and government emissions studies. This factor was multiplied by the distance to the MSW or residual waste endpoint to calculate a representative effective rail mileage which was input into WARM.

Ratios of rail to truck emissions were determined from US DOT and Texas A&M studies (see attached email). The ratios were averaged to create a single correction factor for rail using the following process:

$$\frac{MT\ GHG\ Emissions\ per\ rail\ ton - mile}{MT\ GHG\ Emissions\ per\ truck\ ton - mile} = 0.13524$$

This correction factor was used to adjust the mileage for shipments taken by rail. The milage used for input into the WARM model is as follows:

- $Landfill: 190\ miles\ by\ rail\ \times 0.13524 = 25.70\ miles$
- $Anaerobic\ Digestion: (20\ miles\ by\ rail\ \times 0.13524) + (20\ miles\ by\ truck) = 22.70\ miles$
- $Recyclables = 0\ miles$

Interpolation for Scenario 1C (45%) using 1A (30%) and 1B (60%) and Original (52%)

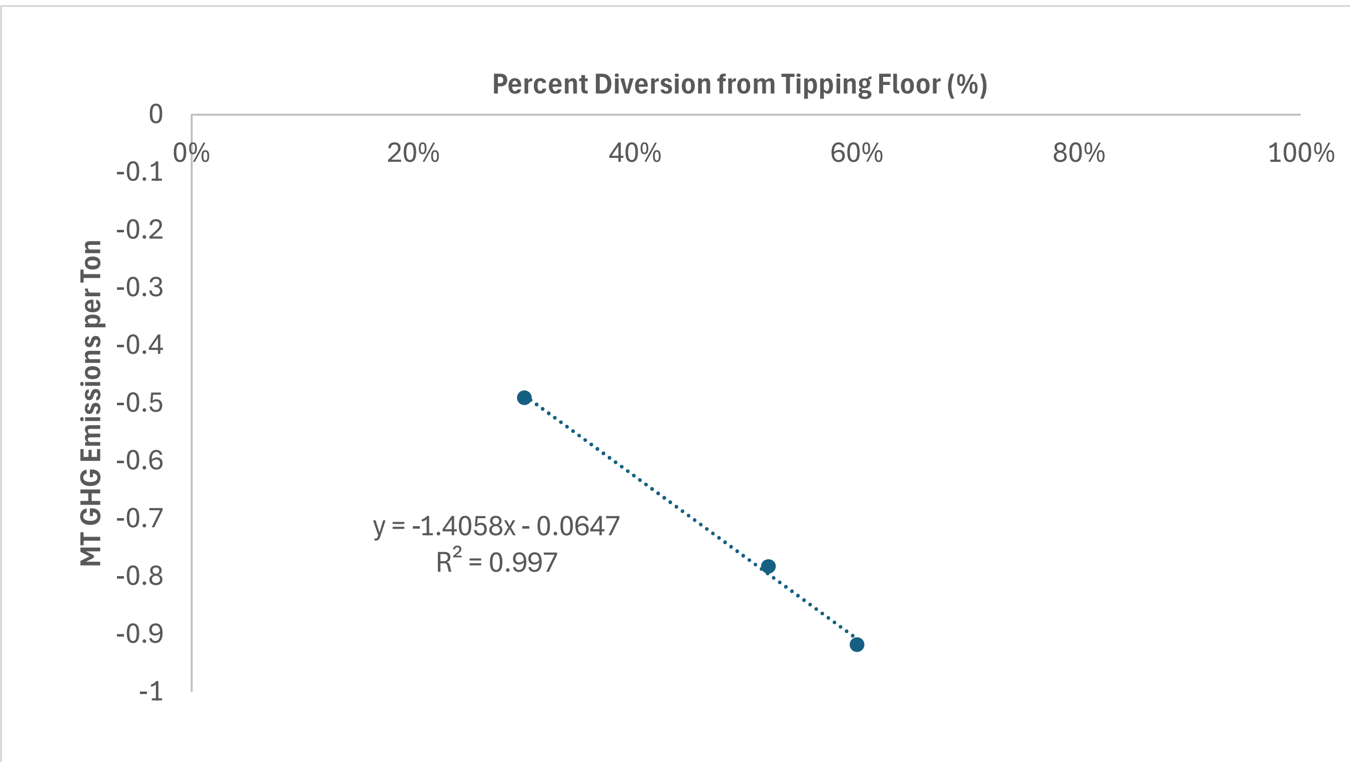


Table 1
U.S. EPA WARM Model Results
Comparison of LCA GHG Emissions Between RRF and MRBT Alternatives - 52% Diversion
Municipal Solid Waste Management System Alternatives Analysis
Montgomery County, Maryland

GHG Emissions Analysis -- Summary Report

Version 16

GHG Emissions Waste Management Analysis for

Prepared by: Arcadis

Project Period for this Analysis: 01/00/00 to 01/00/00

Note: If you wish to save these results, rename this file (e.g., WARM-MN1) and save it. Then the "Analysis Inputs" sheet of the "WARM" file will be blank when you are ready to make another model run.

GHG Emissions from Baseline Waste Management ($MTCO_2E$): 0.01

Material	Tons Recycled*	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$
Corrugated Containers	-	-	0.05	NA	NA	(0.02)
Magazines/third-class mail	-	-	0.01	NA	NA	(0.00)
Office Paper	-	-	0.02	NA	NA	(0.01)
Mixed Paper (general)	-	-	0.11	NA	NA	(0.05)
Mixed Paper (primarily residential)	-	-	0.03	NA	NA	(0.01)
Food Waste	NA	-	0.17	-	-	(0.02)
Grass	NA	-	0.02	-	-	(0.00)
Leaves	NA	-	0.02	-	-	(0.00)
HDPE	-	-	0.01	NA	NA	0.01
LDPE	NA	-	0.08	NA	NA	0.10
PET	-	-	0.02	NA	NA	0.03
PS	NA	-	0.01	NA	NA	0.02
Mixed Plastics	-	-	0.06	NA	NA	0.07
Mixed Electronics	-	-	0.02	NA	NA	0.01
Aluminum Cans	-	-	0.00	NA	NA	0.00
Aluminum Ingot	-	-	0.01	NA	NA	0.00
Steel Cans	-	-	0.02	NA	NA	(0.03)
Glass	-	-	0.03	NA	NA	0.00
Carpet	-	0.03	-	NA	NA	0.00
Concrete	-	0.01	NA	NA	NA	0.00
Dimensional Lumber*	-	-	0.07	NA	NA	(0.04)
Drywall	-	0.01	NA	NA	NA	(0.00)
Tires	-	-	0.00	NA	NA	0.00
Mixed Recyclables	-	-	0.03	NA	NA	(0.01)
Mixed Organics	NA	-	0.17	-	-	(0.02)
						0

GHG Emissions from Alternative Waste Management Scenario ($MTCO_2E$): (0.77)

Material	Tons Source Reduced	Tons Recycled*	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$	Change (Alt - Base) $MTCO_2E$
Corrugated Containers	-	0.03	0.01	-	NA	NA	(0.11)	(0.08)
Magazines/third-class mail	-	0.00	0.00	-	NA	NA	(0.02)	(0.01)
Office Paper	-	0.01	0.01	-	NA	NA	(0.03)	(0.02)
Mixed Paper (general)	-	0.08	0.03	-	NA	NA	(0.29)	(0.24)
Mixed Paper (primarily residential)	-	0.02	0.01	-	NA	NA	(0.07)	(0.06)
Food Waste	-	NA	0.05	-	-	0.12	0.02	0.04
Grass	NA	NA	0.01	-	-	0.01	0.00	0.00
Leaves	NA	NA	0.01	-	-	0.01	(0.01)	(0.00)
HDPE	-	0.01	0.00	-	NA	NA	(0.00)	(0.02)
LDPE	-	NA	0.08	-	NA	NA	0.00	(0.10)
PET	-	0.02	0.01	-	NA	NA	(0.02)	(0.05)
PS	-	NA	0.01	-	NA	NA	0.00	(0.02)
Mixed Plastics	-	0.04	0.02	-	NA	NA	(0.04)	(0.11)
Mixed Electronics	-	-	0.02	-	NA	NA	0.00	(0.01)
Aluminum Cans	-	0.00	0.00	-	NA	NA	(0.02)	(0.02)
Aluminum Ingot	-	0.00	0.00	-	NA	NA	(0.03)	(0.03)
Steel Cans	-	0.02	0.00	-	NA	NA	(0.03)	(0.00)
Glass	-	-	0.03	-	NA	NA	0.00	(0.00)
Carpet	-	-	0.03	-	NA	NA	0.00	0.00
Concrete	NA	-	0.01	NA	NA	NA	0.00	0.00
Dimensional Lumber*	-	-	0.07	-	NA	NA	(0.08)	(0.03)
Drywall	-	-	0.01	NA	NA	NA	(0.00)	0.00
Tires	-	-	0.00	-	NA	NA	0.00	(0.00)
Mixed Recyclables	NA	0.02	0.01	-	NA	NA	(0.06)	(0.05)
Mixed Organics	NA	NA	0.05	-	-	0.12	(0.00)	0.02
							0	0.00

Table 1
U.S. EPA WARM Model Results
Comparison of LCA GHG Emissions Between RRF and MRBT Alternatives - 52% Diversion
Municipal Solid Waste Management System Alternatives Analysis
Montgomery County, Maryland

GHG Emissions from Baseline Waste Management ($MTCO_2E$): 0.01

Material	Tons Recycled*	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$

GHG Emissions from Alternative Waste Management Scenario ($MTCO_2E$): (0.77)

Material	Tons Source Reduced	Tons Recycled*	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$	Change (Alt - Base) $MTCO_2E$

Total Change in GHG Emissions ($MTCO_2E$): (0.78)

Note: a negative value (i.e., a value in parentheses) indicates an emission reduction; a positive value indicates an emission increase.

*Wood Flooring and Dimensional Lumber model reuse under the recycling management pathway.

a) For explanation of methodology, see the EPA WARM Documentation:

Documentation Chapters for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)

-- available on the Internet at https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-and-energy-factors-used-waste-reduction-model

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

c) The GHG emissions results estimated in WARM indicate the full life-cycle benefits waste management alternatives. Due to the timing of the GHG emissions from the waste management pathways, (e.g., avoided landfilling and increased recycling), the actual GHG implications may accrue over the long-term. Therefore, one should not interpret the GHG emissions implications as occurring all in one year, but rather through time.

This is equivalent to...		
Removing annual emissions from	**0**	Passenger Vehicles
Conserving	**88**	Gallons of Gasoline
Conserving	**33**	Cylinders of Propane Used for Home Barbeques
	0.00000%	Annual CO_2 emissions from the U.S. transportation sector
	0.00000%	Annual CO_2 emissions from the U.S. electricity sector

Table 1
U.S. EPA WARM Model Results
Comparison of LCA GHG Emissions Between RRF and MRBT Alternatives - 1A 30% Diversion
Municipal Solid Waste Management System Alternatives Analysis
Montgomery County, Maryland

GHG Emissions Analysis -- Summary Report

Version 16

GHG Emissions Waste Management Analysis for

Prepared by: Arcadis

Project Period for this Analysis: 01/00/00 to 01/00/00

Note: If you wish to save these results, rename this file (e.g., WARM-MN1) and save it. Then the "Analysis Inputs" sheet of the "WARM" file will be blank when you are ready to make another model run.

GHG Emissions from Baseline Waste Management ($MTCO_2E$): 0.01

Material	Tons Recycled*	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$
Corrugated Containers	-	-	0.05	NA	NA	(0.02)
Magazines/third-class mail	-	-	0.01	NA	NA	(0.00)
Office Paper	-	-	0.02	NA	NA	(0.01)
Mixed Paper (general)	-	-	0.11	NA	NA	(0.05)
Mixed Paper (primarily residential)	-	-	0.03	NA	NA	(0.01)
Food Waste	NA	-	0.17	-	-	(0.02)
Grass	NA	-	0.02	-	-	(0.00)
Leaves	NA	-	0.02	-	-	(0.00)
HDPE	-	-	0.01	NA	NA	0.01
LDPE	NA	-	0.08	NA	NA	0.10
PET	-	-	0.02	NA	NA	0.03
PS	NA	-	0.01	NA	NA	0.02
Mixed Plastics	-	-	0.06	NA	NA	0.07
Mixed Electronics	-	-	0.02	NA	NA	0.01
Aluminum Cans	-	-	0.00	NA	NA	0.00
Aluminum Ingot	-	-	0.01	NA	NA	0.00
Steel Cans	-	-	0.02	NA	NA	(0.03)
Glass	-	-	0.03	NA	NA	0.00
Carpet	-	0.03	-	NA	NA	0.00
Concrete	-	0.01	NA	NA	NA	0.00
Dimensional Lumber*	-	-	0.07	NA	NA	(0.04)
Drywall	-	0.01	NA	NA	NA	(0.00)
Tires	-	-	0.00	NA	NA	0.00
Mixed Recyclables	-	-	0.03	NA	NA	(0.01)
Mixed Organics	NA	-	0.17	-	-	(0.02)
						0

GHG Emissions from Alternative Waste Management Scenario ($MTCO_2E$): (0.48)

Material	Tons Source Reduced	Tons Recycled*	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$	Change (Alt - Base) $MTCO_2E$
Corrugated Containers	-	0.02	0.03	-	NA	NA	(0.06)	(0.04)
Magazines/third-class mail	-	0.00	0.00	-	NA	NA	(0.01)	(0.01)
Office Paper	-	0.01	0.01	-	NA	NA	(0.01)	(0.00)
Mixed Paper (general)	-	0.05	0.07	-	NA	NA	(0.17)	(0.12)
Mixed Paper (primarily residential)	-	0.01	0.02	-	NA	NA	(0.04)	(0.03)
Food Waste	-	NA	0.10	-	-	0.07	0.04	0.06
Grass	NA	NA	0.01	-	-	0.01	0.00	0.00
Leaves	NA	NA	0.01	-	-	0.01	(0.01)	(0.00)
HDPE	-	0.00	0.01	-	NA	NA	(0.00)	(0.01)
LDPE	-	NA	0.08	-	NA	NA	0.00	(0.10)
PET	-	0.01	0.01	-	NA	NA	(0.01)	(0.04)
PS	-	NA	0.01	-	NA	NA	0.00	(0.02)
Mixed Plastics	-	0.02	0.03	-	NA	NA	(0.02)	(0.10)
Mixed Electronics	-	-	0.02	-	NA	NA	0.00	(0.01)
Aluminum Cans	-	0.00	0.00	-	NA	NA	(0.02)	(0.02)
Aluminum Ingot	-	0.00	0.00	-	NA	NA	(0.03)	(0.03)
Steel Cans	-	0.02	0.00	-	NA	NA	(0.03)	(0.00)
Glass	-	-	0.03	-	NA	NA	0.00	(0.00)
Carpet	-	-	0.03	-	NA	NA	0.00	0.00
Concrete	NA	-	0.01	NA	NA	NA	0.00	0.00
Dimensional Lumber*	-	-	0.07	-	NA	NA	(0.08)	(0.03)
Drywall	-	-	0.01	NA	NA	NA	(0.00)	0.00
Tires	-	-	0.00	-	NA	NA	0.00	(0.00)
Mixed Recyclables	NA	0.01	0.02	-	NA	NA	(0.04)	(0.03)
Mixed Organics	NA	NA	0.10	-	-	0.07	0.01	0.03
							0	0.00

Table 1
U.S. EPA WARM Model Results
Comparison of LCA GHG Emissions Between RRF and MRBT Alternatives - 1A 30% Diversion
Municipal Solid Waste Management System Alternatives Analysis
Montgomery County, Maryland

GHG Emissions from Baseline Waste Management ($MTCO_2E$): 0.01

Material	Tons Recycled*	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$

GHG Emissions from Alternative Waste Management Scenario ($MTCO_2E$): (0.48)

Material	Tons Source Reduced	Tons Recycled*	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$

Change (Alt - Base) $MTCO_2E$

Total Change in GHG Emissions ($MTCO_2E$): (0.49)

Note: a negative value (i.e., a value in parentheses) indicates an emission reduction; a positive value indicates an emission increase.

*Wood Flooring and Dimensional Lumber model reuse under the recycling management pathway.

a) For explanation of methodology, see the EPA WARM Documentation:

Documentation Chapters for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)

-- available on the Internet at https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-and-energy-factors-used-waste-reduction-model

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

c) The GHG emissions results estimated in WARM indicate the full life-cycle benefits waste management alternatives. Due to the timing of the GHG emissions from the waste management pathways, (e.g., avoided landfilling and increased recycling), the actual GHG implications may accrue over the long-term. Therefore, one should not interpret the GHG emissions implications as occurring all in one year, but rather through time.

This is equivalent to…

Removing annual emissions from	**0**	Passenger Vehicles
Conserving	**55**	Gallons of Gasoline
Conserving	**20**	Cylinders of Propane Used for Home Barbeques
	0.00000%	Annual CO_2 emissions from the U.S. transportation sector
	0.00000%	Annual CO_2 emissions from the U.S. electricity sector

Table 1
U.S. EPA WARM Model Results
Comparison of LCA GHG Emissions Between RRF and MRBT Alternatives - 1B 60% Diversion
Municipal Solid Waste Management System Alternatives Analysis
Montgomery County, Maryland

GHG Emissions Analysis -- Summary Report

Version 16

GHG Emissions Waste Management Analysis for

Prepared by: Arcadis

Project Period for this Analysis: 01/00/00 to 01/00/00

Note: If you wish to save these results, rename this file (e.g., WARM-MN1) and save it. Then the "Analysis Inputs" sheet of the "WARM" file will be blank when you are ready to make another model run.

GHG Emissions from Baseline Waste Management ($MTCO_2E$): 0.01

Material	Tons Recycled*	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$
Corrugated Containers	-	-	0.05	NA	NA	(0.02)
Magazines/third-class mail	-	-	0.01	NA	NA	(0.00)
Office Paper	-	-	0.02	NA	NA	(0.01)
Mixed Paper (general)	-	-	0.11	NA	NA	(0.05)
Mixed Paper (primarily residential)	-	-	0.03	NA	NA	(0.01)
Food Waste	NA	-	0.17	-	-	(0.02)
Grass	NA	-	0.02	-	-	(0.00)
Leaves	NA	-	0.02	-	-	(0.00)
HDPE	-	-	0.01	NA	NA	0.01
LDPE	NA	-	0.08	NA	NA	0.10
PET	-	-	0.02	NA	NA	0.03
PS	NA	-	0.01	NA	NA	0.02
Mixed Plastics	-	-	0.06	NA	NA	0.07
Mixed Electronics	-	-	0.02	NA	NA	0.01
Aluminum Cans	-	-	0.00	NA	NA	0.00
Aluminum Ingot	-	-	0.01	NA	NA	0.00
Steel Cans	-	-	0.02	NA	NA	(0.03)
Glass	-	-	0.03	NA	NA	0.00
Carpet	-	0.03	-	NA	NA	0.00
Concrete	-	0.01	NA	NA	NA	0.00
Dimensional Lumber*	-	-	0.07	NA	NA	(0.04)
Drywall	-	0.01	NA	NA	NA	(0.00)
Tires	-	-	0.00	NA	NA	0.00
Mixed Recyclables	-	-	0.03	NA	NA	(0.01)
Mixed Organics	NA	-	0.17	-	-	(0.02)
						0

GHG Emissions from Alternative Waste Management Scenario ($MTCO_2E$): (0.91)

Material	Tons Source Reduced	Tons Recycled*	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$	Change (Alt - Base) $MTCO_2E$
Corrugated Containers	-	0.04	0.01	-	NA	NA	(0.12)	(0.10)
Magazines/third-class mail	-	0.01	0.00	-	NA	NA	(0.02)	(0.02)
Office Paper	-	0.01	0.00	-	NA	NA	(0.04)	(0.03)
Mixed Paper (general)	-	0.09	0.02	-	NA	NA	(0.33)	(0.28)
Mixed Paper (primarily residential)	-	0.02	0.01	-	NA	NA	(0.08)	(0.07)
Food Waste	-	NA	0.03	-	-	0.13	0.01	0.03
Grass	NA	NA	0.00	-	-	0.02	0.00	0.00
Leaves	NA	NA	0.00	-	-	0.02	(0.00)	(0.00)
HDPE	-	0.01	0.00	-	NA	NA	(0.01)	(0.02)
LDPE	-	NA	0.08	-	NA	NA	0.00	(0.10)
PET	-	0.02	0.00	-	NA	NA	(0.02)	(0.05)
PS	-	NA	0.01	-	NA	NA	0.00	(0.02)
Mixed Plastics	-	0.05	0.01	-	NA	NA	(0.04)	(0.12)
Mixed Electronics	-	-	0.02	-	NA	NA	0.00	(0.01)
Aluminum Cans	-	0.00	0.00	-	NA	NA	(0.03)	(0.03)
Aluminum Ingot	-	0.01	0.00	-	NA	NA	(0.05)	(0.05)
Steel Cans	-	0.02	0.00	-	NA	NA	(0.03)	(0.00)
Glass	-	-	0.03	-	NA	NA	0.00	(0.00)
Carpet	-	-	0.03	-	NA	NA	0.00	0.00
Concrete	NA	-	0.01	NA	NA	NA	0.00	0.00
Dimensional Lumber*	-	-	0.07	-	NA	NA	(0.08)	(0.03)
Drywall	-	-	0.01	NA	NA	NA	(0.00)	0.00
Tires	-	-	0.00	-	NA	NA	0.00	(0.00)
Mixed Recyclables	NA	0.03	0.01	-	NA	NA	(0.07)	(0.06)
Mixed Organics	NA	NA	0.03	-	-	0.14	(0.01)	0.02
							0	0.00

Table 1
U.S. EPA WARM Model Results
Comparison of LCA GHG Emissions Between RRF and MRBT Alternatives - 1B 60% Diversion
Municipal Solid Waste Management System Alternatives Analysis
Montgomery County, Maryland

GHG Emissions from Baseline Waste Management ($MTCO_2E$): 0.01

Material	Tons Recycled*	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$

GHG Emissions from Alternative Waste Management Scenario ($MTCO_2E$): (0.91)

Material	Tons Source Reduced	Tons Recycled*	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$	Change (Alt - Base) $MTCO_2E$

Total Change in GHG Emissions ($MTCO_2E$): (0.92)

Note: a negative value (i.e., a value in parentheses) indicates an emission reduction; a positive value indicates an emission increase.

*Wood Flooring and Dimensional Lumber model reuse under the recycling management pathway.

a) For explanation of methodology, see the EPA WARM Documentation:

Documentation Chapters for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)

-- available on the Internet at https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-and-energy-factors-used-waste-reduction-model

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

c) The GHG emissions results estimated in WARM indicate the full life-cycle benefits waste management alternatives. Due to the timing of the GHG emissions from the waste management pathways, (e.g., avoided landfilling and increased recycling), the actual GHG implications may accrue over the long-term. Therefore, one should not interpret the GHG emissions implications as occurring all in one year, but rather through time.

This is equivalent to…

Removing annual emissions from	**0**	Passenger Vehicles
Conserving	**103**	Gallons of Gasoline
Conserving	**38**	Cylinders of Propane Used for Home Barbeques
	0.00000%	Annual CO_2 emissions from the U.S. transportation sector
	0.00000%	Annual CO_2 emissions from the U.S. electricity sector

U.S. EPA WARM Model Results
Comparison of GHG Emissions between Baseline RRF and Alternatives 2A and 2B - Long Haul Rail by Rail
Municipal Solid Waste Management System Alternatives Analysis
Montgomery County, Maryland

GHG Emissions Analysis -- Summary Report

Version 16

GHG Emissions Waste Management Analysis for

Prepared by:

Project Period for this Analysis: 01/00/00 to 01/00/00

Note: If you wish to save these results, rename this file (e.g., WARM-MN1) and save it. Then the "Analysis Inputs" sheet of the "WARM" file will be blank when you are ready to make another model run.

GHG Emissions from Baseline Waste Management ($MTCO_2E$): 0.01

Material	Tons Recycled*	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$
Corrugated Containers	-	-	0.05	NA	NA	(0.02)
Magazines/third-class mail	-	-	0.01	NA	NA	(0.00)
Office Paper	-	-	0.02	NA	NA	(0.01)
Mixed Paper (general)	-	-	0.11	NA	NA	(0.05)
Mixed Paper (primarily residential)	-	-	0.03	NA	NA	(0.01)
Food Waste	NA	-	0.17	-	-	(0.02)
Grass	NA	-	0.02	-	-	(0.00)
Leaves	NA	-	0.02	-	-	(0.00)
HDPE	-	-	0.01	NA	NA	0.01
LDPE	NA	-	0.08	NA	NA	0.10
PET	-	-	0.02	NA	NA	0.03
PS	NA	-	0.01	NA	NA	0.02
Mixed Plastics	-	-	0.06	NA	NA	0.07
Mixed Electronics	-	-	0.02	NA	NA	0.01
Aluminum Cans	-	-	0.00	NA	NA	0.00
Aluminum Ingot	-	-	0.01	NA	NA	0.00
Steel Cans	-	-	0.02	NA	NA	(0.03)
Glass	-	-	0.03	NA	NA	0.00
Carpet	-	0.03	-	NA	NA	0.00
Concrete	-	0.01	NA	NA	NA	0.00
Dimensional Lumber*	-	-	0.07	NA	NA	(0.04)
Drywall	-	0.01	NA	NA	NA	(0.00)
Tires	-	-	0.00	NA	NA	0.00
Mixed Recyclables	-	-	0.03	NA	NA	(0.01)
Mixed Organics	NA	-	0.17	-	-	(0.02)

GHG Emissions from Alternative Waste Management Scenario ($MTCO_2E$): (0.02)

Material	Tons Source Reduced	Tons Recycled*	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$	Change (Alt - Base) $MTCO_2E$
Corrugated Containers	-	0.03	0.01	-	NA	NA	(0.11)	(0.08)
Magazines/third-class mail	-	0.00	0.00	-	NA	NA	(0.02)	(0.01)
Office Paper	-	0.01	0.01	-	NA	NA	(0.03)	(0.02)
Mixed Paper (general)	-	0.08	0.03	-	NA	NA	(0.29)	(0.24)
Mixed Paper (primarily residential)	-	0.02	0.01	-	NA	NA	(0.07)	(0.06)
Food Waste	-	NA	0.05	-	-	0.12	0.01	0.03
Grass	NA	NA	0.01	-	-	0.01	(0.00)	0.00
Leaves	NA	NA	0.01	-	-	0.01	(0.01)	(0.01)
HDPE	-	0.01	0.00	-	NA	NA	(0.00)	(0.02)
LDPE	-	NA	0.08	-	NA	NA	0.00	(0.10)
PET	-	0.02	0.01	-	NA	NA	(0.02)	(0.05)
PS	-	NA	0.01	-	NA	NA	0.00	(0.02)
Mixed Plastics	-	0.04	0.02	-	NA	NA	(0.04)	(0.11)
Mixed Electronics	-	-	0.02	-	NA	NA	0.00	(0.01)
Aluminum Cans	-	0.00	0.00	-	NA	NA	(0.02)	(0.02)
Aluminum Ingot	-	0.00	0.00	-	NA	NA	(0.03)	(0.03)
Steel Cans	-	0.02	0.00	-	NA	NA	(0.03)	(0.00)
Glass	-	-	0.03	-	NA	NA	0.00	(0.00)
Carpet	-	-	0.03	-	NA	NA	0.00	0.00
Concrete	NA	-	0.01	NA	NA	NA	0.00	0.00
Dimensional Lumber*	-	-	0.07	-	NA	NA	(0.08)	(0.03)
Drywall	-	-	0.01	NA	NA	NA	(0.00)	0.00
Tires	-	-	0.00	-	NA	NA	0.00	(0.00)
Mixed Recyclables	NA	0.02	0.01	-	NA	NA	(0.06)	(0.05)
Mixed Organics	NA	NA	0.05	-	-	0.12	(0.02)	0.00

Total Change in GHG Emissions ($MTCO_2E$): (0.03)

GHG Emissions Analysis -- Summary Report

Version 16

GHG Emissions Waste Management Analysis for

Prepared by:

Project Period for this Analysis: 01/00/00 to 01/00/00

Note: If you wish to save these results, rename this file (e.g., WARM-MN1) and save it. Then the "Analysis Inputs" sheet of the "WARM" file will be blank when you are ready to make another model run.

Note: a negative value (i.e., a value in parentheses) indicates an emission reduction; a positive value indicates an emission increase.

*Wood Flooring and Dimensional Lumber model reuse under the recycling management pathway.

a) For explanation of methodology, see the EPA WARM Documentation: Documentation Chapters for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)
-- available on the Internet at https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-and-energy-factors-used-waste-reduction-model

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

c) The GHG emissions results estimated in WARM indicate the full life-cycle benefits waste management alternatives. Due to the timing of the GHG emissions from the waste management pathways, (e.g., avoided landfilling and increased recycling), the actual GHG implications may accrue over the long-term. Therefore, one should not interpret the GHG emissions implications as occurring all in one year, but rather through time.

This is equivalent to…		
Removing annual emissions from	**0**	Passenger Vehicles
Conserving	**3**	Gallons of Gasoline
Conserving	**1**	Cylinders of Propane Used for Home Barbeques
	0.00000%	Annual CO_2 emissions from the U.S. transportation sector
	0.00000%	Annual CO_2 emissions from the U.S. electricity sector

U.S. EPA WARM Model Results
Comparison of GHG Emissions between Baseline RRF and Alternative 2C - Long Haul Tractor-Trailer from TFS
Municipal Solid Waste Management System Alternatives Analysis
Montgomery County, Maryland

GHG Emissions Analysis -- Summary Report

Version 16

GHG Emissions Waste Management Analysis for

Prepared by:

Project Period for this Analysis: 01/00/00 to 01/00/00

Note: If you wish to save these results, rename this file (e.g., WARM-MN1) and save it. Then the "Analysis Inputs" sheet of the "WARM" file will be blank when you are ready to make another model run.

GHG Emissions from Baseline Waste Management ($MTCO_2E$): 0.01

Material	Tons Recycled*	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$
Corrugated Containers	-	-	0.05	NA	NA	(0.02)
Magazines/third-class mail	-	-	0.01	NA	NA	(0.00)
Office Paper	-	-	0.02	NA	NA	(0.01)
Mixed Paper (general)	-	-	0.11	NA	NA	(0.05)
Mixed Paper (primarily residential)	-	-	0.03	NA	NA	(0.01)
Food Waste	NA	-	0.17	-	-	(0.02)
Grass	NA	-	0.02	-	-	(0.00)
Leaves	NA	-	0.02	-	-	(0.00)
HDPE	-	-	0.01	NA	NA	0.01
LDPE	NA	-	0.08	NA	NA	0.10
PET	-	-	0.02	NA	NA	0.03
PS	NA	-	0.01	NA	NA	0.02
Mixed Plastics	-	-	0.06	NA	NA	0.07
Mixed Electronics	-	-	0.02	NA	NA	0.01
Aluminum Cans	-	-	0.00	NA	NA	0.00
Aluminum Ingot	-	-	0.01	NA	NA	0.00
Steel Cans	-	-	0.02	NA	NA	(0.03)
Glass	-	-	0.03	NA	NA	0.00
Carpet	-	0.03	-	NA	NA	0.00
Concrete	-	0.01	NA	NA	NA	0.00
Dimensional Lumber*	-	-	0.07	NA	NA	(0.04)
Drywall	-	0.01	NA	NA	NA	(0.00)
Tires	-	-	0.00	NA	NA	0.00
Mixed Recyclables	-	-	0.03	NA	NA	(0.01)
Mixed Organics	NA	-	0.17	-	-	(0.02)

GHG Emissions from Alternative Waste Management Scenario ($MTCO_2E$): 0.00

Material	Tons Source Reduced	Tons Recycled*	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$	Change (Alt - Base) $MTCO_2E$
Corrugated Containers	-	0.03	0.01	-	NA	NA	(0.11)	(0.08)
Magazines/third-class mail	-	0.00	0.00	-	NA	NA	(0.02)	(0.01)
Office Paper	-	0.01	0.01	-	NA	NA	(0.03)	(0.02)
Mixed Paper (general)	-	0.08	0.03	-	NA	NA	(0.29)	(0.24)
Mixed Paper (primarily residential)	-	0.02	0.01	-	NA	NA	(0.07)	(0.06)
Food Waste	-	NA	0.05	-	-	0.12	0.01	0.03
Grass	NA	NA	0.01	-	-	0.01	(0.00)	0.00
Leaves	NA	NA	0.01	-	-	0.01	(0.01)	(0.01)
HDPE	-	0.01	0.00	-	NA	NA	(0.00)	(0.02)
LDPE	-	NA	0.08	-	NA	NA	0.00	(0.10)
PET	-	0.02	0.01	-	NA	NA	(0.02)	(0.05)
PS	-	NA	0.01	-	NA	NA	0.00	(0.02)
Mixed Plastics	-	0.04	0.02	-	NA	NA	(0.04)	(0.11)
Mixed Electronics	-	-	0.02	-	NA	NA	0.00	(0.01)
Aluminum Cans	-	0.00	0.00	-	NA	NA	(0.02)	(0.02)
Aluminum Ingot	-	0.00	0.00	-	NA	NA	(0.03)	(0.03)
Steel Cans	-	0.02	0.00	-	NA	NA	(0.03)	(0.00)
Glass	-	-	0.03	-	NA	NA	0.00	(0.00)
Carpet	-	-	0.03	-	NA	NA	0.00	0.00
Concrete	NA	-	0.01	NA	NA	NA	0.00	0.00
Dimensional Lumber*	-	-	0.07	-	NA	NA	(0.08)	(0.03)
Drywall	-	-	0.01	NA	NA	NA	(0.00)	0.00
Tires	-	-	0.00	-	NA	NA	0.00	(0.00)
Mixed Recyclables	NA	0.02	0.01	-	NA	NA	(0.06)	(0.05)
Mixed Organics	NA	NA	0.05	-	-	0.12	(0.02)	0.00

Total Change in GHG Emissions ($MTCO_2E$): (0.01)

U.S. EPA WARM Model Results
Comparison of GHG Emissions between Baseline RRF and Alternative 2C - Long Haul Tractor-Trailer from TFS
Municipal Solid Waste Management System Alternatives Analysis
Montgomery County, Maryland

GHG Emissions Analysis -- Summary Report

Version 16

GHG Emissions Waste Management Analysis for

Prepared by:

Project Period for this Analysis: 01/00/00 to 01/00/00

Note: If you wish to save these results, rename this file (e.g., WARM-MN1) and save it. Then the "Analysis Inputs" sheet of the "WARM" file will be blank when you are ready to make another model run.

Note: a negative value (i.e., a value in parentheses) indicates an emission reduction; a positive value indicates an emission increase.

*Wood Flooring and Dimensional Lumber model reuse under the recycling management pathway.

a) For explanation of methodology, see the EPA WARM Documentation: Documentation Chapters for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)
-- available on the Internet at https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-and-energy-factors-used-waste-reduction-model

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

c) The GHG emissions results estimated in WARM indicate the full life-cycle benefits waste management alternatives. Due to the timing of the GHG emissions from the waste management pathways, (e.g., avoided landfilling and increased recycling), the actual GHG implications may accrue over the long-term. Therefore, one should not interpret the GHG emissions implications as occurring all in one year, but rather through time.

This is equivalent to…		
Removing annual emissions from	**0**	Passenger Vehicles
Conserving	**1**	Gallons of Gasoline
Conserving	**0**	Cylinders of Propane Used for Home Barbeques
	0.00000%	Annual CO_2 emissions from the U.S. transportation sector
	0.00000%	Annual CO_2 emissions from the U.S. electricity sector

U.S. EPA WARM Model Results
Comparison of GHG Emissions between Baseline RRF and Alternative 2D - Hybrid Transportation (65% Rail and 35% Truck)
Municipal Solid Waste Management System Alternatives Analysis
Montgomery County, Maryland

GHG Emissions Analysis -- Summary Report

Version 16

GHG Emissions Waste Management Analysis for

Prepared by:

Project Period for this Analysis: 01/00/00 to 01/00/00

Note: If you wish to save these results, rename this file (e.g., WARM-MN1) and save it. Then the "Analysis Inputs" sheet of the "WARM" file will be blank when you are ready to make another model run.

GHG Emissions from Baseline Waste Management ($MTCO_2E$): 0.01

Material	Tons Recycled*	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$
Corrugated Containers	-	-	0.05	NA	NA	(0.02)
Magazines/third-class mail	-	-	0.01	NA	NA	(0.00)
Office Paper	-	-	0.02	NA	NA	(0.01)
Mixed Paper (general)	-	-	0.11	NA	NA	(0.05)
Mixed Paper (primarily residential)	-	-	0.03	NA	NA	(0.01)
Food Waste	NA	-	0.17	-	-	(0.02)
Grass	NA	-	0.02	-	-	(0.00)
Leaves	NA	-	0.02	-	-	(0.00)
HDPE	-	-	0.01	NA	NA	0.01
LDPE	NA	-	0.08	NA	NA	0.10
PET	-	-	0.02	NA	NA	0.03
PS	NA	-	0.01	NA	NA	0.02
Mixed Plastics	-	-	0.06	NA	NA	0.07
Mixed Electronics	-	-	0.02	NA	NA	0.01
Aluminum Cans	-	-	0.00	NA	NA	0.00
Aluminum Ingot	-	-	0.01	NA	NA	0.00
Steel Cans	-	-	0.02	NA	NA	(0.03)
Glass	-	-	0.03	NA	NA	0.00
Carpet	-	0.03	-	NA	NA	0.00
Concrete	-	0.01	NA	NA	NA	0.00
Dimensional Lumber*	-	-	0.07	NA	NA	(0.04)
Drywall	-	0.01	NA	NA	NA	(0.00)
Tires	-	-	0.00	NA	NA	0.00
Mixed Recyclables	-	-	0.03	NA	NA	(0.01)
Mixed Organics	NA	-	0.17	-	-	(0.02)

GHG Emissions from Alternative Waste Management Scenario ($MTCO_2E$): (0.01)

Material	Tons Source Reduced	Tons Recycled*	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total $MTCO_2E$	Change (Alt - Base) $MTCO_2E$
Corrugated Containers	-	0.03	0.01	-	NA	NA	(0.11)	(0.08)
Magazines/third-class mail	-	0.00	0.00	-	NA	NA	(0.02)	(0.01)
Office Paper	-	0.01	0.01	-	NA	NA	(0.03)	(0.02)
Mixed Paper (general)	-	0.08	0.03	-	NA	NA	(0.29)	(0.24)
Mixed Paper (primarily residential)	-	0.02	0.01	-	NA	NA	(0.07)	(0.06)
Food Waste	-	NA	0.05	-	-	0.12	0.01	0.03
Grass	NA	NA	0.01	-	-	0.01	(0.00)	0.00
Leaves	NA	NA	0.01	-	-	0.01	(0.01)	(0.01)
HDPE	-	0.01	0.00	-	NA	NA	(0.00)	(0.02)
LDPE	-	NA	0.08	-	NA	NA	0.00	(0.10)
PET	-	0.02	0.01	-	NA	NA	(0.02)	(0.05)
PS	-	NA	0.01	-	NA	NA	0.00	(0.02)
Mixed Plastics	-	0.04	0.02	-	NA	NA	(0.04)	(0.11)
Mixed Electronics	-	-	0.02	-	NA	NA	0.00	(0.01)
Aluminum Cans	-	0.00	0.00	-	NA	NA	(0.02)	(0.02)
Aluminum Ingot	-	0.00	0.00	-	NA	NA	(0.03)	(0.03)
Steel Cans	-	0.02	0.00	-	NA	NA	(0.03)	(0.00)
Glass	-	-	0.03	-	NA	NA	0.00	(0.00)
Carpet	-	-	0.03	-	NA	NA	0.00	0.00
Concrete	NA	-	0.01	NA	NA	NA	0.00	0.00
Dimensional Lumber*	-	-	0.07	-	NA	NA	(0.08)	(0.03)
Drywall	-	-	0.01	NA	NA	NA	(0.00)	0.00
Tires	-	-	0.00	-	NA	NA	0.00	(0.00)
Mixed Recyclables	NA	0.02	0.01	-	NA	NA	(0.06)	(0.05)
Mixed Organics	NA	NA	0.05	-	-	0.12	(0.02)	0.00

Total Change in GHG Emissions ($MTCO_2E$): (0.02)

U.S. EPA WARM Model Results
Comparison of GHG Emissions between Baseline RRF and Alternative 2D - Hybrid Transportation (65% Rail and 35% Truck)
Municipal Solid Waste Management System Alternatives Analysis
Montgomery County, Maryland

GHG Emissions Analysis -- Summary Report

Version 16

GHG Emissions Waste Management Analysis for

Prepared by:

Project Period for this Analysis: 01/00/00 to 01/00/00

Note: If you wish to save these results, rename this file (e.g., WARM-MN1) and save it. Then the "Analysis Inputs" sheet of the "WARM" file will be blank when you are ready to make another model run.

Note: a negative value (i.e., a value in parentheses) indicates an emission reduction; a positive value indicates an emission increase.

*Wood Flooring and Dimensional Lumber model reuse under the recycling management pathway.

a) For explanation of methodology, see the EPA WARM Documentation:
Documentation Chapters for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)
-- available on the Internet at https://www.epa.gov/warm/documentation-chapters-greenhouse-gas-emission-and-energy-factors-used-waste-reduction-model

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

c) The GHG emissions results estimated in WARM indicate the full life-cycle benefits waste management alternatives. Due to the timing of the GHG emissions from the waste management pathways, (e.g., avoided landfilling and increased recycling), the actual GHG implications may accrue over the long-term. Therefore, one should not interpret the GHG emissions implications as occurring all in one year, but rather through time.

This is equivalent to…		
Removing annual emissions from	**0**	Passenger Vehicles
Conserving	**2**	Gallons of Gasoline
Conserving	**1**	Cylinders of Propane Used for Home Barbeques
	0.00000%	Annual CO_2 emissions from the U.S. transportation sector
	0.00000%	Annual CO_2 emissions from the U.S. electricity sector

Appendix D: Additional Detail on Financial Model

Montgomery County, MD
Department of Environmental Protection
Municipal Solid Waste Management System Alternatives Analysis
Summary of Waste Processing System Costs - Base Cost

ARCADIS

	Planning Horizon (Years)				
	1	5	10	20	30
Cummulative Tons MSW Processed Over Planning Horizon	589,793	2,990,541	6,087,226	12,614,233	19,612,795

Alternative No.	Waste Processing System	Cost of Service NPV $/Ton	Approximate Lifecycle Expenditures (NPV $)				
1A	MRBT-Low (30% Tipping Floor Recovery Rate) & Long Haul of Residuals by Rail Out of Dickerson (2A)	$ 203	$ 119,524,055	$ 606,045,732	$ 1,233,602,114	$ 2,556,327,871	$ 3,974,616,157
1B	MRBT-Medium (45% Tipping Floor Recovery Rate) & Long Haul of Residuals by Rail Out of Dickerson (2A)	$ 189	$ 111,356,257	$ 564,630,980	$ 1,149,302,657	$ 2,381,638,602	$ 3,703,006,714
1C	MRBT-High (60% Tipping Floor Recovery Rate) & Long Haul of Residuals by Rail Out of Dickerson (2A)	$ 175	$ 103,188,459	$ 523,216,228	$ 1,065,003,201	$ 2,206,949,334	$ 3,431,397,272
2A	Long Haul Rail from RRF	$ 154	$ 90,684,179	$ 459,813,379	$ 935,947,117	$ 1,939,513,296	$ 3,015,583,788
2B	Long Haul Rail from TFS	$ 167	$ 98,220,526	$ 498,026,365	$ 1,013,729,400	$ 2,100,697,373	$ 3,266,195,160
2C	Long Haul Tractor-Trailer from TFS	$ 201	$ 118,558,397	$ 601,149,372	$ 1,223,635,605	$ 2,535,674,806	$ 3,942,504,468
2D	Long-Haul Rail from RRF (65%) & Long-Haul Tractor Trailer from TFS (35%)	$ 175	$ 103,463,353	$ 524,610,076	$ 1,067,840,368	$ 2,212,828,646	$ 3,440,538,512
2E	Long Haul Tractor Trailer from RRF	$ 197	$ 116,074,661	$ 588,555,608	$ 1,198,001,081	$ 2,482,553,748	$ 3,859,911,067
Baseline for Comparison	Resource Recovery Facility Upgrades with Long Haul of MWC Ash by Rail Out of Dickerson	$ 124	$ 73,210,163	$ 371,211,525	$ 755,598,624	$ 1,565,786,731	$ 2,434,508,230

Alternative No.	Waste Processing System	Differential Cost (NPV $/Ton)	Incremental Lifecycle Expenditure Exceeding RRF Upgrades (NPV $)				
1A	Materials Recycling and Biological Treatment Facility and Long Haul of Residuals by Rail Out of Dickerson (30% Tipping Floor Recovery Rate)	$ 79	$ 46,313,892	$ 234,834,208	$ 478,003,490	$ 990,541,140	$ 1,540,107,927
1B	MRBT-Medium (45% Tipping Floor Recovery Rate) & Long Haul of Residuals by Rail Out of Dickerson (2A)	$ 65	$ 38,146,094	$ 193,419,456	$ 393,704,033	$ 815,851,871	$ 1,268,498,485
1C	Materials Recycling and Biological Treatment Facility and Long Haul of Residuals by Rail Out of Dickerson (60% Tipping Floor Recovery Rate)	$ 51	$ 29,978,296	$ 152,004,703	$ 309,404,577	$ 641,162,603	$ 996,889,042
2A	Long Haul MSW By Rail from RRF	$ 30	$ 17,474,016	$ 88,601,854	$ 180,348,494	$ 373,726,565	$ 581,075,558
2B	Long Haul MSW By Rail from TFS	$ 42	$ 25,010,363	$ 126,814,841	$ 258,130,777	$ 534,910,642	$ 831,686,930
2C	Long Haul Tractor-Trailer from TFS	$ 77	$ 45,348,235	$ 229,937,848	$ 468,036,981	$ 969,888,075	$ 1,507,996,238
2D	Long-Haul Rail from RRF (65%) & Long-Haul Tractor Trailer from TFS (35%)	$ 51	$ 30,253,190	$ 153,398,551	$ 312,241,745	$ 647,041,915	$ 1,006,030,282
2E	Long Haul Tractor Trailer from RRF	$ 73	$ 42,864,498	$ 217,344,084	$ 442,402,457	$ 916,767,017	$ 1,425,402,837
Baseline for Comparison	Resource Recovery Facility Upgrades with Long Haul of MWC Ash by Rail Out of Dickerson	$ -	$ -	$ -	$ -	$ -	$ -

Montgomery County, MD
Department of Environmental Protection
Municipal Solid Waste Management System Alternatives Analysis
Summary of Waste Processing System Costs - Base + HEI Cost

ARCADIS

		Planning Horizon (Years)				
		1	5	10	20	30
Cummulative Tons MSW Processed Over Planning Horizon		589,793	2,990,541	6,087,226	12,614,233	19,612,795

Alternative No.	Waste Processing System	Cost of Service NPV $/Ton	Approximate Lifecycle Expenditures (NPV $)				
1A	Materials Recycling and Biological Treatment Facility and Long Haul of Residuals by Rail Out of Dickerson (30% Tipping Floor Recovery Rate)	$ 192	$ 119,524,055	$ 606,045,732	$ 1,233,602,114	$ 2,556,327,871	$ 3,974,616,157
1B	Materials Recycling and Biological Treatment Facility and Long Haul of Residuals by Rail Out of Dickerson (45% Tipping Floor Recovery Rate)	$ 173	$ 111,356,257	$ 564,630,980	$ 1,149,302,657	$ 2,381,638,602	$ 3,703,006,714
1C	Materials Recycling and Biological Treatment Facility and Long Haul of Residuals by Rail Out of Dickerson (60% Tipping Floor Recovery Rate)	$ 155					
2A	Long Haul Rail from RRF	$ 194	$ 114,275,899	$ 579,435,000	$ 1,179,436,142	$ 2,444,082,616	$ 3,800,095,585
2B	Long Haul Rail from TFS	$ 207	$ 121,812,246	$ 617,647,986	$ 1,257,218,425	$ 2,605,266,693	$ 4,050,706,957
2C	Long Haul Tractor-Trailer from TFS	$ 241	$ 142,150,117	$ 720,770,993	$ 1,467,124,630	$ 3,040,244,126	$ 4,727,016,265
2D	Long-Haul Rail from RRF (65%) & Long-Haul Tractor Trailer from TFS (35%)	$ 215	$ 127,055,073	$ 644,231,696	$ 1,311,329,393	$ 2,717,397,966	$ 4,225,050,309
2E	Long Haul Tractor Trailer from RRF	$ 237	$ 139,666,381	$ 708,177,229	$ 1,441,490,106	$ 2,987,123,069	$ 4,644,422,864
Baseline for Comparison	Resource Recovery Facility Upgrades with Long Haul of MWC Ash by Rail Out of Dickerson	$ 130	$ 73,210,163	$ 371,211,525	$ 755,598,624	$ 1,565,786,731	$ 2,434,508,230

Alternative No.	Waste Processing System	Differential Cost (NPV $/Ton)	Incremental Lifecycle Expenditure Exceeding RRF Upgrades (NPV $)				
1A	Materials Recycling and Biological Treatment Facility and Long Haul of Residuals by Rail Out of Dickerson (30% Tipping Floor Recovery Rate)	$ 62	$ 36,287,411	$ 183,995,019	$ 374,520,654	$ 776,099,178	$ 1,206,690,413
1B	Materials Recycling and Biological Treatment Facility and Long Haul of Residuals by Rail Out of Dickerson (60% Tipping Floor Recovery Rate)	$ 43	$ 25,170,648	$ 127,627,564	$ 259,785,070	$ 538,338,745	$ 837,016,996
2A	Long Haul MSW By Rail from RRF	$ 64	$ 37,526,978	$ 190,280,232	$ 387,314,165	$ 802,610,487	$ 1,247,910,586
2B	Long Haul MSW By Rail from TFS	$ 76	$ 45,063,325	$ 228,493,218	$ 465,096,448	$ 963,794,564	$ 1,498,521,958
2C	Long Haul Tractor-Trailer from TFS	$ 111	$ 65,401,197	$ 331,616,225	$ 675,002,652	$ 1,398,771,997	$ 2,174,831,266
2D	Long-Haul Rail from RRF (65%) & Long-Haul Tractor Trailer from TFS (35%)	$ 85	$ 50,306,152	$ 255,076,929	$ 519,207,416	$ 1,075,925,837	$ 1,672,865,310
2E	Long Haul Tractor Trailer from RRF	$ 107	$ 62,917,460	$ 319,022,461	$ 649,368,128	$ 1,345,650,940	$ 2,092,237,865
Baseline for Comparison	Resource Recovery Facility Upgrades with Long Haul of MWC Ash by Rail Out of Dickerson	$ -	$ -	$ -	$ -	$ -	$ -

Montgomery County, MD
Department of Environmental Protection
Municipal Solid Waste Management System Alternatives Analysis
Summary of Waste Processing System Costs - Condensed Summary A

MSW Management System			Cost of Service		
			NPV $/Ton	CAPEX NPV $/Ton	Net OPEX NPV $/Ton
Baseline for Comparison		RRF Upgrades with Long Haul of MWC Ash by Rail Out of Dickerson	$ 124	$ 22	$ 102
Alternative 1	1A	MRBT - Low (30% Tipping Floor Recovery) & Residue by Rail from Dickerson	$ 203	$ 53	$ 150
	1B	MRBT - Medium (45% Tipping Floor Recovery) & Residue by Rail from Dickerson	$ 189	$ 53	$ 136
	1C	MRBT - High (60% Tipping Floor Recovery) & Residue by Rail from Dickerson	$ 175	$ 53	$ 122
Alternative 2	2A	MSW Long Haul by Rail Derwood/Dickerson	$ 154	$ 12	$ 142
	2B	MSW Long Haul by Rail Derwood	$ 167	$ 21	$ 146
	2C	MSW Long Haul by Truck Derwood	$ 201	$ 2	$ 199
	2D	MSW Long Haul Hybrid Rail and Truck	$ 175	$ 8	$ 167
	2E	MSW Long Haul Hybrid Truck from Dickerson	$ 197	$ 30	$ 167

Montgomery County, MD
Department of Environmental Protection
Municipal Solid Waste Management System Alternatives Analysis
Summary of Waste Processing System Costs - Condensed Summary B

Cost Component	System Cost (NPV $/Ton)											
	1A		1B		1C		2A		2C		Baseline for Comparison	
	MRBT - Low (30% Tipping Floor Recovery) & Residue by Rail from Dickerson		MRBT - Medium (45% Tipping Floor Recovery) & Residue by Rail from Dickerson		MRBT - High (60% Tipping Floor Recovery) & Residue by Rail from Dickerson		MSW Long Haul by Rail Derwood/Dickerson		MSW Long Haul by Truck Derwood		RRF Upgrades with Long Haul of MWC Ash by Rail Out of Dickerson	
CAPEX	$	53	$	53	$	53	$	12	$	2	$	22
Net OPEX	$	150	$	136	$	122	$	142	$	199	$	102
Sub-Total Base Cost	**$**	**203**	**$**	**189**	**$**	**175**	**$**	**154**	**$**	**201**	**$**	**124**
H&E Impact	$	(11)	$	(16)	$	(20)	$	40	$	40	$	6
Total	**$**	**192**	**$**	**173**	**$**	**155**	**$**	**194**	**$**	**241**	**$**	**130**

NOTES:
1. Net OPEX includes offsetting revenues

ARCADIS

Montgomery County, MD
Department of Environmental Protection
Municipal Solid Waste Management Systems Alternatives Analysis
Input Parameters

Category	Parameter	Unit	Waste Processing Technologies & Location							
			Baseline for Comparison	1A	1B	1C	2A	2B	2C	2D
			RRF Upgrades with Long Haul of MWC Ash by Rail Out of Dickerson	MRBT - Low (30% Tipping Floor Recovery) & Residue by Rail from Dickerson	MRBT - Medium (45% Tipping Floor Recovery) & Residue by Rail from Dickerson	MRBT - High (60% Tipping Floor Recovery) & Residue by Rail from Dickerson	MSW Long Haul by Rail Derwood/Dickerson	MSW Long Haul by Rail Derwood	MSW Long Haul by Truck Derwood	MSW Long Haul Hybrid Rail and Truck
			Dickerson	Derwood/Dickerson	Derwood/Dickerson	Derwood/Dickerson	Derwood/Dickerson	Derwood	Derwood	Derwood/Dickerson
Mass Balance/MSW Waste Stream Metrics (2024)	2024 Annual Average Quantity of Waste Processed	tpy	589,793	589,793	589,793	589,793	589,793	589,793	589,793	589,793
	2024 Daily Average Quantity of Waste Processed	tpd	1,966	1,966	1,966	1,966	1,966	1,966	1,966	1,966
	2024 Residue or Byproduct Produced for Disposal	tpy	176,938	412,855	324,386	235,917	N/A	N/A	N/A	N/A
Tipping Floor Tonnage	Starting Tonnage (2024)	tons/year	589,793	589,793	589,793	589,793	589,793	589,793	589,793	589,793
	Change in Per Capita Waste Generation Rate (%/yr)	%/year	0	0	0	0	0	0	0	0
	Population Growth Rate	%/year	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
	Technology Efficiency (Capture of Recyclables and Organics from MSW for MRBT; Reduction of Raw MSW to MWC Ash for RRF)	% Mass	70%	57.1%	85.7%	114.3%	0%	0%	0%	0%

ARCADIS

Category	Parameter	Unit	Waste Processing Technologies & Location							
			Baseline for Comparison	1A	1B	1C	2A	2B	2C	2D
			RRF Upgrades with Long Haul of MWC Ash by Rail Out of Dickerson	MRBT - Low (30% Tipping Floor Recovery) & Residue by Rail from Dickerson	MRBT - Medium (45% Tipping Floor Recovery) & Residue by Rail from Dickerson	MRBT - High (60% Tipping Floor Recovery) & Residue by Rail from Dickerson	MSW Long Haul by Rail Derwood/Dickerson	MSW Long Haul by Rail Derwood	MSW Long Haul by Truck Derwood	MSW Long Haul Hybrid Rail and Truck
			Dickerson	Derwood/Dickerson	Derwood/Dickerson	Derwood/Dickerson	Derwood/Dickerson	Derwood	Derwood	Derwood/Dickerson
Cost and Revenue Inputs Current 2024$	Technology CAPEX - Unit Based Not Including Contingency, EPC Fee or Offsetting County Tip Fee & Tax Credit	$/tpy processing capacity	N/A	$ 868.25	$ 868.25	$ 868.25	N/A	N/A	N/A	N/A
	OPEX - Annual Unit Includes Contingency but does NOT include Transport /Disposal of Residuals or Offsetting Revenue from Sale of RECs	$/ton Processible MSW	$ 53.75	$ 82.54	$ 82.54	$ 82.54	$ 15.36	$ 15.36	$ 15.36	$ 15.36
	Transfer Station Operating Costs (Does NOT include 'upper lot')	$/ton Processible MSW	$ 15.36	$ 6.14	$ 6.14	$ 6.14	$ -	$ -	$ -	$ -
	Railyard Operating Cost (MRBT is Derwood & Dickerson; RRF is Dickerson Only; Long Haul is Derwood & Dickerson)	$/ton Processible MSW	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
	Residue Transport Hauling by Rail - Unit Based	$/ton MRBT Residue	N/A	$ 25.00	$ 25.00	$ 25.00	N/A	N/A	N/A	N/A
	MWC Ash Transport Hauling by Rail - Unit Based	$/ton MWC Ash	$ 23.44	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	MSW Transport Hauling by Rail - Unit Based	$/ton MSW	N/A	$ -	$ -	$ -	$ 76.34	$ 76.34	N/A	$ 76.34
	MSW Transport by Truck - Unit Based	$/ton MSW	N/A	N/A	N/A	N/A	N/A	N/A	$ 123.64	$ 123.64
	Residue Disposal ((Tipping Fee) MRBT is MSWLF; RRFis MWC Ash to Henrico County; Long Haul is MSW to MSWLF) - Unit Based	$/ton residue	$ 35.12	$ 50.00	$ 50.00	$ 50.00	$ 50.00	$ 50.00	$ 50.00	$ 50.00
	Sub-Total OPEX including processing facility, railyard, hauling and disposal of residue, ash or MSW.	$/ton	$ 127.67	$ 163.68	$ 163.68	$ 163.68	$ 141.70	$ 141.70	$ 189.00	$ 265.34
	Revenue - Unit Based	$/ton recovered materials	$ -	$ 60.00	$ 60.00	$ 60.00	$ -	$ -	$ -	$ -
	Biogas Revenue /Ton Organics/Year	$/year/ton MSW	N/A	6.49	6.49	6.49	N/A	N/A	N/A	N/A

ARCADIS

Category	Parameter	Unit	Waste Processing Technologies & Location							
			Baseline for Comparison	1A	1B	1C	2A	2B	2C	2D
			RRF Upgrades with Long Haul of MWC Ash by Rail Out of Dickerson	MRBT - Low (30% Tipping Floor Recovery) & Residue by Rail from Dickerson	MRBT - Medium (45% Tipping Floor Recovery) & Residue by Rail from Dickerson	MRBT - High (60% Tipping Floor Recovery) & Residue by Rail from Dickerson	MSW Long Haul by Rail Derwood/Dickerson	MSW Long Haul by Rail Derwood	MSW Long Haul by Truck Derwood	MSW Long Haul Hybrid Rail and Truck
			Dickerson	Derwood/Dickerson	Derwood/Dickerson	Derwood/Dickerson	Derwood/Dickerson	Derwood	Derwood	Derwood/Dickerson
Other Project Costs	EPC Professional Fees	Percent (%) Capital Cost of Construction	2.0%	2.0%	2.0%	2.0%	2.0%			2.0%
	PCS Contract (Developers Fee)		3.0%	3.0%	3.0%	3.0%	3.0%	0.0%	0.0%	3.0%
	Permitting Fees		10%				10%	10%	10%	10%
	Contingencies		15%	15%	15%	15%	0.0%	0.0%	0.0%	0.0%
Bond Financing	Bonding	Percent (%) Capital Cost of Construction	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
	Finance Rate	Percent (%)	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
	Module 1 Finance Term	Years	30	30	30	30	30	30	30	30
	Module 2 Finance Term	Years	N/A	20	20	20	30	30	30	30
	Module 3 Finance Term	Years	N/A	10	10	10	N/A	N/A	N/A	N/A
Schedule	Award PCS Contract (MRBT) & Start Design (Others)	Fiscal Year	2026	2026	2026	2026	2027	2027	2027	2027
	Start Permitting		2029	2029	2029	2029	2029	2029	2029	2029
	Start Construction		2029	2029	2029	2029	2029	2029	2029	2029
	Start Commercial Operation		2032	2032	2032	2032	2031	2031	2031	2031
	Number of Payment Installments	#	1	1	1	1	1	1	1	1
	Time Between Build Phases	Years	N/A	10	10	10	N/A	N/A	N/A	N/A