Recycling Steering Committee

Modernizing Oregon's recycling system with support from Oregon Consensus

Infrastructure Research Subcommittee Meeting Notes

February 13, 2020
12:30 p.m. - 3:30 pm
City of Portland – Bureau of Planning and Sustainability
1900 SW 4th Ave., Portland, OR 97201 (7th Floor Conference Room)

AGENDA

Meeting Purpose: Presentation and discussion of Infrastructure Processing Alternatives research (Phase 2, Task 2) conducted by Cascadia Consulting Group; assist contracted team in refining infrastructure scenarios for study (Phase 2, Task 4).

12:30 p.m. **Welcome, Introductions, Housekeeping, Frame for the Day:** Oregon Consensus

- Brief welcome and frame for today; participant introductions.
- Brief reminder of high-level research objective(s).

12:45 p.m. **Processing Alternatives Research results (Phase 2, Task 2):** Cascadia Consulting Group

- The consultant team will present the research results, answer questions, and take feedback from the group.

Objectives: Infrastructure Research Subcommittee and interested Recycling Steering Committee members have answers to questions about research. Cascadia has feedback on processing alternatives case studies, summary and recommendations for scenario development from IRS and RSC members.

2 p.m. **Informing Scenario Development (Phase 2 Task 5):** Cascadia Consulting Group

- Cascadia Consulting Group will ask the group detailed questions about potential elements or considerations across scenarios that will help CCG further refine draft scenario definitions.

Objectives: Cascadia Consulting Group has necessary feedback on refining questions in order to fully draft scenario definitions that will be discussed by the RSC on February 28.

3:15 p.m. **Wrap Up and Next Steps**

- The group will recap the day and determine next steps and expectations for the research.

3:30 pm Adjourn

MEETING NOTES

ACTION ITEMS:

ACTION	BY WHOM?	BY WHEN?
● Request for commercial contamination data which will be beneficial for baseline modeling	Pam will provide this to Cascadia Consulting	As available
● Contribute additional comments or questions to Brian Stafki regarding Processing Research Report	RSC and Subcommittee Members	February 21
● Circulate July Recycling Steering Committee Doodle Poll	Amy Delahanty, OC	Completed.

Meeting Attendees:

Recycling Steering Committee and Subcommittee Members: Bruce Walker, Jeff Murray, Dave Claugus, Vinod Singh, Bryce Jacobson, Laura Leebrick, David Allaway, Nicole Janssen, Pam Peck, Timm Schimke, Sarah Grimm (via phone), and Matt Stern (via phone).

Facilitation Team: Amy Delahanty and Jennah Stillman

DEQ Staff: Sanne Stienstra, Justin Gast, Peter Spendelow, and Brian Stafki

Cascadia Consulting Group: Jessica Branom-Zwick, Chris Bell (via phone), Tim Buwalda (via phone), and Doug Drennen

MEETING SUMMARY:

Welcome, Introductions, Housekeeping and Frame for the Day

Facilitator Amy Delahanty, Oregon Consensus, welcomed the group and Infrastructure Research Subcommittee (IRS) and Recycling Steering Committee members and provided brief introductions. Amy then reviewed the meeting agenda and purpose, which was for members to hear a presentation and discussion of Infrastructure Processing Alternatives research (Phase 2, Task 2) conducted by Cascadia Consulting; and assist contracted team in refining infrastructure scenarios for study (Phase 2, Task 5). It was noted that the IRS and Steering Committee would have an opportunity to provide input on elements that would go into the draft scenarios being modeled by Cascadia Consulting. Brian Stafki reminded the group on the arc of the research and high-level research objectives. He noted the goals of the infrastructure research were to improve recycling infrastructure by optimizing the benefits of recycling; create strong and resilient systems; and restore and maintain public trust in the system. To achieve those

goals, he stated the research will seek to explore and identify how markets, collection alternatives, processing alternatives, and effective customer engagement methods to reduce contamination might all need to change. Following this, Brian introduced the Cascadia Consulting research team.

Processing Alternatives Research Results (Phase 2, Task 2): Cascadia Consulting Group

*(**Facilitator note:** Cascadia Consulting Group with subcontractors Circular Matters and Drennen Consulting Services researched five types (seven facilities) of processing systems/material recovery facilities (MRFs) to understand the operations, costs, and impacts of each type of facility. The goal of this task was to provide DEQ and partners with information on alternative processing methods to assist the group on which collection and processing methods to include in further scenario analysis.)*

Tim Buwalda (Circular Matters) provided a presentation of the draft Processing Alternatives Research. The following presentation topics included, but were not limited to the following: review of the seven processing alternatives case studies; summary learnings by facility type; processing costs; and recommendations. During the presentation, several questions and comments were asked by RSC and IRS members. The following is a synthesis of those discussions.

<u>Learnings: Secondary Container Recycling Facility</u>

Comment: Additional drawbacks should include bailing expenses and looking at the impact of the reduced volume to the existing MRFs (taking containers to secondary facility).

Cascadia Response: In the next phase, we will be diving further into the economics and were not trying to ignore this is part of the expense. In terms of reduced volume, this is intended to be a secondary facility and as long as there is a single stream of materials, these materials would not be bypassing the MRF, but would be forwarded on.

- *Comment:* If you have many MRFs around the state and they're separating containers from other materials, that will mean lower volume to existing MRFs.
- *Cascadia Response:* For context, this phase was hypothetical and not comparing the current to future in Oregon, but rather looking at the benefits, drawbacks, and considerations. Later on, in tasks 4 through 6, we will be looking at the current situation in Oregon and how things might change.

Question: In the research, were there potential facilities that could take on the characteristics of the secondary sorting, like utilizing the infrastructure of an existing facility that makes significant investment in container sorting?

- *Cascadia Response:* We looked at two types of secondary facilities. One only accepts containers and one takes container line residue (like Titus). The difference is that the current materials that go into Titus, have about 50% contamination that remains contamination. Merlin is invested in a California PET reclaimer, that on the front end has put in mixed plastic bale sorting. The true container recycling facilities were designed specifically for sorting bales with lower levels of contamination. The current Titus MRF used to be a single-stream MRF but was converted.

    - *Question:* Do these drawbacks, benefits, and considerations apply if there was a single-stream MRF doing single-stream processing and invested in the ability to act like a CRF?
    - *Cascadia Response:* There's no reason why this type of a facility could not be connected to a single-stream MRF.

Question: Did you look at programs, or cities that have contracts with private MRFs?

- *IRS Comment:* Most MRFs are private and have contracts with a city.

Question: At what scale do these facilities need to exist, and what tons or capital would they need to take in to make it feasible?

- *Cascadia Response:* There could be several primary MRFs feeding into secondary recycling facilities to have the scale to invest in multiple optical sorters that would be required.
- *Question:* A stand-alone facility would need several primary MRFs feeding into it. Do you also need several large single-stream MRFs to feed into a single-stream MRF that also performs regional sorting of containers, or because the existing facility has a large tonnage base, does it need to be so large?
- *Cascadia Response:* It would need a separate container feed to a separate sorting line. For any of the containers already flowing through the host MRF, those tons are already going in and any additional tons could be processed through this facility. Having a separate container infeed would allow separate containers from other facilities. This does not necessarily have to be stand alone and could be located at an existing single-stream MRF.

<u>Learnings: Secondary MRF</u>

Comment: One learning from the Titus pilot was that they expected more marketable materials. Because a facility like this wouldn't be in Portland, but rather somewhere in Washington, there's a need to include additional transportation costs.

- *Cascadia Response:* I think that the place they're more likely to get containers sorted is in Washington State because they don't have a bottle bill as Oregon does.

Comment: One of the problems with the Titus model is the ongoing economic tension between what the primary MRFs can glean and what the secondary MRF wants. I have strong concerns with Secondary MRFs.

- *Comment:* You'll see in the research that we do not recommend utilizing Secondary MRFs.

Question: Did you look at a model that would keep the current infrastructure, but moves material to a facility that washes it and makes it into a product?

- *Cascadia Response:* One example is Merlin Plastics that sorts and uses the material for their own internal needs. There was a plastics recycling facility located in the Baltimore area, which went bankrupt (*facilitator note: QRS/Canusa Hershman Recycling PRF which shuttered in August*

2017), but was owned by a company that did some Washington reclaiming of plastics. For fibers, there are examples of single-stream MRFs that co-locate next to paper mills.

Comment: Looking at the volume of Titus' business model, we wouldn't produce half that number for all containers in curbside materials. To better put it into perspective, we need to know what it is that we have in Oregon to process.

- *Comment:* We could model this using tonnage from both Oregon and Washington. There may be a need to assume that the facility would draw tons from outside Oregon.

Question: Titus wants container line residue, but they don't want the unders. This seconds the tension between primary and secondary MRFs as a point to figure out. People want valuable resources, but how do you draw the line between who gets what? Are there any other examples of secondary MRF examples out there, or just Titus?

- *Cascadia Response:* Titus is the only one with the concept laid out behind it, similar with more integrated facilities with commercial mixed solid waste going into them (takes residuals and process into fuel product). Most of those facilities that do processing of materials into processed engineered fuel are focused more on commercial rather than residential.

<u>Learnings: Dual-Stream MRFs</u>

Question: Is the recommendation for the dual stream to mix glass, plastic and metal?

- *Cascadia Response:* This does not specifically require mixing glass back in, it could stay out. There is less glass in Oregon than in other states without a bottle bill and this is part of developing scenarios to be built out more specifically later.

<u>Learnings: Commercial Dry Mixed-Waste Sorting (Integrated MRF)</u>

Comment: It would be a huge change to the system, but it would be worth looking at dry waste loads.

Comment: Two points for consideration regarding integrated mixed waste processing: 1) much of what's thrown in the commercial waste stream are recoverable commodities; and 2) to make a single stream economical, you need to run more material. Metro is moving forward with a program to eliminate commercial food waste so that in the future, processing some form of commercial mixed waste might make sense. The equipment can give you a clean material to market, but has to fit the system and what you're trying to achieve with your collection.

<u>Processing Costs</u>

Tim noted several brief highlights regarding MRF processing costs and data collected in the research. Following this, there was a question about the prevailing wage for sorters at Solid Waste Authority of Palm Beach County?

- *Cascadia Response:* Generally, their living wage is 50% higher than minimum wage, as per contract. $14/hour is direct pay.

<u>Recommended for Scenario Analysis</u>

Tim then shared the research team's recommended processing systems to be considered by the Recycling Steering Committee for scenario analysis, which included 1.) Modernized single-stream MRFs; 2.) Dual-stream collection and processing; and 3.) Container recovery facility. Following this, there were several questions from subcommittee and Steering Committee members.

Question: I believe there's potential for more contamination if you provide people with more containers, as there is more space and potential for people to mess-up. What is the evidence that it would be otherwise?

- *Cascadia Comment:* One of the things that we advocate for is adjusting rates and providing people incentives. If people don't have an outlet (space in the cart) for their garbage, they find somewhere else to put it.

Question: Are you recommending that a new container recovery facility could play a role in the system? What about a scenario in which current materials flow to existing and expanding facilities?

- *Comment:* The point of the research is to understand options for public investment moving forward. With some level of container recovery systems in existence, playing out scenarios and understanding investment options, is valuable to keep in the research to compare options. If we leave things behind too soon, this will put us at a disadvantage down the road.

Question: Would decentralizing MRFs around the state be more cost effective to make capital investment to existing infrastructure and somehow supplement/have transportation offset? I would suggest different geographic distribution of MRFs to be folded into some of the scenarios.

Question: Looking at different possibilities moving forward, how does assuming a level of contamination (below 10%) change the economics for different scenarios?

- *Cascadia Response:* If you reduce contamination, you don't have to truck additional garbage around the state to different facilities.

Comment: We need to get to a point of evaluating wholistic scenarios between the list, generator facing, collection modes, and processing systems as discreet wholes.

- *Cascadia Comment:* The modeling will be forecasting five years ahead, taking in factors such as population growth.

Informing Scenario Development (Phase 2, Task 5)

As follow-up to the January 17th RSC Meeting, Cascadia Consulting invited members to provide additional input about potential elements or considerations across scenarios that will help the researchers further refine draft scenario definitions. During the brainstorming session, the group had a robust discussion regarding whether there was interest in having some scenarios consider energy recovery or chemical recycling. The following input was provided to Cascadia Consulting:

- *Comment:* I feel that it's important to come to a conclusion on. In sharing the example of Canada's energy recovery program, it was noted that if we move to polypropylene bottles and only process the "4 bigs" and accept the burning, then we are a long way into it without spending

a lot of money. I'm not big on burning plastics, because we don't know all the chemicals in the plastics and how that impacts us or the planet.

- *Comment:* I want to see a couple scenarios limited to familiar mechanical recycling options. Chemical recycling is not a near-future option, but an intriguing option to possibly entertain at a later date. Unless there are near future facilities with a vision of actual environmental impact, it's not worth spending the money on now. Living with uncertainty of human health impacts around combustion should lead us not to automatically oppose it, but perhaps for us look at scenarios that stretch a little further to look at combustion as a bridge. This scenario would include environmental consequences and costs. Even if the answer is "it's a bad idea," we still want to have that answer and be able to say that it was on the table and rejected for justifiable reasons.
- *Cascadia Comment:* Chemical recycling is in its infancy stage. With chemical recycling, it means that the carbons and hydrogens in the molecule in the plastic are broken back to down and put together again. There is a large scale commercial operating facility (Kingsport, TN), taking materials from carpet and investigating other supplies, but it runs materials through an in-house process and turns it back into plastic products.
- *Comment:* Focus on mechanical recycling. I'm intrigued by the possibilities to include a broader suite of materials in collection programs, but to rely on incineration would be woefully misguided without comprehensive emission analysis. Just put in a landfill until we find a bridge market and modernize MRFs.
- *Comment:* Metro looked at waste to energy options and the council decided not to move forward because of concerns. A full health impact assessment would be needed in communities where energy recovery would be happening. There were concerns from the community and around the costs for the research, and it's likely their minds will not have changed on that. Do some level of analysis but not so much as to not afford it. Concerns about relying on single source that may not be stable into the longer term.
- *Comment:* I have concerns that we are bringing in manufactures one way or another and want to encourage manufacturers to move to more sustainable practices and material that has a smaller environmental footprint. Burning is a shortcut and it lets producers off the hook. When you move to energy recovery, we short circuit where we really want to get to.
- *Comment:* I want more information on chemical recycling as not all chemical recycling is the same. Single resin versus everything going together feels like two different things.
- *Comment:* There are no proven technologies that are economically viable now, so why bother? Focus on mechanical recycling and for what is going to be taken to Salem next year, keep our minds open, but for the purpose of scenario analysis not focus on chemical at all.
- *Comment:* I'm concerned that we write this off entirely because in some places and in some scenarios, it may be a viable option to shipping.

Cascadia Question: Do you have a preference on the prioritization of mechanical?

- *Comment:* For dual stream recommendations we need to look at what would be left, based on trends at the curb in 5-10 years. That is a change in infrastructure for something that maybe won't be happening.

Next Steps

In the closing comments, Oregon Consensus shared DEQ will follow-up with the group if there was an opportunity to provide additional feedback on elements to be included in the draft scenarios. Oregon Consensus noted that at a minimum, the feedback from the meeting (as well as feedback from January 17th) will go into informing Cascadia's next step to draft scenarios. The draft scenarios will be presented to the Steering Committee and Infrastructure Research Subcommittee members on February 28th. Following this there were no further questions. The meeting adjourned at 3:30 p.m.

Processing Alternatives Research

Oregon Infrastructure Committee

February 13, 2020

Circular Matters

Presentation Overview

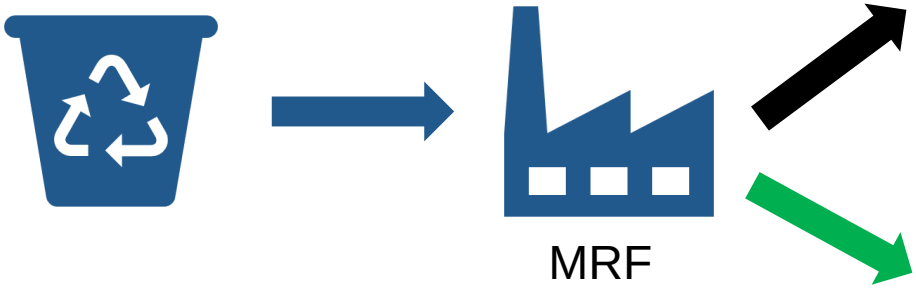
Outine

- Defining "contamination" and "residue"
- Summary learnings by facility type
- Processing costs
- Recommendations

Processing Types Profiled

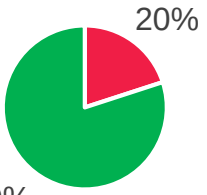
- Container recovery facility (CRF)
  - Merlin
- Secondary MRF
  - Titus
- Modernized single-stream MRF
  - Balcones
  - Firstar
  - Shoreway
- Dual-stream MRF
  - SWA Palm Beach County
- Commercial dry waste MRF
  - Monterey

Meaning of Terms



20% residue

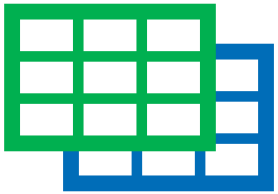
- Contamination
- Recyclables

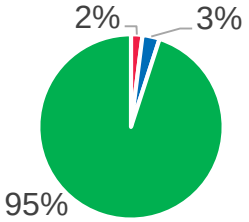


- Contamination
- Recyclables

Incoming contamination

80% commodities





Grade contamination

- Contamination (prohibitive)
- Missort Recyclables (outhrow)
- Market Grade

Learnings: Secondary Container Recycling Facility

- Benefits
  - MRFs do not need to invest in container sorting technologies
  - Potential for optimizing processing infrastructure
  - Can expand list of materials accepted for collection
  - For dual-stream collection, allows smaller, low-capital, and more-distributed MRFs
- Drawbacks
  - Additional transportation and handling expense
- Considerations
  - Will need an assurance of delivered material in order to construct a regional facility

Learnings: Secondary MRF

- Benefits
  - Landfilling is reduced because more MRF residue and package types are recycled
  - Small MRFs can focus on sorting and marketing fiber only
  - Medium and large single-stream MRFs need not invest in additional container-sorting technology
- Drawbacks
  - Uncertain economics - not yet proven at scale
  - Potential for increased cost over direct disposal of MRF residue
- Considerations
  - Need Oregon MRFs to modify residue conveyors and/or sorting practices (more salable containers in stream)
  - Need an assurance of supply in order to construct a regional facility
  - May be a critical link for chemical recycling of plastics in the future

Learnings: Modernized Single-Stream MRFs

- Benefits
  - Reduces manual sorters
  - Reduces screen maintenance labor
  - Improves commodity quality
  - Reduces the production of hard to market mixed grades
- Drawbacks
  - Increases capital cost
  - Requires skilled maintenance staff
- Considerations
  - Technology may not be adaptable to changes in incoming material mix

Learnings: Dual-Stream MRFs

- Benefits
  - Less incoming contamination than single-stream programs
  - Less film in paper stream so less daily screen maintenance (if screens used)
  - Better able to sort small items than single-stream MRFs
- Drawbacks
  - None
- Considerations
  - Can process commercial paper but not commercial single-stream

Learnings: Commercial Dry-Waste Sorting

- Benefits
  - Reduces commercial waste landfilled
  - Equipment has flexibility to process differing waste and recycling streams
- Drawbacks
  - Losses to residue since one size does not fit all
- Considerations
  - Need flexible tip fees charged since incoming value/contamination/residue varies by hauler and jurisdiction
  - Often located at an integrated complex with clean MRF, landfill, transfer station, construction and demolition debris recycling or organics processing

Processing System Case Studies

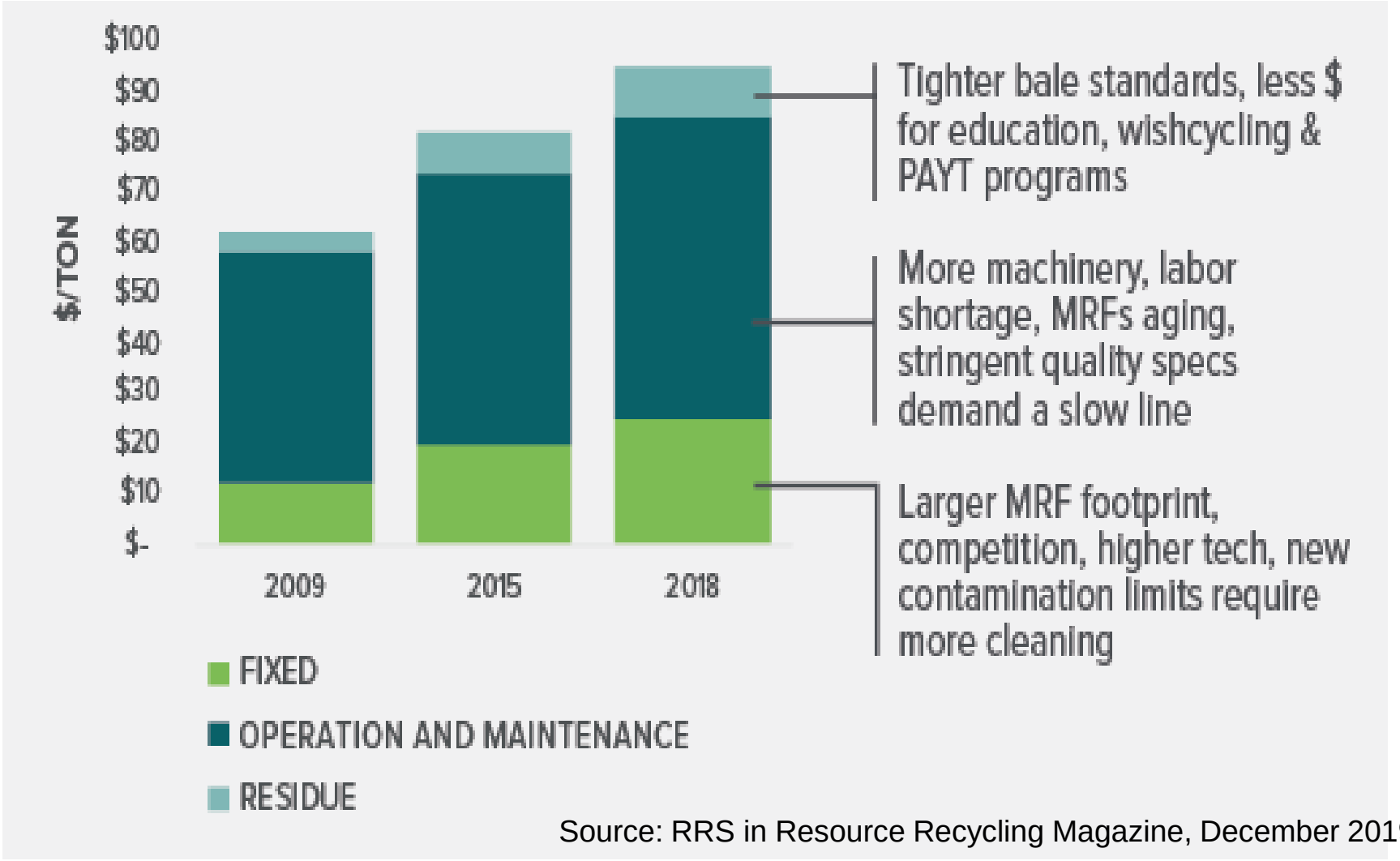
Processing type	Container Recovery Facility	Secondary MRF	Modernized Single-stream MRF			Commercial Dry Waste	Dual-Stream
Case study examples	Merlin Plastics	Titus MRF Services	Balcones Resources	Firstar Fiber	Shoreway Environmental	Monterey RWMD	SWA Palm Beach Co.
Primary stream	Residential containers	Container-rich residue	Residential single-stream	Residential single-stream	Residential single-stream	Residential single-stream[1]	Residential dual-stream
Residential capacity (tons/hour)	21	8	30	10	25-30	30	45
Glass accepted?	No	No	Yes	No	Yes	Yes	Yes
Inbound contamination	>20%[2]	Not applicable	18.2%	8.7%	Unavailable	22%	7.4%
Residue rate	Minimal (most to energy)	~50%	20.3%	12%	20%	36.8%	14.3%
Recyclables quality	Meets ISRI specifications	Meets ISRI specifications	Meets ISRI specifications	Meets ISRI specifications	Meets ISRI specifications	Meets ISRI specifications	Meets ISRI specifications
Advanced equipment used							
Wrap-resistant screens	Not applicable	Not applicable	yes	no	no	yes	no
Advanced air separation	Not applicable	Not applicable	0	0	0	2	Not applicable
Fiber line optical sorters	Not applicable	Not applicable	3	0	0	2	0
Ballistic separators	yes	0	0	1	0	0	Not applicable
Container optical sorters	12	4	2	2	4	3	2
Artificial Intelligence robot sorters	1	0	2	1 (not used)	0	0	0
Manual sorters (for residential)	Not disclosed	Not disclosed	15	20	Unavailable	Unavailable	~30
Capital cost (millions)	Not disclosed ($23 + upgrade)	$15 plus building	$25 (2012) $6 (2019)	$20-25	$17 (2009) plus building	$24 (2018) plus building	$40 (2009)
Cost per ton shipped	Not disclosed	Not disclosed	Proprietary	Proprietary	Unavailable	Unavailable	<$170

1 The processing system can process commercial dry waste or residential single-stream recyclables. It currently is only processing residential recyclables.
2 Includes paper that is not desired, but which is able to be recycled.

Processing Costs

- Most case study facilities could not or chose to not provide cost/ton data
  - Proprietary and not willing to publicly disclose
  - Have not allocated costs between commercial and residential tonnages
- Dual-stream processing cost
  - Normally less than single-stream
  - SWA PBC seemed to have a higher cost than typical single-stream MRFs its size
  - SWA pays sorters a living wage and sorts to high quality and premium grades
- Considerations
  - Labor cost is increasing driving up sorting cost
  - Don‘t compare old fees locked in by contracts to today‘s costs – not representative

Processing Costs are Increasing Exponentially



Source: RRS in Resource Recycling Magazine, December 2019

Recommended for Scenario Analysis

- Modernized single-stream MRFs
  - Least disruption to existing infrastructure
  - Increases quality of marketed recyclables
  - May increase system cost
- Dual-stream collection and processing
  - Potential for reduced incoming contamination
  - Less fiber loss to container line compared to single-stream
- Container recovery facility
  - Potential to collect and market more plastics and paper containers than other approaches
  - May reduce total system cost

Not Recommended at this Stage

- Secondary MRF
  - Economics at scale yet to be proven – cost may depend on energy markets for residuals
  - May be an important future infrastructure element for chemical recycling of plastics
- Commercial dry waste processing
  - Increased sorting and residue disposal cost vrs. single-stream commercial recycling
  - Needs flexible front-end equipment to process residential recyclables on the same line

Questions?

Tim Buwalda

407.756.7220

tbuwalda@circular-matters.com

Circular Matters

Improving Oregon Recycling Systems Infrastructure Research

Processing Alternatives Research Summary (Phase 2 Task 2)

February 6, 2020

Processing Technology Research Summary

Research Overview

Cascadia Consulting Group with subcontractors Circular Matters and Drennen Consulting Services researched seven types of processing systems/material recovery facilities (MRFs) to understand the operations, costs, and impacts. The goal of this task was to provide DEQ and Partners with information on alternative processing methods that will help them decide which collection and processing methods to include in scenario analysis.

This memorandum summarizes the benefits, drawbacks, and other relevant considerations of the processing systems included in case studies. It also includes recommendations on which processing systems to consider including in scenario analysis.

In this report these terms have the following meaning:

- "Contamination" in the context of collected materials is non-requested materials in incoming source-separated recycling streams.
- "Contamination" in the context of marketing sorted materials, refers generally to materials not desired in the commodity grade by a market. In paper commodities, it is normal to have two separate specifications for contamination, one for "prohibitives" and another for "outhrows."
- "Prohibitives" are any materials which by their presence in a packing of paper stock, in excess of the amount allowed, will make the pack unusable as the grade specified, or any materials that may be damaging to equipment.
- "Outthrows" are all papers that are so manufactured or treated or are in such a form as to be undesirable for consumption as the grade specified.
- "Residue" is the combination of contamination removed and target recyclables not successfully sorted by MRFs that process source-separated recyclables – this residue may be disposed or sent for additional processing to a secondary MRF. For MRFs that process waste streams, including construction and demolition debris and commercial dry waste, "residue" is all materials that are disposed and not sorted from the waste stream into recycling, beneficial use, or energy recovery streams.

Following the memorandum are case studies for each of the processing systems researched.

Systems Researched

Summary of Case Study Facilities

Below are brief descriptions of each facility included in the case studies, including facility name, location, material streams processed, capacity, and utilized equipment. Full case studies are provided in the appendix. The appendix also includes a glossary that describes how types of equipment functions in the sorting and contamination removal processes in MRFs.

Secondary Container Recovery Facility Taking Unsorted Containers from Single-Stream MRFs and/or Dual-Stream MRFs

Merlin Plastics Supply, New Westminster, British Columbia, Canada. Merlin accepts mixed plastic, metal, and paper drink containers for sorting from single-stream and dual-stream collection programs in the Pacific Northwest, using 12 optical sorters and one robot. Local MRFs supplying materials separate paper from containers in single-stream programs, and they remove contaminants, but they otherwise do not invest in container-sorting equipment.

Secondary MRF for Unwanted Materials from Single-Stream MRFs

Titus MRF Services, Los Angeles, California. Titus currently only has one facility and targets unwanted materials from single-stream MRFs for additional sorting, using screens, four optical sorters, and manual sorters. Titus conducted a demonstration of its technology and approach in Portland, Oregon in 2019. The demonstration report is available here: https://www.plasticsindustry.org/supply-chain/recycling-sustainability/new-end-market-opportunities-nemo/pacific-northwest-secondary.

Modern MRFs Sorting Single-Stream Collection

Balcones Resources, Austin, Texas. This single-stream MRF sorts 30 tons per hour with non-wrapping screens, paper line and container line optical sorters (five total), and two robots. It is majority owned by Closed Loop Partners (Closed Loop Fund). The facility also processes significant amounts of commercial fiber and commercial single-stream.

Firstar Fiber, Omaha, Nebraska. This single-stream MRF sorts 10 tons per hour with a ballistic separator, container line optical sorters, and a robot. The facility also processes significant commercial fiber and commercial single-stream.

Shoreway Environmental Center, San Carlos, California. This single-stream MRF processes both residential single-stream (30 ton per hour) and commercial single-stream (20 tons per hour). Each line has an in-feed conveying materials to separate pre-sort stations and screening system that includes an OCC and debris roll screen to separate containers and fibers. Fibers from each line conveys materials to an assorting platform with four separate conveyors, two for each line. Containers from both lines are combined on a single process line with a series of three optical sorters and an eddy current separator. The system also includes a glass recovery system.

Commercial Dry Mixed-Waste Sorting for Recyclables (Integrated MRF)

Monterey Regional Waste Management District, Marina, California. This integrated MRF is designed to process 40 tons per hour of mixed commercial waste or 30 tons per hour of residential single-stream recyclables on its main sorting line, and 40 tons per hour of self-haul construction and demolition debris (C&D) on a second processing line. Before accepting delivery of the equipment, the District required the system to pass third-party performance testing with mixed commercial waste. Because of local area residential recyclables processing capacity needs, the MRF is currently processing primarily residential single-stream recyclables and little mixed commercial waste, as well as self-haul C&D debris. The MRF has multiple screens, two Nihot air single-drum separators, three optical sorters on the containers line, and one optical sorter on the fiber line.

Dual-Stream MRF(s) (glass with containers)

Solid Waste Authority (SWA) of Palm Beach County, West Palm Beach, Florida. The SWA's MRF is the largest publicly-owned dual-stream MRF in the country and one of the top two or three largest dual-stream MRFs operating in the United States. The MRF is designed to process 30-35 tons per hour on its fiber line, and 15 tons per hour on the container line. While it contracts for operation and maintenance of the MRF, it markets its own recyclables and is one of the few MRFs to audit the quality of bales. This facility uses two optical sorters to assist in sorting containers.

Results of Research

Secondary Container Recovery Facility Taking Unsorted Containers from Single-Stream MRFs and/or Dual-Stream MRFs.

Merlin Plastics has an existing facility operating at-scale in British Columbia (BC) that processes principally materials from the province as well as material from Oregon and Washington. Because of extended producer responsibility (EPR) for packaging and printed paper in BC, Merlin had a guaranteed flow of the tonnages needed to build its container recovery facility (CRF).

A CRF is different from a secondary MRF in that the primary MRFs are not supposed to sort containers at all and instead supply them to the CRF for advanced sorting, transferring them either baled or loose. CRFs can process either containers collected in dual-stream programs or can be designed to process both single-stream and dual-stream recyclables.

There are few examples of CRFs in the United States. Sims Municipal Recycling operates a CRF, the Sunset Park Material Recovery Facility, in New York City. Although Sims primarily processes loose containers delivered from the New York City dual-stream residential recycling program, it also buys and sorts mixed plastics bales from other MRFs in the Northeast. Primarily accepting materials loose directly from dual-stream collection vehicles from a megacity with a population of 8 million, and operating under a 20-year municipal contract, the Sims container MRF is a special case and that would not be transferrable to Oregon.

Financial terms for incoming material for both Merlin and Sims depend on the composition of incoming materials being primarily recyclable. Because only containers collected by dual-stream programs, or containers separated from single-stream programs are received by the CRF, the percentage of incoming material that is non-recyclable or non-container is much smaller than that of the secondary MRF approach.

Benefits

Local primary MRFs can be smaller, simpler, and more geographically dispersed. Fiber can be sorted and baled locally including at local commercial paper recycling sorting and baling establishments since they are more prevalent than MRFs. According the U.S. Census there are over 1,600 such paper recycling establishments in the U.S. but only a little over 500 MRFs. If single-stream collection is used, screens and/or ballistic separators may need to be added to separate paper from containers since commercial paper recyclers do not normally have such equipment. Less transfer of loose recyclables, notably paper, is needed. These local paper recyclers are already shipping OCC, office paper, and pre-consumer paper to mills and they can add residential fiber to their businesses rather than transferring fiber to the Metro area saving transportation cost.

MRFs need not invest in additional container sorting technology. MRFs need not invest in polishing screens, ballistic separators, or other fiber removal technologies or container sorting technologies. Manual removal of contaminants before baling or transport is all that is required.

Processing infrastructure can be optimized. A financially-optimized processing network across a state or region is possible. Expensive technologies can be concentrated at fewer CRFs rather than at all MRFs.

Marketable materials that are present in smaller quantities can be added to the list of accepted recyclables by collection programs. The larger scale of CRFs allows categories of recyclables with small quantities to be added to collection programs. Materials such as PLA plastic, polypropylene, and polystyrene can all be added to collection programs and sorted for domestic markets, rather than having MRFs depend on export markets for mixed container sorting. For example, some MRFs in Oregon are not currently sorting cartons to the PSI 52 grade. Instead they are left in mixed paper and/or allowed to become part of residue. A secondary container recycling facility would allow them to be sorted as their own grade for recycling by premium markets in Korea, the United States, or Mexico.

Drawbacks

Glass may need to be separately collected. While not currently a drawback for Oregon because it is the norm, the need for separate glass collection is considered a drawback of this processing type for other states. Rural communities that are more than a reasonable transfer distance from a CRF (e.g., more than 100 miles) may need to collect glass separately so that the mixed containers can be baled without glass in the bales. Otherwise glass shards would become embedded in the plastics.

Other Considerations

Container flows must be guaranteed. It may be difficult for a CRF developer to obtain financing to construct a large-scale CRF without a commitment from enough primary MRFs to send all of their valuable containers such as natural HDPE bottles, PET bottles, and aluminum cans to the CRF unsorted.

Merlin has existing operations in Oregon. Merlin is a joint venture partner in the ORPET reclamation plant. Merlin has the potential to consolidate container sorting at or near an existing reclamation plant, similar to what Merlin has done in BC and its California locations.

Secondary MRF Taking Unwanted Materials from Single-Stream MRFs

Titus is unique as the only known company in the United States to target unwanted materials from single-stream MRFs for secondary sorting using a high technology approach. Currently, Titus has only one facility. Its secondary MRF in Los Angeles is a retrofitted, former single-stream MRF that can process eight tons per hour of materials. This secondary MRF serves as a reduced-scale demonstration facility for its technology and business case. The demonstration facility operates with two optical sorters and manual sorters, but Titus' vision is for larger secondary MRFs operating around the country sorting 100,000 tons per year per MRF (approximately 25 tons per hour) using more optical sorters.

Titus believes that such a secondary MRF could be located in the Pacific Northwest servicing Oregon and Washington, and that it could process 100,000 tons per year of unwanted materials from MRFs, so that an estimated 50,000 tons per year of additional recyclable materials could be recovered at a regional Secondary MRF, including approximately 23,000 tons of mixed paper, 10,000 tons of polypropylene (PP), 4,800 tons of PET bottles, 2,800 tons of cartons, 2,000 tons of polyethylene (PE), and 800 tons of polystyrene (PS). Such secondary sorting would improve overall recovery of residential recyclables by an estimated 3 to 6%.

Benefits

Landfilled materials are reduced, and more packaging is recycled by including a secondary MRF servicing a region. Titus is able to recover at least half of materials discarded by MRFs and market it to commodity markets. Some of this marketed material consists of materials that were not successfully sorted by MRFs as well as "small percentage" materials such as PS, Polylactic Acid plastic (aka compostable bioplastic), PP, and cartons that are not generated in sufficient quantities for MRFs to sort and store materials until truckload quantities accumulate. Additionally, the other half of discarded MRF materials are not marketed as commodities and can be processed into a feedstock intended for cement kilns or plastics chemical recycling technologies.

Small MRFs can be established in rural areas to partially process single-stream recyclables. A secondary MRF allows small MRFs processing 5-10 tons per hour of residential recyclables to be established throughout a larger area in a hub-and-spoke model. Small MRFs could use a screen and/or ballistic separator to separate fibers from containers to allow them to accept single-stream recyclables, then send unsorted containers to a secondary MRF or container recycling facility for additional sorting. These small, local MRFs would be able to sort and market fibers, sort out select containers using simple magnets and eddy current separators, potentially with some manual sorting of PET and HDPE bottles, and the remaining material would be baled and shipped to a secondary MRF or container recycling facility.

Medium and large single-stream MRFs need not invest in additional container-sorting technology. While primary MRFs may need to make some modifications to produce ideal feedstock for a secondary MRF, they would not need to invest in polishing screens, ballistic separators, or other fiber removal

technologies to remove small paper from the container sorting stream to allow it to be recycled. Furthermore, materials that are a smaller percentage of the total from the incoming stream (such as cartons, PP, injection tubs/lids, PS, thermoform PET, and 3-7 plastic containers) can be recovered by the secondary facility without primary MRFs needing to invest capital in robotic technologies or additional optical sorters or increase operating costs with additional manual sorters. The container-line discarded materials can be more cost-effectively sorted by a secondary MRF. It should be noted that some MRFs in Oregon have committed private capital and received Metro grants to upgrade processing equipment, including robotics and optical sorters.

Drawbacks

Uncertain economics. Titus' full-scale concept is not yet operating, so the economics are uncertain. Currently about half of received material is disposed. Double handling and transporting this unmarketable material increases the cost of a secondary MRF, which increases processing tip fees. As a result, a local MRF may or may not realize a financial benefit from partnering with a secondary MRF, which may depend on distance to the secondary MRF and local disposal tip fee levels.

Potential for increased cost. The demonstration project also concluded that adding a secondary MRF to increase material capture could increase ratepayer costs if increased commodity sales and avoided landfill disposal costs do not fully cover the secondary MRF's processing fee and any additional costs for expanded recycling service. Titus estimated that at least $8 per ton of additional funding may be required for MRFs to send residue to a secondary MRF versus disposing of it.

Other Considerations

Need for container-rich residue. The Pacific Northwest Secondary Sorting Demonstration Project, conducted by Titus, found that the non-recyclable component of residue from current Oregon MRFs was larger than would support the business case for a secondary MRF. A secondary MRF would need a residue stream with more containers to be economically viable.

Assurance of supply. The demonstration project also concluded that a secondary MRF in the Pacific Northwest would need to serve both Oregon and Washington to achieve economies of scale and would need to establish long-term supply agreements with primary MRFs for guaranteed quantities of container-rich residue. Expanding recycling collection programs and materials lists would also support the need for more supply.

Transition to chemical recycling markets. Secondary MRFs could be an important part of a future in which plastics that can be cost-effectively recycled mechanically are sorted out and sent to market and the other plastics sent for chemical recycling.

Modern MRFs Sorting Single-Stream Collection

Three MRFs were profiled for the case studies included in this report. The facilities range from 10 to 30 tons per hour of residential recyclables processing. All three also process or have the capacity to process significant amounts of commercial recyclables. By processing more than just residential recyclables the capital cost of buildings and equipment is also spread across commercial tons, which reduces the

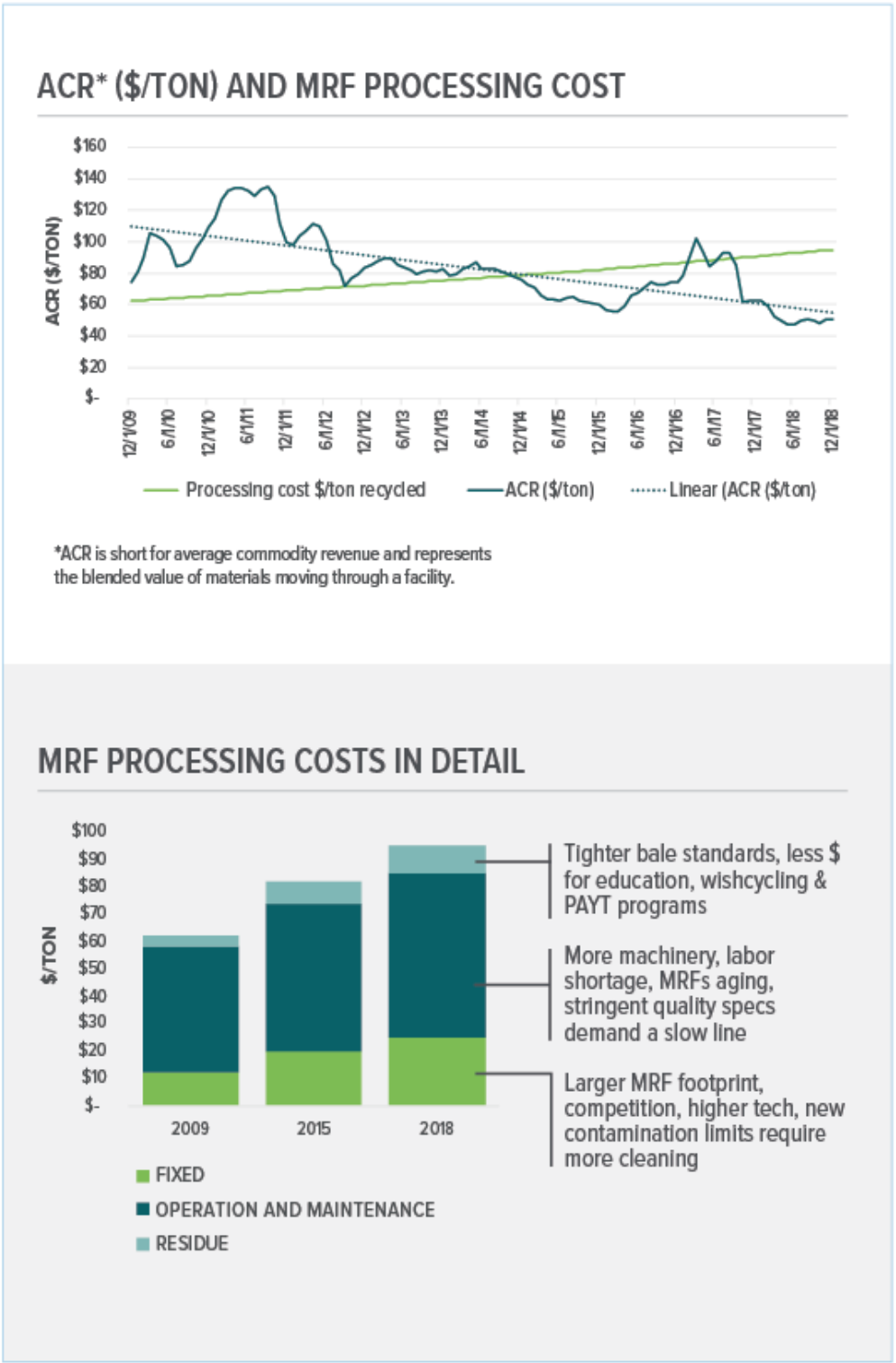
processing cost for both residential and commercial recyclables. While more tons may also mean more than one shift per day, it also results in a lower operating cost per ton before factoring in tip fee revenues and/or materials revenues.

Single-stream MRFs of all sizes are finding they need to invest in more labor and equipment as well as slow their processing speeds to sort and market materials effectively given recent changes in incoming materials from shifts in consumption and package design, increasing levels of incoming contamination, and stricter market specifications related to bale contamination. MRFs are also have increasing difficulty finding and retaining manual sort labor for sorting lines, which is also contributing to either higher sorter wages or more reliance on technology. These changes are significantly increasing processing cost as shown in Figure 1 below. Costs have escalated even more in 2019 and 2020 than shown in Figure 1.

Modern MRFs have invested in technology with advanced screening that is resistant to plastic film wrapping, air separation of materials, and optical sorters on paper sort lines. Some are now adding AI (robotics) to perform quality control and sort smaller volume materials to not only improve bale purity but also reduce labor. Small fiber and three-dimensional fiber received by MRFs is growing and as a result fiber is being carried over to container sort lines. Some modern MRFs are adding optical sorters, ballistic separators, or other processes to recover small fiber from the containers resulting from the initial screening processes.

While some technologies such as larger screens, wrap-resistant screens, and paper line optical sorters are proving effective, other technologies such as artificial intelligence robotic sorters are still undergoing improvements, which is delaying widespread adoption.

Figure 1. Single-Stream MRF Processing Costs (2009 to 2018)



Source: "Data Corner: The expanding cost-revenue gap that is plaguing MRFs," Resource Recycling Magazine, December 2019.

Benefits

Technology reduces manual sorters and daily maintenance. Technology improvements reduce the number of manual sorters needed for sorting work that is low-skill, repetitive, and sometimes dangerous. Wrap-resistant screens also reduce the cost and time spend on screen maintenance. As an example, after Balcones' 2019 retrofits, it was able to reduce its headcount per shift by 43% while increasing its throughput by 25%. Screen maintenance declined from two hours per day to 30 minutes per day as well.

Many MRFs also have difficulty finding laborers willing to do this type of work. According to a December 11, 2019 Waste Dive article:[1]

- "Growth within the automated equipment sector is taking off in a large part because of labor shortages for sorters".
- "A confluence of events on the labor front — especially increasing wages and worker shortages — makes robotic investments especially attractive right now. MRF operators say the machines plug gaps with vacant sorting and picking positions they experience difficulty filling otherwise."
- "'Right now, we're at one of the all-time lows in unemployment, and it's hard to find people willing to work in this environment,' Lakeshore's Schroeder said. In addition, he said, 'we were increasing laborers to help keep the material clean, and the robot was able to reduce that need.'"
- "'It's hard to get [sorters] to show up for work,' said Bell. Waste Management has 2,500-3,000 sorter positions throughout the company and it cycles through an estimated 14,000-15,000 people from temporary staffing agencies each year to fill them."

Improves sorted material quality. Optical sorters used for quality control and sorting, and robotic sorters to a lesser extent, improve material quality. Optical sorters on paper lines can reduce non-paper prohibitives to low levels needed to meet strict paper market specifications. According to Balcones, adding optical sorters to their paper lines resulted in "improving material quality…and they can produce bales with contaminants in the 1.5% range."

Reduces the production of low-value mixed grades, which have less market value and demand. As newspapers have declined, many MRFs shifted to producing only two paper grades from residential recyclables: old corrugated containers (OCC) and mixed paper. Old Newspapers (ONP) is no longer an official ISRI grade and has been phased out. Paper line optical sorters allow PSI 56 Sorted Residential Papers & News to be produced as a value-added grade much like ONP used to be produced in the past. PSI 56 needs to exclude boxboard and unbleached fiber, which must be removed and sorted into either an OCC or mixed paper grade. Similarly on container sorting lines, an additional optical sorter or robot can sort PP and cartons as valuable grades, leaving less common grades of plastics to be disposed as residue instead of being shipped in mixed plastics bales, where they may not have been recycled anyway by export markets that they were previously shipped to.

[1] https://www.wastedive.com/news/recycling-labor-mrf-robots-move-in/568554/

Drawbacks

Increases sorting cost. It typically costs several million dollars to upgrade MRFs with the latest advanced sorting equipment. Balcones was fairly new, having originally opened in 2012 with a $25 million investment, which was supplemented with $6 million dollars in capital upgrades in 2019. Firstar's limited 2018 upgrade cost was $2.4 million, but the facility feels that it could benefit from additional upgrades, including paper line optical sorters and wrap-resistant screens. Costly capital upgrades increase the per-ton sorting cost. These upgrades may be affordable only for larger MRFs or MRFs that have enough volume to spread the capital costs across multiple shifts. New MRFs will need to be larger to afford $10-$20 million of advanced processing equipment.

Requires skilled maintenance staff. Robotics and optical sorters have optical systems and computer systems that are not as easy for general mechanical maintenance staff to maintain. While they may reduce unskilled labor requirements, the cost of skilled maintenance technicians increases.

Other Considerations

The changing ton. Capital sorting equipment is designed for a ten-year life. Rapid changes in the composition of incoming recyclables creates a risk that capital equipment with fixed throughput capabilities will need to be upgraded due to material stream changes before the equipment is fully depreciated. Balcones felt the need to upgrade its sorting system after only seven years of use. Optical sorters and robots can be reprogrammed to sort different materials and are flexible in terms of sorting different materials in the future; however, they are limited on a ton-per-hour sorting capacity basis.

Commercial Dry Mixed-Waste MRF Sorting for Recyclables (Integrated MRF)[2]

Monterey Regional Waste Management District desired an integrated complex that could receive and sort 40 tons per hour of mixed commercial waste, 30 tons per hour of single-stream residential recyclables, and 40 tons per hour of self-haul construction and demolition debris (C&D). The mixed commercial and single-stream residential material are processed on a single line, intended for separate shifts, with the C&D sorted on a separate line. Before accepting delivery of the equipment, the District required the system to pass third-party performance testing with mixed commercial waste. Because existing MRFs in the region were older and lacked advanced sorting capabilities, Monterey has used the residential/commercial sort line to exclusively sort single-stream recyclables over two shifts and not performed significant commercial dry waste sorting since the performance testing. The system is new, having started in 2018. The equipment cost was approximately $13 million, excluding the cost of the building. Despite being new, Monterey would like to make some modifications such as adding feeding and screening more applicable to residential recyclables versus commercial waste as well as adding robots for quality control.

[2] Dislaimer: Doug Drennan supported facility design and processing systems procurement for this MRF.

Benefits

Minimize commercial waste disposal. Except for food service establishments, most commercial waste is dry and rich in fiber. The Monterey MRF represents a second- or third-generation equipment line designed to process mixed waste. Many first-generation plants are located in Europe where the primary purpose is to recover high-end commodities; remove metal, glass, and inerts, and then send the byproduct to a waste-to-energy facility. The Monterey MRF is designed to maximize recovery of all commodities, separate a mixed organics stream, and reduce waste disposed in landfills. The residue could be used as a fuel product for energy, something done by other facilities processing mixed commercial waste.

Flexibility. The Monterey MRF demonstrates how an advanced integrated system can be designed to process several waste streams, including commercial waste and residential recyclables, and maximize recovery. The system has shown the flexibility to meet Monterey's goals and offer the opportunity to expand and handle additional materials.

Drawbacks

Fundamentally different streams need to be sorted differently. The system was not designed to handle the amount of single-stream recycling that it currently processes. After the introduction of China National Sword policies, jurisdictions in the region needed a MRF that could process their materials more cost effectively than the older MRFs they had been using in order to minimize negative impacts on their recycling programs. The front end of this system uses a 12" minus screen to split "unders" from larger items for further sorting. This front-end system is less effective when processing primarily single-stream recycling, losing much of the small fiber and some valuable containers through the screen, which can then become contaminated with wet organics in the unders stream.

With long-term commitments from these jurisdictions to continue delivering single-stream recycling, the Monterey MRF is planning to retrofit the equipment line in 2020 with a different front-end screen better suited to residential single-stream material and then convey the material to the back-end system equipped with advanced technology to maximize recovery. With these minor improvements, this system will be able to handle both the mixed commercial waste it was designed and performance tested for as well as a much larger volume of single-stream recycling.

Other Considerations

Accountability and contamination reduction. This facility has a universal service contract with a single hauler, creating direct accountability between the MRF operation and the collection services. The Monterey MRF measures the level of contamination and can assess penalties. The solid waste district also realizes the importance of maintaining an aggressive promotion/education system and has offered participating jurisdictions incentives to implement those programs. Having a MRF that is capable of processing more materials can make it more attractive to smaller communities.

Valuing landfill avoidance. New state laws have driven investments in MRFs in California, ranging from several large, publicly-owned MRFs to private, mid-size collection companies that operate MRFs with advanced technologies. In most cases, these private mid-size companies and public entities do not own landfills, so they are subjected to a true avoided cost model.

Bottle bill deposits supplement MRF economics. Redeeming California redemption value (CRV) deposits from sorted containers also provides a large revenue benefit that offsets the cost to operate MRFs in California.

Dual-Stream MRF(s) (glass with containers)

Over 90% of the tonnage of residential recyclables in the U.S. are now collected single-stream and processed in single-stream MRFs. Most of the remaining dual-stream MRFs are small scale and located in rural communities. The largest dual-stream system in the United States is in New York City, with a population that exceeds 8 million. New York's containers are delivered to Sims Sunset Park Material Recovery Facility, which resembles a container recycling facility since it does not process residential fibers (curbside collected paper is direct-delivered to a Pratt paper mill on Staten Island). For these reasons we did not consider New York City to be a good model for Oregon. While there are a number of small dual-stream MRFs in small communities, the Project Team selected the largest public sector dual-stream MRF in the U.S. to profile due to the availability of public data on processing cost and processed material quality.

The Solid Waste Authority (SWA) of Palm Beach County Florida operates a dual-stream MRF that is one of the three largest MRFs for dual-stream residential recyclables in the U.S. The other two MRFs are private MRFs in the Northeast. Although Sims Municipal Recycling operates the largest container recycling MRF in the U.S., it does not handle the paper from New York City's residential recycling program and is focused only on container sorting. In this respect it is more like a container recycling facility than a dual-stream MRF. Incidentally, Sims Municipal Recycling is the contract operator for the Palm Beach MRF. Most other dual-stream MRFs in the U.S. are highly manual and use limited technology, so they were not considered meaningful case studies for this research.

The Palm Beach MRF opened over 10 years ago at an original cost of $40 million for both the building and equipment. It has two optical sorters, but otherwise lacks new equipment. The MRF has a separate commercial single-stream sorting line. As the residential recycling stream has evolved in the past decade, the container sorting part of the plant is at its sorting limit. The SWA would like to upgrade its container sorting line with higher capacity optical sorters as well as add optical sorting to its paper lines so that it can produce more of PSI 56 Sorted Residential Papers & News and reduce its labor costs. Its current residential papers grade has too much unbleached fiber to officially count as that grade.

The Palm Beach MRF has a high processing cost at $95 per ton of incoming material (as much as $170 per ton marketed if unwanted materials disposal and building and equipment replacement costs are included) despite factors that should reduce processing costs. Factors that reduce processing costs include: the MRF has a high throughput capacity (45-50 tons per hour), incoming contamination is reasonably low at 7.4%, and less labor and equipment are needed than in a single-stream MRF because the material is dual-stream.

Benefits

Low contamination rate. Dual-stream collection programs where recyclables are set out in bins allows collectors who are manually loading the recyclables into the collection vehicle to visually inspect the recyclables and leave behind contamination for education of the residents — this reduces future

contamination if collectors leave and tag contaminants. Bins are more common than roll carts in dual-stream collection systems and the SWA's system uses bins. SWA collection employees also tag bins when they have high levels of contamination. The SWA attributes its low contamination rate in marketed recyclables to its dual-stream collection and sorting system, and its fiber grades can be consistently marketed. Its mixed paper has always sold for at least $18 per ton, even while mixed paper from other MRFs has sold for nothing or for negative value.

Reduced daily maintenance. The SWA has conducted educational campaigns to ensure that film plastics are not included in either the paper or container recycling streams. Although the SWA uses paper screens to help, it produces Sorted Residential Papers & News in addition to mixed paper, its screens are not wrap-resistant. Despite this fact, the SWA's dual-stream collection and its educational programs keep the need for film removal from the paper screens to a manageable level. Its optical sorters are standard with what other MRFs use.

Drawbacks

Old equipment design. Despite the fact that the SWA has a high throughput, is mostly relies on manual sorting like other dual-stream MRFs that are much smaller than it. Labor in Palm Beach County is expensive as well, and as a result the SWA's processing cost is high. The SWA believes that upgraded optical sorting on its paper and container lines will allow it to reduce headcount and sorting cost while improving sorted commodity quality and capture of desired commodities that are currently being lost to residue.

Other Considerations

None

Comparison of Systems

Table 1 provides a matrix of key elements of the different system types reviewed. It should be noted that container recycling facilities and secondary MRFs are secondary facilities that do not directly replace primary MRFs and so they are not directly comparable to MRFs in terms of processing cost, equipment utilized, and throughput.

Table 1. Comparison of Processing Systems

Processing type	Container Recovery Facility	Secondary MRF	Modernized Single-stream MRF			Commercial Dry Waste	Dual-Stream
Case study examples	Merlin Plastics	Titus MRF Services	Balcones Resources	Firstar Fiber	Shoreway Environmental	Monterey RWMD	SWA Palm Beach Co.
Primary stream	Residential containers	Container-rich residue	Residential single-stream	Residential single-stream	Residential single-stream	Residential single-stream[1]	Residential dual-stream
Residential capacity (tons/hour)	21	8	30	10	25-30	30	45
Glass accepted?	No	No	Yes	No	Yes	Yes	Yes
Inbound contamination	>20%[2]	Not applicable	18.2%	8.7%	Unavailable	22%	7.4%
Residue rate	Minimal (most to energy)	~50%	20.3%	12%	20%	36.8%	14.3%
Recyclables quality	Meets ISRI specifications	Meets ISRI specifications	Meets ISRI specifications	Meets ISRI specifications	Meets ISRI specifications	Meets ISRI specifications	Meets ISRI specifications
Advanced equipment used							
Wrap-resistant screens	Not applicable	Not applicable	yes	no	no	yes	no
Advanced air separation	Not applicable	Not applicable	0	0	0	2	Not applicable
Fiber line optical sorters	Not applicable	Not applicable	3	0	0	2	0
Ballistic separators	yes	0	0	1	0	0	Not applicable
Container optical sorters	12	4	2	2	4	3	2
Artificial Intelligence robot sorters	1	0	2	1 (not used)	0	0	0
Manual sorters (for residential)	Not disclosed	Not disclosed	15	20	Unavailable	Unavailable	~30
Capital cost (millions)	Not disclosed ($23 + upgrade)	$15 plus building	$25 (2012) $6 (2019)	$20-25	$17 (2009) plus building	$24 (2018) plus building	$40 (2009)
Cost per ton shipped	Not disclosed	Not disclosed	Proprietary	Proprietary	Unavailable	Unavailable	<$170

[1] The processing system can process commercial dry waste or residential single-stream recyclables. It currently is only processing residential recyclables.

[2] Includes paper that is not desired, but which is able to be recycled.

As Table 1 shows, the dual-stream MRF has the lowest level of incoming contamination of the primary MRFs. Its operating contract allows up to 10% of targeted recyclables to be missed in sorting and be disposed as unwanted materials. This allowance may be part of why the facility has a somewhat high rate of unwanted materials in comparison to incoming contamination levels.

The tons per hour per manual sorter were 2.0 for Balcones, 0.5 for Firstar, and 1.5 for the SWA. Several factors impact this calculation:

- Modernization upgrades to incorporate optical sorters, wrap-resistant screens, and robots can reduce manual sorter headcount and improve the tons/sorter calculation;
- High incoming contamination levels reduces sorter productivity;
- Facility ton per hour capacity impacts sorting efficiency — facility efficiency improves at higher throughput rates.

Two of the five primary MRFs have installed optical sorters on their fiber lines. The other three expressed either future plans or a desire to also add fiber line optical sorters to remove non-paper materials and upgrade a portion of the fiber stream to more-valuable PSI 56 Sorted Residential Papers & News grade in comparison to the mixed paper grade.

Previously it was discussed, and the above table shows, that proprietary information on cost could not be included in this public report. Two of the private single-stream MRFs did share cost-per-ton data that can be used as averages and for sensitivity analysis when modeling Oregon-wide results. The research team also has experience, data, and modeling tools that will be used for systems analysis in the next steps of the project.

It should be noted that MRF operating costs and revenues are rapidly changing due to changes in incoming contamination, market quality measures, labor cost and availability, and equipment cost and effectiveness. A discussion with Oregon MRFs suggests that a 1.5 to 1% bale contamination limit increases the processing cost to $140 to $150 per ton rather than lower costs (and higher contamination rates that were tolerated in previous years) because the belt runs slower, more sorters are needed on the line, additional technology is needed, and in some instances, a second sort may be necessary to achieve the required specification. The factors noted above are MRF capital and operating responses resulting in significant changes in sorting cost.

Table 1 shows example MRF processing fee increases to contracted communities that occurred in 2019. This table is not a comprehensive list of fee increases, but is believed by the project team to be representative of increases in the MRF processing industry.

Table 2. 2019 MRF Processing Fee Increases

Processor	Jurisdiction	Old[1]	New[1]
Casella	Gouldsboro, ME	$45	$140
Firstar Fiber	Omaha, NE	$26	$110
GEL Recycling	DeBarry, FL	$0	$80-120
GEL Recycling	Deland, FL	$35	$80
GEL Recycling	New Smyrna Beach, FL	$35	$80

GEL Recycling	Volusia County, FL	$35	$80
Republic services	Kirkwood, MO	$35	$115
Sims Municipal Recycling	SWA Palm Beach Co., FL	$77	$95
Waste Management	Largo, FL	($50)	$105
Waste Management	North Lauderdale, FL	$51	$96
Waste Management	Baltimore, MD	$54	$82.93
Waste Management	Philadelphia, PA	$30	$90-100
Waste Management	Richland, WA	($16)	$122
WCA	St. Petersburg, FL	n/a	$90

[1] Fees are on a dollars-per-incoming-ton basis and include a variety of revenue share agreements, incoming contamination levels, materials accepted (e.g., glass in or out), and financial responsibility for contamination disposal so that comparison among companies and jurisdictions cannot be directly made.

All of the processing agreements in the table above are for single-stream recyclables, except for the SWA of Palm Beach County, which is a dual-stream system. As can be seen from the table, fees increased significantly when opportunities for amending contracts came up in 2019. Contract prices for processing that were negotiated more than two years ago should no longer be considered valid reference points for assessing what current-day and future processing costs may be.

Recommendations

The research team recommends considering the following processing systems in infrastructure scenario analysis:

- **Dual-stream processing.** Dual-stream processing has lower overall MRF unwanted materials rates because incoming contamination is often less (depending on the collection approach and whether carts are used), less fiber is lost to the containers sorting line, sorting costs may be lower, and fiber bale quality is better. Although the SWA case study indicated a higher processing cost than many single-stream programs, it may not be directly comparable to them because:
  - It has a new processing contract that started in the fall of 2019 that is more reflective of current sorting costs whereas other MRF contracts reflect conditions from several years ago; and
  - It requires sorter labor to be paid a living wage that is nearly 50% higher than the Florida minimum wage.

  Furthermore, glass collected dual-stream with containers is cleaner than single-stream glass and requires less processing to meet market specifications.
- **Container recovery facility.** There is significant opportunity to collect more plastic types and sort them into grades that can be consumed domestically. The U.S. in general lacks the capacity to sort mixed plastics, and areas outside of the Portland-Metro area lack the ability to sort containers cost-effectively and market plastics. A container recycling facility option would allow these areas to consider dual-stream collection with local fiber processing and shipment of mixed containers to a central container recovery facility. The containers that are accepted in the collection program could be expanded as well and sent to domestic markets. A CRF can also be paired with a lower level of investment in primary MRFs (such as limiting investments in optical sorting), although the

effectiveness of Oregon's bottle bill in removing valuable containers from the curbside recycling stream reduces the available curbside container stream.

- **Modernized single-stream MRFs**. It is important to evaluate the ability of modernized single-stream MRFs to upgrade fiber to more valuable grades, reduce contamination, and sort plastics for domestic markets. The cost and benefits of such upgrades should be compared to other approaches that may have implications for greater changes to Oregon's existing processing infrastructure.

When forming scenarios for investigation in the next phase of this project, there are two issues that will likely come up for discussion.

1. Policy frameworks and options available to Oregon that could shape a future Oregon collection and processing system; and
2. How a system transition or interest in a transition, if any, could be impacted by processing system investments and upgrades that have been recently made or are in the process of being made.

Neither of these should limit the forming of the scenarios for the next phase of the project. The first issue is in the scope of a different DEQ project and both projects can be mutually informing to each other. The second issue relates to the stranding of assets before fully depreciated, which would reduce existing Oregon MRF's interest in partnering with a secondary MRF or container recycling facility. This is a timing and financing issue that can be addressed.

Appendix 1

Improving Oregon Recycling Systems Infrastructure Research

Container Recovery Facility: Merlin Plastics

Case Study February 6, 2020

Case study completed by Tim Buwalda, Circular Matters, LLC.

Business Overview

Facility Information

Material Recovery Facility (MRF) Name	Merlin Plastics Gifford Plant
Address	351 Gifford Street, New Westminster BC V3M 0A6
Owner	Merlin Plastics
Operator	Merlin Plastics
Startup date or date of most recent major retrofit	Started in 2015 with 75,000 tons per year of sorting capacity. Expanded capacity by an additional 15,000 tons per year by first quarter of 2020.
Anonymity/confidentiality promised to MRF	Merlin declined to provide detailed operating cost information for its Container Recycling Facility (CRF) or a detailed processing flow diagram.
Data Sources (e.g., contacts, articles, or reports)	Tony Moucachen, founder and CEO of Merlin Plastics Supply https://resource-recycling.com/recycling/2019/02/26/west-coast-reclaimers-expand-mixed-plastic-capacity https://www2.gov.bc.ca/assets/gov/environment/waste-management/recycling/recycle/paper-package/ars/2015_mmbc_annual_report.pdf

Facility Information

Case Study Type	Secondary container recovery facility taking unsorted containers from single-stream MRFs.
Capacity/Throughput	90,000 tons per year container sorting capacity in 2020 at the Gifford Street plant. The plant was expanded at the end of 2019 by 20% from the prior 75,000 tons per year capacity because the plant was operating at capacity.
Accepted Generator Streams and Preparation Methods	• Mixed containers from a variety of sources including MRFs that separate containers from single-stream recyclables and ship the containers by transfer trailers and single-stream and dual-stream MRFs that remove contaminants and bale the mixed containers for shipment by van trailer. • Some clean commercial materials. • Some containers directly from dual-stream collection route trucks. •
Inbound Contamination and Outbound Residue and Material Quality	• Merlin chose to not provide average incoming material composition for this case study. • Most of the material received is from programs that exclude glass, film plastics, and polystyrene foam. Most of this material has been pre-sorted to remove some contamination. Although not targeted, 20% of the material Merlin receives is small paper in the mixed container stream, even though their specifications say not more than 5% is allowed. • Merlin sorts all materials for markets, and all are marketed except for PVC. Marketed materials include an undisclosed amount of material sent to a cement kiln for energy recovery. • Marketed material meets North American quality specifications.

Description of Operations and Focus

Merlin Plastics has several facilities. This profile focuses on the Gifford Street container recovery facility in the Vancouver metropolitan area of British Columbia (BC) that accepts residential containers. The area is also covered by a container deposit-return system (operated by Encorp Pacific) and an extended producer responsibility (EPR) program for residential packaging and printed paper (operated by Recycle BC). Merlin Plastic is a partner in a PET reclamation plant in Oregon called ORPET. The company also has wholly owned or joint-venture plastics reclamation plants in Turlock, California; Calgary, Alberta for PET bottles; and Sarnia, Ontario for HDPE and PP plastics. The California plant, Peninsula Plastics Recycling, reclaims PET bottles and also has a 40 million pounds per year sort line to sort mixed plastic container bales that contain PET.

The Merlin-Gifford facility is a state-of-the-art container sortation plant, the largest on the West Coast, where mixed container materials from the curbside recycling collection programs in BC get sorted into their respective streams. This facility also accepts material from recycling programs in Washington State

and Oregon. Plastics sorted by the Gifford plant go to Merlin's BC reclamation plant and Merlin's Calgary facility, which reclaims PET. A new sort line was installed at the end of 2019 to handle bales of plastics #3-#7. This new line will open an additional 15,000 tons per year of sorting capacity for communities throughout the Pacific Northwest.

Merlin is aggressively working to source material from Oregon and Washington MRFs. The Gifford plant will accept custom streams based on what level of sorting the MRFs want to do — anything from mixed containers to fully-sorted plastics commodities. Merlin Plastics seeks long-term agreements and is not interested in short-term or spot market buying. Merlin is also very interested in expanding its Oregon plant to handle more than just Oregon bottle bill PET because Merlin believes it is in a good centralized location to process bottles collected from Pacific Northwest curbside recycling systems; however, the plant is not currently equipped to accept and recycle PET thermoforms.

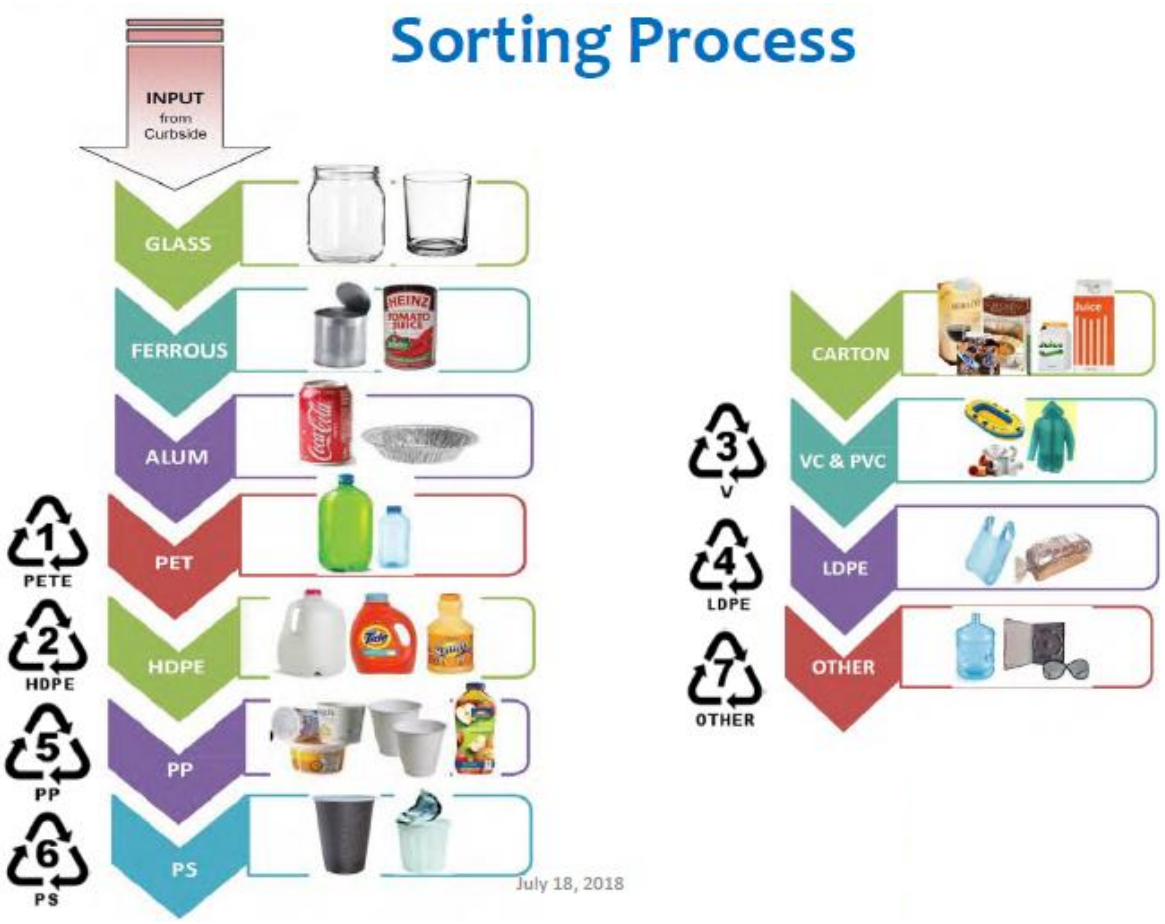
System Overview

Merlin considers detailed information on the processing flow at its Gifford plant to be proprietary; however, it was willing to show a general depiction of the sorting process in Figure 2. The equipment layout and selection were designed by their in-house team and cost over $30 million CAD ($22.58 million USD). Table 3 includes a description of the equipment Merlin uses for sorting.

Table 3. Major Equipment List

Equipment Type	Materials Used On
Ballistic separator	Separates plastic film and fibers from the 3-D containers
Screens	Size separation
Glass crusher	Glass
Glass cleanup	Removes shredded paper and small plastics from the glass
Magnet	Ferrous materials
Eddy current separator	Aluminum
12 Optical sorters	Various purposes including to capture PET, separate PE from PP, capture PS, separate colors, capture PVC, and separate paper from flexible plastics
Suction equipment	Separates paper from film along with optical sorters
1 Robot	Works best for uniform product but is still not good at dealing with variable material
3 Balers	PE, PP, PET and other materials.

Figure 2. Sorting Process



Unusual Maintenance Needs

Optical sorters use compressed air, and this air needs to be clean and dry otherwise the nozzles can clog and the optical sorters are not effective. Merlin believes it is best to have their own experienced mechanics maintain and repair optical sorters because experts from the equipment vendors are expensive to call in. It may not make sense economically to have in-house maintenance staff if a facility is only operating say one or two optical sorters. But, because Merlin is operating a dozen optical sorters, it makes more sense for Merlin to employ an in-house maintenance technician(s) that is specially trained and experienced in optical sorter maintenance and repairs.

Staffing

Merlin has 400 employees across all of its facilities. The Gifford plant runs six days a week with two shifts per day. Merlin would not disclose exactly how many people operate the plant, other than to say it takes in the neighborhood of 75 people to run this type of operation, and that includes many high-skilled and well-paid workers. Merlin believes that its staff are key to its success. Staff retention is a challenge for Merlin, so it pays premium wages to retain skilled employees.

Incoming Materials

Materials Accepted

Merlin's Gifford plant primarily processes residential materials accepted in British Columbia's residential recycling system. Container materials accepted in the program (as would be seen by public) are listed in Table 4.

Table 4. Accepted Materials

Category	Specific Materials
Plastic containers	Plastic bottles, jugs, and jars with screw-on caps or lids, plastic clamshells with hinged lids, plastic bottom trays and tops from delis/bakeries, plastic cups, garden pots and trays, pails, microwavable bowls and cups, and empty coffee and tea pods
Metal packaging	Aluminum food and beverage cans, aluminum aerosol cans, aluminum foil and pie plates/baking pans, steel food cans, steel food and aerosol cans and lids
Paper cartons and cups	Beverage, soup, sauce, and broth cartons, hot and cold drink cups, ice cream cartons

The facility also sorts the following types of streams sorted by primary MRFs outside of BC:

- Mixed containers from MRFs and dual-stream collection programs including all three-dimensional plastic, metal, carton, and glass containers, baled or delivered loose in transfer trailers. However, the facility prefers not to receive PVC or glass.
- Bales of #3-#7 and #1-#7 plastics.
- Individual plastic grades, such as baled HDPE bottles, baled film plastics, baled HDPE bottles.

Incoming Composition

Merlin preferred to not provide average incoming material composition for this case study. Most of the material received is from BC's curbside recycling system, which asks that glass, film plastics, and polystyrene foam be recycled through drop-offs. A significant amount of containers come from 11 MRFs ("pre-conditioning facilities"), which remove large contaminants. Some of these MRFs receive single-stream recyclables and send the separated containers to Merlin for additional sorting. Although not targeted, 20% of the material Merlin receives is small paper in the mixed container stream, even though their specifications say not more than 5% is allowed. The facility receives some PS foam, but not much because this material is not accepted in curbside material.

Outbound Materials and Processing Effectiveness

Materials Shipped

Outgoing products after sorting are:

- HDPE (Natural, Black, Mixed Color)

- PET (Clear, Green)
- PP (Mixed color, Black)
- PS/EPS
- PLA
- Ferrous metal
- Aluminum Beverage Cans
- Other Aluminum
- Glass
- Polycoated paperboard packaging (e.g., cartons and paper cups)
- Mixed paper
- Engineered fuel (sent to a cement kiln)

Everything received is marketed except PVC, which is landfilled. Cartons are sorted and marketed to South Korea with no issues reported. Nearly all of sorted plastics are sent to other Merlin plants, including Merlin's British Columbia plant that reclaims LDPE, PP, and PS and to Merlin's Calgary facility which processes PET. Polystyrene foam is exported for recycling. Other residuals are sent to a BC cement kiln for energy recovery.

Ability to Sort Materials

Merlin believes its large size allows it to invest in equipment to cost-effectively sort materials into a variety of streams by resin type, melt index (e.g., bottles versus tubs), and color. Merlin even sorts and markets materials present in smaller percentages, such as PLA and polystyrene, which are not cost-effective for primary MRFs to sort due to their relatively small quantities found in the annual throughput of primary MRFs. Merlin believes it is far superior to primary MRFs in this respect and its ability to sort desired recycling program materials.

Merlin said that its key to sorting effectiveness is having the right equipment and the right staff to maintain the equipment. The equipment works but only if used appropriately with the right engineering and maintenance teams to keep it fully operational. Using advanced equipment can reduce the number of laborers, but facilities may need to add highly paid technical staff.

Merlin doesn't feel that robotic sorting technology is quite "there" yet as a total replacement for manual sorters. Robots work best when the material to be sorted is uniform in nature, and removal is challenging with the different shapes to be sorted. Robots also require a somewhat high level of maintenance. Lenses need to be kept clean for accurate detection, and dust and glass shards can get into the arms of the robots, requiring additional maintenance.

Merlin said that creating a good working system is not a plug and play process and that it has succeeded due to its engineering capabilities. Merlin also believes it is successful because it is flexible and has the expertise to evolve its system with the evolving nature of the incoming material streams and markets.

Merlin passionately believes that it doesn't make sense for every MRF to install advanced technology, such as optical sorters and robotics. Merlin believes that hi-tech MRFs with high throughput and multiple shifts may be cost-effective in large metro areas, but less populated areas should focus on sorting out fiber from containers, if collected single-stream, removing contaminants and pushing non-

fiber materials (potentially excluding cartons) to a CRF. As previously mentioned, Merlin has expressed interest in expanding processing of Oregon recyclables.

Financials

As noted, the original investment in the Gifford plant in 2015 was roughly $22.58 million USD. Merlin declined to provide the cost of their 2019 expansion. Merlin also declined to provide their operating cost.

Merlin said another key to its success is establishing long-term relationships with all suppliers. They structure revenue paid or fees charged for incoming recyclables based on direct composition sampling of incoming material and adjusting pricing based on exactly what each supplier is providing, in essence using custom pricing. Suppliers can choose in advance how much they want to invest in sorting at their MRF versus sending material for Merlin to sort.

Recycling Regulations

The facility receives material from generators affected by the following types of regulations.

Regulation Type	Regulation Details
Bottle bill	British Columbia's Return-It deposit system covers most beverage containers including aluminum, plastic, glass, bi-metal, cartons (gable top and aseptic drink boxes), pouches and bag-in-a-box. The primary exclusion is containers for milk, milk substitutes, infant formulas, meal replacements and dietary supplements.
Extended producer responsibility (EPR)	British Columbia has an EPR program for printed paper and packaging; Merlin receives all containers collected by this program as a joint venture partner in Green By Nature, which currently has the contract responsibility to process and market all residential recyclables collected through British Columbia's EPR program.
Disposal bans	Many communities sending materials to the facility have disposal bans on materials accepted by the facility (Oregon has no such disposal bans).
Pay-as-you-throw	Prevalent in the Pacific Northwest

Improving Oregon Recycling Systems Infrastructure Research

Secondary Material Recovery Facility: Titus MRF Services

[Case study forthcoming]

Improving Oregon Recycling Systems Infrastructure Research

Modern Material Recovery Facility: Balcones

Case Study February 6, 2020

Case study completed by Tim Buwalda, Circular Matters, LLC.

Business Overview

Facility Information

Material Recovery Facility (MRF) Name	Balcones Resources Austin TX MRF
Address	9301 Johnny Morris Rd, Austin, TX 78724
Owner	Closed Loop Partners (majority owner)/Balcones Resources
Operator	Balcones Resources
Startup date or date of most recent major retrofit	Original startup: 2012 $6 million upgrades: April 2019 (fiber screens and three optical sorters) and August 2019 (two AMP robotic sorters and a new baler)
Anonymity/confidentiality promised to MRF	Cost per ton processing data have been received by the project team but are not included in this public document at the company's request.
Data Sources (e.g., contacts, articles, or reports)	Kerry Getter CEO; Brent Perdue, Austin MRF manger (bperdue@balconesresources.com) https://www.wastetodaymagazine.com/article/balcones-resources-retrofit-optical-sorters/ https://www.youtube.com/watch?v=d5c7ZXa6YOw (Process prior to installation of paper optical sorters) https://www.recyclingtoday.com/article/driving-investment-in-recycling-financing-options/

Facility Information

Case Study Type	Modern MRFs for single-stream
Capacity/Throughput	Design throughput is 30 tons per hour, but the facility can push through 35 tons per hour depending on incoming material quality. Throughput: 165,000 tons per year, 50% commercial and 50% residential. They have a single integrated processing system. They run residential on a morning shift and commercial on an evening shift, using slightly different staffing based on what is being processed. They also directly bale some clean commercial OCC.
Accepted Generator Streams and Preparation Methods	• Single-family residential single-stream recyclables • Commercial single-stream, including some multifamily residential material
Inbound Contamination and Outbound Residue and Material Quality	• 18.2% contamination in incoming single-family residential single-stream recyclables (contamination data for commercial and multi-family residential recyclables were not available). • 20.3% of all tons received, including commercial recycling quantities, become facility residue. This residue is a mix of contaminants removed by the MRF plus target recyclables that were not successfully sorted. • Processed recyclables meet ISRI specs and are sold to a combination of domestic and international markets.

Description of Operations and Focus

This private regional MRF operates in a 100,000 square foot building on a 10-acre site with a rail line. The MRF owner also operates selected collection services, performs waste audits, and offers shredding services. They provide carts, frontload containers, and compactors for multifamily buildings, small businesses, and other customers.

The MRF handles 60% of the City of Austin's residential curbside material as well as material from commercial customers, serving approximately 75% of Austin's Class A office buildings. In addition to multi-tenant facilities, Balcones is also the chosen recycling partner for several corporate campuses, including the University of Texas and the state's Capitol Complex, manufacturing facilities and distribution centers.

System Overview

Major Equipment List

The processing flow of this facility is considered proprietary and was not provided by Balcones. The facility was willing to provide a list and description of major equipment, shown below in Table 1. Equipment comes from several manufacturers including Bulk Handling Systems (BHS), CP Manufacturing (CP), MSS, and Macpresse.

Table 5. Major Equipment List

Equipment Type	Materials Sorted
2-deck Bulk Handling Systems (BHS) OCC screen	Old corrugated containers
Screens — 4-deck CP glass breaker screen	Glass and fines removal
140-inch wide CP anti-wrap screen	Large fiber
140-inch wide CPScreen	Small mixed paper
Magnet	Ferrous
Eddy current separator	Aluminum
Optical sorter #1 BHS NRT (original in 2012)	Unique and proprietary configuration and use
Optical sorter #2 BHS NRT (original in 2012)	Unique and proprietary configuration and use
Optical sorter #3 CP MSS CIRRUS FiberMax	Remove non-paper contaminants from paper QC line
Optical sorter #4 CP MSS CIRRUS FiberMax	Positive paper sort or contamination removal
Optical sorter #5 CP MSS CIRRUS FiberMax	Positive paper sort
Robot #1	HDPE natural and QC removal of fugitive paper
Robot #2	HDPE natural and pigmented
Baler — Sierra International	Model REB-4, 2 ram baler with pre-compression flaps. Keeps material from pushing up so denser bales, faster output — uses this on OCC and containers
Baler — Macpresse	Used to bale mixed paper

According to CP, the heart of its recent retrofit of the Balcones MRF are three MSS CIRRUS FiberMax optical sorters. MSS is the optical sorting division of CP Group. MSS FiberMax optical sorters run at 1,000 feet per minute on 112-inch wide belts using near-infrared vision technology and compressed air jets to clean the fiber streams with both positive and negative sorting. The new FiberMax system for Balcones focuses on removing fugitive plastics and other non-conforming items from the paper stream to create cleaner, more valuable material.

The Balcones retrofit also includes a new four-deck CP Glass Breaker screen to remove glass and fines, a 140-inch wide CP AntiWrap Screen to separate large fiber from other materials, and an additional 140-inch wide CP Screen to separate the remaining mixed paper from containers.

The new glass breaker was implemented to increase the recovery of glass and eliminate disc wear. The fiber screens were upgraded to increase material recovery while greatly reducing the labor required to clean the screens due to anti-wrapping capabilities.

In total, Balcones reports that the optical sorter upgrades eliminated 13 sorters to reduce operating cost while improving material quality on the fiber line. Robots eliminated additional two sorters on the container line for an overall reduction of 15 sorters due to optical and robotic equipment upgrades. As a result of the retrofit, Balcones was able to reduce its headcount per shift by 43% while increasing its throughput by 25%. Screen. At the same time, screen maintenance decreased from two hours per day to 30 minutes per day.

Unusual Maintenance Needs

Balcones said that they spend a lot of time on maintenance to keep the equipment running right, but less than before they installed the new equipment. The fiber line has been running in excess of 95% uptime on the system. New equipment has helped increase the throughput and made maintenance easier overall according to Balcones.

On the container line, the robots are working well, and maintenance staff have been able to keep them operational. The only unexpected maintenance according to Balcones is that suction cups must be changed out more frequently than expected.

Staffing

The facility runs two shifts adding up to a total of 48 employees, with more people on the morning shift that processes residential material. Fifteen sorters are used when processing residential recyclables. The facility does not hire temporary employees and prefers long-tenured personnel because they are important for quality control.

Incoming Materials

Materials Accepted

Residential materials accepted (as would be seen by public) are listed in Table 4.

Table 6. Accepted Materials

Category	Specific Materials
Fiber	Newspapers, magazines, phone books, white and colored paper, mixed paper, paperbacks, boxboard, cardboard, paper cups
Cartons	Egg cartons
Plastics	Water/soda bottles, jars/tubs, non-battery toys, buckets/baskets, lawn chairs
Metals	Aluminum cans, steel and tin cans including aerosol cans and empty paint cans, aluminum foil, and baking pans
Glass	Glass bottles and jars including caps
Other	

Not all community recycling programs that direct their materials to Balcones accept glass. Balcones has variable fee structures and communities without glass have a lower processing fee. Balcones also accepts commercial recyclables and industrial plastics.

Incoming Composition

Table 7 shows the composition of incoming residential material by weight. The facility declined to provide a commercial composition because it varies from one type of business to another.

Table 7. Incoming Residential Materials Composition

Residential Single Stream Composition %	
OCC-Old Corrugated Cardboard	19.3%
Mixed Paper	27.0%
Plastic Bottles - PETE	2.3%
HDPE Natural	0.6%
HDPE Color	0.5%
Mixed Plastics 3 - 7	1.0%
MRP (Mixed Rigid Plastics)	0.4%
UBC Alum-Used Beverage Cans	1.9%
Tin Cans	1.6%
Scrap Metal	0.7%
Glass	26.6%
Residuals , Trash, & Wood	18.2%

The City of Austin, which makes up one-third of the incoming residential material, uses municipal employees to collect waste and recyclables. Part of the collected recyclables goes to Balcones and part to a Texas Disposal Systems MRF. The City of Austin wants contamination to be less than 10%. In May 2018, the contamination rate was 23.08% for recyclables delivered to Balcones pickups. Another audit in November of 2018 showed it to be 19.72%. Because of contamination concerns, the City implemented a contamination reduction campaign in 2019 including America Recycles Day outreach, social media outreach, and improved education on its website. The City uses fully automated collection trucks in which drivers do not exit the collection vehicles when collecting recyclables, so no active cart inspection and tagging program was undertaken. The education program did appear to help reduce contamination somewhat.

Outbound Materials and Processing Effectiveness

Materials Shipped (Outbound Commodities) and Product Quality

Outbound products, including commercial tonnages, are listed in Table 8.

Table 8. Outbound Material Composition

Outbound Composition	
Product	**%**
3-7 Plastics	0.6%
Glass	18.4%
Hdpe - Color	0.4%
Hdpe - Natural	0.5%
Metal	2.0%
Mrp - Mixed Rigid Plastic	0.8%
Mxp - Mixed Paper 02	34.1%
Occ - Old Corrugated Containers 11	40.9%
Pet	1.5%
Ubc - Used Beverage Containers	0.8%
Trash	20.3%
TOTAL:	100%

Ability to properly sort materials

Contaminants

The following contaminants are difficult to remove according to Balcones and must be sorted manually: plastic film, scrap metal, wood, and yard trimmings. The equipment does not sort them out well because the processing system was not designed to handle these non-program materials.

Fiber line: According to Balcones, they are pleased with the effectiveness of the optical sorting equipment in cleaning up fiber (aside from removal of the contaminants listed above) and they can produce bales with contaminants in 1.5% range. Downtime is minimized on this line, with an uptime in excess of 95%. Balcones spends a lot of time on maintenance to keep the equipment running right. The combination of the new paper screens and paper optical sorting equipment has helped increase the throughput of the MRF and reduced the need for line shutdowns to clean screens.

Balcones has not had any loads rejected by mills for prohibitives, but there have been moisture issues from time-to-time. The facility sells everything as produced, has a lot of material under contract, and has good demand for its material.

Container line: The robots are working well and have reduced the staffing head count. Maintenance staff can keep them operational, although the suction cups must be changed frequently.

According to Balcones, since the latest retrofit, the facility has done a better job at keeping recoverable materials out of the residue stream and undesired materials out of the plastics #3-#7 stream.

The facility has experienced an unforeseen increase in the volume of containers from when the MRF was originally designed and reports that it should have invested in a PET optical sorter with greater capacity. Based on recently completed PET audits, the facility is capturing 80% or more of transparent PET, including bottles and thermoforms, into PET bales. The facility is still losing some PET material, mainly into the #3-#7 stream and residue stream.

Residue generated at the MRF is landfilled. Seven years ago when the facility received material only from the City of Austin, the residue rate was 14%. Now that the facility is accepting material from third-party haulers who bring in more contaminated materials, the average residue rate is 18%, with some months at even higher percentages.

As of now, Balcones has no additional upgrade plans, but it is always looking for opportunities and improvements.

Markets Accessed

Balcones declined to provide information on where its materials are marketed, other than confirming that glass is sent to Strategic Material's plant in Midlothian, Texas.

Financials

Initial Capital Costs

Balcones gross cost per ton marketed is proprietary. The facility was not willing to provide additional detail on the components of cost, other than publicly available information. The MRF originally opened in 2012 with a $25 million investment to handle 25 tons per hour of single-stream residential material with BHS equipment. There was $6 million in capital upgrades in 2019 by CP, which increased the capacity to 30+ tons per hour.

Annualized Capital and Operating Costs

The facility was not willing to share capital and operating costs. The City of Austin pays Balcones a $75 per-ton processing fee and receives 70% of materials revenues for positive value grades. The amount the City of Austin pays Balcones is capped at $41,000 net of material revenues. Payment arrangements with commercial accounts and other residential suppliers are subject to different terms.

Recycling Regulations

City of Austin material (making up one-third of the incoming residential material) is affected by:

- Universal recycling ordinance, which mandates recycling and organics service provision to single-family, multi-family and commercial properties.
- Pay-as-you-throw rate structure.

None of the other municipalities supplying residential material to Balcones have regulations like Austin.

Improving Oregon Recycling Systems Infrastructure Research

Modern Materials Recovery Facility: Firstar Fiber, Omaha NE

REVISED Case Study February 6, 2020

Case study completed by Tim Buwalda, Circular Matters, LLC.

Business Overview

Facility Information

Material Recovery Facility (MRF) Name	Firstar Fiber, Omaha NE
Address	10330 I St, Omaha, NE 68127
Owner	Firstar Fiber Inc.
Operator	Firstar Fiber Inc.
Startup date or date of most recent major retrofit	Started in 1997, residential single stream retrofit in Jan 2006, most recent upgrade: spring 2018.
Anonymity/confidentiality promised to MRF	Cost per ton processing data have been received by the project team but are not included in this public document at the company's request.
Data Sources (e.g., contacts, articles, or reports)	Dale Gubbels, President/CEO/Chairman Mike Bachman, Plant Manager Omaha instructions : https://wasteline.org/wasteline-brochures/recycling-preparation-and-collection/ https://resource-recycling.com/recycling/2018/10/01/mrf-of-the-month-firstar-fiber/

Facility Overview

Case Study Type	Modern MRFs for single-stream
Capacity/Throughput	Total MRF throughput is about 90,000 tons per year (tpy) of which 45% is residential. Residential throughput is 40,500 tpy. Commercial throughput is 49,500 tpy. Residential single-stream capacity is 10 tons per hour. The plant has a separate infeed for container sorting because it also processes dual-stream recyclables. The container-sorting part of the plant is limited to processing 2.5 tons per hour of containers either from dual-stream programs or the containers that have been separated from single-stream material. The facility also directly bales some clean commercial OCC. Capacity Line 1 — Residential single-stream (10 tons/hour) + commercial fibers (varies with composition) Capacity Line 2 — residential dual-stream containers and containers separated from single stream material: 2.5 tons/hour
Accepted Generator Streams and Preparation Methods	Residential single-stream is about 34% of the total tonnage, residential dual stream is around 11% of the total tonnage, and commercial fiber 55% of total tonnage according to Firstar Fiber.
Inbound Contamination and Outbound Residue and Material Quality	Contamination in incoming residential single-stream recyclables is 8.67%. Total facility residue from both residential and commercial materials processed is 12%. Firstar produces high-quality recyclables that meet ISRI specifications and ships to markets in the United States and Mexico.

Description of Operations and Focus

- 180,000 square-foot, private MRF operation offering processing as well as selected collection service (e.g. for businesses)
- Operates as a hub-and-spoke MRF to process residential recyclables delivered by transfer trailer
- More commercial paper is processed than residential recyclables. In 2018 Firstar had to notify some commercial accounts that were supplying commercial single-stream recyclables that it could no longer accept their commercial stream because contamination was as high as 40%. These accounts either changed to only delivering source-separated fiber or have worked to reduce the contamination levels to more reasonable levels.
- Also offers audits, training and other supplementary services
- Serves multiple cities — curbside, drop-off and commercial recycling
- Does not accept glass

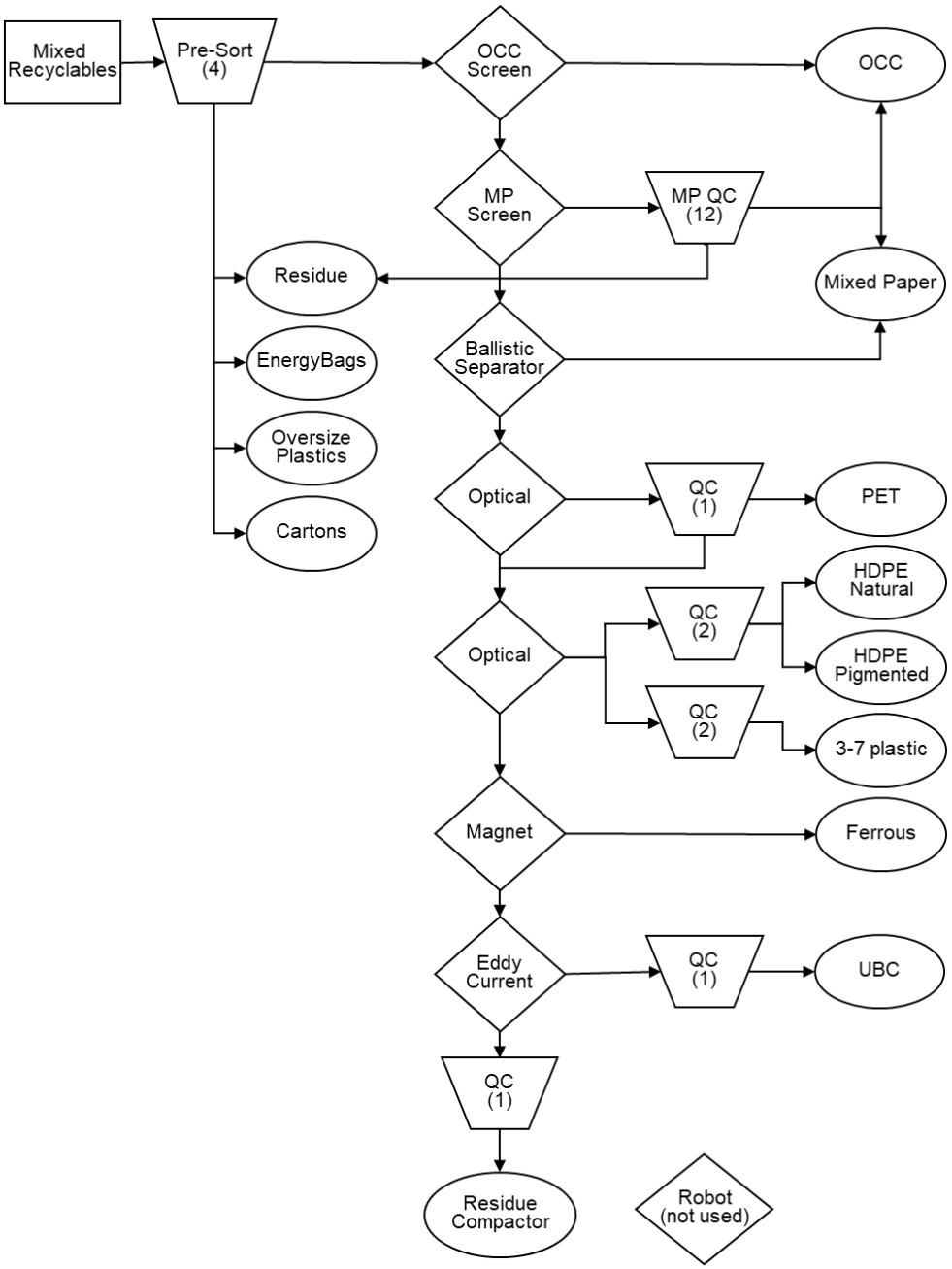
- This MRF also participates in the Hefty® EnergyBag® program in which otherwise non-recyclable plastics are contained in a separate orange colored bag that is placed into the recycling stream and is separated from the other target incoming recyclables by Firstar at the pre-sort station of the MRF. Other than receiving and baling orange bags, Firstar does not perform any other processing of the orange bag material. These materials Firstar believes that this program reduces contamination in incoming recyclables.

System Overview

Equipment

A layout of the processing flow is depicted in Figure 1.

Figure 1 – Processing Layout



Major equipment list

Equipment Type	Materials Sorted
Screens (Bulk Handlin Systems — BHS)	OCC and ONP
Ballistic separator (BRT Hartner)	2-D material from 3-D material
Magnet (Green Machine)	Ferrous
Eddy current separator (Eriez)	Aluminum
Optical sorter #1 (Green Machine)	PET
Optical sorter #2	Natural HDPE and 3-7 — higher count of picks is natural HDPE. Hand sorting of the natural then hand sorting the colored HDPE
Baler (Bollergraaf- HVC 120)	Fiber
Baler (72-43 American)	Commercial LDPE, commercial office paper
Baler on container line (EXCEL 2r10)	Containers
Robot (AMP)	Early generation piloted on bottles; not currently used

Unusual Maintenance Needs

According to Firstar Fiber, the ballistic separator is relatively maintenance free and the equipment is an improvement over the screen it replaced since it does not have exposed shafts that film or tanglers can wrap on. They have had only one bearing go out on the ballistic separator in the nearly two years it has been in operation. It has a good design with a straight shaft instead of a crank shaft. Also easy to get to bearings and fix when needed.

Removal of film plastic and tanglers from their paper screen takes a lot of daily maintenance time according to Firstar Fiber — they would like to replace it with a newer non-wrapping design that also has more capacity.

Maintenance on the optical sorters is not time-consuming and they are easy to keep running. They get parts easily from Granger. The rest of their equipment is standard with routine maintenance.

Staffing

Firstar Fiber MRF uses approximately 20 direct people to sort residential recyclables per shift (15 on fiber and five on containers). The MRF operates three shifts per day but not all the shifts process residential recyclables. Staffing for each shift also includes two loader operators, three bale operators, and at least three skid steer operators.

Incoming Materials

Materials Accepted

Category	Specific Materials
Fiber	• Old corrugated containers (OCC) • Newspaper • Junk mail • Magazines and catalogues • Boxboard (e.g., detergent doxes, cereal boxes) • Writing paper (e.g., "school paper") • Greeting Cards • Phonebooks • Paperback Books • Wrapping Paper • Paper Egg Cartons *Note: Residents are told to place paper (excluding newspaper) into a paper bag or small cardboard box to prevent windblown litter because materials are collected in bins.*
Cartons	• Gable top (e.g., milk cartons) • Aseptic containers (e.g., juice boxes and soup or broth cartons)
Plastics	Plastic bottles, cups, caps, lids, food containers and packaging marked PETE (#1), HDPE (#2), V (#3), or PP (#5). Includes: snap top container, clamshell deli containers, cookie trays, DVD cases, clear plastic packaging, and microwave meal trays
Metals	• Aluminum cans • Steel (tin) cans (food can lids accepted if secured inside the can) • Empty aerosol cans • Empty and dry paint cans with lid removed • Aluminum foil is not accepted, but any foil received is mixed with used beverage cans.
Glass	None

Incoming Composition

The overall contamination rate by weight is 8.67%, consisting of bags and film (1.87%), glass (1.41%), and other non-requested materials (5.39%). Table 9 shows a breakdown on a percent by weight basis of incoming material composition.

Table 9. Incoming Composition

Material	Incoming Percentage
OCC and Chip	42.54%
ONP	18.03%
Mixed paper	5.93%
UBC	1.87%
PET	8.74%
Natural #2	4.22%
Color #2	2.42%
3/7s	4.22%
Steel cans	3.36%
Subtotal desired recyclables	*91.33%*
Bags and film	1.87%
Glass	1.41%
Other non-requested materials	5.39%
Subtotal contaminants	*8.67%*
Total	**100.00%**

Outbound Materials and Processing Effectiveness

Materials Shipped

Outgoing products after sorting are shown in Table 10. Firstar noted that, from the marketing standpoint, they are moving all materials and have had very few downgrades. Firstar markets its recyclables domestically. Firstar has always had to produce high-quality material because it is not near many end markets or export ports, so they have had to produce premium product grades to ensure market demand.

Table 10. Outbound Products Produced

Output Product	Amount	Notes
Mixed paper	30%	Includes commercial office paper
Cardboard (OCC)	28%	Includes commercial OCC
Cartons	<1%	
Ferrous metal	4%	
Aluminum, UBCs	6%	Includes deposit cans from Iowa
PET bottles & thermoforms	10%	
HDPE/LDPE	10%	Includes commercial film plastics and commercial HDPE
PS/EPS	<1%	
Residue	12%	

Ability to Sort Materials

Firstar leadership expressed that they would benefit by adding a drum feeder to even out material flow and allow for more effective sorting.

The single-deck OCC screen is more than 13 years old but still works well.

Firstar would like to improve on its existing paper screen which was designed to sort ONP, a material that has declined in volume. The paper screen is undersized, limits the facility's tons-per-hour processing rate, and gets hung up with tanglers. Medium-sized fiber was previously separated from containers by a second paper screen, but that screen also needed daily maintenance to remove film and tanglers and lost small fiber to the container-sorting part of the plant. The second screen was replaced in the recent retrofit with a ballistic screen, which does an amazing job of separating small paper from containers, so the small paper is not lost to residue. They added some fans to help push fiber up the screen. Firstar feels that they made the right business decision when they added it and it works very well for the scale of their facility and other equipment they use.

They were the recipient that AMP Robotics' 2nd robot installed in a MRF. It was a learning experience for both the robot developer as well as for them. The robot was intended to replace two manual sorters who were sorting HDPE natural. Those bottles are quite variable in shape and it was hard for the robot to pick up them up. They now use a combination of optical sorters with manual quality control in place of the robot. They may add robots again in the future as the technology improves.

They feel the Green Machine optical sorters sort effectively in terms of material capture.

The Project Team believes that Firstar doesn't have enough space on the front end to cost-effectively sort program materials and remove contaminants because the facility was originally designed for sorting commercial fiber, and it was subsequently converted to also process residential recyclables in addition to commercial recyclables. The pre-sort area has room for only four presort laborers with a single bunker underneath it. Contamination, bulky recyclable plastics, Hefty EnergyBag program materials, and drink

cartons are all removed at the pre-sort station and dropped into the bunker below. This material is later resorted to separate the bulky recyclable plastics, Hefty® EnergyBag® program materials, and drink cartons for baling as their own commodity streams. According to Firstar, a significant amount of contamination is not able to be sorted out at the presort station, and as a result much of the contamination removal happens elsewhere in the plant. All contaminants from the paper side of the MRF are removed manually, leaving fiber and missed contaminants to be baled. On the container sorting side of the plant, all commodities are positively sorted, leaving contaminants and missed target recyclables on the sorting belt to be directed to disposal.

Financials

Cost elements are summarized in the below table. The 2018 equipment upgrades cost $2.4 million, which was largely financed with a $2 million low-interest loan from the Closed Loop Fund.

Cost category	Amount
Facilities (excluding land)[1]	$10 million
Fixed equipment costs	$10-15 million
Rolling stock	$500,000
Labor	proprietary
Residue disposal	$600,000 per year
Other costs[2]	proprietary
Total	proprietary
Gross cost per ton marketed	**proprietary**

1 Insured value.

2 Includes utilities, supplies, and all other general and administrative costs, profit, etc.

On the revenues side, they recently renegotiated a new recycling tip fee with Omaha for $110 per ton for 2020 (it previously was $25.92 per ton, which is equal to the landfill tip fee). They also receive revenues from the sale of recycled materials.

Recycling Regulations

The facility receives material from generators affected by the following types of regulations:

- They process material from Lincoln, which is transferred into trailers. Lincoln has an OCC disposal ban, which makes a huge difference in OCC tonnage from there.
- They also process residential recycling subscription material from independent haulers in the Omaha metropolitan region where waste and recycling is subscription and independent haulers are responsible for education. This material is more contaminated than material from municipal recycling programs, which do a better job with municipal recycling program promotion and education than do the independent subscription haulers.

Firstar Fiber (doing business as First Star Recycling) also works with Curbside Rewards and RecycleBank to provide an easy-to-use residential recycling program that offers rewards.

Improving Oregon Recycling Systems Infrastructure Research

Modern Material Recovery Facility: Shoreway

Case Study February 6, 2020

Case Study completed by Doug Drennen, Drennen Consulting, LLC. Doug was project manager for preparing the site master plan and design of the MRF and transfer station expansion. He also coordinated with SBWMA staff on the equipment installation project but was not involved with the procurement and selection of the operator and equipment vendor.

Business Overview

Facility Information

Material Recovery Facility (MRF) Name	Shoreway Environmental Center
Address	333 Shoreway Rd, San Carlos, CA
Owner	South Bayside Waste Management Authority (SBWMA) aka RETHINK WASTE
Operator	South Bay Recycling (SBR)
Startup date or date of most recent major retrofit	April 2011 / Proposed Upgrades scheduled for 2020
Anonymity/confidentiality promised to MRF	None
Data Sources (e.g., contacts, articles, or reports)	Hilary Gans, Senior Operations & Contracts Manger

Facility Overview

Case Study Type	Modern MRFs for single-stream

Capacity/Throughput	• The MRF processes 80,000 tons per year over a single shift
	  ○ Residential single stream — 30 tons per hour (the process line was slowed down to 25 tons per hour to improve product quality)
	  ○ Commercial single stream — 15 tons per hour

Accepted Generator Streams and Preparation Methods	• Single-family residential single-stream • Multifamily residential single-stream • Commercial single-stream
Inbound/Outbound Contamination	No information is available in inbound contamination. SBWMA reported the disposal residuals represented 18.8% of incoming tons for an 11-month period in 2019.

Description of Operations and Focus

Located midway between San Francisco and San Jose in San Carlos, California, the South Bayside Waste Management Authority (SBWMA) operates as a joint powers authority serving 11 different jurisdictions and one utility district with approximately 450,000 residents and over 10,000 commercial businesses. In 2011 SBWMA changed their collection system from dual stream to a single stream collection for their customers. To process the materials, SBWMA built a new 70,000 square foot building and installed a new state-of-the-art single-stream MRF including advanced screening, air separation equipment, optical sorting, and more. The system was purchased as part of a full service /turnkey operator contactor with a proposed equipment supplier. South Bay Recycling (SBR) was selected with Bulk Handling Systems (BHS) to supply and install equipment.

SBR has made minor improvements since start up and commissioning in early 2011. The first major equipment upgrades are proposed for 2020.

System Overview

Equipment

Current Processing System

The initial MRF processing system includes two (2) separate in feeds: one for residential and one for commercial commingled materials. The residential line has a metering bin to regulate flow. Both lines convey materials to a pre-sort platform with 12 sort stations to remove non-recyclable items, wood, large metal and film plastic items, and other undesirable materials. See Figure 3, below, for a diagram of the current system and upgrades proposed for 2020. The major equipment list includes:

- Advanced BHS OCC screen with secondary debris and polishing screens both lines
- Glass removal system

- Eddy current separator
- NRT Optical sorter #1 — PET
- NRT Optical sorter #2 — HPDE sort
- NRT Optical sorter #3 — HDPE color sort
- NRT Optical sorter #4 — Optional Optical — can be set to recover different materials as required

The primary characteristics of the processing system are as follows:

1. Metering bin on residential line and large, 12-person presort stations on in-feed.
2. Glass breaker and removal at first old corrugated containers (OCC) paper screen to protect downstream equipment from abrasion.
3. Four NRT optical plastic container sorters, which allow the entire container line to be operated with only six sorters.
4. Three-level container sort platform to minimize equipment footprint.
5. Two separate sort lines for mixed paper and newspaper on each line.
6. Fully integrated pneumatic film collection and baling system for recovery of film at all sort stations.
7. Hoods and dust collection system with four-unit bag house system located at all fiber screens.
8. Split conveyor container QC stations to allow each sorter to QC multiple streams.
9. Container line bypass system that allows fiber sort system to operate in the event the container line is down.
10. Two-ram baler for containers and high-speed, single-ram baler for fiber baling.
11. Dual-baler feed capability, so all materials can be fed to either baler, allowing for full system to operate in case of baler failure.
12. Large sub-grade conveyor pits for easy cleaning and belt maintenance.
13. Aspirators and air classifiers remove shredded fiber from broken glass stream and residue.
14. Two post-sort stations to sort any recyclables from the plant residue line.
15. Integrated system platform to second floor of office/tour area for easy access.
16. Climate-controlled control room centrally located on second level next to sort lines.
17. Auxiliary system control touchscreens located at pre-sort station. 26 video cameras and DVR system for monitoring system performance remotely.
18. Internet-connected system controls so entire sort system can be operated and monitored from BHS headquarters.
19. Easy-to-use touchscreen user interface, data recording and reporting software system.
20. Approximately 200 high-efficiency motors and extensive use of variable frequency drives for power conservation.
21. Large-capacity fiber and container storage bunkers to reduce need to switch between different materials at balers.
22. Preventative maintenance software diagnostic tool that anticipates potential motor/gear/conveyor failures by monitoring electrical supply current.
23. Color coordinated painting of equipment systems to provide easy identification by tours.
24. Central residue conveyor to transport materials directly to transfer station tip floor.

Upgrades Proposed for 2020

In 2020, SBWMA and SBR are proposing several upgrades to the system centered on cleaning up fibers and improving throughput to meet stricter commodity market conditions. The primary upgrade includes adding optical sorters to the fiber line to remove film and small browns to improve mixed paper quality. Improvements are expected to increase throughput of commercial line from 15 tons per hour to 20 tons per hour. The Phase 1 MRF equipment upgrades include:

1. **Install metering bin on commercial in feed**. This will regulate the flow of materials onto the presort.
2. **Enhance glass cleanup system**. This system is designed to remove contaminants, including, shredded paper, batteries, and metals from mixed glass, reducing the risk of lithium battery caused fires, and improving material value.
3. **Third-sort optical line**. This system mechanically scalps recyclable materials that are 4 inches or less and conveys this material through optical sorters. It is designed to recover high-value fiber, and California Redemption Value (CRV) containers. It will convey paper to the fiber post-sort QC and send residue directly to the Transfer Station. Robotic technology will provide accurate measurement of material compositions enabling real-time adjustments to equipment settings.
4. **Add optical sorters for paper**. Adding six optical sorters (two each on three paper lines) will recover OCC, produce high value fiber (High Grade Paper), recover CRV containers, and remove film plastic and residual material. There will be a significant increase in SBWMA revenue due to reducing the amount of Mixed Paper, creating a new commodity High Grade Paper (HGP), and increasing the amount of OCC generated.

Figure 1 shows the current processing system along with Phase 1 equipment upgrades proposed for 2020 shown in green shading. SBWMA is also planning Phase 2 upgrades that will include several artificial intelligence (AI) and robotics to primarily perform quality control sorting or other related purposes. Figure 4 is a process flow diagram showing the system with the proposed modifications.

Figure 3. Processing System with Proposed Upgrades

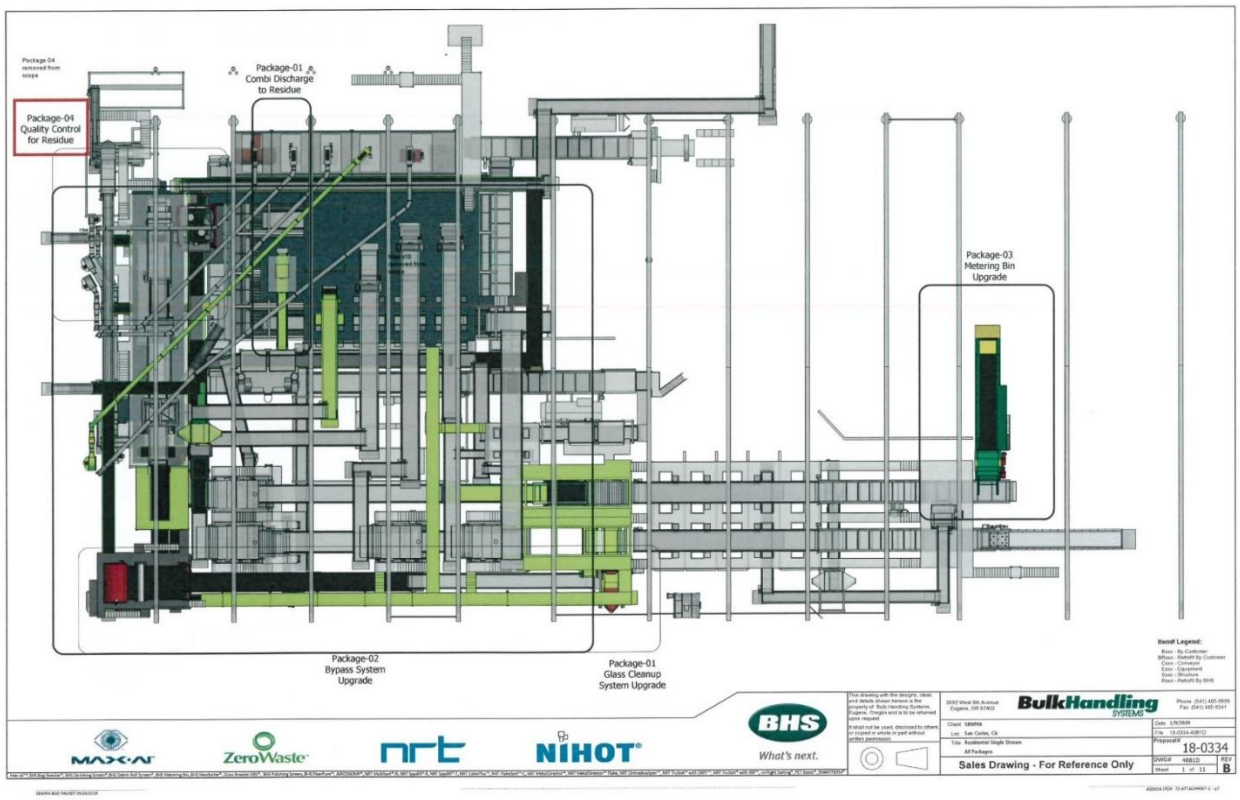
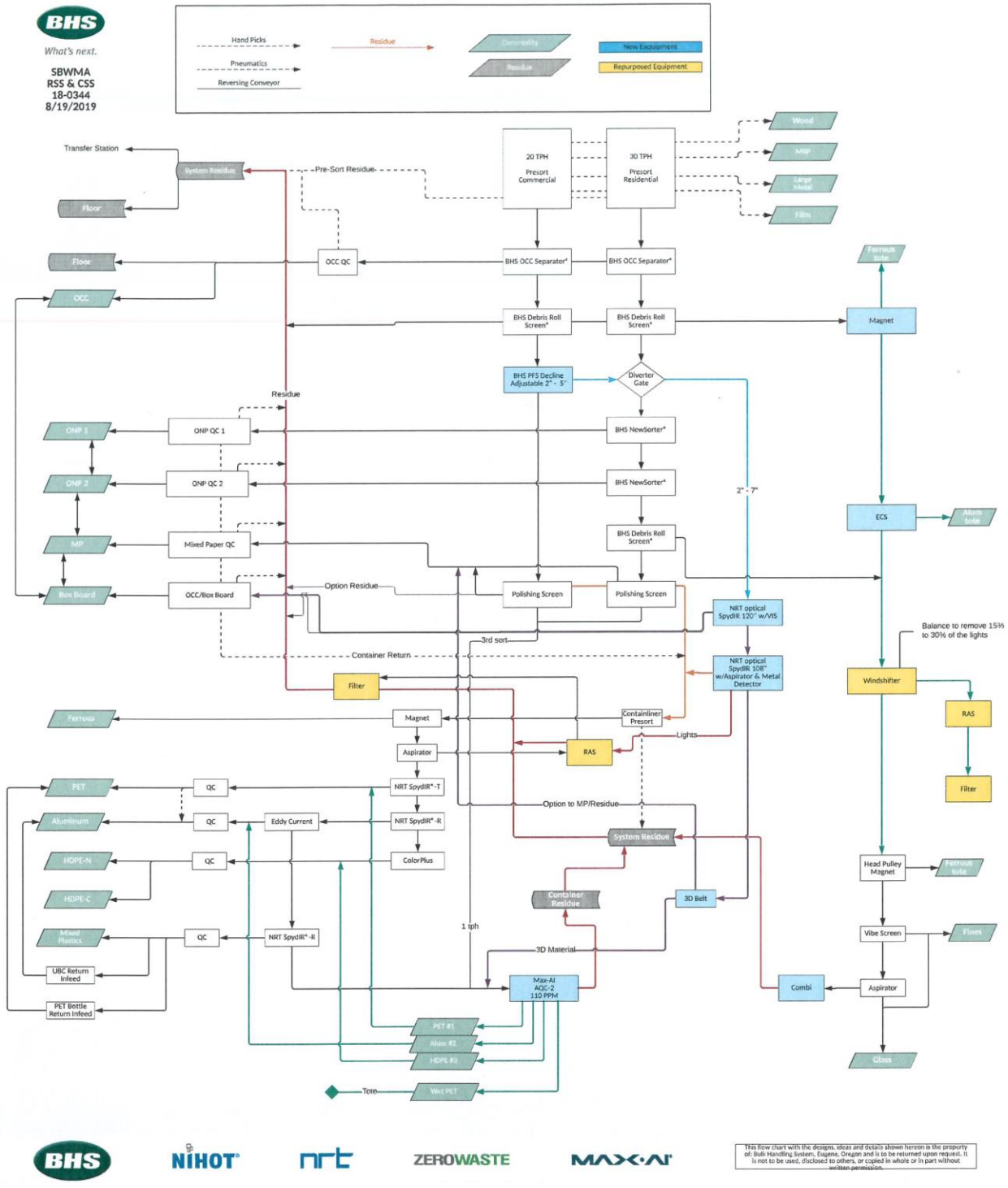


Figure 4. Flow Diagram with Proposed Upgrades



Unusual Maintenance Needs

The facility did not mention having any extensive downtime or unusual maintenance needs.

Staffing

The MRF has been operated since startup in 2011 by South Bay Recycling under a contract with SBWMA. The operator is responsible for operations, maintenance, and marketing of all materials. Staff operate two process lines over a single shift. SBR staff include:

- 13 non-sorting employees, including general manager, administrative staff, MRF supervisors, and equipment operators
- 32 sorters/laborers

Incoming Materials

Materials Accepted

Category	Specific Materials
Fiber	• Cardboard (non-waxed) • Paper bags and Kraft paper • Printing and writing paper • Egg cartons • Magazines, catalogues, and junk mail • Newspapers • Phone books and paperback books • Shredded paper • Wrapping paper (non-metallic)
Cartons	• Gable-top cartons
Plastics	• Plastic containers #1-#7 (including bottles, tubs, and clamshells; excluding black plastics)
Metals	• Aluminum cans • Aluminum foil, trays, and pans • Steel/tin cans • Aerosol cans • Small scrap metal
Glass	• Glass bottles and jars

Incoming Composition

The Shoreway MRF has been processing single-stream materials from residential and commercial customers since 2011 when the new collection franchise agreement was issued to Recology. As a result of converting the collection services from dual stream to single stream in 2011, the amount of recycled materials increased by about 25%. Recology established a commercial recycling program as part of the 2011 agreement. Commercial recyclables now range from 40 to 50% of incoming materials. SBWMA requires Recology to conduct audits of generators recycling stream to minimize inbound contamination. Failure to perform audits and fully monitor generators can result in penalties.

Detailed composition and contamination data for in-bound materials are not available. During the period from 2011 to 2016 the disposed residue from the system averaged 7% on an annualized basis. Residue has increased to an average of 17% over the past few years. In 2019 the residue was about 20%.

Outbound Materials and Processing Effectiveness

Materials Shipped

Table 1 summarizes actual inbound delivered (collected) material and outbound (shipped) commodity tonnage for an 11-month period in 2019. Materials are marketed by an independent broker that has access to both domestic and off shore markets.

Table 11. Products Recovered in 2019 (11 months)

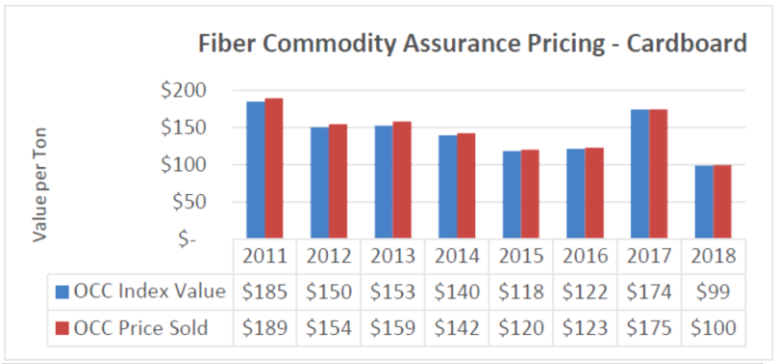
Total Inbound Tons	67,668.00 YTD	
Total Inbound Tons Net of Residue	**54,967.66 YTD**	
OUTBOUND FIBER TONS	**35,309.98**	**65.8%**
OCC	14,359.99	26.8%
SCP (mixed paper)	-	-
SMP (mixed paper)	20,943.60	39.0%
OCC PURCHASE	6.39	0.0%
OUTBOUND CONTAINER TONS	**18,356.61**	**34.2%**
PET	1,571.37	2.9%
HDPE Natural	402.79	0.8%
HDPE Color	673.08	1.3%
PRC Clean Glass	239.48	0.4%
Aluminum	346.19	0.6%
MRF 3 Mix Glass	12,918.15	24.1%
Tin	786.86	1.5%
Plastic #3-#7	-	-
MRP (mixed rigid plastic)	515.00	1.0%
MFP (mixed film plastic)	-	-
Polypropylene Plastic #5	-	-
Bi-Metal	903.69	1.7%
OTHER MATERIALS	**1,301.07**	
Variance (due to clean glass & clean OCC)	1,301.07	

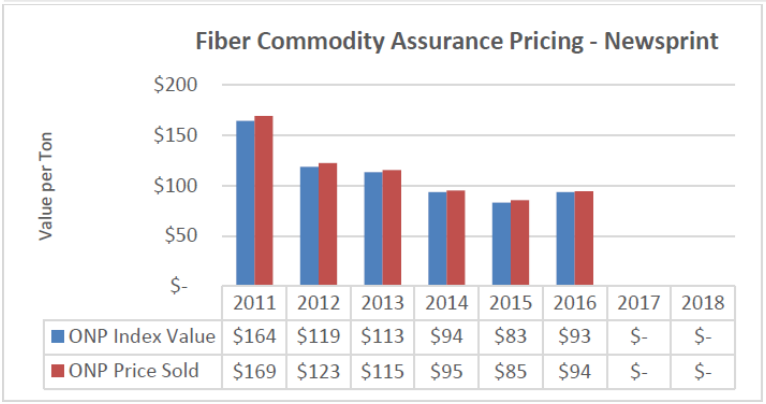
Ability to Sort Materials

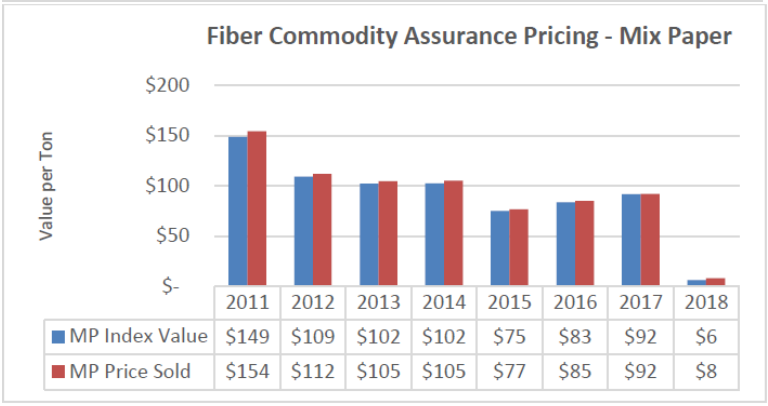
Since SBR began operating this MRF, the recovered materials have met or exceeded indexed market values. When the China National Sword was adopted, the fiber markets in California were particularly impacted. Table 2 shows the price for fibers recovered from the Shoreway MRF since 2011. The price

received by SBR for fibers in red is compared to the fiber market index shown in blue. The MRF is still marketing materials at or above published indexes.

Figure 5. History of Fiber Markets Since 2011







Financials

SBWMA purchased the system through a competitive contract to provide full services/turnkey design, building, installation and operation. The initial equipment cost was $17 million in 2009. The capital cost reflects the design that includes several areas for redundancy including two in-feeds and screening systems, a conveyance system that can feed both balers, and larger holding bins due to limited bale storage space.

SBR operates the MRF under a contract with SBWMA. There is no detailed breakdown of the operating expenses. The following table shows what SBWMA pays per ton to operate the system. This includes all expenses including transporting and marketing materials and a profit margin for SBR. This does not include transportation and disposal of residue. For the 11-month period in 2019, the total MRF operating expense was $6,232,223. This does not include revenues from sale of materials or California Redemption Value (CRV).

Table 12. SBWMA Payments Per Ton

2019	2020
$92.10 per Ton	$98.93 per Ton*
*As reported by SBWMA	

SBWMA generates revenues from two different sources: from the sale of recovered commodities and from the CRV redeemed for deposit containers. These revenues help offset payments to SBR for operating the facility. Prior to China National Sword, revenues exceeded operating costs. In the first 11 months of 2019, operating costs exceeded revenues by approximately $120,000. SBWMA shares some portion of the revenues with SBR.

In California, MRFs can redeem the value of CRV-eligible containers recovered at their facilities. The estimated revenues from the CRV program for the 11-month period was about $5.3 million. The MRF uses a glass recovery system to maximize the potential revenue assigned to these materials. In 2019, revenues for the sale of commodities was $1.24 million for the 11-month period, an average of $23 per ton for all materials.

Table 13. 2019 Revenue (11 months)

TOTAL SCRAP VALUE BY COMMODITY	TYPE
OCC	$848,731.06
SCP (mixed paper)	$-
SMP (mixed paper)	$36,653.31
PET	$228,219.80
HDPE Natural	$126,049.80
HDPE Color	$96,127.30
PRC Clean Glass	$1,676.36
Aluminum	$186,721.20
MRF 3 Mix Glass	$(414,156.07)
Tin	$60,506.40
Plastic #3-#7	$-
MRP (mixed rigid plastic)	$33,590.37
MFP (mixed film plastic)	$-
Polypropylene Plastic #5	$-
Bi-Metal	$36,196.26
TOTAL SCRAP VALUE	**$1,240,315.79**

OVERALL TOTALS	
Tons	53,666.59
Total Scrap Value	$1,240,315.79
Total Transportation	$(613,145.56)
Total Mix Glass Residue T&D	$-
Revenue (Scrap Value + Trans + Residue T&D)	$627,170.24
Estimated Commodity Revenue Payment to SBWMA	$5,360,793.93
TOTAL SCRAP REVENUE	**$627,170.24**
TOTAL REVENUE ACCRUAL	**$6,111,500.41**

Recycling Regulations

Bottle bill: in California, most beverage containers (aluminum, glass, plastic and bi-metal containers) are covered by the CRV recycling program. Milk, wine, and distilled spirits are excluded from the bottle bill. Processing facilities receive redemption values for containers sorted from curbside recycling.

Mandatory commercial recycling: in California, businesses that generate more than four cubic yards of garbage (including multifamily properties with five or more units) are required to subscribe to recycling service.

Mandatory residential recycling: in California, new organics-focused regulations will soon make recycling and organics collection practically mandatory for all residents; however they are not currently in place.

Improving Oregon Recycling Systems Infrastructure Research

Mixed Waste Material Recovery Facility: Monterey Regional Waste Management District

Case Study February 6, 2020

Case study completed by Doug Drennen, Drennen Consulting Services, LLC. Doug was project manager for the District to prepare an RFP to solicit proposals from equipment vendors and to design retrofits to the existing MRF building to install the equipment. He was not involved with startup and operation of the MRF facility.

Business Overview

Facility Information

Material Recovery Facility (MRF) Name	Monterey Regional Waste Management District (District)
Address	14201 Del Monte Blvd, Marina, CA 93933
Owner	Monterey Regional Waste Management District (District)
Operator	Monterey Regional Waste Management District (District)
Startup date or date of most recent major retrofit	April 2018
Anonymity/confidentiality promised to MRF	*None*
Data Sources (e.g., contacts, articles, or reports)	Tim Brownell, Director of Operations Monterey Regional Waste Management District https://whatgoeswhere.info/wp-content/uploads/2018/08/Accepted-recyclables-MRF-6-18.pdf

Facility Overview

Case Study Type	Commercial dry mixed-waste MRF sorting for recyclables. Note: as this case study was developed, we learned that this facility was designed as an integrated MRF to process commercial mixed waste but has delayed processing that material entirely because of the unanticipated large demand to process the region's single-stream residential recycling. As a result, performance estimates for commercial mixed waste processing are available from the equipment manufacturer and start-up performance testing, but full operational data are not available.
Capacity/Throughput	This MRF was designed to process both mixed commercial waste and residential commingled materials from the District's participating jurisdictions. A second parallel equipment line is used to process C&D and waste delivered by self-haul customers. The District proposed to operate the equipment over two shifts: five days per week. **Design Annual Capacity** • Mixed commercial waste: 100,000 tons per year • Commingled /single-stream recycling: 20,000 tons per year **Design Throughput** • Mixed waste processing: 40 tons per hour • Commingled / single-stream recycling: 30 tons per hour **Construction and Demolition (C&D) — Self-Haul Equipment** • Capacity: 50,000 — 60,000 tons per year • Design throughput: 40 tons per hour
Accepted Generator Streams and Preparation Methods	Designed for mixed waste from commercial. Currently accepting primarily residential single-stream and self-haul C&D debris.
Inbound/Outbound Contamination	Based on the data provided the inbound contamination is shown to average 21.9%. 61.9% of incoming materials are recovered and 38.1% of materials are disposed as residuals. Note: The District estimates that 5-7% of residuals may contain materials that marketable and/or have CRV value.

Description of Operations and Focus

The MRF is in Marina, CA along the Monterey Bay peninsula at the District's recycling and disposal complex. The system was procured using a turnkey solicitation process to select the equipment vendor that best met the performance requirements. Two equipment vendors submitted well-qualified

proposals, and the District ultimately selected Bulk Handling Systems (BHS), which completed installation and commissioning of the MRF in February 2018 and completed start-up activities in April 2018. The final cost of the equipment was $14.5 million which includes the California state sales tax plus $9.5 million in site and building improvements.

The system was designed to process both mixed commercial waste and commingled single-stream materials collected from the seven member cities and one special utility district. The facility is designed to process 100,000 tons per year (or 385 tons per day) of mixed commercial waste and 20,000 tons per year (80 tons per day and 30 tons per hour) of residential single-stream recycling.

The MRF also has a second parallel line to process 50,000 to 60,000 tons per year of C&D or dry waste. The material processed on this line is primarily self-haul waste delivered by cars, pickups and small contractors. Based on sampling data, the self-haul C&D materials contain recoverable non-C&D commodities such as OCC, mixed paper, plastics and containers recognized by the California Refund Value (CRV) system. Therefore, the C&D processing line is integrated to convey residuals from initial sorting stations on the C&D line for processing on the to the mixed waste/commingled process line to maximize recovery if there are recoverable materials on this conveyor. Final residuals are used for daily cover at the District's landfill which is located on the same property.

As the MRF was undergoing startup, several communities in the region (including the cities of Watsonville and Salinas and neighboring San Benito County) requested that the District process their single-stream recycling. These communities were delivering materials to older MRFs with subpar performance, and new market conditions brought on by the National Sword regulation changes in China began to force a change in processing needs. Given the financial benefits of processing the higher-grade materials, the District decided to contract with these other communities to process their commingled materials. With the addition of these communities, the new MRF is processing about 70,000 tons per year of single-stream recycling, instead of the mixed commercial waste that the facility was designed to process.

System Overview

Equipment

The following provides a description of the process line and identifies the major sorting equipment.

Mixed Waste / Single-Stream System

1. In-feed hopper with metering drum to regulate the flow of material.
2. Debris screen (12" minus) to remove fine debris from materials stream. Material can be diverted to a bag breaker system as needed.
3. Post-screen sorting stations to remove trash and large items. Wood and metal are conveyed and combined with materials from C&D processing into bunkers.
4. Secondary screens combined with air classification for dimensional (2D versus 3D) separation.
5. Glass recovery system from fines.

Fiber Sort Line — After 2D/3D sort

1. Old corrugated cardboard (OCC) from initial screens and secondary screens conveyed to a quality control (QC) station.
2. Polishing screens with an optical sorter to remove film and browns from mixed paper.
3. Negative post-sort to clean up mixed paper materials.

Container Line

1. Magnet and eddy current system to remove aluminum and metal.
2. Containers are conveyed to three optical sorters: PET, HDPE, and an optional sorter for PP or other post sort materials.
3. QC stations perform a negative sort of contaminants.

The two figures show the flow diagram (Figure 6), plan view (Figure 7), and 3D model (Figure 8) of the equipment lines.

Figure 6. Flow Diagram of MRF Equipment

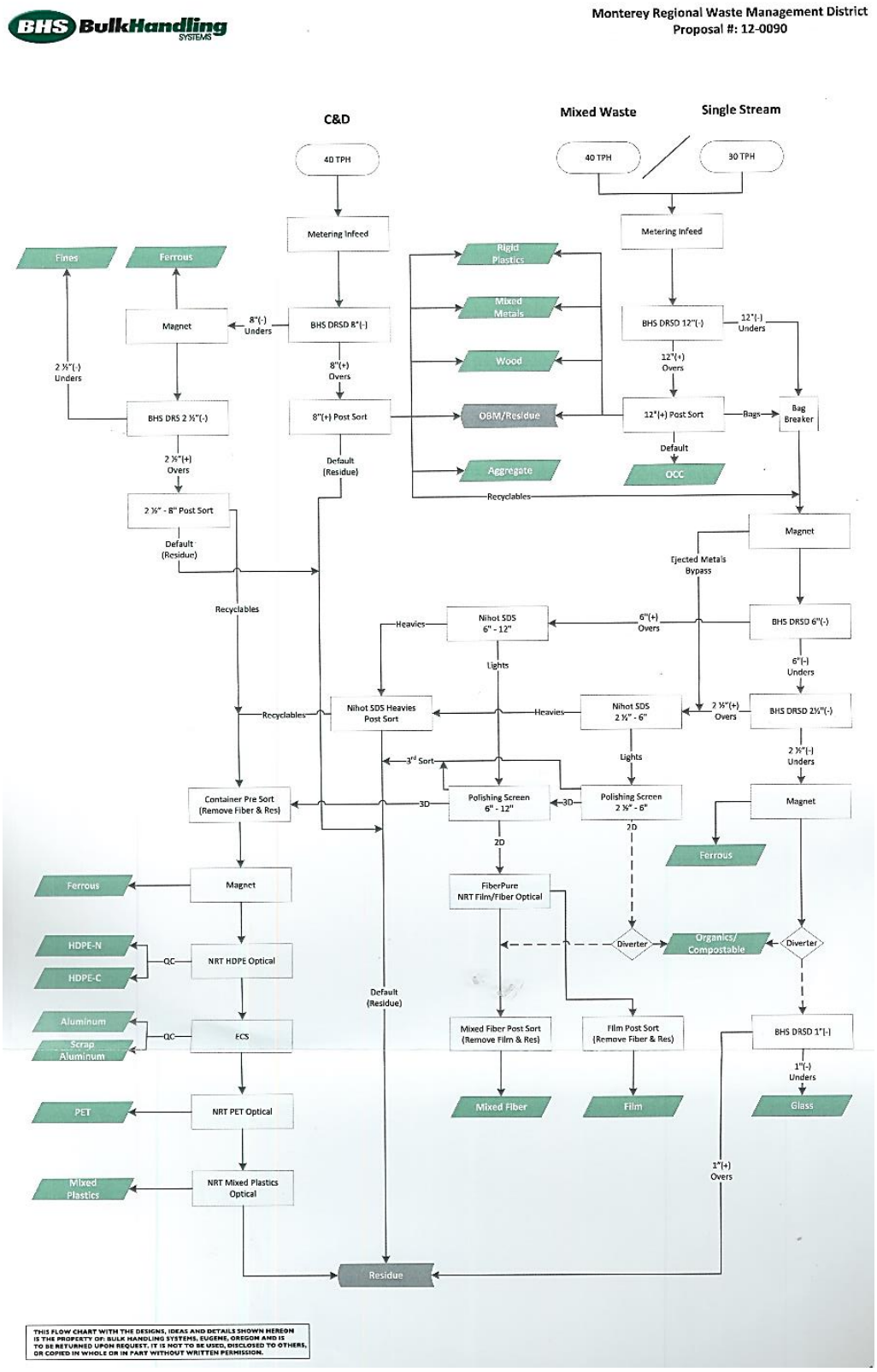


Figure 7. Plan View of MRF Equipment Layout

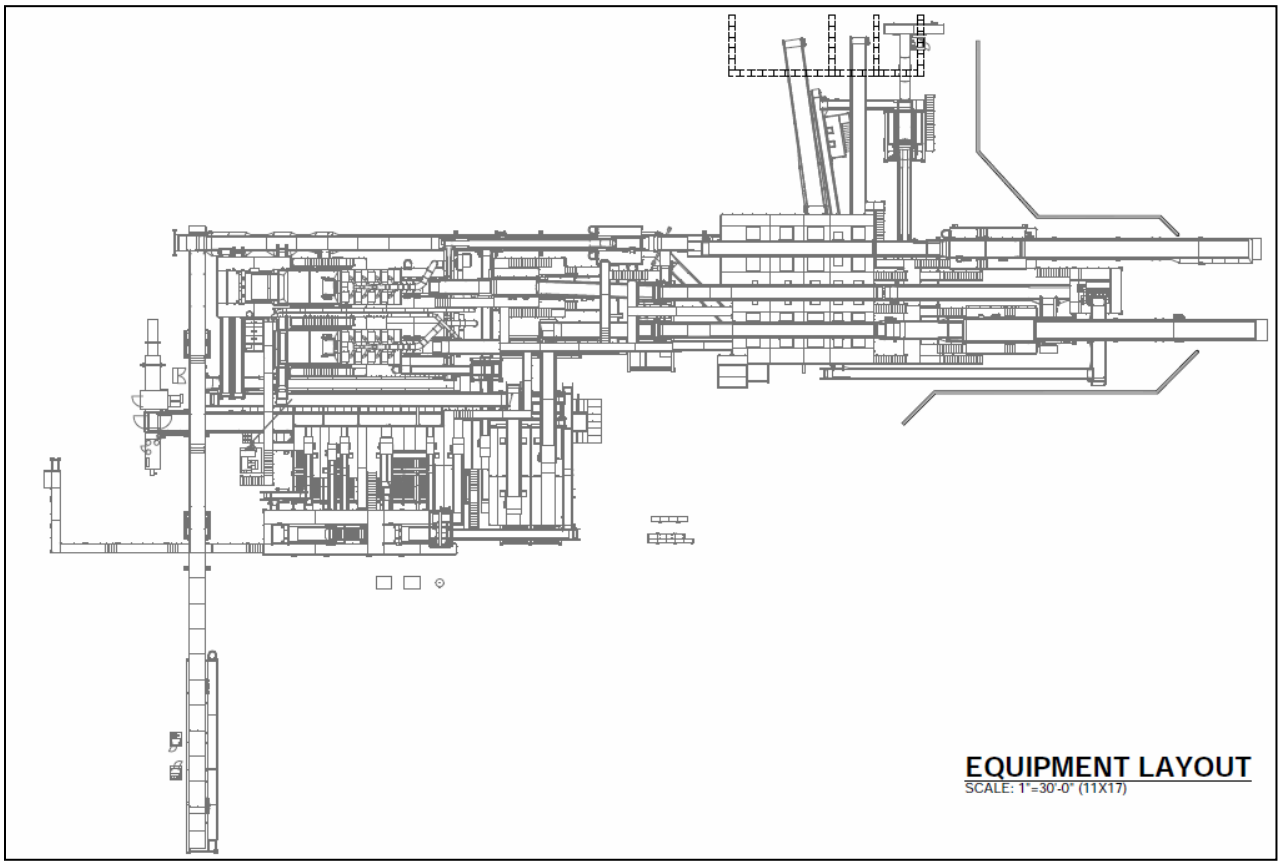
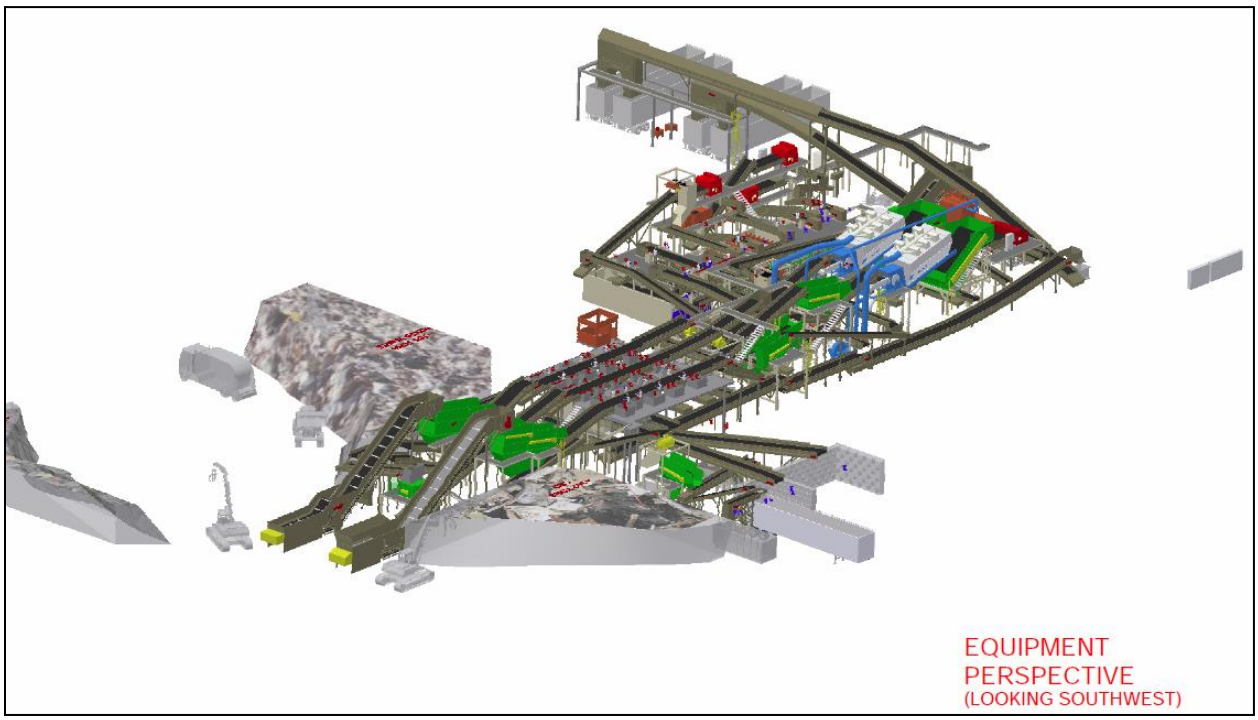


Figure 8. 3D Model of MRF Equipment



Anticipated System Upgrades

After operating the system for 18 months, the District is planning to add equipment to improve performance, reduce labor, and improve reliability in providing quality bales. The new equipment will include modifying the front-end screens to separate OCC and prepare materials for additional optical sorters on the fiber line for brown fiber separation. The modifications also include adding two artificial intelligence robotics on the residual stream to capture CRV aluminum and PET materials currently lost to disposal. When completed, the system will process the single-stream recycling and make available capacity for mixed waste.

Some of this additional equipment was included in the original layout but delayed to reduce initial costs. The original layout also anticipated the possible expansion of the line to handle more materials. The new equipment is also intended to better handle the increase in the amount of residential single-stream recycling being delivered by regional jurisdictions.

Unusual Maintenance Needs

The operator reported the equipment does a good job and they do not experience unusual downtime for wrapping or leakage. The system uses Single drum Nihot air separator in conjunction with debris roll screen declined with optical to remove film.

Staffing

The District's fiscal year 2018/2019 budget documents the facility's staffing levels. The budget includes operation of two processing lines that together handle about 140,000 tons per year. Information on how many sorters are used on each line is not available. During the start-up testing phase, the MRF used temporary sorters to determine appropriate staffing levels; the facility's labor agreement limits use of temporary labor during full operation.

Table 1. Staffing Levels and Costs

Staffing Type	2017/2018 FTE	2018/2019 FTE
Director of Operations	0.25	0.25
MRF Operations Manager	1	1
Assistant Manager	1	1
Supervisor	3	3
Sr. Operator	2	2
MRF Operator II	9	8
Associate Operator	4	4
Operations Support Specialist	1	1
Sort Line Lead	2	3
MRF Resource Associate (sorter)	5	13
MRF Resource Assistant (sorter)	20	21
TOTAL AUTHORIZED POSITIONS	48.25	57.25
TOTAL PERSONNEL EXPENSES		$4,664,000

The levels of labor shown are used to operate two MRF lines.

Incoming Materials

Materials Accepted

Accepted materials for single-stream residential are listed in Table 14.

Table 14. Accepted Materials List for Single-Stream

Category	Specific Materials
Fiber	• Cardboard, including clean pizza boxes • Paper bags • Newspapers and inserts • Boxboard, including frozen food boxes • Catalogs, magazines, and junk mail • Printing and writing paper, including shredded paper if bagged in a clear plastic or paper bag • Egg cartons • Gift wrap and gift tissue (non-metallic) • Telephone, hardcover, and softcover books
Cartons	• Gable-top cartons
Plastics	• Plastic containers #1-#5 (including bottles, tubs, and clamshells) • Rigid plastic items large than 12 inches (such as buckets, plastic #2 flower pots, coat hangers, non-foam coolers, and crates)
Metals	• Aluminum cans • Steel/tin cans and lids • Aerosol cans • Aluminum foil, trays, and pans • Small scrap metal (such as screws and nails, empty paint cans, pots and pans, tools).
Glass	Glass bottles and jars containers

Incoming Composition

In October 2019, the District completed a recycling waste characterization study to evaluate the level of contamination in the single-stream recycling being delivered. The study found an average contamination rate of 22% from all sources.

The lowest contamination levels were from the City of Monterey (17.9%), the City of Watsonville (18.7%), and District's member agencies (18.9%). The highest rates of contamination are from the communities of Salinas and San Benito County, at 26.2% and 25.4% respectively. Table 15 summarizes sample and contamination data from the study.

The District charges a $40 per-ton fee to process the materials from these outside jurisdictions. In addition, it charges for disposal of residuals at $62 per ton disposed. According to the operator, based on residual rates, the residual disposal fee averages about $7.50 per ton of total incoming materials processed. The result is a total fee averaging about $47.50 per ton of incoming material processed. The District incentivizes each jurisdiction to conduct an aggressive promotion and education program to reduce contamination: if their program is accepted and executed, the District will provide a rebate of $5.00 per ton to that jurisdiction.

Table 15. Summary of Contamination Delivered to MRWMD Per Month

Hauler (City)	Tons/ Month	No of Samples	Contamination			
			Proportion		Monthly Tons	
			Average	90% Confidence	Average	90% Confidence
Greenwaste Recovery	**905**	**61**	**18.9%**	**+/- 2.9%**	**171**	**+/- 26**
Marina	170	10	25.5%	+/- 13.7%	43	+/- 23
Sand City	10	5	15.2%	+/- 4.7%	2	+/- 0.5
Del Rey Oaks	25	5	15.9%	+/- 3.6%	4	+/- 1
Seaside	265	10	18.2%	+/- 4.5%	48	+/- 12
Carmel by the Sea	150	11	16.0%	+/- 3.4%	24	+/- 5
Pebble Beach	110	10	18.1%	+/- 6.7%	20	+/- 7
Pacific Grove	175	10	20.4%	+/- 7.1%	36	+/- 12
Monterey Disposal	**175**	**10**	**17.9%**	**+/- 4.8%**	**31**	**+/- 8**
City of Monterey	175	10	17.9%	+/- 4.8%	31	+/- 8
Waste Management	**1,500**	**50**	**21.4%**	**+/- 3.3%**	**320**	**+/- 50**
Unincorporated Monterey County	1,350	40	22.4%	+/- 3.7%	302	**+/- 50**
King City	150	10	17.3%	+/- 7.2%	26	**+/- 11**
Republic Services	**1,600**	**50**	**26.2%**	**+/- 2.6%**	**420**	**+/- 42**
Salinas	1,600	50	26.2%	+/- 2.6%	420	+/- 42
City of Watsonville (Public Works Dept.)	**120**	**10**	**18.7%**	**+/- 7.1%**	**22**	**+/- 9**
City of Watsonville	120	10	18.7%	+/- 7.1%	**22**	**+/- 9**
Recology	**416**	**20**	**25.4%**	**+/- 5.7%**	**106**	**+/- 24**
San Benito County	416	20	25.4%	+/- 5.7%	106	+/- 24
IN DISTRICT	**2,430**	**111**	**20.1%**	**+/- 2.1%**	**487**	**+/- 52**
OUT OF DISTRICT	**2,286**	**90**	**24.2%**	**+/- 2.3%**	**554**	**+/- 52**
Total	**4,716**	**201**	**21.9%**	**+/- 1.6%**	**1,034**	**+/- 74**

Outbound Materials and Processing Effectiveness

Materials Shipped

Table 16 shows the materials processed and recovered from C&D and single-stream recycling (SSR) over the first four months of fiscal year (FY) 2019/2020 (i.e., July through October 2019). The District's MRF was also designed to process mixed commercial waste; however, it has delayed processing this material because of the unanticipated large demand to process the region's single-stream recycling.

Table 16. Materials Processed and Recovered July — October 2019

MRF Tonnage					
MRF - Accepted Materials					
C&D					
MRF C&D Net of Material Landfilled	2,936.31	3,103.25	3,260.83	3,689.91	12,990.30
SSR					
MRF Single Stream Recycling	5,210.91	4,922.65	5,390.03	5,617.90	21,141.49
Buy Back Center	245.49	129.91	132.45	213.71	721.56
Free Recycling/ Z Wall	42.72	66.29	77.62	57.56	244.19
MRF SSR Net of Material Landfilled	5,499.12	5,118.85	5,600.10	5,889.17	22,107.24
Total MRF Accepted Materials	8,435.43	8,222.10	8,860.93	9,579.08	35,097.54
MRF - Diverted Materials					
C&D					
Metal	429.86	382.70	423.52	468.86	1,704.94
Mattresses	47.32	35.05	35.35	39.95	157.67
Asphalt/Concrete	198.24	136.94	207.83	272.58	815.59
Unders from Sort Line	860.20	888.25	850.85	1,028.50	3,627.80
Last Chance Material	54.21	51.14	51.14	54.21	210.70
Roofing Materials	204.72	221.78	204.72	204.72	835.94
Tires Hauled	21.09	12.70	13.13	9.86	56.78
Sheetrock	146.70	97.80	127.14	107.90	479.54
Wood Out	211.31	461.98	350.49	294.76	1,318.54
Total C&D Diverted	2,173.65	2,288.34	2,264.17	2,481.34	9,207.50
SSR					
Mixed Plastic	60.50	40.75	73.49	42.30	217.04
OCC/Cardboard	1,447.31	1,392.01	1,582.49	1,370.76	5,792.57
Mixed Glass	702.54	678.66	724.08	856.67	2,961.95
PET	82.74	88.13	85.24	93.15	349.26
Aluminum UBC	24.11	3.29	22.29	44.66	94.35
Poly Prop #5	26.50	24.90	29.20	29.53	110.13
HDPE - Color	66.84	13.74	84.00	53.30	217.88
HDPE - Natural	43.34	34.49	43.12	43.77	164.72
Mixed Paper	961.56	869.10	1,132.00	1,018.48	3,981.14
Aluminum scrap	-	-	-	0.73	0.73
Tin Lined Steel Cans	50.07	42.00	51.30	71.29	214.66
Shredded Paper	9.56	6.00	7.50	6.80	29.86
Total Single Stream Recycling Diverted	3,475.07	3,193.07	3,834.71	3,631.44	14,134.29
Total MRF Diverted Materials	5,648.72	5,481.41	6,098.88	6,112.78	23,341.79
C&D Percent Diversion	74.0%	73.7%	69.4%	67.2%	70.9%
Single Stream Recycling Percent Diversion	63.2%	62.4%	68.5%	61.7%	63.9%
Percent Diversion - Entire MRF	67.0%	66.7%	68.8%	63.8%	66.5%

12 Month Average	
C&D Percent Diversion	70.4%
Single Stream Recycling Percent Diversion	61.6%
Percent Diversion - Entire MRF	64.9%

In the first quarter of the fiscal year, the single-stream recycling line processed 21,141 tons and recovered 14,134 tons. On the following page, Figure 9 show the percentage of materials recovered from the system for a month in this period.

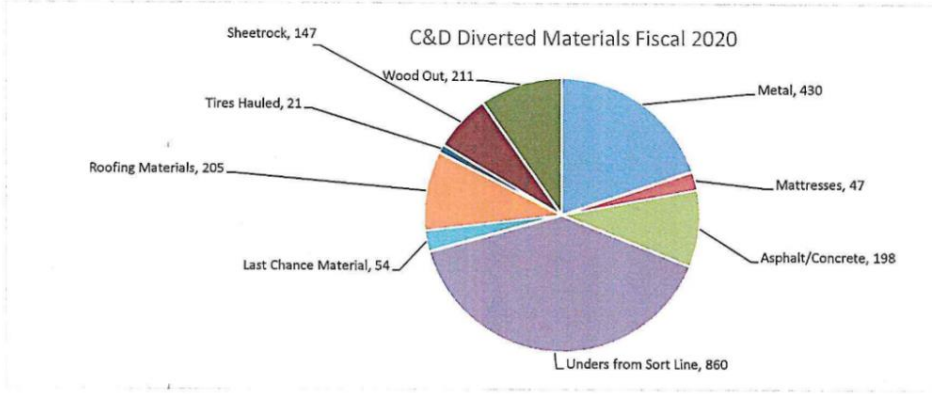
Figure 9. Monterey Regional Waste Management District Recycling Report

MONTEREY REGIONAL WASTE MANAGEMENT DISTRICT
RECYCLING REPORT
SEPTEMBER 2019

Fiscal 2020 MRF Diverted Materials - Month Ended October 31, 2019

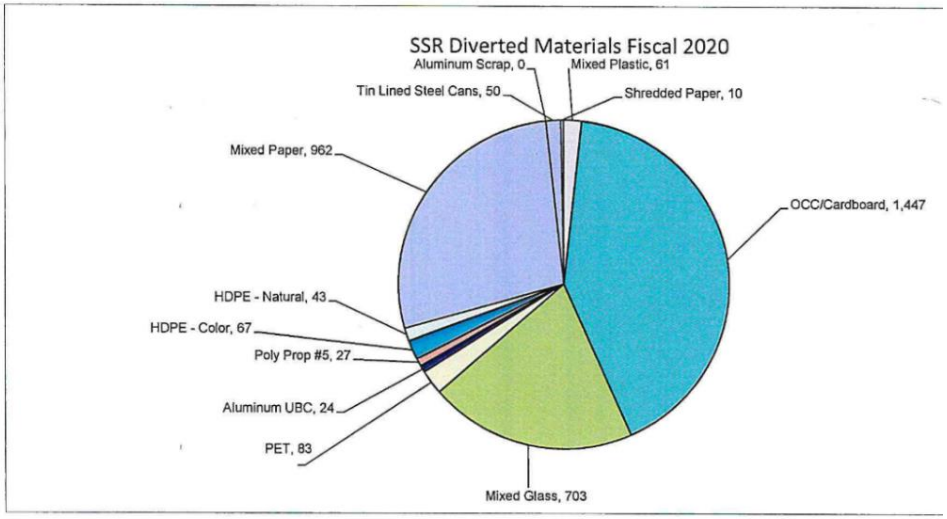
C&D Diverted Materials

		Tons	
Metal		430	19.8%
Mattresses		47	2.2%
Asphalt/Concrete		198	9.1%
Unders from Sort Line		860	39.6%
Last Chance Material		54	2.5%
Roofing Materials		205	9.4%
Tires Hauled		21	1.0%
Sheetrock		147	6.7%
Wood Out		211	9.7%
	Total	2,174	
C&D Percent Diversion		74.0%	



SSR Diverted Materials

		Tons	
Mixed Plastic		61	1.7%
OCC/Cardboard		1,447	41.6%
Mixed Glass		703	20.2%
PET		83	2.4%
Aluminum UBC		24	0.7%
Poly Prop #5		27	0.8%
HDPE - Color		67	1.9%
HDPE - Natural		43	1.2%
Mixed Paper		962	27.7%
Aluminum Scrap		0	0.0%
Tin Lined Steel Cans		50	1.4%
Shredded Paper		10	0.3%
	Total	3,475	
SSR Percent Diversion		63.2%	



The District reports that sorted materials are sent to the markets shown in Figure 10.

Figure 10. Commodity Markets

Monterey Regional Waste Management District (MRWMD) process recyclables from most of Monterey County (excluding Monterey and the Tri-City area). Here is a list of where recycled materials go and what products they become.

MATERIAL TYPE	DESTINATION	WHAT IT BECOMES
#1 PET Plastic	Georgia	Carpet
#2 HDPE Natural Plastic	California	Resin & flake for remanufacturing
#2 HDPE Colored Plastic	Iowa	Industrial Piping
Mixed Rigid Plastics	Taiwan	Molded plastic Products
#5 Polypropylene	Alabama/California	Plastic Paint Cans, packaging
Aluminum	California	Sold to broker
Steel	Sold to US broker	Rebar, car parts
Mixed paper	Thailand / Indonesia	Boxboard
Cardboard	Vietnam	Linerboard
Shredded Paper	Domestic	Tissue paper
Aluminum Cans & Foil	Pennsylvania	Aluminum roll stock for remanufacturing
Glass	California	Glass bottles, insulation, filter media

Source: https://whatgoeswhere.info/end-markets/

Ability to Sort Materials

Current System Performance (Single-Stream)

Besides contamination, the District also loses another 14% of incoming material through the initial 12-inch screen process that was specifically designed to process mixed waste. Most of these materials are small containers and small paper that get contaminated when in contact with wet materials including food waste. The operator reports that perhaps 5% of this material represents commodities that could be recovered if the front end were modified to handle the amount of single-stream recycling being processed. With the decision to continue processing larger than anticipated amounts of single-stream materials, the District expects add more front-end equipment better suited to handling this material mix.

Nonetheless, the District reports that all recovered materials meet product specifications needed to sell materials and they have no problems marketing the materials.

Designed and Tested Performance (Mixed Waste)

As previously discussed, the system was designed as an integrated mixed waste/single-stream recycling MRF. Because the facility is focusing on the region's commingled materials instead of commercial mixed waste, at this time only projected and performance testing data are available for regarding the system's ability to handle mixed waste.

Figure 3 on the following page illustrates the projected system performance from processing the District's mixed commercial waste stream. The District provided potential vendors with commercial waste characterization data and specified the performance standard in terms of desired recovery rates by material type. Vendors projected the recovery rates their systems were designed to achieve, based on similar systems sold to other facilities. Before accepting the equipment and making final payment to the vendor, the District required the system to meet the vendor's projected performance standards though performance testing conducted by an independent company.

The data shows an estimated 31% to 40% of the materials processed are recovered organics composed of food waste, yard debris and compostable paper. This material can be processed at the Districts on-site anaerobic digester system used to make electric power and/or at the on-site composting operation.

Figure 4. Estimated Recovery Rates for the Mixed Waste Stream

Mixed Waste Stream

Mixed Waste Stream	Data Supplied by MRWMD								BHS Recovery Projected		
100,000 TPY	Lower Commodity Volumes				Higher Commodity Volumes				Based on Higher Commodity		
	%	Recovery Rate	Quantities (TPY)	Recovery (TPY)	%	Recovery Rate	Quantities (TPY)	Recovery (TPY)	BHS Recovery Rate*	Quantities (TPY)	Recovery (TPY)
Food	27.00%	70%	27,000	18,900	27.00%	70%	27,000	18,900	90%	27,000	24,300
Compostable Paper	9.00%	70%	9,000	6,300	9.00%	70%	9,000	6,300	85%	9,000	7,650
Yard/Green Waste	8.70%	80%	8,700	6,960	8.70%	80%	8,700	6,960	90%	8,700	7,830
Cardboard	2.60%	75%	2,600	1,950	6.00%	75%	6,000	4,500	90%	6,000	5,400
Paper	7.50%	60%	7,500	4,500	8.00%	60%	8,000	4,800	85%	8,000	6,800
Glass	1.00%	80%	1,000	800	1.00%	80%	1,000	800	95%	1,000	950
PET	0.30%	75%	300	225	0.70%	75%	700	525	95%	700	665
HDPE	0.30%	75%	300	225	0.60%	75%	600	450	95%	600	570
Tin/Steel Cans/ FE Scrap	1.20%	80%	1,200	960	3.00%	80%	3,000	2,400	95%	3,000	2,850
Aluminum Cans	0.10%	80%	100	80	0.50%	80%	500	400	95%	500	475
Wood/Lumber	4.10%	70%	4,100	2,870	4.10%	70%	4,100	2,870	90%	4,100	3,690
Rock, Soils, Fines	0.50%	80%	500	400	0.50%	80%	500	400	90%	500	450
Sub-Total per MRWMD	62.30%		62,300	44,170	69.10%		69,100	49,305		69,100	61,630
Residue	37.70%		55,830		30.90%		50,695			38,370	
Total recovery projected				**44%**				**49%**			**62%**
Additional recoverables projected based on BHS experience											
Mixed Plastics: #3-#7 containers	3.00%	0%	3,000	-	4.00%	0%	4,000	-	90%	4,000	3,600
Film	2.00%	0%	2,000	-	2.00%	0%	2,000	-	60%	2,000	1,200
Sub-Total adjusted	67.30%		67,300	44,170	75.10%		75,100	49,305		75,100	66,430
Residue adjusted	32.70%		55,830		24.90%		50,695			33,570	
Total recovery adjusted				**44%**				**49%**			**66%**

*Notes on Recovery Rates

1. Recovery rates for food, glass, rock, soils, fines indicate the % of that material that is separated out by a DRS and is (-2-1/2"). These materials will all be in the "organics" stream that will be sent to the future Pre-compost/AD clean-up system.
2. Recovery rates for yard/greenwaste and compostable paper is a combination of larger material and DRS fines (-2-1/2").
3. We have added #3-#7 mixed plastics and film to recoverables based on Table 1.2 in Exhibit A of the RFP. We are effectively recovering these commodities at similar MRF's and the system proposed for MRWM will target these items. This will add significantly to overall recovery rate.

Monterey Regional Waste Management District – Marina, CA · BHS Proposal 12-0090-DV4 · RFQ #07114MRWMD

Financials

The system was purchased by the District through a competitive contract to provide full services/turnkey design and installation. The final cost of the equipment was $14.5 million which includes the California state sales tax plus $9.5 million in site and building improvements. The final installation was delayed due to the need to complete changes to the MRF building. The price included two separate feeds: one for the integrated mixed waste/single-stream recycling line and one for the C&D processing line. Separate pricing for the mixed waste/single-stream recycling line alone are not available.

Table 17 shows annual operating expenses for fiscal year 2018/2019.

Table 17. Non-Salary Facility Expenses for Fiscal Year 2018/2019

EXPENSE CATEGORY	COST
Proposed Contract Services	$1,145,000
Fuels & Oil	$150,000
Office Expenses	$5,000
Operating Supplies	$145,000
Professional Services	$200,000
Recycling Services	$727,000
Safety Equipment, Supplies, Uniforms	$97,000
Training, Education & Meetings	$20,000
Utilities	$75,000
TOTAL NON-SALARY EXPENSES	$2,564,000
TOTAL PERSONNEL EXPENSES	$4,664,000
TOTAL MRF EXPENSES	$7,228,000

The District estimated revenues for fiscal year 2017/2018 were $2,099,000. This represents only a partial year as the MRF was still completing its startup phase. In fiscal year 2018/2019, the projected revenues were $6,312,000, includes both the sale of commodity materials and proceeds from CRV for containers recovered from single-stream recycling.

Recycling Regulations

Bottle bill: in California, most beverage containers (aluminum, glass, plastic and bi-metal containers) are covered by the CRV recycling program. Milk, wine, and distilled spirits are excluded from the bottle bill. Processing facilities receive redemption values for containers sorted from curbside recycling.

Mandatory commercial recycling: in California, businesses that generate more than four cubic yards of garbage (including multifamily properties with five or more units) are required to subscribe to recycling service.

Mandatory residential recycling: in California, new organics-focused regulations will soon make recycling and organics collection practically mandatory for all residents; however they are not currently in place.

Improving Oregon Recycling Systems Infrastructure Research

Dual-Stream Material Recovery Facility: Palm Beach County

Case Study February 6, 2020

Case study completed by Tim Buwalda, Circular Matters, LLC.

Business Overview

Facility Information

Material Recovery Facility (MRF) Name	Palm Beach County (FL) SWA MRF
Address	5860 45th Street, West Palm Beach, FL 33412
Owner	Palm Beach County Solid Waste Authority (SWA)
Operator	Sims Municipal Recycling (based in New York)
Startup date or date of most recent major retrofit	Opened in 2009
Anonymity/confidentiality promised to MRF	None
Data Sources (e.g., contacts, articles, or reports)	Jim Greer, Manager Recovered Materials Processing https://swa.org/258/Recycling-Reports

Facility Overview

Case Study Type	Dual-Stream MRF(s)
Capacity/Throughput	Line 1: Fiber • Two parallel lines: one for residential and one for commercial fiber • Originally capacity of 35 tons per hour (tph) reduced to 30 tph due to evolving material stream • Throughput commercial fiber: 16,952 tons per year • Throughput residential fiber: 36,900 tons per year Line 2: Containers • Capacity: 15 tph • Throughput residential containers: 36,400 tons per year
Accepted Generator Streams and Preparation Methods	• Residential (dual-stream) from single-family and multi-family properties • Commercial fiber
Inbound Contamination and Outbound Residue and Material Quality	• Incoming materials have a combined 7.4% contamination rate • The facility residue rate is 14.3%, which is a combination of contamination and missorted target recyclables • The MRF produces high-quality recyclables to domestic market specifications – these materials are auctioned to domestic and export markets.

Description of Operations and Focus

This dual-stream MRF serves Palm Beach County, Florida, municipalities and unincorporated residents, including over 600,000 households. It also processes some commercial fiber, collected through the Palm Beach County Solid Waste Authority's (SWA) network of commercial paper drop-off containers. The nearly 138,000 square-foot, $40 million facility has a processing capacity of 750 tons per day if operated with two shifts per day.

System Overview

Equipment

The MRF has three tipping floors: one for residential fiber, one for commercial fiber (both on the east end of the facility), and one for containers on the west end of the facility.

Containers

1. Containers are delivered to the facility by route collection trucks or SWA transfer trailers. The containers are then pushed onto a conveyor belt where bulky non-recyclable material is manually removed at a presort station.
2. The steel is then removed using a magnetic conveyor belt, loaded loose onto a truck, and sent to a private facility to be processed.
3. The remaining material is then conveyed to a sorting room where workers manually sort large recyclable PP and HDPE plastic, paper for recycling, cartons for recycling, remove and dispose of contamination.
4. The material continues to a glass breaker where the glass is crushed. The crushed glass is given to a recycler or sent to the landfill to be used as cover.
5. An eddy-current separator repels the aluminum from the line. The aluminum is baled and shipped to market.
6. The remaining material, mostly plastic, is sent to a series of two optical sorters.
    a. The first optical sorter removes PET.
    b. The second optical sorter removes HDPE natural and colored.
7. The remainder — Plastics #3 — 7 — is sorted by hand to remove remaining contaminants. The separated 3-7 material is checked for quality and then baled for shipment.

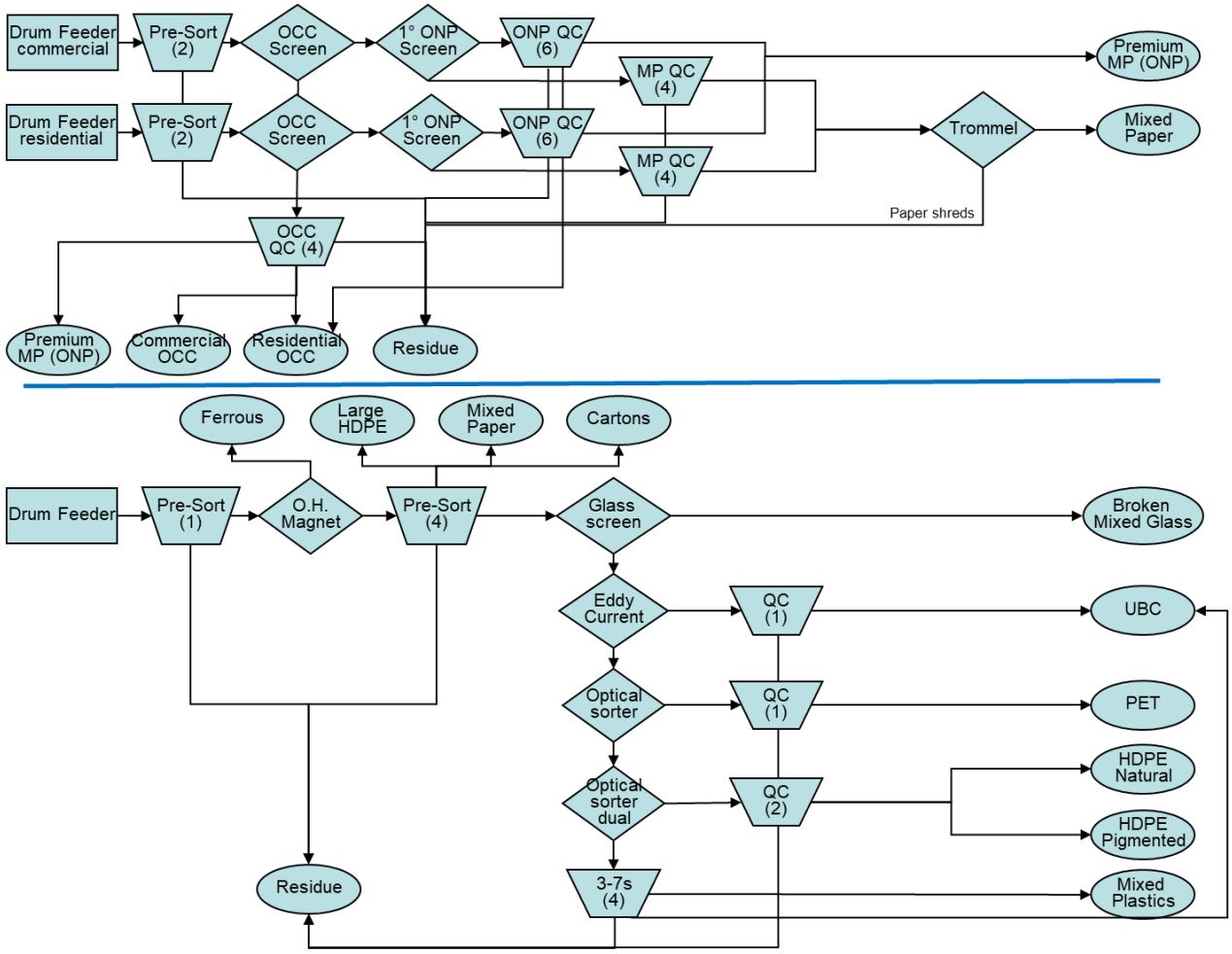
Other than glass, all recovered container materials are baled prior to being transported to market. The residue represents over 14% of materials the MRF receives and includes both contamination and target recyclables that were not successfully sorted. The majority of residue is sent to the SWA's nearby waste-to-energy facility.

Fiber

Fiber is delivered by route collection trucks or SWA tractor trailers and deposited on the fiber tipping floor on either the commercial side or the residential side. The material is then loaded onto conveyors, which transport the material to a presort station where contamination is removed. The remaining materials pass over a disc screen which separates out large OCC, which is followed by a star screen system that separates large paper from smaller mixed paper. The separated OCC, large paper, and small paper streams go to a fiber sorting room where workers remove contamination by hand and redirect brown fiber to the OCC bunker. A trommel cleans fine contaminants out of mixed paper. All paper streams are dropped into bunkers, then baled and shipped to market.

Figure 1 shows a process flow diagram for the MRF. The top half of the diagram shows the paper stream processing flow, and the bottom half shows the container processing flow.

Figure 11. Processing Flow Diagram



Unusual Maintenance Needs

The MRF does not have any specialized equipment with unordinary maintenance costs.

Staffing

The facility currently has approximately 80-85 staff but has been able to operate in the past with under 70 people. Due to seasonal population shifts, staffing is a problem and the MRF needs extended hours and extra shifts in the winter and reduced labor in the summer. Normal staffing is 41 direct people to sort residential recyclables and commercial fiber per shift. Sims is required by its operating contract with the SWA pay workers the Palm Beach County living wage of $12.62, plus annual living wage adjustments. The Florida minimum wage is $8.56 per hour in 2020 so sort labor at the SWA costs nearly 50% more than the minimum wage. The operations contractor uses a mix of permanent employees with benefits and temporary employees without benefits.

Incoming Materials

Materials Accepted

Category	Specific Materials
Fiber	Residential: OCC, boxboard (such as tissue and dry food boxes), newspapers, magazines and catalogs, unwanted mail, school and office papers, phone books, and paper bags Commercial: old corrugated containers and office paper
Cartons	Milk and juice cartons
Plastics	Plastics containers less than 5 gallons except plastic foam
Metals	Steel and aluminum cans
Glass	Glass bottles and jars

Incoming Composition

Current data are unavailable because the last incoming material composition study was conducted three years ago, and the incoming material stream has changed a lot since then. Outgoing commodities and residue composition, which they audit, can be used to estimate inbound material composition. Based on audits of outgoing commodities and residues, incoming materials have a combined 7.4% contamination rate.

Outbound Materials and Processing Effectiveness

Materials Shipped

Outgoing products after sorting, including relative amounts and quality measures are shown below in Table 1. The SWA markets its own materials through an auction process, so where materials are sent for recycling varies. Major export ports are nearby in Fort Lauderdale and Miami and it is not uncommon for brokers to purchase SWA materials for export.

Table 18. Outbound Products Produced and Product Quality

Output Product	Amount	Notes
HDPE	2.07%	
PET	4.70%	
Plastic 3-7	0.52%	20% of the bale content consists of HDPE and PET (equating to about 1.5% of overall HDPE and PET)
Ferrous metal	1.75%	
Aluminum UBCs	0.95%	
Other Aluminum	n/a	
Glass	22.36%	
Cartons	0.06%	
OCC	19.51%	
Mixed Paper	25.94%	3% of these bales are prohibitives
Sorted Residential Fiber	7.83%	7% of these bales are browns outthrows
Residue	14.30%	Includes contamination and missorted recyclables

Ability to Sort Materials

Fiber

Small format OCC poses a challenge for the OCC star screens. As a result, some of the small OCC ends up in the remaining fiber bales. The facility adjusted the star spacing which helped capture more OCC but did not capture all of it.

Currently the facility produces PSI 56 Sorted Residential Papers & News as a grade. The official specification calls for browns (including boxboard) to be less than 3%; however, the facility is only able to get down to 7% browns. Rather than sell it as mixed paper, which is a separate but lower value grade that they also produce, the facility sells the material as a non-conforming PSI 56. The SWA would like to add Tomra optical sorters on the fiber line to better sort the fiber, primarily for fiber sorting to meet grade specifications but also for contamination removal. The facility believes that Tomra equipment is the only equipment that can meet the purity and capture rates desired to produce PSI 56 on the fiber side. Its goal for residential fiber with equipment upgrades would be to produce two grades: residential OCC/Boxboard and Sorted Residential Papers & News.

Containers

PET has increased in volume since the optical sorter was installed in 2009, and the sorter struggles to capture it all. The same is true of the HDPE optical sorter. Despite being operated at capacity, the optical sorters are able to sort 98% of the PET and HDPE correctly into those commodity streams.

The SWA is able to successfully sort 93% of target recyclables. The SWA strongly believes that dual-stream collection and processing make it easier to sort program materials and improves the quality of recyclables when compared to single-stream recycling. They have no interest in converting to single-stream.

Non-Program Materials

According to the SWA they produce high quality materials and can market all products produced, including mixed paper and mixed #3-#7 plastics, even when other MRFs have problems selling materials.

They are operating at 3% prohibitives on the mixed paper line and want to reduce this to the 2% ISRI PSI grade specification.

They manually sort out prohibitives from the OCC with four quality control staff and can meet specifications with the existing system.

The SWA is not currently interested in robotic sorters because SWA staff believe the technology is still too new. SWA engineering staff would consider robotic sorters in future, probably installing them at the end of the container line to sort missed materials and low percentage materials, although there are no current plans to add robots to the MRF. SWA staff believe there is less of a case for using robots for quality control in their facility as a robot needs to replace more than one person to be cost-effective, robots are more effective sorting containers than paper, and the SWA's container line quality control positions are manned by one person.

The SWA reduced the incoming loose film by about 50% through educational efforts. The City of Palm Beach also promotes using reusable bags and passed a plastic bag ban in July 2019 (which was repealed in August 2019).

Financials

SWA keeps all the revenue from the sale of materials and pays Sims a processing fee to operate and maintain the MRF. The processing fee is determined by a complex formula that includes a fixed price for base tonnages of $5.9 million with the SWA guaranteeing 21,660 tons of residential fiber per year, 6,000 tons of commercial fiber per year, and 35,760 tons of containers per year. Additional compensation is paid at a lower rate for quantities over the base tonnages. Compensation for the excess tonnages is $82/ton for containers, $80/ton for residential fiber, and $87.50/ton for commercial fiber. Based on forecasted tonnages for 2020, the SWA anticipates paying Sims an average processing fee of $95 per incoming ton for forecasted base and excess tonnages. The gross cost per ton marketed to the SWA is not precisely tracked but could be as high as $170 per ton after adjusting for the cost of residue disposal and depreciation on the sorting equipment and building. The cost may be less than this since the sorting equipment has been largely depreciated. Table 19 summarizes capital and operation costs for this facility.

Table 19. Capital and Operating Costs

Cost Category	Amount
Capital Costs	**$49 million**
Facilities (excl. land)*	$36 million
Fixed equipment costs*	$13 million
Annual Operating Costs	**$8.9 million/year**
Labor and contracted operation	$8.2 million/year
Residue disposal	$0.3 million/year
Other costs and profit	$0.4 million/year
Gross cost/ton marketed	**As much as $170**

*Replacement value estimates. Original 2009 cost was $40 million.

Recycling Regulations

The facility receives material from generators that are not currently affected by any recycling regulations.

Appendix 2

[Equipment glossary – forthcoming.]