Report

Preliminary Design for Processing Enhancements at the Recycling & Energy Center

Project I.D.: 19R002

Prepared For Ramsey/Washington Recycling & Energy Board

March 2019

RAMSEY/WASHINGTON
RECYCLING & ENERGY
CONNECTING VALUE TO WASTE

Foth

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March 5, 2019

Zack Hansen and Nicole Stewart
Ramsey/Washington Recycling & Energy Joint Leadership Team
2785 White Bear Avenue, Suite 350
Maplewood, MN 55109

RE: Preliminary Design for Processing Enhancements at the Recycling & Energy Center

Dear Mr. Hansen and Mrs. Stewart,

Enclosed is the Report: Preliminary Design for Processing Enhancements at the Recycling & Energy Center (R&E Center). The Processing Enhancements in this report include an addition to the R&E Center building north of the tipping floor, installation of a Durable Compostable Bag Processing System in the addition, and a Recyclables Recovery System installed in the current storage area in the Processing Building. This document is the culmination of research that has been ongoing since 2013 and is a part of the ongoing upgrades and research conducted on behalf of the Recycling & Energy Board.

Please let us know if you have any questions or comments.

Sincerely,

Foth Infrastructure & Environment, LLC

Nathan Klett
Lead Environmental Engineer

Jennefer Klennert
Senior Consultant

Preliminary Design for Processing Enhancements at the Recycling & Energy Center

Distribution

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Preliminary Design for Processing Enhancements

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List of Abbreviations, Acronyms, and Symbols

#1 PET	Polyethylene Terephthalate
#2 HDPE	High Density Polyethylene
AD	Anaerobic Digestion
BMP	Bio-Methane Potential
BWRLO	Bulky Waste Residue Loadout
CCTV	Closed Circuit Television
CM	Construction Manager
DCBs	Durable Compostable Bags
Foth	Foth Infrastructure & Environment, LLC
HDPE	High Density Polyethylene
I-494	Interstate 494
LOTO	Lock Out Tag Out
MPCA	Minnesota Pollution Control Agency
MSW	Mixed Municipal Solid Waste
MUD	Multi-Unit Dwelling
O&M	Operations and Maintenance
OCC	Old Corrugated Cardboard
PE	Polyethylene
R&D	Research & Development
R&E Board	Recycling & Energy Board
R&E Center	Recycling & Energy Center
RDF	Refuse Derived Fuel
RFP	Request for Proposals
SMSC	Shakopee Mdewakanton Sioux Community
SOPs	Standard Operating Procedures
TPH	Tons Per Hour
TPY	Tons Per Year
VDS	Vaporization Delivery System

Definitions

2D/3D Screen	A disc screen used to separate 2-dimensional materials from 3-dimensional materials.
2-dimensional	Typically used to describe something having length and width, but no depth (e.g. flat items such as paper, cardboard, etc.).
3-dimensional	Typically used to describe something having length, width, and depth (e.g. such as bottles, cans, etc.).
A and B Lines	The existing equipment used to process MSW into RDF at the R&E Center. Also known as A and B Processing Lines.
Agents	Title used in the Procurement section to indicate the architects, engineers, and construction manager who act in the Owner's interest providing professional services for compensation.
Burden Depth	Relative thickness or amount of material on a conveyor belt used to move material through a processing system.
Co-collected	The concept of collecting two materials in the same truck. In this report, "co-collected" refers most often to the means of collecting DCBs within, but separate from, MSW.
Commingled	In this report, the concept of organics mixed with the Municipal Solid Waste that is separated on a Recyclables Recovery System into an Organic Rich Material.
Contractors	Title used in the Procurement section to indicate the contracted entities who supply a specified product for a fixed price within the standard established in construction documents. Also referred to as Vendors.
DCB	Durable compostable bag. An extra-strong, compostable bag used for collection of organic materials co-collected with municipal solid waste.
Designation	The common industry phrase to mean the formal and legal designation of the supply of mixed Municipal Solid Waste to a publicly owned facility pursuant to Minnesota Statutes (115A.80 to 115A.89**).** Also known as flow control.
DCB Processing System	The portion of the Processing Enhancements specifically targeting Durable Compostable Bags for removal from municipal solid waste inclusive of equipment, tipping floor area, and transfer trailers. Also known as DCB Processing Lines.
Evolving Ton	The phenomenon where MSW and recyclables composition continues to change over time due to adjustments in packaging and light weighting of materials in general.

Ferrous	Containing or consisting of iron (e.g. steel items).
Fines	Very small particles present in the Municipal Solid Waste.
Master Plans	Ramsey and Washington County's respective Solid Waste Master Plans prepared in 2017 which set a planning vision for solid waste management. These plans address the specific projects and programs to be implemented within the counties to meet the goals, policies, and objectives of the Metropolitan Solid Waste Policy Plan.
Mixed Municipal Solid Waste	Garbage, refuse, and other solid waste from residential, commercial, industrial, and community activities that the generator of the waste aggregates for collection as per MN Statute 115A.03 Subd. 21. Mixed municipal solid waste does not include auto hulks, street sweepings, ash, construction debris, mining waste, sludges, tree and agricultural wastes, tires, lead acid batteries, motor and vehicle fluids and filters, and other materials collected, processed, and disposed of as separate waste streams.
Non-ferrous	Metals other than iron or steel (e.g. Aluminum, copper, etc.).
North Addition	The addition to the north side of the Recycling & Energy Center existing tipping floor to accommodate space for the DCB Processing System.
Optical Sorter	Automated equipment that sorts solid products using cameras and laser sensor systems. The optical sorter can recognize combinations of objects color, size, shape, and composition.
Organic Rich Material	Organics recovered from loose MSW (i.e., not in DCBs) as part of the R&E Center's Recyclables Recovery System. The Organic Rich Material is primarily from the 2-inch minus fraction but also from the 6-inch plus (unders) fraction.
Overs	The material fraction that passes over a separation screen.
Owner	Title used in the Procurement section to indicate the Recycling & Energy Board.
Processing Enhancements	A system of equipment components to remove durable compostable bags as well as recyclable materials from the municipal solid waste.
PLC	Programmable Logic Controller
Recyclables Recovery System	The portion of the Processing Enhancements specifically targeting recyclable materials and Organic Rich Material from municipal solid waste.

Refuse Derived Fuel	The product resulting from the processing of Municipal Solid Waste on the A & B Processing Lines that creates a fuel suitable for combustion.
Residue	Waste material remaining after processing Municipal Solid Waste into Refuse Derived Fuel.
Robot/Robotics	Automated equipment using vision or artificial intelligence to identify objects and remove the objects by mechanical means.
Unders	The material fraction that passes through or under a separation screen.
Waste Characterization Study	A specific composition study conducted by Foth at the Recycling & Energy Center in 2016 and 2017 designed to evaluate the Municipal Solid Waste based on size fraction in order to mimic the mechanics of processing equipment and how potential processing equipment may segregate material based on size or density.

Preliminary Design for Processing Enhancements at the Recycling & Energy Center

Executive Summary

The Recycling & Energy Board (R&E Board) is interested in installing processing enhancement equipment at the Recycling & Energy Center (R&E Center) to recover recyclables that remain in the mixed municipal solid waste (MSW) after source-separation as a compliment to the ferrous and non-ferrous recovery systems already in operation. The purpose of this report is to present information related to installation of additional equipment and necessary infrastructure to increase recovery of recyclables and allow for a method to recover organic materials delivered to the R&E Center co-collected with MSW in durable compostable bags (DCBs).[1] This report details the methodology used for evaluating equipment, evaluating the need for building modifications, estimating material recovery projections, and estimating capital and operations and maintenance (O&M) costs for implementing the processing enhancements.

The R&E Board has spent the last four years investigating various processing enhancement systems (previously identified as Mixed Waste Processing) equipment capabilities, and utilization, as well as vendors providing processing enhancement equipment. Investigations have included reports from the R&E Board's technical consultant, Foth; visits and tours with equipment vendors; visits to view processing systems and discuss operations with processing system operators; and attendance at both local and national conferences to learn from leading experts and others engaged with the industry. See Appendix A for a log of activities.

The accumulation of these learnings have been applied to the following analysis. The preliminary design outlines how a processing system could be designed and implemented to manage 225,000 tons of MSW for DCB recovery followed by management of 194,000 tons of MSW for recyclable commodities recovery at the R&E Center. The processing enhancements to the R&E Center would be located with the current Refuse Derived Fuel (RDF) system at the R&E Center within the existing R&E Board-owned property.

This analysis addresses the following elements:

- Summary of Analysis of Recovery of Recyclable Commodities using processing enhancements[2]
- Summary of process to determine the required equipment for processing enhancement needs
- Identification of processing enhancements to the R&E Center
- Layouts for processing enhancements at the R&E Center
- Estimate of costs associated with processing enhancements at the R&E Center
- Estimate of material recovery utilizing processing enhancements at the R&E Center
- Estimate of potential revenue and costs associated with material recycling and recovery at the R&E Center

[1] Foth. *Processing Alternatives: Durable Compostable Bag (DCB) Technology.* November 20, 2018.
[2] Foth. *Analysis for Recovery of Recyclable Commodities using Pre-Processing.* June 12, 2018.

E1 Policy Support

The R&E Board is committed to a continual effort to move materials up the waste hierarchy to be managed in the most environmentally preferable manner. The R&E Board also understands two realities. First, there is a cost to collect, gather, process and deliver materials to end markets. Second, stable end markets need to be available for the use of the diverted materials. A successful system of resource use depends on a strong network of industries to use materials as well as markets for the end products. The strategies within Ramsey and Washington County's respective Solid Waste Master Plans identify where the Counties can influence, regulate, and support waste being used to its highest value.

The respective Master Plans set a planning vision where Ramsey and Washington Counties continue to work together to find new technologies to use in the coming 20 to 30 years. The goal is to process what is remaining in the trash from homes and businesses and get the most value out of what is thrown away. The Counties plan to continue to increase recycling and reduce the amount thrown away. Additionally, these new technologies can help the Ramsey and Washington communities continue to provide high-quality jobs locally and protect taxpayers and the environment. Commissioners in both counties recognize a desire to do better and move trash from being a negative to being a resource with value; extract more recyclables from trash; use trash to make energy more efficiently; and use trash to make materials that can be used by others to manufacture consumer goods.

E2 Materials Targeted for Diversion

The *Summary of 2016-2017 Seasonal Waste Characterization*[3], by Foth, was used as the basis for understanding what materials remain in the waste stream and which materials were available for mechanical extraction. This understanding leads the preliminary design of the processing enhancements at the R&E Center. Results from the Seasonal Waste Characterization indicated that the processing enhancements would be most effective in targeting organics and recyclable containers including cardboard (OCC), ferrous, non-ferrous, #1 PET, and #2 HDPE. Based on equipment sizing information provided by equipment vendors a preliminary design is presented using much of the existing infrastructure at the R&E Center and includes additional enclosed spaces to accommodate new equipment.

Table ES-1 shows the estimated percent recovery with processing enhancements and the estimated tons of material recovered. The lower percent recovery estimated for organics is considered appropriate since there is very little data available for comparable systems accepting MSW and targeting organics using Durable Compostable Bags (DCBs) and considering the East Metro region's well-established source separation recycling programs.

[3] Foth. *Summary of 2016-2017 Seasonal Waste Characterization.* December 18, 2017.

Table ES-1
Estimated Tons Recovered with Recyclables Recovery System at the R&E Center

Material	Waste Composition (%)	Total Tons [1, 2]	Low Estimated Percent Recovery (%)	Low Estimated Tons Recovered	High Estimated Percent Recovery (%)	High Estimated Tons Recovered
PET	1.63%	3,153	60%	1,892	85%	2,680
HDPE	0.73%	1,407	60%	844	85%	1,196
Cardboard/Boxboard	1.28%	2,478	30%	744	50%	1,239
Ferrous (tin/steel containers)	1.30%	2,522	65%	1,639	90%	2,270
Non-ferrous (Aluminum)	1.03%	1,989	65%	1,293	90%	1,790
Organic Rich Materials (food and yard waste)[3]	25%	48,452	30%	14,535	50%	24,226
Totals	**NA**	**59,999**	**NA**	**20,946**		**33,400**

1 Material in Waste Stream Based on Waste Characterization
2 Assumes 194,000 tons of MSW will be processed with two processing lines at the R&E Center annually.
3 Assumes recovery of Organic Rich Materials from the processing enhancements equipment targeting recyclables only (not DCB organics recovery). Volumes may change significantly at DCB system maturity.

E3 System Economics

Table ES-2, Summary of Costs Associated with Processing Enhancements and Potential Revenue, presents a summary of the capital costs, O&M costs, and revenues for the installation of Processing Enhancements. The potential annual revenue for the DCB Processing System does not include transportation, processing fee, or tipping fees associated with DCB management once removed.

Table ES-2
Summary of Costs Associated with Processing Enhancements and Potential Revenue

System	Site Capital Costs[1]	Equipment Capital Costs	Total Estimated Capital Costs[2]	Annual O&M Costs	Potential Annual Revenue[3]
DCB Processing	$7,000,000 - $10,800,000	$5,240,000 - $7,000,000	$13,366,000 - $19,286,450	$2,333,000 - $2,468,000	($3,798,000) – ($3,948,000)
Recyclables Recovery	NA	$15,100,000 – $20,500,000	$17,365,000 – $23,575,000	$2,382,000 - $2,621,000	$1,986,000 - $2,785,000
DCB Processing + Recyclables Recovery	$7,000,000 - $10,800,000	$20,340,000 - $27,500,000	$30,731,000 - $42,861,450	$4,715,000 - $5,089,000	($1,163,000) - ($1,812,000)

[1] Includes estimated architecture and engineering services.
[2] Assumes construction management agency procurement method and includes estimated architecture and engineering and construction manager services.
[3] Negative revenue indicates there is a net cost associated with the System.
NA = Minor site capital costs associated with the Recyclables Recovery System are accounted for within the Equipment Capital Costs.

1 Purpose & Consideration

A preliminary design for installation of additional equipment (Processing Enhancements) at the Recycling & Energy Center (R&E Center) was requested by the Ramsey/Washington Recycling & Energy Board (R&E Board). The purpose of this report is to present information related to installation of additional equipment and necessary infrastructure to increase recovery of recyclables and allow for a method to recover organic materials delivered to the R&E Center co-collected with Mixed Municipal Solid Waste (MSW) in durable compostable bags (DCBs). This report details the methodology used for evaluating equipment, evaluating the need for building modifications, the estimated material recovery projections, and the estimated capital and operations and maintenance (O&M) costs for implementing the Processing Enhancements.

1.1 Design for System Flexibility

The preliminary design for the Processing Enhancements includes enclosed building space and equipment targeting recovery of organics that are anticipated to be contained in DCBs co-collected with MSW upon delivery to the R&E Center. Additionally, the Processing Enhancements include equipment that will target old corrugated cardboard (OCC), ferrous, non-ferrous, #1 PET, #2 HDPE, and Organic Rich Materials with flexibility for future modifications based on recycling markets and the Evolving Ton (i.e. the changing composition of the waste stream).

In order to move towards Minnesota's State goal that Metropolitan Counties recycle 75 percent of their waste generated by 2030, Ramsey and Washington Counties have specific recyclables recovery goals. One of the main goals of the preliminary design for Processing Enhancements is to assist in bringing Ramsey and Washington Counties closer to achieving the State goals.

1.2 Existing R&E Center Location

The preliminary design for Processing Enhancements takes into account the unique location and limited amount of space the R&E Center has for expansion on its property. The R&E Center is bounded by Interstate 494 (I-494) and the on-ramp for I-494, the Mississippi River, Maxwell Avenue, and the Xcel Energy Substation. Xcel Energy owns the land the scale house occupies, the R&E Center entrance, a portion of the parking lot adjacent to the Xcel Energy Substation, and the entrance to the Bulky Waste Residue Load Out (BWRLO) back-in. The Xcel Energy property is subject to an existing Easement Agreement with the R&E Board. At this time, Xcel Energy is not willing to sell portions of their neighboring property or provide further easements on which the R&E Board could build permanent structures.

1.3 Existing R&E Center Longevity of Operation

The preliminary design for Processing Enhancements adds equipment onto the front-end of the R&E Center focused on recovery of recyclables from MSW in order to enhance ferrous and non-ferrous recovery from exising Refuse Derived Fuel (RDF) production. However, Foth's design recognizes the R&E Center's 30 plus years of successful operations and integrates the R&E Center's existing RDF production lines (A and B Processing Lines) as integral components to work in conjunction with the new Processing Enhancement system.

1.4 General Hours of Operation

The R&E Center currently processes MSW 18 hours per day, 4 days per week, 10 hours per day 2 days per week, and 8 hours per day the remaining day per week. The total time of operation at the R&E Center is 4,836 hours per year, which takes into account 1 hour per day for start-up and shut-down operations when processing does not occur. The non-processing time is utilized for maintenance and cleaning. The preliminary design for Processing Enhancements mirrors the current hours of operation to fully utilize the Processing Enhancement equipment.

1.5 Focus on Automation

The preliminary design for the Processing Enhancements focuses on utilization of automation and mechanization of activities for sorting MSW at the R&E Center. The R&E Board provided direction to minimize manual sorting by individuals, known as pickers, throughout the Processing Enhancement design. The two primary drivers for automation are a quality work environment and the safety of employees of the R&E Center. The existing R&E Center is completely automated with limited direct manual handling of MSW by employees.

1.6 R&E Center Waste Composition Studies

Before a preliminary design for additional equipment Processing Enhancements was developed, an analysis of the waste composition was necessary to determine what materials the system should be targeting for recovery. As a part of the overall project for the R&E Board, several waste composition studies have been conducted at the R&E Center over the past six years. These waste analyses included traditional waste composition studies[4] performed in accordance with ASTM Standard D5231[5] as well as four seasonal waste characterization studies that were conducted in 2016-2017.

The Foth *Summary of 2016-2017 Seasonal Waste Characterization*s was designed to evaluate the MSW based on size fraction in order to mimic the mechanics of processing equipment and how the potential processing equipment may segregate material based on size or density[6]. The Recyclables Recovery System design is based primarily on these 2016-2017 seasonal waste characterizations, which were designed to mimic mechanical equipment. A synopsis of the Waste Characterization is as follows.

- In 2016 and 2017, a series of four waste characterization events took place at the R&E Center in October 2016, March 2017, May 2017, and August 2017.
- Each event sampled approximately 2,000 pounds of residential waste from Ramsey and Washington Counties.

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[4] The following waste characterization studies were prepared for the R&E Board using standard sampling and sorting procedures in accordance with ASTM Standard D5231:

- Foth. *Waste Composition Study*. September 2014.
- Burns & McDonnell. *Solid Waste Composition Analyses – Letter Report*. February 13, 2018.
- SAIC. *Solid Waste Composition Study – Newport Resource Recovery Facility*. September 17, 2012.

[5] ASTM Standards. *ASTM D5231 – 92(2016): Standard Test for Determination of the Composition of Unprocessed Municipal Solid Waste*. 2016.

[6] Foth. *Summary of 2016-2017 Seasonal Waste Characterizations.* December 18, 2017.

- ♦ Waste samples were sorted and characterized according to size fraction, whether material was contained in a bag or loose, and recyclables including plastics, glass, metals, cardboard, and food waste.

The full body of waste composition and characterization analyses conducted at the R&E Center is deemed as sufficiently robust for this current level of planning and design of the Processing Enhancements, but is not guaranteed to exactly replicate the waste characteristics on a daily basis. The past waste studies have documented the material by material composition of the incoming MSW with adequate sampling rigor achieving a 90 percent confidence level, the industry standard for such analyses. For example, the Foth 2014 Waste Composition Study analyzed a total of 56 samples in order to achieve the 90 percent confidence level. As another example, the Burns & McDonnell 2018 Solid Waste Composition Analysis collected and sorted a total of 30 samples in order to achieve the 90 percent confidence level.

The 2016 – 2017 Seasonal Waste Characterization analysis conducted by Foth[7] was designed in part to estimate the seasonal variation in residential material composition and other waste characteristics (e.g., bagged vs. loose, percent by size, moisture content, etc.). For each of the four seasonal sorting events (October 2016, March 2017, May 2017, and August 2017), a total of ten random samples were collected from residential route trucks for a total of 40 samples. Foth believes that the sampling procedure was sufficiently robust to provide adequate statistics for this preliminary design of the Processing Enhancements system. Additional characterization studies should be considered to replicate the sampling and characterization procedures used in the 2016 – 2017 Seasonal Waste Characterization analysis. A replicate study with a larger sample size may be needed to enhance statistical confidence levels.

Each Waste Characterization event consisted of collecting 200-pound samples twice a day for five days. The material from each sample was separated into bagged or loose material and then processed through a shaking table designed specifically for this classification study.

The shaking table in Picture 1-1 was used to sort the material through two sieve sizes: 2-inch and 6-inch. Material greater than 12-inches was immediately placed in a separate pile. Material less than 2-inches fell to the bottom of the shaking table. The remaining materials waste was then captured on the 6-inch sieve or 2-inch sieve. Plastics, glass, food waste, non-ferrous and ferrous materials were sorted with respect to type of material and weighed.

Picture 1-1
Waste Characterization Team Demonstrate the Shaking Table Sort Process
Source:Foth Photos

As waste was placed onto the top sieve, the 6-inch sieve, it either falls through or stays on top of the sieve depending on its size. However, lighter objects like paper strips, napkins, and plastic bags float along the 6-inch sieve and do not pass through the appropriate size sieve easily. Thus, shaking is necessary. Each sieve is given thirty shakes to attempt to replicate mechanical

[7] Foth. *Summary of 2016-2017 Seasonal Waste Characterizations.* December 18, 2017.

separation. The process of adding material and shaking the table is repeated until there is an overburden of material on the 6-inch sieve. The material on top of the 6-inch sieve is removed by sorting into bins based on material type, and each bin is weighed.

Once the material has been removed and sorted, additional material is placed on top until all the loose material is sorted. Then the bagged material is sorted separately through the same procedure as loose material. Bags required a box cutter and approximately three cuts to remove and separate waste effectively. Picture 1-2 shows the bags that were cut and contents removed for sorting.

Picture 1-2
Bags Separated After Opening
Source: Foth Photos

Three separate five-gallon samples of the following materials were also collected twice a day for five days for each event:

- ♦ RDF from the existing A and B Lines at the R&E Center,
- ♦ Residue from the existing A and B Lines at the R&E Center, and
- ♦ Less than 2-inch material from the characterization.

At the end of the Waste Characterization event, each sample was weighed and mixed to create one sample of RDF, one sample of less than 2-inch residue, and one sample of residue from the existing A and B Lines. These samples were sent to Dr. Morton Barlaz at North Carolina State University and analyzed for several items including biomethane potential, carbon, and fines.

The results of the Study have been summarized in Appendix B.

Below are some similar trends and differences comparing the four events.

- ♦ Cardboard continues to be found mainly in the loose stream. However, in the August characterization, it was found mainly in the greater than 12-inch size fraction. Previously, cardboard was found mainly in the 6- to 12-inch size fraction.
- ♦ The majority of the waste continues to be bagged in traditional polyethylene (PE) plastic bags.
- ♦ PET plastics represent the majority of the incoming plastics stream.
- ♦ Approximately 89percent to 93percent of the sample was waste and not traditional recyclables (excluding the Organic Rich Materials). The 2- to 6-inch size fraction is the highest proportion of the waste.
- ♦ From the four waste characterizations, 56 percent to 69 percent of the sample comes from bagged material. New packaging designs continue to create stronger trash bags.
- ♦ During the August characterization, 12.3 percent of the sampled waste was food waste in the 2- to 6-inch fraction. During the May characterization, 10.4 percent of sampled waste

was food waste in the 2- to 6-inch fraction. During the March characterization, 5.3 percent of the sampled waste was food waste in the 2- to 6-inch fraction. Seasonal differences were noticed with different types of food waste (e.g. corn cobs, watermelon) being more prevalent at different times of the year.

- Source separation continues to be the preferred method of removing recyclables from the waste stream. Robust outreach and education on recycling of recyclables should continue and be expanded.
- Yard waste has been banned from the waste stream since 1991 but was still found in the waste sampled. Outreach and education on proper yard waste separation should continue and be expanded.

1.7 Engagement of R&E Staff

Supervisory staff from the R&E Center have been engaged in the process of designing Processing Enhancement options. R&E Center supervisory staff have attended local and national conferences as well as visited multiple equipment vendors. See Appendix A for details. Supervisory staff from the R&E Center have provided input on the benefits and drawbacks of several of the equipment locations, and types suggested in the document. Ongoing R&E Center staff review of Processing Enhancements continues to occur.

1.8 Equipment Manufacturer Input

In designing this project, Foth has strived to remain manufacturer agnostic and focus specifically on the equipment and system design. As mentioned previously, assistance has been provided through site visits and consultation with equipment vendors BHS, CP Group, Machinex, and Van Dyk. In addition, representatives from AMP Robotics, Eggersman, Green Machine, Mayfran International, Novamont, Optibag, Organix Solutions, Plexus, RRT Design & Construction, SSI Shredders, Stadler, Vecoplan, and Waste Robotics have all met with R&E staff and Foth and provided additional feedback and input into the design through R&E Center visits, meetings, and telephone discussions.

Pictures are provided throughout indicating various types of equipment that will be used throughout the Processing Enhancement System. Except where specifically documented, there is no implied preference for the equipment type, style or manufacturer pictured.

1.9 Transfer Station Infrastructure

MSW delivered to the R&E Board contracted transfer stations is not included in the volume for sorting of DCBs. Further details of this analysis can be found in the *Processing Alternatives: Durable Compostable Bag (DCB) Technology*[8] memorandum. R&E staff have met with all current contracted transfer stations, and all contracted transfer stations have expressed an interest in sorting DCBs from the MSW delivered to their transfer stations. Per the requirements of the transfer station contracts and Designation, the remaining MSW will continue to be delivered to the R&E Center from the transfer stations after the DCBs have been removed.

[8] Foth. *Processing Alternatives: Durable Compostable Bag (DCB) Technology.* November 20, 2018.

The sorting of recyclables from the MSW by transfer stations similar to the Recyclables Recovery System at the R&E Center was not discussed with the transfer stations, but should be further reviewed. It is likely that if DCBs are being removed by the transfer stations, other high-value recyclables may also be recovered. Any new contracts with transfer stations should consider this possibility as part of the proposed terms as well as tracking mechanisms of recyclables recover.

2 Preliminary Design for a Processing Enhancement System

A preliminary design for installation of additional equipment at the R&E Center is known as Processing Enhancements. The additional equipment and necessary infrastructure to increase recovery of recyclables and allow for a method to recover organic materials delivered to the R&E Center co-collected with MSW in DCBs is collectively known as the Processing Enhancement System and is described further.

2.1 General Processing Enhancement System Layout

In order to accomplish recovery of organics delivered in DCBs and additional recyclable materials at the R&E center, additional equipment is necessary. Figure 2-1 shows the general location of the addition on the north side of the building where the DCB processing system will be added and the area for the Recyclables Recovery System. A general step-by-step process follows.

2.1.1 Step 1: Removing Organics

Based on this analysis and the R&E Board's desire to minimize manual sorting of materials from MSW, the preliminary design for Processing Enhancements for DCB recovery known as the DCB Processing System includes the use of metering equipment, conveyors and robotics to remove the DCBs. This equipment is designed to be located in a building addition north of the current tipping floor (North Addition). Additional details pertaining to the building addition and DCB sorting equipment are discussed in later sections of this report.

2.1.2 Step 2: Extracting Recyclables

Once DCBs have been removed, the MSW will be conveyed to the existing tipping floor and transferred to the new Processing Enhancement system known as the Recyclables Recovery System via front end loader for recovery of additional recyclables up to capacity limits. This new Recyclables Recovery System capacity is estimated at 170,000 to 194,000 tons. The remainder of the MSW that cannot go to the new Recyclables Recovery System will be conveyed to the existing tipping floor and transferred via front end loader to the A or B Processing Lines.

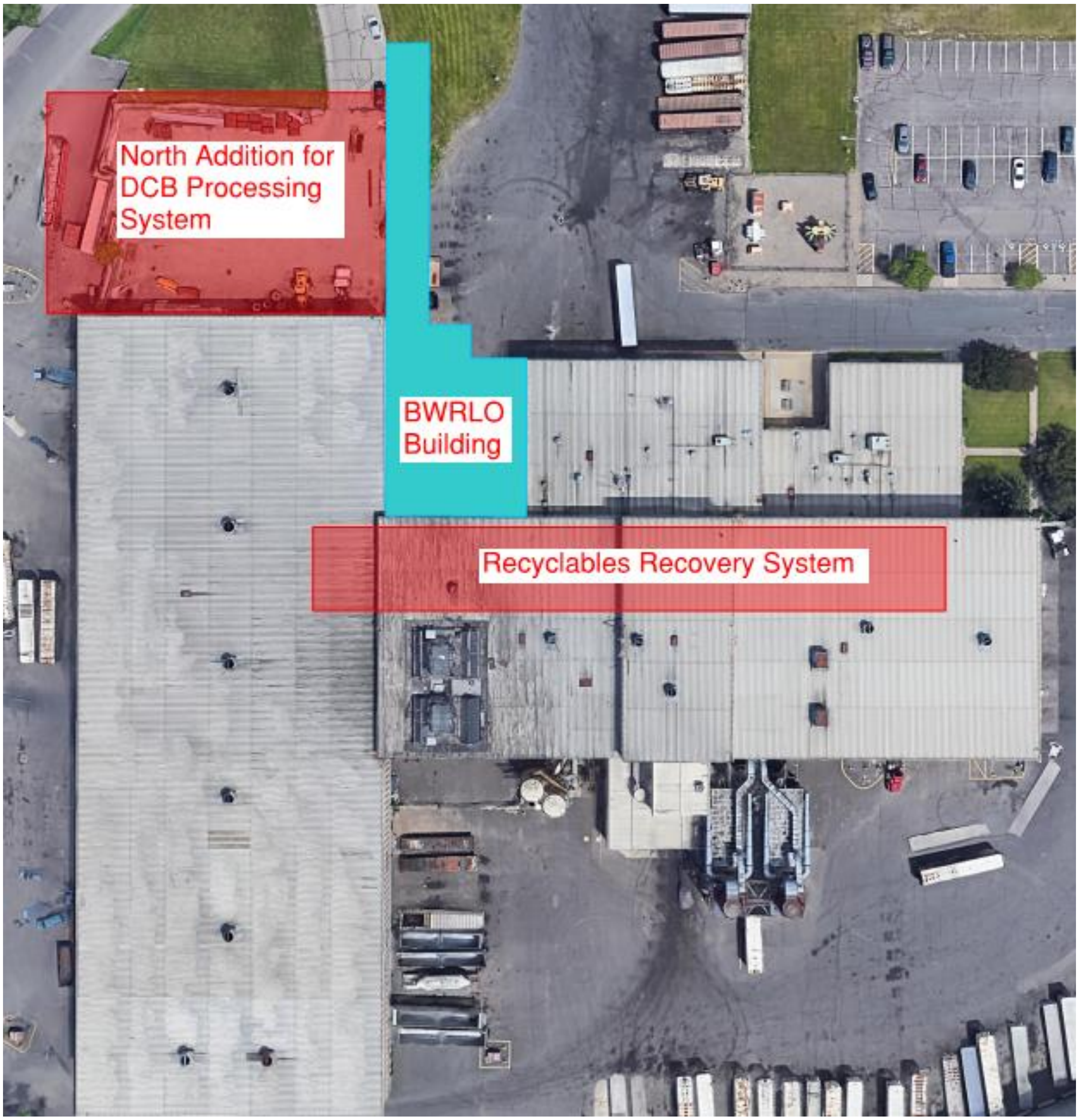
The new Recyclables Recovery System equipment will be located within the available space that is currently used as storage north of the two existing A and B Processing Lines. The new equipment that is designed for this space includes a shredder, various size disc screens, magnets, air classification, optical sorting, eddy current separation, and robotics for quality control of separated recyclable materials.

2.1.3 Consideration of Separate Projects

While the Processing Enhancement system layout encompasses the North Addition housing the DCB Processing System and the Recyclables Recovery System, the two projects can be separated. The DCB Processing System and North Addition are considered one project as they are integral to each other.

Costs for construction, operation, and maintenance are split between the Processing Enhancement components where possible. It is important to note that there may be opportunities for efficiencies with the combined projects in construction mobilization costs.

Figure 2-1
R&E Center Preliminary Design Processing Equipment Layout



3 North Addition

Foth anticipates that the R&E will need to construct an addition on the north side of the existing tipping floor to accommodate the space necessary for the equipment related to recovery of DCBs and to minimize the DCB Processing System's impact on existing operations. The size of the North Addition is as large as the space can accommodate without extending onto the adjacent Xcel Energy property. The site is anticipated to provide enough space to manage the residential and commercial waste that will be directly delivered to the R&E Center that will require processing to remove the DCBs from the waste stream as long as the system is operational.

The North Addition is anticipated to provide approximately 8,000 square feet of tipping floor space for inbound waste with co-collected DCBs. Assuming the waste is piled to a height of 14 feet, there is space for approximately 4,000 cubic yards or 800 to 1,400 tons of MSW (pounds per cubic yard range based on the EPA published volume-to-weight conversion factors[9]). If additional space was available, the North Addition would be planned to be slightly larger to accommodate waste delivery fluctuations.

Based on the projected participation rate of a fully developed organics program[10] and the amount of material that is currently directly hauled to the R&E Center, Foth anticipates 225,000 tons being delivered to the DCB processing area. In order to accommodate this volume of material, as well as metering equipment, conveyors, and sorting equipment within an enclosed area, Foth estimates that the building expansion will need to be a minimum of approximately 120 feet by 180 feet or 21,600 square feet.

Other considerations for determining the size of the North Addition include the need for short-term emergency storage space for waste, available property owned by the R&E Board, and the fluctuation of inbound material. Currently, MSW deliveries can fluctuate between approximately 1,500 and 2,200 tons per day.

3.1 Building Modifications

The North Addition would be constructed similar to the current tipping floor building with concrete push walls 14-feet in height to allow MSW co-collected with DCBs to be piled against the push walls prior to processing. A metal building would be constructed on top of the push walls to an elevation consistent with the existing tipping floor building. This would allow for installation of adequately sized overhead doors to comply with Minnesota transfer station rules[11].

[9] U.S. Environmental Protection Agency, Office of Resource Conservation and Recovery, *Volume to Weight Conversion Factors*. April, 2016.
[10] Foth. *Processing Alternatives: Durable Compostable Bag (DCB) Technology.* November 20, 2018.
[11] Minnesota Rules, part 7035.2870 Subp. 4; MINN. R. 7035.2870 (2006).

3.2 Equipment

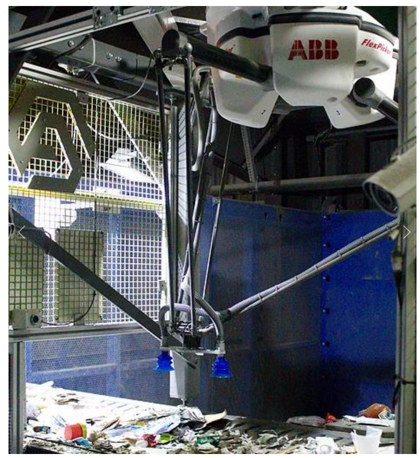
The North Addition would have three high-speed overhead doors on the north end of the building to allow vehicles delivering MSW to enter and exit the building as well as allow for the transfer trailers containing DCB organics to exit the building. A single high-speed overhead door on the southwest side of the addition would allow the organics transfer trailer vehicles to enter the North Addition in order to transfer the DCBs to an offsite facility for composting or anaerobic digestion (AD). The North Addition will require installation of several access doors, a dry fire suppression system as heating is not anticipated to be installed, dust and odor control systems and electrical service for equipment, fans, doors, closed circuit television (CCTV), and lighting. The dust and odor control system is anticipated to provide a negative pressure on the North Addition.

4 DCB Processing System

The memorandum *Processing Alternatives: Durable Compostable Bag (DCB) Technology*[12] describes the estimated participation rate for an organics program using DCBs. Based on the number of households in Ramsey and Washington Counties and the estimated participation rate, Foth estimates that the average quantity of DCBs set out annually will range from 1.9 million bags at the beginning of the DCB program to 7.6 million bags at program maturity. The DCB Processing System design is to handle the projected participation rate of a fully developed DCB organics program and the amount of material that is currently directly hauled to the R&E Center of 225,000 tons. All 225,000 tons of directly hauled material is anticipated to be delivered to the DCB processing area for recovery of the co-collected DCBs.

4.1 Equipment

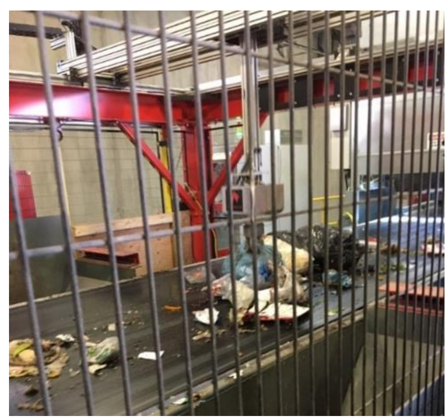
Several options for recovering DCBs that are delivered to the R&E Center were considered; including manual picking from the tipping floor, using the grapple crane to remove DCBs, installation of an elevated manual sort line, and installation of a sort line using robotics. Based on the R&E Board's desire to minimize the use of manual sorting and the recent and rapid evolution of robotics for sorting materials, the recommendation is to use robotics to remove the DCBs.



Picture 4-1
Robotic Sorter with a Suction Grabbing Mechanism
Source: www.amprobotics.com/value-proposition

Foth and R&E staff have met with vendors to discuss options for using robotics to remove the DCBs from the incoming MSW. For example, Waste Robotics has a robot installed at Randy's Sanitation in Delano, Minnesota that is used for removing DCBs from MSW. AMP Robotics has a robot used to remove contaminants from plastic at Dem-Con in Shakopee, Minnesota. Other companies including BHS, Plexus, and Machinex all have robotic sorters.

Robots currently use two different methods of extraction: a claw to grab or air for suction. The robots produced by Plexus and Waste Robotics both use a claw mechanism to physically grab materials whereas the robots produced by BHS, AMP Robotics, and Machinex use suction to pick up materials. The use of suction has been used in the recycling industry to pick contaminants out of various plastics streams, however suction has not been observed with DCB removal. See Pictures 4-1 and 4-2.



Picture 4-2
Robotic Sorter with a Mechanical Claw
Source: Foth photograph from Randy's Sanitation, Delano MN

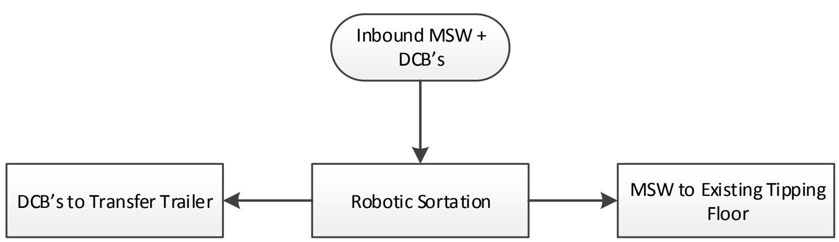
[12] Foth. *Processing Alternatives: Durable Compostable Bag (DCB) Technology.* November 20, 2018.

There is concern that a suction mechanism may not be capable of picking the DCBs, particularly due to the weight of the bags when full. However, this type of suction mechanism can achieve more picks per minute than a mechanical claw. Various manufacturers report approximately 60 picks per minute with suction as compared to approximately 30 picks per minute using a mechanical claw.

Processing Alternatives: Durable Compostable Bag (DCB) Technology[13] describes the estimated participation rate for an organics program using DCBs. Based on the number of households in Ramsey and Washington Counties and the estimated participation rate, Foth estimates that the average quantity of DCBs set out annually will range from 1.9 million bags at the beginning of the DCB program to 7.6 million bags at program maturity.

Using this information and the 4,836 annual processing hours at the R&E Center, this equates to approximately 7 to 27 picks needed per minute, which is within the vendor published range for picks per minute for a single robot using a mechanical claw. However, the DCBs are anticipated to be co-collected with approximately 225,000 tons of MSW. This is the equivalent to 45 tons per hour, which will require the system to operate at a rate faster than a single robot can manage with the speed required of the conveyor belts in order to minimize the burden depth. Burden depth is the relative thickness or amount of material on the conveyor belt. Therefore, Foth estimates that a minimum of two robotic sorting lines will be required to manage the anticipated amount of MSW co-collected with DCBs. Additionally, adequate space exists for installation of 2 robotic arms on each line for a total of 4 robotic arms to provide redundancy if necessary. Multiple vendors providing robotic sorters indicated that a single sensing system can control up to two robotic arms.

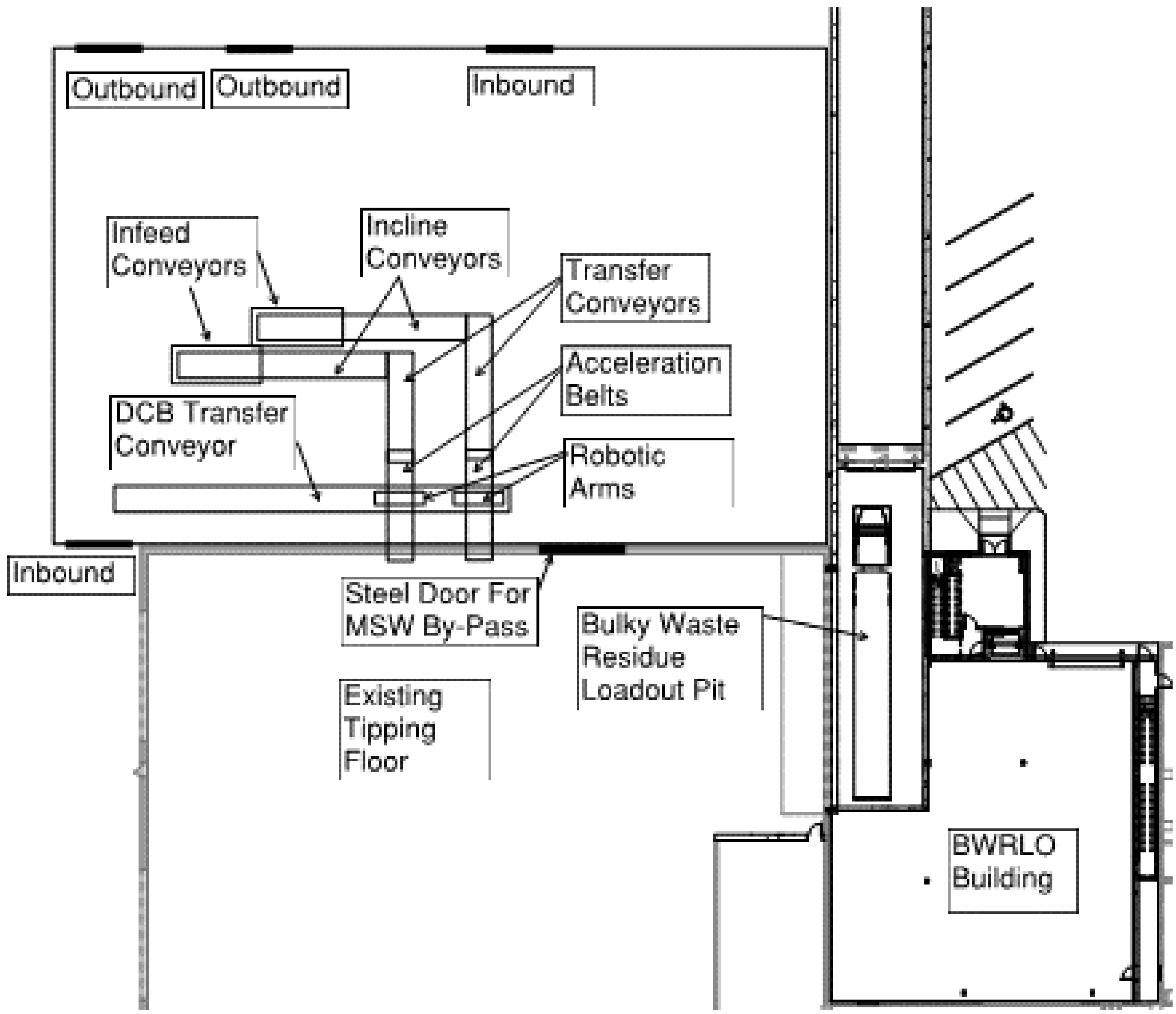
Figure 4-1
Process Flow Diagram for the DCB Processing Equipment.



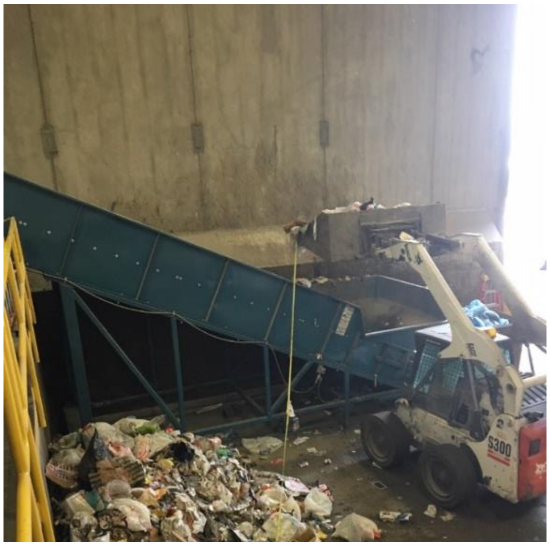
Each sorting line would consist of a metered in-floor infeed, an inclined conveyor, an elevated conveyor, and an acceleration conveyor belt with a robotic arm and associated sensing technology to detect the DCBs. The general schematic is shown in Figure 4-2. The robotic arms would drop bags onto a shared conveyor that would convey the DCBs to a transfer trailer for transport to a market for processing. The MSW remaining on the conveyor will be conveyed to the existing tipping floor for further processing.

[13] Foth. *Processing Alternatives: Durable Compostable Bag (DCB) Technology.* November 20, 2018.

Figure 4-2
General Schematic Layout for the DCB Processing System



The two DCB Processing Lines are shown offset from one another to allow for both lines to be loaded via front end loader. The infeed conveyors are left (west side) of the transfer and acceleration conveyors to allow for adequate tipping floor space to manage inbound MSW to the right (east side) of the DCB Processing Lines. Traffic flows and patterns for the incoming truck traffic and front end loaders will need to be set similar to the current operations at the R&E Center tipping floor.



Picture 4-3
Conveyor – Side View
Source: Foth photo taken at Randy's Sanitation, Delano, MN

Picture 4-4
Conveyor – Top View
Source: Foth photo taken at Grand Central Station, Industry, CA

The MSW remaining after DCB removal would be conveyed to the existing tipping floor through an opening in the existing building wall (approximately 14 to 16 feet above the existing tipping floor). See Picture 4-3 and 4-4 for example conveyors. This opening would be elevated above the existing tipping floor concrete push wall to allow the front end loaders, see Picture 4-5, to transfer the MSW to the Recyclables Recovery System. This will also provide adequate space for processed MSW to pile up prior to moving with front end loaders to the Recyclables Recovery System.

Additionally, the relatively small conveyor opening would help to manage the potential odors from the DCB system within the North Addition by allowing only minimal air transfer between the two tipping floor areas (new and existing).

Picture 4-5
Front end Loader
Source: www. zieglercat.com

A heavy-duty steel door, approximately 24 feet wide is included between the new DCB processing conveyors and the BWRLO pit loading area to allow for MSW to by-pass the DCB line in case of equipment malfunction. This door is heavy-duty steel so it can be used as a part of the push wall since there is limited push wall space to manage the inbound MSW.

Proper material management on the north side of the existing tipping floor will be critical to avoid creating a "bottleneck" between conveyance of sorted MSW from DCB removal to the DCB Processing System and operation of the BWRLO pit. The new BWRLO expected to be operational in June, 2019 is anticipated to be more efficient than current operations which will help minimize cross flow traffic in this area.

4.1.1 Control System

The electrical control system for the DCB Processing System will be integrated within the existing Control Room operation located on the second floor of the Administrative Building of the R&E Center. The electrical control system controls all electrical on and off functions within the R&E Center. All control panels can be operated directly from the Control Room. The R&E Center utilizes Allen Bradley ControlLogix Programmable Logic Controllers (PLC) with RSLogix 5000 Software[14].

Day-to-day management and trouble-shooting of the electrical control system is done by the R&E Center electrician with back-up from TKDA. The DCB Processing System design assumes the electrical control system will be integrated within the existing system and be operated by the current R&E Center Control Room Operator. The same PLC system and Software or compatible systems are planned to be used to ease management of the system. The PLC system will not require additional control room operators, rather the existing operators will be trained in its operation and the electrician will be trained in its maintenance.

4.1.2 Specialty Trailers for DCBs

DCB's sorted from MSW will be conveyed into transfer trailers. The transfer trailers will be standard with the addition of a leak proof Live Floor™. The "W" Floor Conveyor system from Hallco Industries, see Picture 4-6, would be appropriate for this usage and match the current Live Floors™ in use at the R&E Center. DCBs containing food waste are estimated at 463 pounds per cubic yard[15]. The weight of this material will necessitate the transfer trailers not be filled full volume-wise to meet legal weight load requirements. Roll-off containers were considered for DCBs but are not proposed as roll-off containers would add the complexity of a new type of container. The weight of the roll-off containers with DCBs would also necessitate hauling by a semi-truck, but the truck must now be compatible with roll-offs versus trailers.

Picture 4-6
Hallco Live Floor™ "W" Floor Leak Proof Conveyor System
Photo Courtesy of Hallco

A minimum of six trailers would be needed to allow the trailers to be swapped out when the materials are being taken to the designated organics processing facility(ies). Two trailers would be in use at the end of the DCB Processing line at all times when processing is in use, and four trailers would be required as back-up for swapping out of trailers and when repairs are needed.

[14] TKDA. *Electrical Control System Manual for the Recycling & Energy Center.* September, 2017.
[15] U.S. Environmental Protection Agency, Office of Resource Conservation and Recovery, *Volume to Weight Conversion Factors*. April, 2016.

4.2 Design Details

The DCB Processing System focuses on recovery of organic materials delivered directly to the R&E Center in packer trucks (not transfer trailers) in DCBs co-collected with MSW. The system would include two processing lines located in the North Addition. The following description is for one of the two lines but applies to the operation of both lines.

The DCBs co-collected with MSW would be loaded into the in-floor infeed pit (running west to east) to allow for metering of the material to the incline conveyor, which is in line with the infeed conveyor to control burden depth. The incline conveyor would convey the co-collected material up to an elevated conveyer. The elevated conveyor would be positioned so that the co-collected material on the inline conveyor (eastbound) would change direction 90 degrees onto the transfer conveyor (southbound). Given the space limitations and potential traffic flows into the new building, the 90-degree direction change is necessary, but is located at a point in the system that is not anticipated to be problematic. It is not anticipated that waste will bottleneck at the 90-degree direction change.

The co-collected material would drop onto an in-line (southbound) acceleration belt (anticipated to be 72 inches wide) to minimize burden depth, which would allow the robotic vision system and robotic arm to more easily see and recover the DCBs. It is not anticipated that additional robotic arm will be necessary since two arms (one per line) are reported to be capable of removing 50 bags per minute. At full system maturity, 27 bags per minute are anticipated. The robotic arm would drop the DCBs into a chute to deposit the DCBs onto a shared conveyor located below the acceleration belt that would convey the DCBs to the west and into a transfer trailer.

4.3 Air Flow Design and Operation

Air flow design and operation is important to ensure workers are not exposed to an environment with unsafe dust and carbon monoxide levels such as those that come from diesel engines. The North Addition for the DCB Processing System is fully enclosed with four high-speed garage doors. The building addition will maintain negative air pressure to assist with odor control. High-plume exhaust fans triggered by carbon monoxide alarms will be installed as a part of the building addition. The exhaust fans will only function when a specific concentration of carbon monoxide is detected in the building. An additional OMI – Ecosorb Vaporization Delivery Systems (VDS) will be purchased for the building to assist with odor neutralization when the fan is in use.

4.4 Identification of Inbound Material

The DCB Processing System is designed to run all 225,000 tons of MSW direct hauled, not transferred, to the R&E Center. Inbound loads with DCBs co-collected with the MSW will need to be identified by the driver when they enter the facility and then directed to empty the truck on the DCB tipping floor area. R&E Center employees working in the MSW tipping floor area including the loader operators, crane operators, and the Traffic Director will also need to watch for loads of MSW that have DCBs mixed in with the MSW that are dumped onto the wrong (existing) tipping floor area.

If the DCB program is offered to all Ramsey and Washington County households at the same time, all residential loads should be tipped on the DCB processing tipping floor. Commercial DCB program implementation to businesses and multi-unit dwelling (MUD) households not picked up with residential loads will require coordination as well to identify the loads containing DCBs. The same process where drivers identify that there are DCBs in the MSW should be used for commercial routes as well. Roll-off loads and more industrial waste streams are unlikely to contain DCBs and will continue to be directed to the existing MSW tipping floor.

4.5 DCB Processing System Throughput

The DCB Processing System equipment is estimated to operate at 45- to 50-tons per hour (TPH). If the equipment operation generally follows the current processing hours at the R&E Center (4,836 hours per year) the two DCB lines can process approximately 217,000 to 242,000 tons per year (TPY). This does not provide capacity to process the entire waste stream (450,000 TPY) but has capacity to process the residential and commercial MSW (225,000 tons) delivered directly to the R&E Center. It is anticipated that all inbound transfer trailers will have had DCBs removed from the MSW at the transfer stations.

4.6 Management of Materials

The current marketing plans for DCB organics is that this material will be transported to a composting or AD facility that is designed and equipped to handle food waste and other organics (besides yard waste). There are currently two full commercial scale composting facilities serving the East Metro area: SET in Rosemount and the Shakopee Mdewakanton Sioux Community (SMSC) in Shakopee. Both of these facilities should be able to readily receive, manage and compost organics from the DCB Processing System if the material is below the contamination thresholds. The current organics processing tipping fees at these two composting facilities range from about $40 to $60 per ton not including transportation.

4.7 Design for System Flexibility

Depending on the length of time for the roll out of the DCB program and the anticipated program participation rates in the first few years of the program, it is realistic that the robotic sorters could be trained to remove other recyclable materials such as #1 PET and #2 HDPE. This would require locating bins or small roll off containers and separate chutes for the robotic arms to drop the recyclables in for recovery.

5 Recyclables Recovery System

The Recyclables Recovery System focuses on recovery of loose organics, ferrous, non-ferrous, #1 PET, #2 HDPE, and OCC. The Recyclables Recovery System design is based on work completed in the Foth *Summary of 2016-2017 Waste Characterizations*[16]. The Recyclables Recovery System will be located in the storage area of the Processing Building.

5.1 Equipment

This section reviews has reviewed available equipment for targeting additional recyclable materials in the MSW. These recyclables specifically remain in the fraction of the inbound MSW, mainly residential loads, that have been processed in the DCB processing equipment, as well as some targeted commercial and MUD loads that are anticipated to contain high value recyclables. These loads will be targeted based on operational experience by staff at the R&E Center.

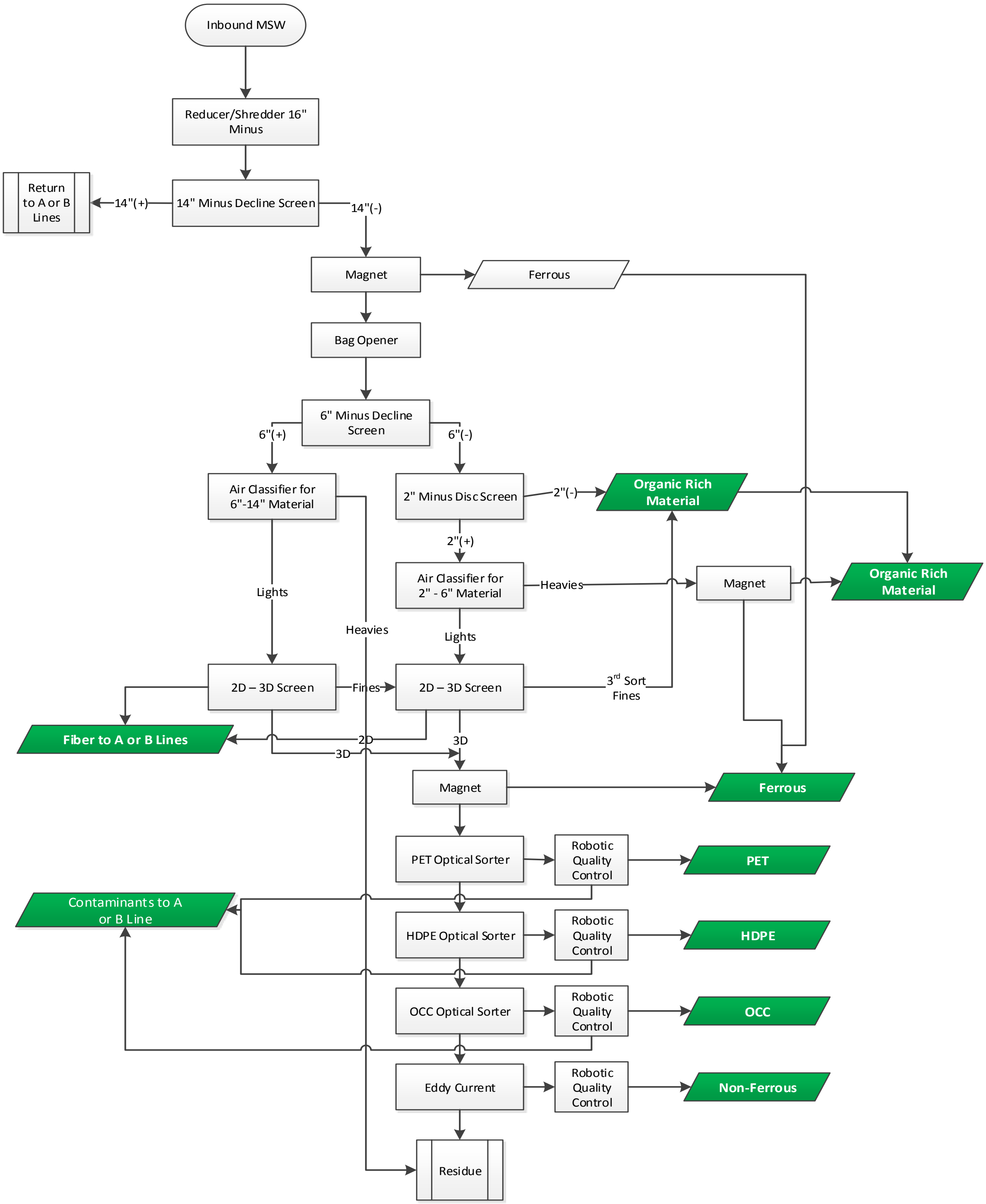
Based on the waste characterization data and discussions with R&E staff, the specific equipment for the Recyclables Recovery System was selected to target additional organics that have been commingled with in MSW (i.e. not separated into DCBs), ferrous, non-ferrous, #1 PET, #2 HDPE, and OCC. See Picture 5-1.

The equipment was designed to minimize the use of manual sorting. Typical system design includes a manual presort area with people manually picking large, bulky items that could damage the equipment prior to the MSW entering the system. These large, bulky items include large pieces of concrete, LP tanks, etc. The MSW would be loaded into the system with the existing front end loader and monitoring of the infeed conveyor would be accomplished by the BWRLO grapple crane. The grapple crane operator would be trained to monitor and sort large items out of the waste stream with the grapple crane prior to the shredder in the new Recyclables Recovery System. See Picture 5-1.

Picture 5-1
Grapple Crane at the R&E Center
Source: www.morevaluelesstrash.com

[16] Foth. *Summary of 2016-2017 Seasonal Waste Characterizations.* December 18, 2017.

Figure 5-1
Preliminary Process Flow Diagram for Recyclables Recovery Equipment



The Recyclables Recovery System design includes a small manual sorting station that does not need to be staffed, but is designed into the original system in the event it is necessary to capture large OCC and remove materials that may damage the equipment. After the manual sorting station there is a shredder for re-sizing the material to approximately a 16-inch minus material and would also open some of the bags, see Picture 5-2. This shred size of 16-inch minus was selected to minimize damage to the recyclable materials.

Shredded material would be conveyed to a 14-inch minus screen where material 14-inches and smaller would fall through the screen and be conveyed to the next piece of equipment. The material between 14- and 16-inches would be conveyed back to the existing tipping floor to be processed through the existing A or B Processing Line. It is anticipated that a significant amount of cardboard may be returned to the A and B Processing Line with this design.

The Recyclables Recovery System is purposely designed without manual sorters, and mechanically there is not a known solution to remove this fraction with cardboard for recycling. However, there may be an opportunity to examine the 14- to 16-inch fraction to evaluate the amount of cardboard in this fraction and install equipment to target the cardboard in the future.

The 14-inch minus material would pass an over-belt electro-magnet to remove ferrous and continue to a bag opener to liberate material that was not liberated in the initial shred. See Picture 5-3.

Picture 5-2
Shredder
Source: *www.ssiworld.com/en/products/pri_max_primary_reducers/pri-max_pr780*

Picture 5-3
Over-Belt Electro-Magnet
Source: www.machinexrecycling.com/products/additional-recycling-equipment/

The bag opener is included to make sure materials that are double bagged or in smaller bags that may not have been opened in the initial shred are liberated. See Picture 5-4.

Picture 5-4
Bag Opener
Source: www.bulkhandlingsystems.com/equipment/bag-breaker/

Picture 5-5
Air Classifier
Source: vdrs.com/walair/

Material would then be conveyed to a second decline screen that would separate the material into a 6- to 14-inch fraction and a 6-inch minus fraction. This size separation into two separate size fractions is included to reduce the burden depth on the equipment used for removal of fine material and dimensional separation.

The 6- to 14-inch fraction would be conveyed to an air classifier, see Picture 5-5 to separate the light fraction from the heavy fraction. The heavy fraction is anticipated to be residue that would be conveyed to the residue line used for the A and B Lines. The light fraction would be conveyed to a 2D/3D screen to separate the 2-dimensional fiber from the 3-dimensional containers. Additionally, there is a fines fraction that falls through the 2D/3D screen that is anticipated to be an organic rich fraction (Organic Rich Material). The 2-dimensional fiber from the 2D/3D screen would be conveyed to the existing A or B line to be processed into RDF. See Picture 5-6.

The 6-inch minus fraction would be conveyed to a 2-inch minus disc screen to remove the organic-rich fraction. See Picture 5-7. This organic-rich fraction would be combined with the fines. The 2- to 6-inch material would be conveyed to an air classifier to separate the light fraction from the heavy fraction. The heavy materials would pass an over-belt magnet to remove any remaining ferrous. Based on the Waste Characterization analysis, this 2- to 6-inch heavy fraction will likely be an additional organic rich fraction and would be combined with the other organic rich fractions from the Recyclables Recovery System equipment.

It is important to note that none of the loose organic rich fractions from the processing lines would be combined with the DCB organics from the DCB Processing System line since the organics from the DCB Processing System should be less contaminated.

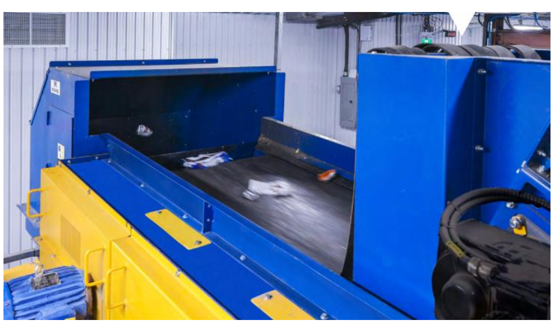
The light fraction would be conveyed to a separate 2D/3D screen to separate the 2-dimensional fiber from the 3-dimensional containers and the fines fraction that would be combined with the other organic rich fractions. The 2-dimensional fiber would be conveyed to the existing A or B Lines to be processed into RDF. The 3-dimensional containers would be combined with the 3-dimensional containers from the 6- to 14-inch fraction. The combined 3-dimensional containers fraction would be conveyed past an over-belt magnet to remove any remaining ferrous.

The 3-dimensional containers would be conveyed past a series of three optical sorters to remove #1 PET, #2 HDPE, and OCC. See Picture 5-8. The optical sorter for OCC recovery is shown for potential full build-out of the system and could be installed at a later date depending on market conditions. This also provides flexibility (space) for installation of future equipment depending on recycling markets and the Evolving Ton.

Picture 5-7
Disc Screen
Source: https://vdrs.com/lubo-usa-llc/

Picture 5-8
Optical Sorter
Source: vdrs.com/tomra-optical-sorting/

Finally, the remaining material would be conveyed to an eddy current separator to recover the non-ferrous materials. See Picture 5-9. Any remaining material would be considered residue and would be conveyed to the residue line used for the existing A and B Processing Lines for disposal.

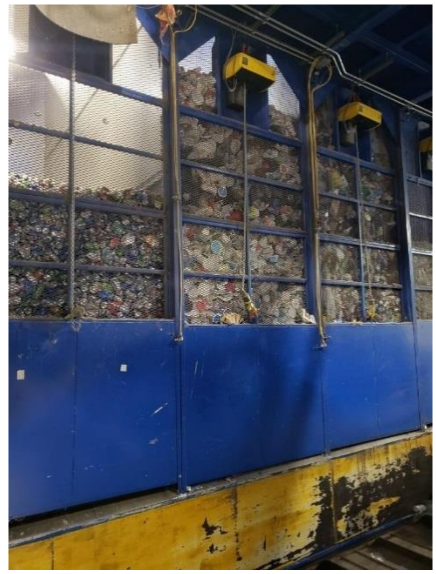


Picture 5-9
Eddy Current
Source: www.machinexrecycling.com/products/additional-recycling-equipment/

Picture 5-10
Forklift with Telescopic Fork Extension
Source: www.directindustry.com/prod/cascade/product-25312-1644137.html

There would be robotic quality control stations for the #1 PET, #2 HDPE, OCC, and non-ferrous to remove contaminants prior to the individual materials being conveyed to separate silos. The silos would be used for storage until adequate material was recovered to make a bale. The contaminants removed in the quality control station for #1 PET, #2 HDPE, and OCC would be conveyed to the existing A or B line to be processed into RDF.

The full build-out of the new Recyclables Recovery System includes individual silos for each of the five traditional recyclable commodities: #1 PET, #2 HDPE, ferrous, non-ferrous and OCC. See Picture 5-11. Each silo would store the sorted material until a full bale quantity is available. Each commodity would then be unloaded as needed from the individual silo using gravity to feed a common in-floor conveyor to feed into the horizontal baler. This method of staging material for baling is designed to optimize the silo storage capacity and fully utilize the common in-floor conveyor and baler capacity. Finished bales would be moved by forklift to individual bale storage locations throughout the new Recyclables Recovery System processing area (e.g., in the southwest and northwest corners, etc.). Bales would be stacked as high as possible using a specialized forklift equipped with a telescopic fork extension. See Picture 5-10. Height of the stacked bales would be limited by safety to assure all stacks are fully stable.



5.1.1 Control System

The electrical control system for the Recyclables Recovery System will be integrated within the existing Control Room operation located on the second floor of the Administrative Building of the R&E Center. The electrical control system controls all electrical on/off functions within the R&E Center. All control panels can be operated directly from the Control Room. The R&E Center utilizes Allen Bradley ControlLogix Programmable Logic Controllers (PLC) with RSLogix 5000 Software[17].

Day-to-day management and trouble-shooting of the electrical control system is done by the R&E Center electrician with back-up from TKDA. The Recyclables Recovery System design assumes the electrical control system will be integrated within the existing system and be operated by the current R&E Center Control Room Operator. The same PLC system and Software or compatible system are planned to be used to ease management of the system. The PLC system will not require additional control room operators, rather the existing operators will be trained in its operation and the electrician will be trained in its maintenance.

[17] TKDA. *Electrical Control System Manual for the Recycling & Energy Center.* September, 2017.

5.2 Design Details

The Recyclables Recovery System focuses on recovery of loose organics, ferrous, non-ferrous, #1 PET, #2 HDPE, and OCC. The system would include a single line with an infeed conveyor located on the existing tipping floor near the BWRLO grapple crane and would utilize the grapple crane for monitoring and removing bulky non-processable materials. Figure 2-1 shows the existing site with the space required for the Processing Enhancements system overlaid in red in the proposed location. Material would be conveyed into a shredder to open bags, resize the material to a 16-inch minus material, and help provide a more consistent burden depth of material across the conveyor. The material would then be conveyed to a decline screen in order to remove material larger than 14-inches. The cascading action of the decline screen is less violent than an inclined screen and was selected to reduce equipment damage while accommodating the desire for no manual presorting. However, there will likely be some recyclables remaining in the 14- to 16-inch fraction. Additionally, some recyclable materials less than 14-inches may be intermixed in the 14- to 16-inch fraction.

Other equipment selections include:

- Magnets are located in several locations to maximize removal of ferrous within the Processing Enhancements system.
- The bag opener was selected to liberate materials that were not liberated in the shredding process.
- The second decline screen was selected to separate the material stream into two size fractions to minimize burden depth and promote maximum recovery.
- Air classification equipment was selected to separate heavy materials (residue and organics) from the light materials (fiber and recyclable containers).
- The 2-inch disc screen was selected to promote recovery of organic rich fines from the 6-inch minus fraction.
- The 2D/3D screens were selected to separate 3-dimensional containers from the 2-dimensional fiber. There may be some loss of OCC and containers in the 2D/3D screens depending on the shape and size of the various commodities (i.e. flattened containers may act like a 2-dimensional material on the screen).
- The optical sorters and eddy current separators were selected since they are a very proven technology and work well for this application once the materials have been segregated into containers only.
- Robotic quality control equipment was selected for the #1 PET, #2 HDPE, OCC, and non-ferrous to meet the desired goal of no manual sorting and to obtain a quality marketable product. Additional space is available if future goals require installation of additional robotic sorting arms for a higher quality of recyclable materials.
- The ferrous and non-ferrous from the new Processing Enhancement equipment would be combined with the ferrous (clean) and non-ferrous from the existing A and B Lines. Current plans are to install non-ferrous clean up equipment in 2019. Costs and design for the non-ferrous clean up equipment associated with the current process are not included.

5.3 Air Flow Design and Operation

Currently, the storage area next to the existing A and B Processing Lines is exhausted through the same processing building fans as the A and B Processing Lines. The R&E Center processing system was initially designed with the assumption that this area could be used to house a third line and it would utilize the existing fans in the processing building.

No changes are anticipated to be needed for the addition of the Recyclables Recovery System equipment in the storage area next to the existing A and B Lines. While the air flow may have been adequate when the R&E Center was constructed, additional modeling should be conducted once final designs and equipment selection is finalized to ensure any changes in air quality standards are incorporated.

5.4 Identification of Inbound Material

The majority of the material that is processed through the DCB Processing System will be directed to the Recyclables Recovery System. Ultimately all residential loads will be processed on the DCB line and then be processed through the recyclables recovery equipment. A SOP will need to be developed to identify additional loads that have targeted recyclables in the MSW that could be recovered. Loads with recoverable recyclables could be initially identified by R&E Center employees working in the MSW tipping floor area including the loader operators, crane operators, and the Traffic Director.

Commercial and MUD route trucks typically follow the same route during any given week, and the loads should be similar for the same load week to week. Identification of loads with a significant amount of recyclables for recovery could also be used to target specific commercial businesses or areas with Biz Recycling© information. Roll off loads could also be targeted if they contain high amounts of recyclables, but currently this is not anticipated.

5.5 Recyclables Recovery System Throughput

The Recyclables Recovery System equipment targeting traditional recyclables is estimated to operate at 35 to 40 TPH. If the equipment operation generally follows the current processing hours at the R&E Center (4,836 hours per year) a single line can process approximately 170,000 to 194,000 TPY. This equipment has the capacity to process most of the MSW (225,000 tons) delivered directly to the R&E Center and processed through the DCB line first.

Some material processed in the DCB processing line (commercial) may be bypassed to A and B Lines. Larger equipment or an additional line were considered as a part of this analysis, but due to space constraints within the building and property boundaries, these options are not feasible. Excess material may need to be by-passed directly to the existing A or B Processing Lines, or operating hours could be adjusted to attempt to accommodate up to 225,000 tons per year.

5.6 Management of Materials

The addition of the Recyclables Recovery System means additional commodities must be marketed from the R&E Center. There are three ways recyclable commodities can be marketed: a commodity market contract from a Request for Proposal (RFP) process, a broker under contract with the R&E Board, or managed by a staff member on a spot market basis.

5.6.1 Commodity Market Contract from an RFP

The monthly sale prices for each commodity floats with the current market value based on recognized published industry price indexes. The grade of each commodity is based on industry specifications, including quality requirements (e.g., for contaminant and moisture thresholds). This RFP and contract method of procuring commodity sales services is proven and requires very little ongoing staff administration. The new commodities added as a result of Processing Enhancements (e.g., PET plastics, HDPE plastics, and OCC) could also be marketed in the same manner using RFPs and long-term contracts with monthly prices indexed to recognized industry publications.

As an example, the R&E Board has current, three year contracts for sale of ferrous metals (with AMG Resources Corporation) and non-ferrous metals (with DLTL Industries, Inc.) for these commodities recovered during the production of RDF. These material sales contracts were procured through a competitive RFP.

5.6.2 Broker Under Contract

The R&E Board could employ alternative methods of marketing the recyclable materials. A broker could be contracted to manage the marketing of all or some of the commodities. The advantage of the broker alternative is that an expert from within the industry is retained to help assure the most competitive price possible. Brokers usually get paid on a commission basis, with the percentage depending on the amount of material, quality and value of the material, and relationship with the supplier-customer (i.e., the R&E Board).

Brokers bring added value though their in-depth expertise and knowledge of markets, including their relationships with the end markets (e.g. mills) and vice versa; the end markets trust the brokers to provide steady flows of quality materials. A disadvantage of the broker alternative is that it is used more frequently in longer-term business to business relationships; government agencies are not as well suited to this method due to procurement policies.

5.6.3 Internal Staff Member as a Broker

As the third alternative, the R&E Board could train a staff member to spot market the commodities as a means to obtain higher prices in the short term. A disadvantage of this method is that it includes the ongoing costs of a portion of a staff member (e.g., 10 to 20 percent of one full time equivalent person). Another disadvantage of this method is that, due to the specialized nature of commodities marketing, the training period is fairly long and employee recruiting and retention is challenging due to the specialty skills needed.

5.6.4 Additional Complexity of Organic Rich Material

Marketing of organics recovered from the organic rich fraction from loose MSW (i.e., not in DCBs) has special constraints. While this will be an Organic Rich Material fraction, this also implies there is a substantial amount of non-organic materials that can be considered as contaminants. See Pictures 5-12, 5-13, and 5-14 for photographs of the organic rich fraction derived from the Foth Waste Characterization conducted in 2016 and 2017. It is important to clarify that the organics from the DCBs Processing System will not be combined with the organics from the Recyclables Recovery System.

Picture 5-13
Organic Rich Fraction from Waste Characterization
March 23, 2017
Source: Foth. Summary of March 2017 Waste Characterization. July 25, 2017.

Picture 5-14
Organic Rich Fraction from Waste Characterization
May 23, 2017
Source: Foth. Summary of May 2017 Waste Characterization. September 28, 2017.

Table 5-1 is a summary of the lab test results on the Organic Rich Material (2-inch minus fraction) as conducted done by North Carolina State University. The percent inorganics is one indication of the potential contaminants in this Organic Rich Material depending on method of processing. The data indicates relatively high variability of moisture content, percent fines, inorganics and bio-methane potential (BMP) within the Organic Rich Material. This variability and contaminant levels may indicate the challenges of processing this material into a usable commodity.

Table 5-1
Test Results on the Organic Rich Material (2-inch minus)
As Sampled from the Seasonal Waste Composition Studies, 2016 – 2017

	October 2016	March 2017	May 2017	August 2017
Moisture Content (%)	47.0%	33.3%	37.2%	60.0%
Percent Fines (<6mm, %)	30.2%	no data	19.8%	11.4%
Inorganics (%)	NT	47.7%	30.2%	14.6%
BMP (mL CH4/g)	196.9	NA	149.6	339.0

5.7 Design for System Flexibility

This Recyclables Recovery System has the capacity to process 170,000 to 194,000 tons of MSW. This will include the majority of the MSW processed through the DCB Processing System first as well as additional identified loads. The design was limited by the existing footprint of the building and lack of space to expand the building. Space for additional equipment has been reserved in the design to allow for additional sorting equipment to be added in the future.

This could include additional optical sorters, additional screens, or robots. Both optical sorters and robots are capable of removing additional materials with a relatively simple, programming change. The limit to the proposed design is the available space, integration with the existing A and B Processing Lines, and the number of chutes and silos which cannot be expanded due to the footprint of the existing building.

5.8 Additional Organics Management Options (DCBs and Organic Rich Materials)

Anaerobic Digestion (AD) is an option for processing of organics. There are no full commercial scale AD facilities in the Twin Cities area yet to manage food waste types of organics. It is possible that a commitment of a supply of the two types of organics (DCBs and Organic Rich Material recovered loose from MSW) could help spur further planning and development of an AD facility. It is anticipated that if such an AD facility were to be constructed, the operator would likely set two or more processing tipping fees. The first tipping fee could be set for the cleaner, DCB organic material. T

his first DCB tipping fee at any potential AD facility may likely be higher than the current composting facility tipping fees. A second tipping fee for Organic Rich Material derived from processing of MSW may likely be higher than the first rate due to a higher level of non-organic contaminants (e.g., plastic, glass, other grit, etc.). Zero Waste Energy in San Jose, CA, suggested informally during a 2016 tour, that the processing and organic recovery cost for such organics recovered from loose MSW may be over $100 per ton.

Outlets for organics from source-separated sources such as from DCBs exist today and are readily available. The timing for the development of an outlet for organics from MSW will take several more years. It is likely that additional research and development (R&D) steps will be needed to characterize the composition further, test the BMP, and analyze contaminants in organics from MSW. If a concerted program were started in 2019, a mature market potentially could be expected to be developed within five years assuming successful pilot testing of the material.

There are several considerations in identifying and securing a long-term outlet agreement for processing the two types of organics, including:

- The volume forecasts by type by year,
- The material supply quality guarantees that can be provided,
- The length of any contract term,
- Any regulations that may restrict or increase the cost of processing and marketing of either type of organics,
- Strength and development of end use applications for the digestate and compost (end) products,

Similar to recyclable materials, the quality of the organics recovered using equipment for the Recyclables Recovery System is an important factor related to the cost of organics end markets and the material produced from the organics (e.g. biogas, digestate, and compost). The additional processing equipment is targeting organics from the fine material in MSW, which means there is will also be broken glass fragments, grit, small plastic pieces, and small metal pieces. These contaminants in the organic materials will affect the cost to have a private vendor take the material and will affect the quality of the end product produced by the private vendor.[18]

[18] Foth. *Analysis for Recovery of Recyclable Commodities using Pre-Processing.* June 12, 2018.

6 Construction Cost Estimate

The estimated cost for the Processing Enhancement system includes the site and building related costs as well as the cost for purchasing and installing the Processing Enhancement equipment. The construction costs are shown separately for the North Addition, DCB Processing System, and the Recyclables Recovery System.

6.1 North Addition

The site work generally includes:

- Revisions to parts of the north tipping floor wall and foundation
- Excavation and grading
- Foundation excavation
- Concrete push wall installation
- Metal building installation
- Fire suppression system installation (assume separate system)
- High-speed overhead doors
- Dust and odor control systems
- Additional stormwater management
- Permitting
- Equipment related foundation installation
- Utilities installation necessary for DCB equipment

The site improvement costs described above are estimated (based on contractor bid results for similar building/renovation projects recently awarded, cost data presented by RSMeans Gordian Group) and costs for known specialty components (high speed overhead doors, OMI system, high plume fans, etc.) Table 6-1 shows the major cost components included in this estimate.

Table 6-1
North Addition Construction Cost Range

Description	*Low Range Cost*	*High Range Cost*
General Conditions	$533,600	$816,400
Site Development	$637,300	$975,000
Concrete	$1,353,500	$2,070,900
Metals	$1,190,100	$1,820,900
Woods & Plastics	$52,500	$80,400
Thermal & Moisture Protection	$149,600	$228,900
Doors & Windows	$555,000	$849,200
Finishes	$70,000	$107,100
Mechanical	$314,200	$480,800
Electrical	$397,400	$607,900
SUBTOTAL	$5,253,200	$8,037,500
Contingency	$1,050,700	$1,607,500
TOTAL CONSTRUCTION COST	**$6,303,900**	**$9,645,000**
ADMIN/OTHER PROJECT COSTS(SEE NOTE 3)	**$725,000**	**$1,109,200**
TOTAL	**$7,028,900**	**$10,754,200**

NOTES:

1. Costs above do not include:
   a. Equipment
   b. Relocation Expenses.
2. Costs were developed using 2019 dollars.
3. Includes engineering fees and an allowance for miscellaneous administrative costs.

The total cost for the construction of the North Addition is estimated to be approximately $7.0 to $10.8 million. The range in cost can be refined with further design development and is believed to be appropriate for the level of design detailed at this time. The total cost for construction of the North Addition does not include any components of the DCB Processing System.

6.2 DCB Processing System

The estimated cost for the Processing Enhancement equipment includes two DCB Processing Lines capable of processing a total of 45 to 50 TPH and all associated conveyors. Also included in the equipment cost estimate is a single additional front end loader for the tipping floor in the North Addition for the DCB processing equipment. Table 6-2 shows a summary of the cost for the main components of the DCB Processing system.

Table 6-2
Summary of Major Component Cost for the DCB Processing System

Equipment Description	Quantity	Low Range Cost	High Range Cost
Robotics	2	$1,600,000	$2,000,000
Additional Loader	1	$500,000	$700,000
Conveyor Allowance	1	$1,125,000	$1,575,000
Subtotal		$3,225,000	$4,275,000
Installation	25%	$806,250	$1,068,750
Contingency	30%	$1,209,375	$1,603,125
Total Capital Costs		**$5,240,625**	**$6,946,875**

The estimated equipment cost, including installation and contingency, is approximately $5.2 to $7.0 million. Further refinements in the design will help to narrow this range in estimated cost. The total cost for the DCB Processing System does not include any of the construction of the North Addition in which it will be located.

6.3 Recyclables Recovery System

The estimated cost for the Recyclables Recovery System includes a 35 to 40 TPH processing line from the shredder to the eddy current separator including the quality control station for the eddy current separator and all associated conveyors. Note that this eddy current quality control station is in addition to the quality control station budgeted for purchase in 2019 for the existing non-ferrous. Table 6-3 shows a summary of the cost for the main components of the Recyclables Recovery System.

Table 6-3
Summary of Major Component Cost for the Recyclable Recovery System

Equipment Description	Quantity	Low Range Cost	High Range Cost
Shredder	1	$750,000	$1,000,000
Decline Screen	2	$700,000	$900,000
Electro-Magnets	3	$105,000	$180,000
Bag Opener	1	$150,000	$200,000
Two Inch Minus Screen	1	$275,000	$400,000
2D/3D Screen	2	$700,000	$850,000
Air Classifier	2	$900,000	$1,150,000
Optical Sorters	3	$1,800,000	$2,250,000
Eddy Current Separator	1	$300,000	$450,000
Robotic Quality Control	4	$1,100,000	$1,700,000
Conveyor Allowance	1	$2,000,000	$2,750,000
Grapple Crane	1	$225,000	$275,000
Silo Allowance	1	$300,000	$500,000
Subtotal		$9,305,000	$12,605,000
Installation	25%	$2,326,250	$3,151,250
Contingency	30%	$3,489,375	$4,726,875
Total Capital Costs		**$15,120,625**	**$20,483,125**

The estimated equipment cost, including installation, and a new grapple crane to replace the existing aged grapple crane is approximately $15.1 to $20.5 million, based on communication with processing and heavy equipment vendors and current Recyclable Recovery System preliminary design. The range in cost can be refined with further design development.

6.4 Processing Enhancement

The total cost for adding all Processing Enhancement system including the North Addition, DCB Processing System, and the Recyclables Recovery System is estimated to be between $27.3 and $38.3 million. See Table 6-4

Table 6-4
Summary of Major Component Cost for the Recyclable Recovery System

Construction Costs	Low Range	High Range
North Addition	$7 million	$10.8 million
DCB Processing System	$5.2 million	$7 million
Recyclables Recovery System	$15.1 million	$20.5 million
Total Processing Enhancement System	$27.3 million	$38.3 million

7 Operation and Maintenance Cost Estimate

The operation and maintenance cost associated with the Processing Enhancements System includes the estimated costs associated with the DCB Processing System as well as the Recyclables Recovery System. An additional front end loader operator would be required to bring co-collected MSW to the in-feed of the DCB processing lines. An additional grapple operator is anticipated in order to observe and remove bulky materials from the processing line feeding into the Recyclables Recovery System.

7.1 DCB Processing System

Based on the operating schedule previously discussed, it is anticipated that two operators (loader operator and traffic director), an additional helper, an additional maintenance staff member, and an additional electrician will be necessary for the new DCB Processing System during the hours of operation necessary to process the incoming material. An additional helpers, mechanic and electrician will be necessary during non-operational hours, which are estimated to be 8 hours per day for 7 days per week.

Labor rates for the positions are estimated based on the current, fully loaded labor rate categories. An additional 18% is added to each labor rate to account for vacation, sick leave and holiday pay when overtime pay may be required (1.5 to 2 times the typical hourly rate). See Table 7-1 for the detailed assumptions of shift hours and labor rates used to estimate the labor costs for the DCB Processing System.

Table 7-1
Labor Cost Estimates
DCB Processing System Only

Position	Shift	Staff/ Shift	Shifts/ Day	Hours/ Shift	Days/ Week	Labor Rate/ Hour	Weekly Cost/ Shift	Total Weekly Cost	TOTAL ANNUAL COST
Electrician	Day	1	1	10	6	$52.09	$3,125	$5,228	$271,856
	Afternoon	1	1	8	5	$52.56	$2,103		
Maintenance	Day	1	1	10	6	$52.09	$3,125	$5,228	$271,856
	Afternoon	1	1	8	5	$52.56	$2,103		
Operator	Day	2	1	10	6	$48.04	$5,765	$9,646	$501,608
	Afternoon	2	1	8	5	$48.52	$3,881		
Helper	Day	1	1	8	7	$40.18	$2,250	$4,527	$235,430
	Afternoon	1	1	8	7	$40.67	$2,277		
Subtotal of Annual Labor Costs During Operational Hours									**$1,280,750**
Helpers	Night	1	1	8	7	$41.81	$2,341	$2,341	$121,745
Mechanic	Night	1	1	8	7	$53.71	$3,008	$3,008	$156,393
Electrician	Night	1	1	8	7	$53.71	$3,008	$3,008	$156,393
Subtotal of Annual Costs During Non-Operational Hours									**$434,532**
TOTAL COSTS (During Both Operational + Non-Operational Hours)									**$1,715,281**

7.2 Recyclables Recovery System

For the Recyclables Recovery System labor cost estimates, it is anticipated that one operator, an additional helper, an additional maintenance staff member, and an additional electrician will be necessary during the hours of operation necessary to process the incoming material. An additional helper, mechanic and electrician will be necessary during non-operational hours, which are estimated to be 8 hours per day for 7 days per week.

Labor rates for the positions are estimated based on the current, fully loaded labor rate categories with an additional 18% added similar to the DCB Processing System. See Table 7-2 for the detailed assumptions of shift hours and labor rates used to estimate the labor costs for the Recyclables Recovery System.

Table 7-2
Labor Cost Estimates
Recyclables Recovery System Only

Position	Shift	Staff/ Shift	Shifts/ Day	Hours/ Shift	Days/ Week	Labor Rate/ Hour	Weekly Cost/ Shift	Total Weekly Cost	TOTAL ANNUAL COST
Electrician	Day	1	1	10	6	$52.09	$3,125	$5,228	$271,856
	Afternoon	1	1	8	5	$52.56	$2,103		
Maintenance	Day	1	1	10	6	$52.09	$3,125	$5,228	$271,856
	Afternoon	1	1	8	5	$52.56	$2,103		
Operator	Day	2	1	10	6	$48.04	$2,882	$4,823	$250,804
	Afternoon	2	1	8	5	$48.52	$1,941		
Helper	Day	1	1	8	7	$40.18	$2,250	$4,527	$235,430
	Afternoon	1	1	8	7	$40.67	$2,277		
Subtotal of Annual Labor Costs During Operational Hours									**$1,029,946**
Helpers	Night	1	1	8	7	$41.81	$2,341	$2,341	$121,745
Mechanic	Night	1	1	8	7	$53.71	$3,008	$3,008	$156,393
Electrician	Night	1	1	8	7	$53.71	$3,008	$3,008	$156,393
Subtotal of Annual Costs During Non-Operational Hours									**$434,532**
TOTAL COSTS (During Both Operational + Non-Operational Hours)									**$1,464,477**

7.3 Processing Enhancements

Table 7-3 displays the current overall O&M cost estimates for both Processing Enhancement systems: DCB Processing System and Recyclables Recovery System. These estimates are rounded to the nearest $1,000 to better reflect the degree of precision available at this planning stage. The labor estimates in Table 7-3 are derived from the detailed assumptions used in Table 7-1 for the DCB Processing System and Table 7-2 for the Recyclables Recovery System.

Based on the long operating experience at the R&E Center, other assumptions were made for total estimated O&M costs, which include, but are not limited to, parts and supplies, electricity, and fuel. It was assumed that the DCB Processing System would use about one third of the parts, supplies and electricity compared to two thirds for the Recyclables Recovery System. Refinements to these estimates should be made almost continuously as more detailed information about the procurement method, equipment selections, and recovery rates are developed. Note that the current O&M budget at the R&E Center is approximately $5.2M.

Table 7-3
Overall O&M Cost Estimates
For Both Processing Enhancement Systems

Annual Cost Estimates

	DCB Processing System			**Recyclables Recovery System**			**TOTAL**		
Labor[1]			$1,715,000			$1,464,000			$3,179,000
Parts and Supplies	$250,000	to	$333,000	$500,000	to	$667,000	$750,000	to	$1,000,000
Electricity	$108,000	to	$133,000	$217,000	to	$267,000	$325,000	to	$400,000
Fuel	$55,000	to	$70,000	$0	to	$0	$55,000	to	$70,000
Contingency	$205,000	to	$217,000	$201,000	to	$223,000	$406,000	to	$440,000
TOTAL O&M COST ESTIMATE	**$2,333,000**	**to**	**$2,468,000**	**$2,382,000**	**to**	**$2,621,000**	**$4,715,000**	**to**	**$5,089,000**

Notes:
1 Based on labor rates and shift assumptions in Tables 7-1 and 7-2)

The annual O&M costs are presented individually for the DCB Processing System and the Recyclables Recovery System as well as an estimated total cost for both systems. Foth anticipates that there may be some overlap in labor if both systems were installed and the total labor cost may be reduced if the R&E Board proceeded with both projects.

The addition of the DCB Processing System and Recyclables Recovery System will result in an increase in the electrical usage at the R&E Center. However, the exact costs will be dependent on the final design and specific equipment utilized and can be calculated upon the final design approval. The estimated electrical costs are based on the current system electrical usage and a comparison of estimated electrical demand for the preliminary design of the Processing Enhancements.

The Processing Enhancements system equipment maintenance generally includes costs associated with the conveyors, shredder, disc screens, optical sorters, robotics, and air classifiers. Based on the anticipated maintenance items and communication with equipment vendors the estimated maintenance cost for parts and supplies only for the Processing Enhancements system is $750,000 to $1,000,000/year, but will depend on the specific equipment utilized.

Total annual operation and maintenance cost associated with operation of the Processing Enhancements system are estimated to be approximately $4.7 to $5.1 million. It is important to note, this operation and maintenance cost does not including transport and processing fees for recovered DCBs or Organic Rich Materials.

8 Recovery Estimates

8.1 DCB Processing System

The estimated number of DCBs entering the R&E Center was presented in the memorandum *Processing Alternatives: Durable Compostable Bag (DCB) Technology*[19]. The use of robotics for recovery of DCBs from MSW is a relatively new concept, and little information is available for accurately estimating the anticipated recovery rate. Based on observations of existing DCB Processing Lines and discussions with robotic sorting equipment vendors, Foth estimates an 80 to 85 percent recovery rate for the DCBs. When the DCB program is at maturity, this equates to approximately 24,500 to 26,000 tons of organics recovered annually.

8.2 Recyclables Recovery System

The estimated recovery percentages for #1 PET, #2 HDPE, OCC, ferrous, and non-ferrous are generally well documented and are typically included as a performance requirement in contract documents before installation of a system designed to recover these types of traditional recyclables (higher recovery rate guarantees are seen in traditional material recovery facilities). However, providing an accurate estimate of the percent recovery of loose organics from the Recyclables Recovery System is difficult since there is very little data or industry standards available for comparable systems.

Table 8-1 lists a conservative range of recovery percentages for the commodities the Recyclables Recovery System recyclables would attempt to capture.

Table 8-1
Range in Percent Recovery Used for Estimating Potential Tons Recovered from the Recyclables Recovery System at the R&E Center

Material	Range in Percent Recovery	
PET	60%	85%
HDPE	60%	85%
Cardboard/Boxboard	30%	50%
Ferrous (Tin/Steel containers)	65%	90%
Non-ferrous (Aluminum)	65%	90%
Organics	30%	50%[1]

[1] Assumes 30 to 50 percent of the targeted Organic Rich Material is separated from the Recyclables Recovery System. This estimate does not include DCBs.

A range in the estimated percent recovery for the targeted commodities is presented in Table 8-1 to provide a conservative estimate of the amount of each commodity that may be recovered as well as the estimated revenue in Table 8-3 that may be realized from the sale of the recovered commodities.

[19] Foth. *Processing Alternatives: Durable Compostable Bag (DCB) Technology.* November 20, 2018.

Table 8-2 summarizes the estimated range of recovered tons by material type using the Recyclables Recovery System for organics, #1 PET, #2 HDPE, OCC, ferrous, and non-ferrous. The percent of each commodity (Waste Composition Percent) is determined from the average of the four Waste Characterizations conducted in 2016 and 2017.

Table 8-2
Estimated Tons Recovered with Recyclables Recovery System at the R&E Center

Material	Waste Composition (%)	Total Tons [1, 2]	Low Estimated Percent Recovery (%)	Low Estimated Tons Recovered	High Estimated Percent Recovery (%)	High Estimated Tons Recovered
PET	1.63%	3,153	60%	1,892	85%	2,680
HDPE	0.73%	1,407	60%	844	85%	1,196
Cardboard/Boxboard	1.28%	2,478	30%	744	50%	1,239
Ferrous (tin/steel containers)	1.30%	2,522	65%	1,639	90%	2,270
Non-ferrous (Aluminum)	1.03%	1,989	65%	1,293	90%	1,790
Organic Rich Materials (food and yard waste)[3]	25%	48,452	30%	14,535	50%	24,226
Totals	**NA**	**59,999**	**NA**	**20,946**		**33,400**

1 Material in Waste Stream Based on Waste Characterization
2 Assumes 194,000 tons of MSW will be processed with two processing lines at the R&E Center annually.
3 Assumes recovery of Organic Rich Materials from the Processing Enhancements equipment targeting recyclables only (not DCB organics recovery). Volumes may change significantly at DCB system maturity.

The #1 PET, #2 HDPE, OCC, ferrous, and non-ferrous are marketable products that are considered a potential revenue source. The market for these materials is dependent on the quality (cleanliness) and is subject to fluctuations. Table 8-3 presents the estimated revenue from the sale of these marketable materials. It is important to note that each recyclable commodity has its own set of market specifications and price trend.

The amount of price discount will vary by commodity and actual end market (e.g., mill). The current market prices were selected from the RecyclingMarkets.net database. The downgraded percentage is based on an estimated discount that varies by commodity. The current contracts for ferrous and non-ferrous recovery from the R&E Center provide one form of background data for these discounts. Similar pricing for #1 PET, #2 HDPE, and OCC is not readily available. Therefore, these discount estimates should be further verified. Appendix C includes an update on current recycling market trends.

Table 8-3
Estimated Potential Revenue from Materials Recovered Using a Processing Enhancements System

Material	Current Market Price/Ton [1]	Downgraded percentage	Assumed Market Price/Ton[2]	Low Estimated Annual Revenue	Low Estimated Annual Revenue
PET	$305	80%	$244	$461,526	$653,829
HDPE	$380	80%	$304	$256,546	$363,440
Cardboard/Boxboard	$93	60%	$56	$41,488	$69,146
Ferrous (Tin/Steel containers)	$225	55%	$124	$202,863	$280,888
Non-ferrous (Aluminum)	$1,440	55%	$792	$1,023,680	$1,417,403
			Estimated Total Annual Revenue	**$1,986,102**	**$2,784,705**

[1] Current market prices from RecyclingMarkets.net accessed on May 7, 2018 as presented in Foth Memo, *Analysis for Recovery of Recyclable Commodities using Pre-Processing*, June 12, 2018.
[2] The assumed market price is reduced from the current market price to be conservative given market variability and product cleanliness.

The estimated revenue associated with the marketable materials recovered using a Recyclables Recovery System is estimated to be approximately $2.0 to $2.8 million annually. This is considered a conservative estimate based on data from the Waste Characterization, reduced recovery rates, and reduced market value for marketable materials.

There are also costs associated with the Organic Rich Material from the Recyclables Recovery System as well as the organics from the DCB Processing System. As previously discussed, there is currently no established market for the Organic Rich Material recovered from the Recyclables Recovery System.

8.3 Identification of Ongoing Changes to MSW

MSW continues to be subject to the Evolving Ton which is the phenomenon where MSW composition continue to change over time due to adjustments in packaging and light weighting of materials in general. Packaging while being light weighted continues to become stronger over time such as the increased strength of plastic including Polyethylene (PE) used in garbage bags. The Recyclables Recovery System includes a shredder and a bag breaker to assist with this phenomenon. The Recyclables Recovery System design allows for flexibility including room for additional equipment and allowance for changes in equipment and technology over time.

Technology is also evolving to allow for the installation of equipment including cameras that identify material in the MSW by shape, color, and design; and optical sorting that uses a materials chemical fingerprint to allow characterization of the materials. The R&E Board has authorized purchase of a camera and data logging system in 2019 that will be used for identification of waste type and composition. This data can be used going forward to determine what materials continue to remain in the waste stream. However, it is important to note that the technology does have limitations, particularly where the burden depth is such that all items cannot be viewed by the equipment.

Waste Characterization studies should continue on a minimum of an every other year basis to continue to monitor ongoing changes in the waste stream. The ongoing Waste Characterizations will provide the R&E Board with ongoing seasonal data and MSW composition changes over time. The studies should be for Waste Characterization including sizing and composition rather than just traditional waste sorts to continue to mimic mechanical separation. Considering Designation has been in place for approximately one year, it is appropriate to conduct a waste sort in 2019 to determine if there has been a significant change in waste composition as a result of waste designation. Additional studies should be developed and implemented over time of what remains in the MSW after it is processed through the Recyclables Recovery System.

9 Odor Prevention & Management

9.1 Existing Odor Control System

The R&E Center currently has two OMI - Ecosorb VDS, see Picture 8-1, and four Aquafog Jaybird mobile systems for odor neutralization both utilizing Ecosorb 606. The VDS are attached to the dust collection system and the tipping floor fans. With the VDS there is no water added to the Ecosorb 606. The Jaybirds use water mixed with Ecosorb 606 and are used in the RDF load-out and other areas as needed.

Ongoing odor monitoring is currently a best practice implemented at the R&E Center. Odor monitoring currently includes random testing with the Nasal Ranger® Field Olfactometer at different intervals throughout the year as well as bare nose monitoring by R&E Center staff at each shift change. Monitoring should continue with an increased schedule as the DCB Processing System and Recyclables Recovery System begin operation and as DCB volumes increase. Ongoing odor monitoring can more quickly detect odor issues that can then be resolved.

9.2 North Addition

The DCB Processing System will be located in the North Addition in a separate area with a separate tipping floor and load out area for organics. There is one additional VDS system for odor control planned for the North Addition where the DCB Processing System is located. The design for the North Addition also includes four high-speed garage doors which should be closed when access is not needed. These high-speed garage doors will also prevent any odors from leaving the area.

The North Addition will have several high plume exhaust fans installed that will only function when a specific carbon monoxide concentration is detected. The high plume exhaust fans specified were the Aerovent Model B53 Upblast Roof Ventilator evaluated by Emanuelson Podas in their 2017 *Facility Assessment – Observations*[20]. The Aerovent Model B53[21] by design will exhaust air a minimum of 60 feet into the air which will minimize the impact of odors in the vicinity of the R&E Center, see Picture 8-2.

Ongoing odor monitoring as described in the SOP Section should continue.

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[20] Emanuelson-Podas, *Facility Assessment – Observations Prepared for the Ramsey – Washington Recycling & Energy Center*. August, 2017.

[21] Aerovent, *Upblast and Hooded Propeller Roof Ventilators*. February 2015. Accessed from www.aerovent.com/docs/product-bulletins/roof-ventilators-roof-ventilator-upblast-and-hooded-(models-d53-b53-hd53-hb53)---catalog-625.pdf?Status=Master on January 1, 2019.

9.3 DCB Processing System

The DCB Processing System will be located in a separate area with a separate tipping floor and load out area for organics. The existing tipping floor building air fans and the dust collection system currently have OMI - Ecosorb Vaporization Delivery Systems (VDS) in place that are utilized for odor control. The existing OMI – Ecosorb Vaporization Delivery System (VDS) for the tipping floor area is currently at the maximum volume for distribution of Ecosorb to the tipping floor fans. One additional VDS system for odor control is planned for the North Addition where the DCB Processing System will be located.

DCBs are conveyed into an open top Live Floor™ trailer with a rolling cover system. A robust cleaning schedule will need to be maintained to control odor from the trailers both when collecting material from the DCB line as well as when not in use and parked in the lot. The design for the North addition includes four high-speed garage doors which should be closed when access is not needed. These high-speed garage doors will also help to minimize odors from leaving the area.

Cleaning and housekeeping processes should be implemented for the DCB Processing System as well as equipment integral to the system such as the trailers. This will maintain cleanliness standards and control potential odors.

Internal bare nose odor monitoring by R&E Center staff within the R&E Center and the North Addition should be added as the new materials are sorted and the DCB Processing System begins operation. This practice could be instituted to maintain a safe and as odor free as possible work environment. Ongoing odor monitoring as described in the SOP Section should continue.

9.4 Recyclables Recovery System

The new Recyclables Recovery System will utilize the existing processing building air flow system. The tipping floor building air fans and the dust collection system currently have OMI - Ecosorb VDS in place that are utilized for odor control. The odor for the Recyclable Recovery System will be neutralized through the dust collection system similar to the A and B Lines. The VDS for the dust collection system that collects air from the processing floor area should be more than adequate for the existing dust collection system and odor control.

Cleaning and housekeeping processes should be implemented for the Recyclables Recovery System. This will maintain cleanliness standards and control potential odors.

Internal bare nose odor monitoring by R&E Center staff within the R&E Center should be added as the new materials are sorted and the Recyclables Recovery System begins operation. This practice could be instituted to maintain a safe and as odor free as possible work environment. Ongoing odor monitoring as described in the SOP Section should continue.

10 Permitting

Building additions and modifications at the R&E Center require permits. Contact was made with the City of Newport, Minnesota; Minnesota Pollution Control Agency (MPCA); and Washington County to clarify permit requirements for the Processing Enhancements and building addition.

10.1 City of Newport

A Building permit will be required from the City of Newport for the North Addition. Two sets of identical site plans along with the application fee must be submitted to the City with the building permit application. The building permit can be issued and construction can begin as soon as the application is verified as complete which can take four to six weeks.

10.2 MPCA

The proposed North Addition, DCB Processing System, and Recyclables Recovery System will require modification of the Minnesota Pollution Control Agency Solid Waste Permit (SW-286). Foth contacted Julie Henderson, the MPCA Permit Engineer, on November 28, 2018, to inquire if the proposed process changes would require a major permit modification or if the process changes could be managed as a minor permit modification. The MPCA uses two standards typically to determine whether a proposed modification is major or minor: A major modification to the R&E Center's SW-286 Permit would be triggered by a request to increase facility capacity or an increased risk to human health or the environment associated with proposed changes.

At this time, the MPCA does not anticipate that removal of DCBs co-collected with MSW would trigger a major modification of the permit. Additional clarification was requested from Ms. Henderson on December 26, 2018, to ask if her opinion would also support the North Addition. While further clarification has been requested, the two standards used to trigger a major modification are not met and should still apply. The result should be that only a minor permit modification is required.

Obtaining a minor modification will require the Operations Manual and Stormwater Prevention Plan to be reviewed and updated as appropriate to reflect the proposed changes. A signed Solid Waste Permit Application for Construction and Operation will also need to be submitted with the updated documents, revised flow diagram, and appropriate drawings detailing the proposed changes. Minor permit modifications do not require public notice, and state law sets a goal for the MPCA to issue or deny permits within 150 days of receipt of a complete application [Minn. Stat. 116.03, Subd. 2(b)]. As only a minor permit modification is required, Foth anticipates that the MPCA will be able to issue the permit modification within 60 to 90 days of submittal.

The MPCA permit should be obtained before initiating construction. However, contracting and other preconstruction-related activities could proceed concurrent with the permitting activities since it is unlikely that any MPCA comments on the proposed permit modification would require modification of construction-related documents.

10.3 Washington County

The R&E Center has a solid waste permit issued by Washington County. Foth contacted Gary Bruns, Environmental Program Supervisor, regarding Washington County permitting or licensing requirements and associated costs and timing. Mr. Bruns indicated that Washington County would simply need to be informed of the proposed process and schedule and be provided with an opportunity to review the construction plans for compliance with Washington County Solid Waste Management Ordinance No. 202. Concurrent with the ordinance review, regulatory staff would also need to review, and if needed, amend the R&E Center's Washington County solid waste license and conditions, likely adding language related to recovery of organic materials and their management. As there are no new utility services or new access requirements for the proposed Processing Enhancements, it is not anticipated that there will be any other permit requirements that would need to be met for Washington County.

With respect to cost, Mr. Bruns anticipates that Washington County could review and amend the current license for the remainder of the current licensing period without additional cost. Washington County policy is to license facilities according to the largest constituent type of waste, which would not be changed by the proposed improvements. Additional details regarding cost and schedule will be provided by Washington County upon receipt of the construction plans. However, Mr. Bruns indicated that their processes should not affect the R&E Center schedule since the changes would be limited to amendments to existing documents and licenses.

11 Procurement Options Alternatives

The method of procurement for the North Addition, DCB Processing System, and Recyclables Recovery System has not yet been determined. This Report has previously discussed the costs, advantages, and disadvantages of building the North Addition and DCB Processing System at a different time than the Recyclables Recovery System. This section summarizes a number of alternative methods of procurement potentially available to the R&E Board for completion of these projects.

11.1 Alternative Project Delivery

The discussion of alternative project delivery included in this section is based primarily on the AIA Minnesota *Understanding Project Delivery for the Design and Construction of Public Buildings*[22] and the AIA California Council *Integrated Project Delivery: A Guide*[23]. Nothing in this report is intended to replace legal and financial advice related to procurement. Typically four items are considered and prioritized when considering alternative project delivery: project cost, time, quality, and accountability[24].

Three types of entities are typically involved in project delivery:

- Owner – Recycling & Energy Board
- Agents – Architects, engineers, and construction manager who act in the Owner's interest providing professional services for compensation.
- Contractors (Vendors) – Contracted entities who supply a specified product for a fixed price within the standards established in construction documents.

11.2 Alternative Project Methods

Several different alternative project delivery methods exist and are specifically outlined for the Processing Enhancements:

11.2.1 Design-Bid-Build

Design-Bid-Build is the traditional method of project delivery utilized for public sector projects. In Design-Bid-Build, Agents (architects and engineers) work with the Owner to develop plans for the project. Completed construction plans are used for a bidding process. A Contractor is selected through an open, competitive bidding process for a set price. The contract is typically awarded to the lowest cost qualified bidder. The Agent works with the Vendor to ensure the contractor builds according to the plans and specifications and the Vendor is compensated by the Owner per the contract. Advantages are that this is a familiar delivery method with defined roles

[22] AIA Minnesota – A Society of the American Institute of Architects. *Understanding Project Delivery for the Design and Construction of Public Buildings.* Accessed from www.aia-mn.org/resource/understanding-project-delivery/ on January 1, 2019.

[23] AIA National, AIA California Council, The American Institute of Architects. *Integrated Project Delivery: A Guide, 2007.* Accessed from info.aia.org/siteobjects/files/ipd_guide_2007.pdf on January 1, 2019.

[24] AIA Minnesota – A Society of the American Institute of Architects. *Understanding Project Delivery for the Design and Construction of Public Buildings.* Accessed from www.aia-mn.org/resource/understanding-project-delivery/ on January 1, 2019.

and responsibilities and allows more firms to bid. Disadvantages are that Design-Bid-Build is difficult to fast track and the low bidder may not understand project goals, objectives and criteria. The Owner has no control or input on sub-contractors and there is a high potential for change orders and conflict.

11.2.2 Construction Manager-Agent

In the Construction Manager-Agent model, the Owner contracts with a design team and a Construction Manager as Agent for early cost estimating, scheduling, and assistance. The Owner then contracts direct with one or more Prime Contractors through a competitive bidding process. Advantages of this method include that the Construction Manager-Agent provides additional cost accuracy and control and condensed scheduling. The Agent acts as an additional representative of the Owner's interest. Disadvantages include that there is typically increased administrative time and expense to the Owner with multiple prime Contractors.

11.2.3 Construction Manager-Contractor (Construction Manager at Risk)

Construction Manager-Contractor is also known as Construction Manager at Risk. In Construction Manager-Contractor, the Owner contracts with a design team (Agent) and a Construction Manager at risk or Construction Manager as Contractor (CM-Contractor) early in the process based on qualifications and fee. The CM is "at risk" since "he" provides both construction management and contractor services for the project, i.e. the CM agrees to complete the work for a guaranteed maximum price, fixed price or other means and contracts with the subcontractors. One of the primary advantages of this method of delivery is that the CM is involved in budgeting the project, controlling budget and schedule with all Contractor work competitively bid by the CM. High quality can be achieved at the lowest cost, and projects can be delivered at an accelerated schedule. Disadvantages include that the CM adds costs and acts as both a Contractor and a CM creating something of a conflict of interest with respect to the CM's relationship with the Owner.

11.2.4 Design-Build

In Design-Build, the Owner contracts with a single entity, Contractor, for both design and construction. Unique to Design-Build, there is no Agent who is obligated to work in the Owner's best interest. The architect and engineer are instead part of the build team. The primary advantage of this system is that it is generally considered to be the fastest delivery system and the cost and scheduling commitments are established early in the project. Disadvantages include that the Owner may receive less building than a bid approach and the construction costs are not necessarily competitive. Owner involvement is limited to the early stages of the project, and hidden reductions in quality are possible when short-term construction savings for the Contractor may outweigh life-cycle costs. There is potential for a major conflict of interest when the Contractor is also the designer. Lastly, there is no independent agent representing the Owner's interests.

11.2.5 Integrated Project Delivery

In Integrated Project Delivery, the Owner selects the CM and Engineer based upon qualifications prior to design being started. The Owner/CM/Engineer all sign a joint contract with the entire team establishing the project goals and objectives. This is a highly efficient delivery method with a fast timeline team approach. The Owner's risk is limited by the team approach to the risk and reward incentives. There is an increased ability to deliver the project within budget and schedule. The disadvantages are the Owner must be very involved. Integrated Project Delivery also a newer delivery method with some questions on contractual issues.

11.3 Special Allowances in Law for Alternative Project Delivery

Special allowances in both Minnesota Statutes and the Ramsey County Charter may allow significant leeway in procurement and the choice of project delivery methods available to the R&E Board.

11.3.1 Minnesota Statutes, Chapter 400.4

Minnesota Statutes provide requirements for procurements by counties and the R&E Board specifically in Chapter 471.345 *UNIFORM MUNICIPAL CONTRACTING LAW*. However, special allowances are provided for solid waste contracts in Minnesota Statute Chapter 400.4[25] under both Subd. 3 "Acquisition, construction, and operation of property and facilities" and Subd. 4. "Management and service contracts.

> As provided under Subd. 3, "*A county may acquire, construct, enlarge, improve, repair, supervise, control, maintain, and operate any and all solid waste facilities and other property and facilities needed used, or useful for solid waste management purposes. Nothwithstanding any law to the contrary, a county may purchase and lease materials, equipment, machinery, and such other personal property as is necessary for such purposes including recycling upon terms and conditions determined by the board, with or without advertisement for bids including the use of conditional sales contracts and lease-purchase agreements. If a county contract is let by negotiation, without advertising for bids, the county shall conduct such negotiation and award the contract using a fair and open procedure and in full compliance with chapter 13D. If a county contract is to be awarded by bid, the county may, after notice to the public and prospective bidders, conduct a fair and open process of prequalification of bidders prior to advertisement for bids. A county may employ such personnel as are reasonably necessary for the care, maintenance and operation of such property and facilities. A county shall contract with private persons for the construction, maintenance, and operation of solid waste facilities where the facilities are adequate and available for use and competitive with other means of providing the same service.*"

[25] State of Minnesota. *2018 Minnesota Statutes, Chapter 400.4, Solid Waste Program*. Accessed from www.revisor.mn.gov/statutes/cite/400.04 on January 1, 2019.

As provided in Subd. 4,

> "*Notwithstanding sections 375.21 and 471.345, a county may enter into contracts for the construction, installation, maintenance, and operation of property and facilities on private or public lands and may contract for the furnishing of solid waste management services upon terms and conditions determined by the board, with or without advertisement for bids, including the use of conditional sales contracts and lease-purchase agreements. If a county contract is let by negotiation, without advertising for bids, the county shall conduct negotiations and award the contract using a fair and open procedure and in full compliance with chapter 13D. If an agency permit is required for a solid waste service, a contract entered into under this subdivision is not binding until the permit is issued.*"

It should be noted that Minnesota Statutes also allow alternative delivery methods for most State agencies as well, as provided in Minnesota Statutes Chapter 16C.

11.3.2 Ramsey County Charter, Chapter 1

In addition to the considerations provided in Minnesota Statutes 400.4, the Ramsey County Charter appears to allow considerable leeway in usage of alternative project delivery. The Ramsey County Charter[26] in Chapter 1, Section 2.02, Powers of the County Board, Item M states as follows:

> *To contract for the acquisition, construction, or improvement of real property or buildings in a manner determined by the county board, to serve the interest of the public in regard to cost, speed, and quality of construction. Alternative construction procurement methods include, but are not limited to: (1) the solicitation of proposals for construction on a design/build basis and subsequent negotiation of contract terms; or (2) the solicitation of proposals for a construction management agreement which may include a guaranteed maximum price.*

11.4 Consideration of Alternative Project Delivery

Considering the above discussion, the R&E Board appears to have significant leeway in contracting for the procurement of the North Addition and DCB Processing System and the Recyclables Recovery System. All Processing Enhancement projects appear to be suitable for the alternative project delivery methods. This is regardless of whether all three Processing Enhancement occur at the same time or the North Addition and DCB Processing System are completed separately from the Recyclables Recovery System.

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[26] Ramsey County. *Home Rule Charter, Chapter 1, Powers of the County.* Accessed from www.ramseycounty.us/sites/default/files/Leadership/Ramsey%20County%20Home%20Rule%20Charter.pdf on January 1, 2019.

While the North Addition as a building addition procurement is relatively simple and is well-suited to a traditional Design-Bid-Build procurement method, the DCB Processing System and Recyclables Recovery System are not as straight-forward, as they utilize newer technology used in sometimes unique ways to meet the goals of the R&E Board, and may be better suited for one of the alternative delivery methods discussed previously. Notwithstanding the description above, we defer to R&E Board counsel on the methods of contracting available for the projects.

12 Operations & Maintenance Processes

This section contains information on safety policies and procedures and signage, operations and maintenance processes and procedures related to cleanliness and health, and suggested SOPs for development.

12.1 Safety Processes & Procedures

Safety was taken into consideration in the design of the R&E Center Processing Enhancements. Ensuring the design did not utilize manual labor was a priority for the R&E Board. Utilizing automated equipment instead of manual labor ensures employees are not subject to the hazards of sorting MSW. This safety section itemizes required updates to the R&E Center electrical safety and hot work program, signage required for the new Processing Enhancements, and considerations for R&E Center employees to safely access the new machinery added for the DCB Processing System & Recyclables Recovery System.

12.1.1 Electrical

The *Power System Analysis* completed by L & S Electric, Inc. in March, 2016[27] should be updated. The power study consisted of a Coordination Study, an Arc Flash Assessment, and a Short Circuit Study with Device Evaluation. Proper labeling of all new equipment should be verified by the R&E Center Facility Manager.

The *REC Electrical Safety Program (Policy)*[28] last updated in 2016 will need to be updated with the new Processing Enhancements information. This includes permitting and identification of areas where "hot work" can and cannot be completed.

12.1.2 Traffic Flows and Patterns

It is highly likely that traffic flows and patterns will change with the North Addition and two distinct tipping floors. Signs indicating buildings and areas will need to be updated to better direct incoming loads of waste to the appropriate area safely.

12.1.3 Signage

Signs shall be constructed in accordance with the ANSI Z535 (series) standards (current edition), shall be placed conspicuously in hazardous areas to communicate to employees the nature and degree of potential hazards, in such a manner that they are not obscured by or subject to wear from moving parts, and shall not be placed on removable parts unless a second sign is placed on an adjacent area.

Discharge End Warnings

A sign, such as WARNING - STAND CLEAR WHEN MATERIAL IS DISCHARGED, shall be located near the discharge point of processing machinery which deposits material into an area accessible to employees.

[27] L & S Electric, Inc. *Power System Analysis at the REC.* March, 2016.
[28] The REC Facility. *REC Electrical Safety Program (Policy)*, 2016.

Automatic Cycling Machinery
A sign, such as CAUTION - THIS CONVEYOR STARTS AUTOMATICALLY, shall be located on or immediately next to each automatic starting device.

High Voltage Equipment
A sign, such as DANGER - HIGH VOLTAGE (or appropriate voltage), shall be located on each control panel and power unit (motor). Panels may also need "ARC FLASH" warning signs as required by the NEC.

Picture 12-1
Arc Flash and Shock Hazard Warning Sign
Source: www.compliancesigns.com

Access Points
A sign, such as DANGER - DISCONNECT AND LOCK OUT POWER BEFORE OPENING THIS PANEL, shall be located on or near any access cover, door, or protective shield.

Energy Lockout
A sign shall be located on each access door, such as WARNING - BEFORE OPENING DOOR, LOCK-OUT AND BLOCK ALL ENERGY SOURCES.

Material Depositories
A sign, such as WARNING - HEAVY MATERIAL DEPOSITED HERE, shall be located near the access points to silos or other areas where employees may have access to places where materials are accumulated.

Gates
A sign shall be located on each gate that prevents access to any hopper loaded from a processing machine or system, such as WARNING - GATE MUST BE CLOSED BEFORE OPERATING (name of machine).

Picture 12-2
Gate Warning Sign
Source: www.amazon.com/Warning-Closed-Operating-Compactor-Aluminum/dp/B0714J9MHB

Loading Hoppers
On each loading hopper, a sign shall be located at the loading sill(s) such as DANGER - DO NOT ENTER. This sign shall be visible from all angles of approach.

Machinery Equipped with Discharge End Lockout Devices
On machinery or systems equipped with discharge end lockout devices, a sign shall be located near the device, such as WARNING - TO PREVENT OPERATION, LOCK AND REMOVE KEY.

Container Lifting Systems
The following requirements apply to signs related to container lifting systems.

- *Lifter Controls*
  A sign shall be located in the vicinity of the container lifter controls, such as CAUTION - BEFORE OPERATING DUMPER, CLEAR AREA OF ALL INDIVIDUALS.

- *Container Dumping Area*
  A sign shall be located in clear view of the dumper system and container, such as DANGER - STAY CLEAR OF DUMPER AND DUMPING AREA.

- *Compatibility*
  A label shall be located near the operating controls such as COMPATIBLE WITH ANSI Z245.60 TYPE CONTAINERS only if the lifting system is designed to accommodate containers manufactured in accordance with ANSI Z245.60-2008.

Special Work Areas
A sign shall be located in clear view limiting access by unauthorized persons to each special work area which is associated with processing machinery or systems, such as WARNING - (name of special work area, e.g., loading pit), - RESTRICTED AREA, AUTHORIZED EMPLOYEES ONLY.

Conveyor Pits
All conveyor pits shall be marked with a sign, such as
WARNING - CONFINED SPACE, CONVEYORS MUST BE SHUT DOWN AND LOCKED OUT BEFORE ENTERING,
unless other non-mechanical hazards exist in which case the sign must read DANGER -- PERMIT-REQUIRED CONFINED SPACE, DO NOT ENTER, or other sign conforming to U.S. Code of Federal Regulations 29 CFR 1910.146(c)(2).

Overhead Conveyors
Each walking/working surface where an open conveyor passes overhead shall have signs posted such as CAUTION - MATERIAL CONVEYOR OVERHEAD. *NOTE: This may be applied to the incline conveyors.*

12.1.4 Alarms

Audible Alarms
All non-adjustable audible alarm signals must provide a pulsing or intermittent signal of at least 87 dB(A) or be pre-set to at least 10 dB(A) above the ambient noise level. Automatic adjustment types must be able to generate a signal at least 10 dB(A) above the ambient noise level.

Visual Alarms
When visual alarms are employed, they must be visible from all areas normally occupied by employees who may be affected by the operations signaled by the alarm.

Start-up Alarm
An audible and visual start-up alarm shall be provided for every processing system that will signal for 5 seconds, and there shall be a minimum delay of 15 seconds after the starting control is activated and before the main motor(s) can be started. If start-up sequence is not initiated within 30 seconds, the alarm cycle must reset. NOTE: *This subsection may be applied to the start-up of the entire DCB Processing System, Recyclables Recovery System, and the baler in-feed conveyors.*

12.1.5 Security and Camera System

The surveillance video system at the R&E Center is comprised of 21 analog only cameras and 8 high-definition cameras and is centrally run to the control room. These cameras provide real-time security and monitoring of the existing waste processing equipment. Additional cameras will need to be added to the DCB Building, DCB Processing System and the Recyclables Recovery System for appropriate monitoring. The current quantity of additional cameras has not yet been determined. However, Matrix, the current video server and software utilized for multi-view monitoring of the cameras should be sufficient for any additional cameras that may be needed for these processing enhancements.

12.1.6 IT Infrastructure and Control System

No additional IT infrastructure is planned to be added to the R&E Center to accommodate the processing enhancements. If additional computers or hardware are necessary for the addition of processing enhancements, space is available and is adequate to meet the needs of the R&E Center.[29] The Control System as discussed in Section 4.1.1 is adequate for the needs of the additional processing enhancements.

12.2 Operation and Maintenance Training

Additional training will be required for new DCB Processing System and Recyclables Recovery System for all operational staff at the R&E Center. This include lock out tag out, emergency stop usage, and additional training on safely repairing new equipment.

12.2.1 Preventative Maintenance Program

R&E Center staff will need to continue their robust preventative maintenance program that has been ongoing since the R&E Center was constructed. This includes after shift, daily, weekly, monthly, and annual cleaning, maintenance, and upkeep. Manufacturer requirements should be followed as a best practice and documented to maintain the equipment warranty. MP2, a computerized maintenance management system by Info is currently used to track work orders and inventories at the R&E Center. MP2 can continue to be used to generate work and maintenance orders similar to past practices. Staff should be trained initially by the manufacturer and also cross-trained to ensure adequate staff for maintenance.

12.2.2 Health and Cleaning

The DCB Processing System has organics material that is removed from MSW. Policies and procedures will need to be developed for safe handling, moving, and cleaning of equipment to meet sanitation and safety requirements of employees.

[29] Heartland Business Systems. *Resource Recovery Technology, LLC (RRT) Newport Resource Recovery Facility IT Assessment for Ramsey/Washington Recycling and Energy Board*. November, 2015.

New policies will need to be developed for cleaning of DCB Processing System equipment. Consideration will need to be given to the type of cleaning agent, if the agent is wet or dry, onsite or off site (for trailers), and management of materials including liquids from the cleaning. Parts of the DCB Processing System equipment line may require different types of cleaning than typically used in the past to remove the more viscous organic material. Cleaning may need to be conducted more frequently to control odor and maintain employee safety in an environment that may tend to be more slippery than a standard RDF line. There are not anticipated to be any changes in staff uniforms or Personal Protective Equipment at this time to accommodate the new Processing Enhancements.

Cleaning policies for the Recyclable Recovery System will likely be similar to that currently utilized for the A&B lines. However additional cleaning may be required in the Organics Rich Material collection area.

No Leak Live Floor™ Trailers used to transfer separated materials from the DCB Processing System will require updated maintenance and safety procedures for upkeep and cleaning. Cleaning maintenance procedures may include additional Ecosorb 606 application at the trailer storage area.

12.2.3 Job Classifications

Tasks and responsibilities will need to be identified along with job classification and training or certification required to complete the task. The following is not intended to be a comprehensive list:

Equipment Certification Processes
Processes to certify employees to interact with the new DCB Processing System and Recyclables Recovery System equipment will need to be developed. Training type and frequency will need to be determined and may be based on final design of equipment.

Staffing Repair Approval
Determinations will need to be made on who can repair equipment and when manufacturer representatives rather than R&E Center staff conduct maintenance. Initial training needs to be provided by the selected equipment manufacturer(s).

Lock Out Tag Out
Lock Out Tag Out (LOTO) processes will need to be evaluated for the additional equipment added. LOTO requirements should be provided by the selected equipment manufacturer (s) and needs to be included during procurement. Specific processes for maintenance and cleaning will need to be documented and employees trained.

12.2.4 Staff Training

All new equipment installed will require additional training for staff. The level of training will vary depending on the equipment and the level of interaction (e.g. operation, cleaning, maintenance, or repair). In addition to manufacturer recommended operation and maintenance training, R&E Center specific safety processes and procedures training will be necessary.

12.2.5 Tier II

The Tier II reporting requirement which is sent annually to the State of Minnesota as well as the City of Newport Fire Department will need to reviewed and updated with any relevant information. Additional communication should occur with the City of Newport Fire Department on changes to the existing R&E Center as well as the North Addition.

12.2.6 Solid Waste Hauler Handbook

The Solid Waste Hauler Handbook will need to be updated to incorporate the updated traffic patterns, policies, and procedures for the Building Addition, DCB Processing System, and the Recyclables Recovery System. The haulers will need to be notified of the changes in where incoming loads will be tipped.

12.3 Standard Operating Procedures Development

Standard Operating Procedures (SOPs) will need to be developed and implemented for safety, operations, equipment maintenance, and on-going staff training once the new Processing Enhancement final design, equipment vendor(s), and operational procedure(s) are finalized. Table 12-1, List of Proposed Standard Operating Procedures provides a proposed list of SOPs to be developed. The list of existing SOPs should also be reviewed for any relevant updates.

Table 12-1
List of Proposed Standard Operating Procedures

Purpose of SOP	Responsible for Input	Pertains to	Purpose
Recyclables Recovery System Maintenance	Facility Manager, Supervisors, Manufacturers	Processors, Maintenance, Electricians, Supply Chain Manager	Ongoing maintenance of recyclables line including cleaning and preventative maintenance.
DCB Processing System Maintenance	Facility Manager, Supervisors, Manufacturers	Processors, Maintenance, Electricians, Supply Chain Manager	Ongoing maintenance of DCB separation line including cleaning and preventative maintenance.
Electrical Work (Hot Work)	Facility Manager, Supervisors, Electricians, Consultant	Supervisors, Maintenance Electrician, Processors	Process and documentation of electrical work including hot work based on safe processes and procedures dictated in R&E Center and regulatory policy.

Purpose of SOP	Responsible for Input	Pertains to	Purpose
Recyclable Bale Management and Storage	Facility Manager, Supervisors Transportation Manager, Supply Chain Manager	Processors, Supply Chain Manager	Process for managing recyclables once they are baled including location of storage and tracking of on-site quantities,
Recyclable Bale End Markets	Procurement Logistics Manager Transportation Manager	Processors, Transportation Manager	Shipment of truckloads of bale quantities to end markets including arranging for transportation and sale of materials.
Recyclables Management in Bunkers	Facility Manager, Consultant, Manufacturer, Supervisor	Processors, Maintenance	Management of loose recyclables in the temporary storage bunkers and process for recyclables to be conveyed to the baler.
DCB Processing System By-pass Process	Facility Manager, Consultant, JLT, Supervisors, Transportation Manager	Scalehouse, Facility Manager, Traffic Manager, Supervisors	Process to manage MSW containing DCBs when the DCB line is not operating including tipping floor management.
Determination of MSW Tipping Floor Management at the R&E Center	Facility Manager, Consultant, Supervisors	Scalehouse, Traffic Manager, Supervisors	Process for determining initial tipping floor and processing line destination of incoming MSW (MSW tipping floor, Recyclables Recovery System processing line, non-processable, DCB tipping floor). This process includes ongoing tracking of load destination.
Traffic Flow Patterns	Facility Manager, Consultant, Supervisors, Traffic Manager	Scalehouse, Facility Manager, Traffic Manager, Supervisors	Descriptive process of appropriate traffic flow patterns for incoming and outgoing trucks.
Recyclables Recovery System By-pass Process	Facility Manager, Consultant, JLT, Supervisors	Scalehouse, Facility Manager, Traffic Manager, Supervisors	Process to manage MSW typically designated to the recyclables line area when the Recyclables line is not operating.
Transfer Station MSW Management	Facility Manager, JLT, Consultant, Supervisors, Transportation Manager	Scalehouse, Traffic Manager, Supervisors, Facility Manager, Transportation Manager	Process for handling of MSW in transfer station loads including

Purpose of SOP	Responsible for Input	Pertains to	Purpose
			evaluation of processing accuracy for DCBs.
Parts and Inventory Management	Facility Manager, Manufacturer, Supervisors, Supply Chain Manager	Supply Chain Manager, Supervisors, Maintenance	Updated management of incoming parts and tracking of inventory for the additional processing lines (DCB and Recyclables). Replacement policies and timelines should be included.
Recyclable Bales - Contaminated Bale Management (internal and external)	Facility Manager, JLT, Consultant, Supervisors, Transportation Manager, Supply Chain Manager	Supervisors, Facility Manager, Transportation Manager	Process for management of baled material rejected at the end market.
DCBs – Contaminated Organics Load Management (internal and external)	Facility Manager, JLT, Consultant, Supervisors, Transportation Manager	Supervisors, Facility Manager, Transportation Manager	Process for management of DCB material rejected at the end market
Recyclable Quality Control Checks Process	Facility Manager, Consultant, Supervisors, Supply Chain Manager	Supervisors, Processors	Process for quality control checks of bales of recyclables for contamination levels on a regular ongoing basis.
DCB Trailer Management (weights, cleaning, preventative maintenance)	Facility Manager, Manufacturer, Supervisors, Transportation Manager	Supervisors, Processors, Transportation Manager,	Management of DCBs in trailers including verification of weights and process for unloading overweight trailers. Cleaning processes and preventative maintenance standards should be included.
Testing/Commissioning of Recyclables Recovery System	Facility Manager, Consultant, Engineer, Manufacturer, Supervisors, Procurement Manager	Facility Manager, Supervisors Processors, Maintenance, Electrician, Consultant	Process for testing and commissioning of the recyclables processing line.
Testing/Commissioning of DCB Processing System	Facility Manager, Consultant, Engineer, Manufacturer, Supervisors, Procurement Manager	Facility Manager, Supervisors Processors, Maintenance, Electrician, Consultant	Process for testing and commissioning of DCB processing line.
Audit Process for Accuracy of DCB	Facility Manager, Consultant, Engineer, Manufacturer,	Supervisors, Facility Manager, Processors	Process for verification of DCB removal at the

Purpose of SOP	**Responsible for Input**	**Pertains to**	**Purpose**
Sorting (internal and external)	Supervisors, Procurement Manager		R&E Center and transfer stations.
Audit Process for Percent Recovery of Recyclables Recovery System	Facility Manager, Consultant, Engineer, Manufacturer, Supervisors, Procurement Manager	Supervisors, Facility Manager, Processors	Process for verification of ongoing recyclables removal at the R&E Center.
Waste Characterization Process	Supervisors, Facility Manager, Consultant, JLT	Scalehouse, Traffic Manager, Facility Manager, Consultant	Process to conduct a waste characterization at the R&E Center
Management of Visual Equipment Data for MSW	Supervisors, Facility Manager, Consultant, Engineer, JLT	Facility Manager, Consultant, Supervisors	Process for handling of data from visual equipment documenting what is in the MSW stream.
Employee Equipment Certification	Supervisors, Facility Manager, Consultant, Engineer, Manufacturers, Electrician, Maintenance	All R&E Center Staff	Process for training and certifying employees on interacting with equipment.
Staffing Repair Approvals	Supervisors, Facility Manager, Consultant, Engineer, Manufacturers, Electrician, Maintenance	All R&E Center Staff	Process for training and certifying employees on equipment maintenance.
Preventative Maintenance Program	Supervisors, Facility Manager, Consultant, Engineer, Manufacturers, Electrician, Maintenance	All R&E Center Staff	Process for ongoing maintenance as recommended by the equipment manufacturer
Lock Out Tag Out	Supervisors, Facility Manager, Consultant, Engineer, Manufacturers, Electrician, Maintenance	All R&E Center Staff	Process for safety during equipment operation or maintenance for new equipment

13 System Economics & Financial Planning

13.1 Economic Pro Forma Development

Estimated costs for the DCB Processing System and the Recyclables Recovery System are provided. Additional recyclable markets information can be found in Appendix C. Table 13-1 provides a summary of the capital costs, O&M costs, and revenues.

Table 13-1
Summary of Costs Associated with
Processing Enhancements and Potential Revenue

System	Site Capital Costs[1]	Equipment Capital Costs	Total Estimated Capital Costs[2]	Annual O&M Costs	Potential Annual Revenue[3]
DCB Processing	$7,000,000 - $10,800,000	$5,240,000 - $7,000,000	$13,366,000 - $19,286,450	$2,333,000 - $2,468,000	($3,798,000) – ($3,948,000)
Recyclables Recovery	NA	$15,100,000 – $20,500,000	$17,365,000 – $23,575,000	$2,382,000 - $2,621,000	$1,986,000 - $2,785,000
DCB Processing + Recyclables Recovery	$7,000,000 - $10,800,000	$20,340,000 - $27,500,000	$30,731,000 - $42,861,450	$4,715,000 - $5,089,000	($1,163,000) - ($1,812,000)

[1] Includes estimated architecture and engineering services.
[2] Assumes construction management agency procurement method and includes estimated architecture and engineering and construction manager services.
[3] Negative revenue indicates there is a net cost associated with the System.
NA = Minor site capital costs associated with the Recyclables Recovery System are accounted for within the Equipment Capital Costs.

The potential annual revenue for the DCB Processing System does not include transportation, processing fee, or tipping fees associated with DCB management once removed (DCB cost data from *Processing Alternatives: Durable Compostable Bag (DCB) Technology*).[30] Negative potential revenue as listed in Table 13-1 indicates there is a net cost associated with the purchase of the bags for the DCB processing system. The potential revenue for the Recyclables Recovery System will follow the commodity market prices and may decrease. Additionally, the potential revenue does not take into consideration any of the annual Operations and Maintenance costs or amortization costs associated with the capital costs. This information can be utilized by the R&E Board and its financial consultant, Ehlers & Associates, Inc., to determine the best methods for financing the project as well as costs amortization.

[30] Foth. *Processing Alternatives: Durable Compostable Bag (DCB) Technology.* November 20, 2018.

Appendix A
References and Vendor Engagement

Reports on new technologies and recovery methodologies

- **2018**
  - Pre-Processing: End Market Analysis for Process Residue, *June 2018*
  - Analysis for Recovery of Recyclable Commodities using Pre-Processing, *June 2018*
  - History of Residential Recyclables Prices, *November 2018*
  - Processing Alternatives: Durable Compostable Bag (DCB) Technology, *November 2018*
  - R&E Center Equipment Research, *December 2018*

- **2017**
  - Emanuelson-Podas Facility Assessment – Observations, *August 2017*
  - Summary of 2016-2017 Seasonal Waste Characterizations, *December 2017*
  - Technologies to Control Odor at the Ramsey/Washington Recycling & Energy Center, *December 2017*

- **2016**
  - Options for Scope of Work for Alternative Technology at the Recycling & Energy Center (R&E Center)**,** *April 2016*
  - Scope of Work for Alternate Technology Equipment Review**,** *April 2016*

- **2015**
  - Report: Life Cycle Financial Analysis, *February 2015*
  - Report: Greenhouse Gas Systems Analysis, *April 2015*
  - Anaerobic Digestion (AD) - Update on Technology Status, *April 2015*
  - Mixed Waste Processing - Update on Technology Status, *May 2015*
  - Report: System Changes to Achieve the Scope for Resource Management, *April 2015*
  - Water Needs and Use for Selected Technologies, *April 2015*

- **2014**
  - Follow-up on Technology Siting and Permitting Analysis, *April 2014*
  - Technology Comparative Analysis, *January 2014*
  - Two Additional Technology Options Requested, *April 2014*
  - Analysis of Mixed Waste Processing (MWP)**,** *September 2014*
  - Estimated Calculations of Additional SSR/SSO Tons**,** *September 2014*
  - Waste Composition Study**,** *September 2014*
  - Peer Review of Meeting a 75% Recycling Goal by 2030, *December 2014*

- **2013**
  - Alternative Technologies for Municipal Solid Waste, *July 2013*

Equipment and Durable Compostable Bag vendor engagement, formally and informally

- AMP Robotics
- Biobag
- BHS
- CP Group
- Eggersmann
- Green Machine
- Machinex Technologies
- Mayfran International
- Novamont
- Optibag
- Organics Solutions
- Plexus
- RRT Design & Construction
- SSI Shredders
- Stadler
- Van Dyk
- Vecoplan
- Waste Robotics
- Wolf Material Handling Systems

Conferences and visits attended/completed

- **2018**
  - Biocyle BioREFOR Conference, Raleigh, NC
  - RAM/SWANA, Brooklyn Park, MN
  - Waste Expo, Las Vegas, NV
  - WasteCON, Nashville, TN
  - Midwest Food Recovery Summit, Des Moines, IA
  - Tour of Perham and Pope Douglas Facilities, Perham and Alexandria, MN
  - Tour of Concord Energy Partners Anaerobic Digestion Facility, Charlotte, NC
  - Tour of Randy's Sanitation, Delano, MN
  - Tour of NRT (BHS) Optical Sorting Facility, Nashville, TN
  - Tour of MSS (CP) Optical Sorting Facility, Nashville, TN
  - Tour of Green Fire Biodigester, Milwaukee, WI
  - Tour of BioFerm, Oshkosh, WI

- **2017**
  - Visit to Hennepin Energy Recovery Center (HERC), Minneapolis, MN
  - ISWA/SWANA WasteCON, Baltimore, MD
  - RAM/SWANA, Brooklyn Park, MN
  - Tour of GRE Elk River Processing Plant and Energy Recovery Station, Elk River, MN
  - Tour of Dem-Con, Shakopee, MN
  - Tour of Penn Waste Recycling, York County, PA

- **2016**
  - RAM/SWANA, Bloomington, MN

- NAWTEC, Minneapolis, MN
- Waste Expo, Las Vegas, NV
- Renewable Energy from Waste, LA, CA
- Tour of Randy's Sanitation, Delano, MN
- Tour of Dem-Con, Shakopee, MN
- Tour of Zero Waste Energy, San Jose, CA
- Tour of Republic, Newby Island Resource Recovery, San Jose, CA

- **2015**
  - RAM/SWANA, Bloomington, MN
  - Renewable Energy from Waste, West Palm Beach, FL

Appendix B
Waste Characterization, 2016-2017[31]

Table App B-1
Seasonal Comparison of Characterization

	Oct-16	Mar-17	May-17	Aug-17
Pounds of Sample (lbs.)	2257.9	2209.42	2118.3	2201.3
Percent of Bagged	56%	65%	69%	65%
Percent of Loose Material	39%	35%	31%	35%
Percent of Plastics	3.4%	4.9%	3.7%	4.1%
Percent of Polyethylene Terephthalate (PET)	1.2%	2.0%	1.7%	1.6%
Percent of HDPE	0.4%	1.2%	0.5%	0.8%
Percent of PVC	0.0%	0.0%	0.0%	0.0%
Percent of LDPE	0.0%	0.0%	0.0%	0.0%
Percent of PP	0.8%	0.9%	0.9%	0.8%
Percent of PS	0.3%	0.7%	0.5%	0.6%
Percent of Plastics #7 Other	0.2%	0.1%	0.1%	0.3%
Percent of Old Corrugated Containers (OCC)	0.46%	0.75%	1.88%	2.02%
Percent of Metals (non-Ferrous and Ferrous)	2.0%	2.4%	2.9%	2.0%
Percent of Ferrous	1.0%	1.4%	1.8%	1.0%
Percent of non-Ferrous	0.9%	1.0%	1.2%	1.0%
Percent of Glass	-	3.3%	2.2%	1.7%
Percent Waste	95%	89%	90%	90%
Percent in +12"	15.3%	14.5%	14.1%	13.7%
Percent in 6" to 12" fraction	29.6%	16.9%	14.1%	21.0%
Percent in 2" to 6" fraction	36.4%	34.2%	27.7%	26.7%
Percent of food waste in 2" to 6" fraction	-	5.3%	10.4%	12.3%
Percent in -2"	13.5%	18.0%	23.8%	16.6%

[31] Foth. *Summary of 2016-2017 Seasonal Waste Characterization.* December 18, 2017.

Appendix C
Recycling Market Trends

Foth provided an analysis on the current Recycling Market Trends to Ramsey County in November 2018. The key market trend analysis is provided, see full memo for methodology and material specific trend information.[32] Regional, historical, and individual recyclable commodity market price trends are presented below.

Like all commodities, recyclables exhibit highly volatile price swings due to many factors, including the overall U.S. economy. The recycling market is currently depressed due to global market conditions. Recent China restrictions on imports of recyclable scrap commodities have significantly impacted prices, especially for mixed paper and mixed plastics.

Several commodities have positive price trends:

- Old corrugated cardboard (OCC);
- Old magazines (OMG);
- Steel cans (in baled form);
- High-density polyethylene (#2 HDPE) plastics – natural (i.e., white or clear coloring); and
- Mixed plastics (resin types #3 - #7).

Except OCC, these are generally “minor” commodities (i.e., less relative weight and value in the total recyclables stream).

Most of the other commodities have negative long-term price trends:

- Old newspapers (ONP);
- Aluminum cans;
- Polyethylene terephthalate (#1 PET);
- #2 HDPE – colored;
- Polypropylene (PP); and
- Glass.

The overall result is that there has been a significant decline in total market price (all commodities combined into a total stream of all residential recyclables), especially in recent months primarily due to the drop in price for mixed paper and mixed plastics.

Figure App C-1 displays the average dollar per ton of end market prices for the Midwest Region from 2010 through 2017. The tonnage composition and total tons are based on readily available local Ramsey County data. Prices are regional, published prices (after processing) based on the data provided by RecyclingMarkets.net.

[32] Foth. *Memo to Ramsey County, History of Residential Recyclables Prices.* November 21, 2018.

Figure App C-1
Midwest Region Recycling Price Trends: 2010 – 2018

(Average $ per ton)