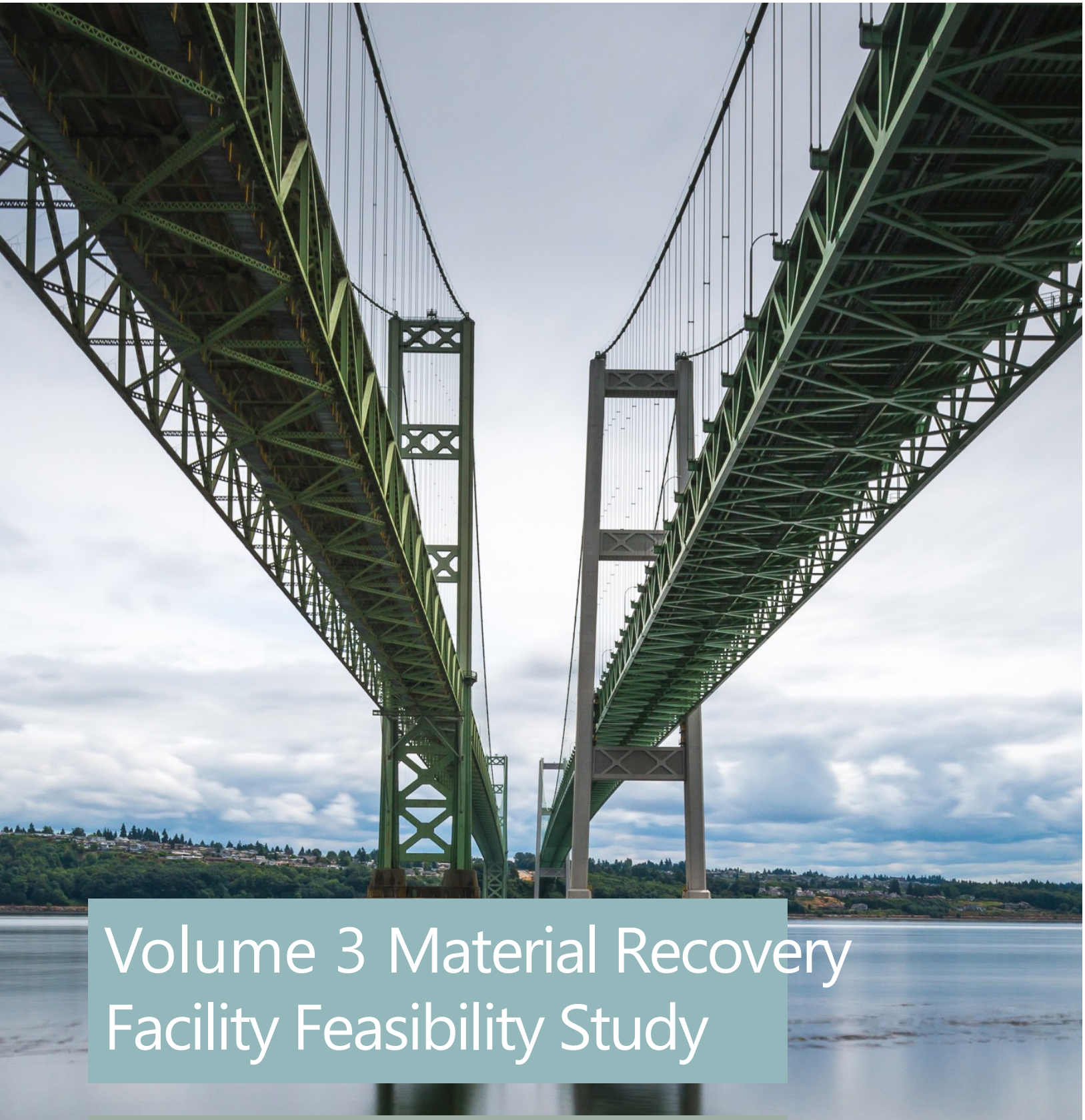

Volume 3 Material Recovery Facility Feasibility Study

Sustainable Materials Management Plan

2015

City of Tacoma
WASHINGTON

CASCADIA
CONSULTING GROUP

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Chapter 1. Introduction

The City of Tacoma (City) provides a full range of solid waste and recycling services to residences and businesses. These services include curbside garbage, recycling, and yard waste collection, as well as options for self-haul customers, including household hazardous waste (HHW) drop-off located at the Tacoma Recovery and Transfer Center (TRTC). Collection and facility operations are provided by the City's Solid Waste Management Division (SWM), which operates as part of the City's Environment Services Department.

The City's SWM is committed to:

- Providing prompt, considerate, and reliable customer service in a professional manner.
- Implementing processes and technologies to make their services fiscally sound and environmentally sustainable.

The City has maintained its commitment to sustainable waste management by providing a wide range of waste prevention, reduction, reuse, and recycling services to residences and businesses. SWM supports these services with a comprehensive public education and promotional information program.

1.1 Purpose

Consistent with its sustainability policies, the City has adopted a goal to achieve a 70% recycling rate by 2028. The results of this feasibility report will be considered in conjunction with sustainability programs to determine the best approach for attaining this goal. This report focuses on the amount of material that could be recovered in an advanced (mixed waste) material recovery facility (MRF). The City already collects source-separated recyclables from residential customers and processes those recyclables at Waste Management's JMK MRF. To achieve higher recycling rates, the City would need to process non-construction and demolition (C&D) waste (also known as mixed commercial waste) to recover additional materials discarded by businesses and institutions. This can also include multifamily residences. Another waste stream that could be processed at an advanced MRF is waste delivered by self-haul customers.

The purpose of this report is to evaluate employing an advanced MRF to recycle and/or divert from disposal at landfills increased quantities of materials. The evaluation involves determining the cost of building, equipping, and operating a facility as well as estimating how much material can be recycled. Using waste composition data from the 2015 spring and fall sampling programs conducted by Cascadia Consulting Group, the project team has identified and evaluated the following four MRF options for processing different waste streams:

1. Commingled residential recyclables
2. Commingled residential recyclables, non-C&D commercial waste, and multifamily waste
3. Commingled residential recyclables and high-grade non-C&D commercial waste
4. Commingled residential recyclables, high-grade non-C&D commercial waste, and high-grade non-C&D self-haul waste

Option 1 evaluates whether it is cost effective to build a stand-alone commingled MRF. Options 2 through 4, on the other hand, consider separately processing both clean commingled recyclables and mixed waste on an integrated processing line. This approach is consistent with current trends to install equipment that can handle various waste streams.

1.2 Background

Before evaluating MRF options to help the City meet its recycling goals for the future, it is important to consider the current collection system, the current processing system, and the markets for commodities.

1.2.1 Current Collection System

SWM provides curbside recycling to single-family residences, multifamily residences, and businesses, as discussed below.

1.2.1.1 SINGLE-FAMILY CURBSIDE RECYCLING

SWM provides single-family residences, including duplexes, with separate carts in which to place garbage, recyclable materials, recyclable glass, and yard debris. Garbage, commingled recyclables, and glass are collected every other week. Yard waste is picked up in a separate cart during the opposite weeks. Residential garbage collection service is mandatory in the City of Tacoma, but recycling and yard debris collection service are voluntary. In 2014, SWM provided garbage service to 54,346 residential customers. Of these customers, about 97% (52,636 residences) participated in the recycling collection program. This represents a high voluntary participation rate when compared to many other cities where between 70% and 80% of residences voluntarily participate in recycling collection programming.

SWM provides single-family residential customers with two containers for their recyclables: one for glass and one for all other commingled recyclables. Drivers currently pick up commingled materials using an automated side-loader and manually unload glass into a separate compartment in the same truck. SWM keeps glass out of the commingled recycling stream to maintain the quality and value of both glass and other commingled recyclables.

At TRTC, SWM operates a recycling center that offers customers the option to drop off source-separated recyclables, appliances, metal, electronics batteries, and other materials.

1.2.1.2 MULTIFAMILY CURBSIDE RECYCLING

SWM provides curbside collection of recyclable materials for tri-plexes and four-plexes. Larger complexes within SWM's service area have also expressed interest in recycling program participation, so SWM designs and delivers programs for apartment complexes and condominiums upon request.

The recycling services provided to multifamily residences is the same as that provided to single-family residences: one container for glass and another container for all other commingled recyclables. This program has been popular, and in 2014, 1,089 customers in multifamily apartment or condominium complexes subscribed to recycling services.

1.2.1.3 COMMERCIAL CUSTOMER CURBSIDE RECYCLING

SWM also offers curbside collection of recyclable materials to commercial customers on a voluntary basis. SWM provides commercial recycling customers with one container for glass and another container for all other commingled recyclables.

In 2014, SWM collected approximately 2,000 tons from 2,170 commercial customers. Note that commercial customers can subscribe to services with private recycling companies. These companies pick up recyclables such as old corrugated cardboard (OCC) and mixed paper from commercial customers. SWM does not have tonnage records related to those transactions. SWM is currently collecting yard waste from a small number of commercial customers and food waste on a pilot basis from about 70 businesses.

1.2.1.4 CURBSIDE RECYCLING PROGRAM EVALUATION

For the City of Tacoma, recovering more materials depends on implementing programs aimed at educating customers and encouraging them to participate in recycling. Programs for providing incentives or encouraging more recycling could increase recovery rates. A complementary approach could include targeting waste streams that contain larger amounts of recyclable materials and developing the infrastructure to process and sort materials to divert from disposal. This might include adding more single-family households to collection or expanding multifamily and commercial recycling. In addition, it is important to consider front end programs aimed at eliminating or reducing recyclable materials from the waste stream.

There may be sustainability programs and policies that can encourage higher participation in recycling collection programs, particularly in the multifamily and commercial sectors. Most communities do not provide direct collection services. SWM has potential to offer more collection services to businesses and institutions and to develop an integrated system.

1.2.2 Current Processing System

After collecting recyclables from residences and businesses, SWM delivers all commingled recyclables to Waste Management's JMK MRF. However, this MRF processes only source-separated materials from residential and commercial generators.

Waste Management purchased JMK in 2013 and retrofitted the existing JMK MRF with updated technology and added a glass removal system. Given these improvements, Waste Management informed SWM that collecting glass separately was no longer necessary. However, SWM continues to collect glass separately: they have a well-established two-stream collection system with high participation rates, and customers have grown accustomed to separating glass. Also, SWM had concerns that commingling the glass with the rest of the recycling stream could contaminate the commingled stream and impact commodity values.

A feasibility study completed in June 2015 indicated that it was not cost effective for SWM to build a dedicated MRF for processing the current recycling stream. It did show that if the amount materials to be processed increased to over 30,000 tons per year, building and operating a MRF might be cost effective for the City. Another factor that might determine the feasibility for SWM to move forward with building a MRF is the future of SWM's contractual agreement with Waste Management to process the materials at the JMK MRF.

1.2.3 Markets for Commodities

Recycling programs throughout the Pacific Northwest have been in place for over 20 years. As such, markets for most materials from local MRFs are established. Some of these markets are local, and others are overseas. These markets are fairly stable, but are subject to variations in domestic and international commodity prices. The feasibility analysis estimated potential revenue from materials recovered by averaging commodity prices for key recyclables over the past 10 years. These prices were based on reports from local processors to the City of Seattle. However, the prices for recycled commodities have been depressed over the past 2 years. Lower oil prices have contributed to a reduction in markets for recycled plastics, and recycled metal has been at a low. Mixed paper and OCC prices have also been affected. For the feasibility study, the 10-year average market price was used. In addition, the financial analysis was performed considering the average market price minus 3 years of the highest market prices. This approach presents a more realistic picture of the recycled commodities market if a recession were to occur. Market conditions will always have ups and downs, but most materials have established markets, and prices vary within certain ranges.

The average prices are shown in **Table 1**.

Table 1. Commodity Prices Averaged Over the Past 10 Years

Commodity	10-Year Average Scenario ($ per ton)	Low Price Scenario ($ per ton)
Baled Aluminum	1,540.00	1,200.00
OCC	115.00	100.00
Mixed Paper	80.00	60.00
Baled Old Newsprint (ONP)	80.00	65.00
Plastic	390.00	260.00
Tin	215.00	110.00
Brown Glass	20.00	17.50
Clear Glass	23.00	17.50
Green Glass	2.50	2.50
Average Glass	16.00	16.00

Although using average market price is appropriate for estimating the potential revenue from the sale of materials, it is important to acknowledge the volatility of the market prices. In 2009, the average market price across all commodities was 25% lower than the average for the prior 6-year period. Similarly, 2015 prices were about 30% lower than the average for the prior 6-year period. Over the past 10 years, the markers appear to be stable but fluctuate significantly over short periods of time. MRF operators need to plan cash flow to account for such events.

1.2.3.1 OFFSHORE MARKETS AND "GREEN FENCE"

China's "Green Fence" was a national policy imposed by the Chinese government Customs Bureau from February to November 2013. This policy, which resulted in the rejection of incoming bales of recyclables that did not meet China's recyclable material acceptance standards, was based on Chinese reports that countries had been sending highly contaminated bales of material to China under the classification of recyclables. The policy prohibited the following:

- Arriving recovered fiber products (paper, cardboard) with more than 1.5% contamination in the form of rejected paper materials
- Arriving materials with a moisture content greater than 12% on an air-dry basis
- Arriving recovered plastics with more than 2% contamination in the form of rejected plastic materials

The policy resulted in a short-term but dramatic shift in the commodity price that China paid for recyclables, particularly fiber products, as well as a shift in the behavior of recyclers worldwide. Conversations with several recycling company representatives and Unites States government officials indicated that recycling practices have changed as a result of the prohibition. China accepted baled fiber shipments containing relatively high quantities of soiled or moist paper and fiber bales containing rejects (primarily film plastics but also mixed plastics and some organics) before the Green Fence, but rejected them once the Green Fence was in place. To assess Green Fence compliance, Chinese port inspectors visually scanned shipping container contents to assess the condition of the load, rejecting those that appeared to exceed allowable levels of contamination. According to United States officials, the Chinese inspectors used foul odor as a key indicator for the high moisture content parameter. As a consequence, recyclers whose practice had been to allow moist or soiled paper or cardboard in bales of paper sent to overseas markets were some of the hardest impacted by the Green Fence.

China was able to impose its Green Fence prohibition because it is one of the largest global users of recyclable products. The International Solid Waste Association reports that China plays a key role in the acceptance of United States recycling materials:

- In scrap commodities, China accounts for 42% of all Unites States exports—at a value of about $9.5 billion.
- In 2012, China bought 68% of the United States' exports of aluminum scrap, 70% of its recovered paper, and 58% of its plastics scrap.
- China receives 70% of the world's plastic waste exports.

Green Fence prohibitions officially ended in November 2013. However, United States recyclers need to expect that China will continue to use methods similar to the Green Fence if commodity quality declines again. Recyclers should plan on modifying operations to produce bales of recyclable products with the least amount of contamination possible, particularly moisture, soiled paper, or organic waste in fiber products. Due to this situation, the following key findings should inform the design of any new MRF:

- Mixed (single stream and/or mixed waste) processing facilities need to remove contaminants (broken glass, film plastics, organics) to the maximum extent possible. Consequently, the infeed rate of the

processing line, particularly the initial screening mechanism, needs to be operated to allow thorough screening of these materials. Overloading the screen with too high a throughput will likely result in the screen being "blinded" by the excess quantity of material and thereby unable to perform its mechanical function of separating two-dimensional (fibers) from three-dimensional (rejects) materials.

- Following the screening mechanism, manual observation and removal of moist or organic soiled fibers is necessary to prohibit the transmission of high moisture content fibers. Again, the Chinese officials use foul odor as the key indicator for the presence of high moisture. Removal of soiled paper is necessary to prevent the biological degradation of the fibers during the shipping process.
- Similar mechanical and manual processes are needed for plastic products. Plastics containing liquids will need to be removed, or the facility will need to employ a perforating process to remove as much of the liquid as possible. Baled plastics containing glass, ceramics, or mixtures of non-spec plastics (film or lower grade) are more likely to be rejected than uniformly graded plastics.

In summary, markets for recycled commodities are established and are fairly mature in the both the United States and abroad. For plastics, markets abroad are stronger, with the United States plastics market continuing to grow. Markets are increasing demand for cleaner materials with stricter rules for less contamination. The Institute of Scrap Recycling Industries (ISRE) has recently issued new guidance reducing the percentage of prohibitives (i.e., contaminants) in recyclable materials, and as mentioned, Asia has enforced the "Green Fence" policies for cleaner materials from MRFs. Many of the MRFs with newer technologies can meet these challenges.

Chapter 2. Material Recovery Facility Design

2.1 Typical MRF Equipment

One of the key factors in developing a successful recycling program and building a MRF is to ensure that the collection programs being implemented are compatible or in sync with the process technology installed at the MRF. The following provides an overview of the typical equipment that might be used in a MRF to maximize the recovery of materials.

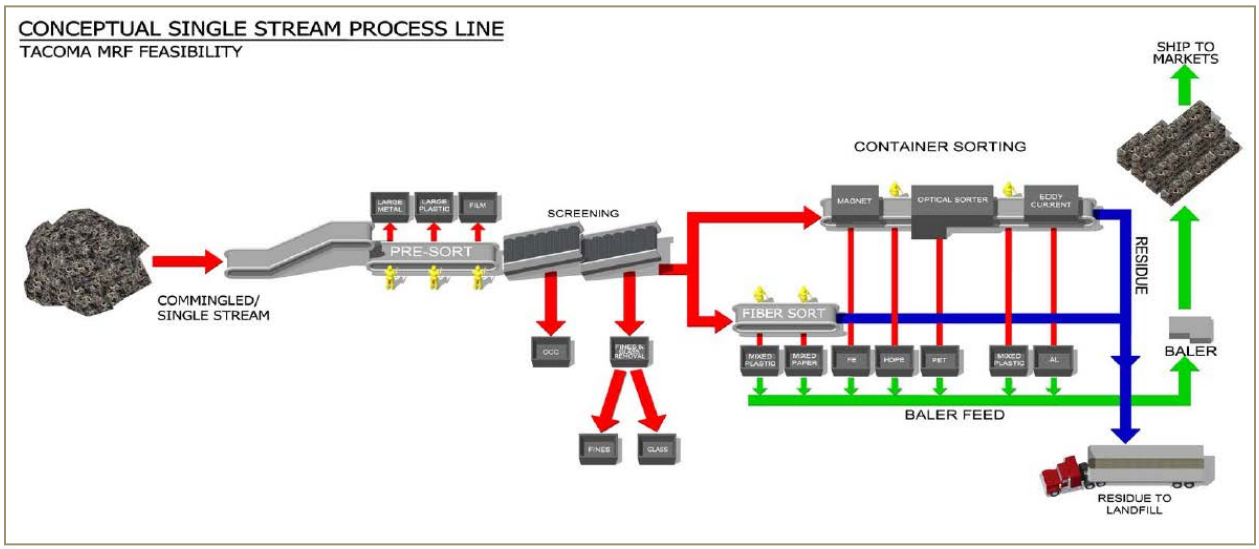
2.1.1 Conceptual Plan for MRF

The MRF technology used to process commingled recyclables from residential and commercial customers is fairly advanced. Processing waste and recyclables has been commonplace for over 25 years. As such, the basic conveyors, screens, magnets, and eddy current separators are developed and tested technologies. In particular, screening equipment is now designed to reduce plugging and wrapping from plastics, wire, cables, etc., and can be easily maintained.

Advances are continually being made and new technologies developed to increase separation efficiencies and reduce labor costs. One such technology is optical sorters, which identify different grades of paper or various resin types in plastic and can instantly separate these from the other materials. Air density and flexibility separators are also used to sort two-dimensional and three-dimensional items. Current technologies being

used throughout the industry are described below for each step of the separation process. **Figure 1** shows key components of a typical single-stream recyclables processing line.

Figure 1. Typical Commingled Process Equipment



Step 1. Tipping Floor

City collection trucks deliver commingled recyclables to the MRF and pile the recyclables on the tipping floor. The MRF operators check the pile to ensure that no oversized or problematic objects are among the recyclables. Operators then load recyclable materials onto an in-ground conveyor belt or feed an above-ground hopper that feeds the conveyor belt. After loading, operators can add a drum feeder or leveling bar to the system to equalize distribution of material. While this is an optional feature, a drum feeder or leveling bar is highly recommended for larger systems to ensure that the material loads are equally distributed. This allows sorting staff to receive a more consistent supply of material to maximize process line production while the front end loader operator is able to charge the infeed conveyor as well as address other tasks such as staging incoming material or removing a bulky object.

Step 2. Pre-Sorting

The commingled recyclables are fed onto a pre-sort platform area; sorters extract materials such as large rigid plastics, metals, film, and other large pieces that cannot pass through the single-stream recycling processing equipment. Plastic bags, film plastic, fabric, hoses, or other contaminants should also be removed during pre-sorting because they can wrap around the processing equipment, creating jams or influencing the performance of the screens. The sorters may be able to open the occasional plastic bag to extract recyclables.

Step 3. Screening

Old Corrugated Cardboard Screening

Next, the recyclable materials pass through an OCC screening process in which bulky cardboard and mixed paper are removed from the waste stream. The OCC screening process uses screens that contain large gaps where small material can fall through and large cardboard materials flow on top. These large cardboard materials are then collected, cleaned at a quality control station, and baled.

Fines and Glass Removal

During the initial screening process, smaller materials (i.e., less than 2 to 3 inches in diameter) fall through onto a separate conveyor and are removed from the larger containers and fiber materials. Also during this process, glass bottles are broken and fall through the screen. The materials referred to as fines are made up of dirt, grit, and some small pieces of plastics and shredded paper. In most cases, the inert fines and glass materials can be used as alternative daily cover at landfills or possibly as clean fill for select uses. In California, where the state has a bottle deposit law, clean glass from containers has a redemption value credit. This factor, along with the fact that mills are more stringently monitoring the amount of outthrows in bales, including glass, have led to development of equipment to remove glass. Therefore, many MRFs throughout the country either include equipment to recover the glass from the fines or design the processing line such that glass removal systems can be easily added. In these MRFs, the fines and glass are conveyed to a secondary screening process to remove the glass using various technologies. One approach is to use micro screens in combination with air density separation. After the glass has been removed, it may be recycled.

Step 4. Fibers Sorting

As the commingled materials continue over the remaining screens, larger flat materials and fibrous materials continue to ride on top of the screens and are then conveyed to a sort line. The plastic containers, tin cans, and aluminum cans fall through the screens onto a separate conveyor. Fibrous materials include white ledger, mixed paper, old newspaper, cardboard, and other various grades of paper. These materials are conveyed to a platform that contains several stations to manually sort the different paper streams to meet market conditions. Some MRFs, particularly ones that handle large throughputs (i.e., greater than 30 tons per hour) might use optical sorting equipment to separate the various grades. Optical sorting equipment is expensive, but it is very efficient and can accurately identify and sort specific grades of paper to increase quality control. This reduces potential contamination and can also improve market quality. Optical sorters are beginning to be able to identify moisture content as well, thus further improving product quality.

Step 5. Container Sorting

The screening process separates the containers from the fibers. The container sorting process uses a variety of equipment such as magnets, eddy currents, and optical sorters to further separate the various containers. Many types of plastics have a market value. PET (such as water and soda bottles), HPDE (such as milk jugs), and PP or #5 plastic containers have a fairly high value in market place. Other plastics such as film and rigid plastics can be recycled, but the markets as less predictable. To maximize revenue, these less valuable plastics

must be separated from higher value plastics and containers. The following describes some of the technologies employed to separate the containers to achieve maximum recycling rates.

Magnetic Separator

Magnets are used to separate metal containers or other items from the sort line conveyor. There are a few types of magnets. Belt magnets run at a 90 degree angle to the sort conveyor, pick up ferrous metal items, and transfer them to a hopper or container. A drum magnet is used at the end of the sort conveyor and will pick ferrous metal objects off and drop them onto a secondary transfer conveyor. The arrangement of the magnet and proximity to the conveyor are important for efficient operation. This technology is well developed and a part of almost all MRF equipment lines.

Eddy Current Separator

The eddy current separator uses different magnetic field technology to recover aluminum materials. The eddy current separator employs a magnetic field that induces electrons in aluminum, creating another magnetic field known as an eddy field. When the eddy field interacts with the separator's magnetic field, it causes the aluminum material to be pushed off the main conveyor onto another conveyor that leads to a collection bin. Like the standard magnets, the eddy current separation unit is well developed, and because of the value of recycled aluminum, it is a key piece of equipment even in places where bottle bills have been adopted. Due to the light weight of the aluminum containers and the ejection action of the eddy current separator, often it is best to place the separator after the point of recovery of most other containers on the sorting line.

Optical Sorter

An optical sorter uses a series of laser sensors and/or cameras that span the entire conveyor to scan and read the characteristics of the materials as they pass under them. The optical sorter identifies the items by the chemical composition and uses air blast to dislodge those items from the main conveyor. This technology evolved from the agricultural industry where it was used to separate damaged products and prevent them from being delivered to markets. The advance of micro-processors has allowed this technology to advance to where it can be used most effectively and efficiently in MRF operations.

The value of the optical sorter is that it can accurately identify materials and pick them off the line four to six times faster than manual sorters, and it does not get tired or lose efficiency across the shift. The transport conveyor used for optical sorters is generally much wider and faster than conveyors for manual sorters to allow for better display of each individual container. Thus, optical sorters allow more consistent material screening, and because it is a mechanical process, it reduces the risk of injury to sort line laborers.

Optical sorting is typically used more frequently for sorting PET and HDPE plastics from the container lines because these items have a higher market value than other recyclables. In recent years, optical units have begun being used on the fiber sort line also because of accuracy and efficiency. Optical sorting is more common in larger MRFs because of the need to increase throughput. The bottom line is that optical sorting can be used to sort any materials because the sorters can be adjusted to identify whatever materials are being targeted.

Manual Sorting

While the various magnets, eddy current separators, and optical sorters have made significant inroads in MRF processing, there are still facilities and situations where manual sorters are used extensively. Often manual sorters provide quality control and remove the occasional contaminant from an optical sorter misfire or remove non-beverage can aluminum from the aluminum product stream to significantly increase the product quality and value. In addition, manual sorters still play a major role in recovery of missed materials in residue lines. Containers with a percentage of the fluid remaining may be too heavy for the optical sorter to eject, or the sorter may identify an issue with a particular optical sorter before significant quantities of product are lost. Smaller MRFs may still operate with all manual sorting for fiber and containers because the cost of the optical sorters may be higher than the increased revenue.

Step 6. Baled Materials / Shipping

The recovered material, such as aluminum, PET, HDPE, mixed plastic, or mixed paper, is fed to a baler. A single bale is approximately 5 feet by 4 feet by 3 feet with the weight varying from 1,000 to as much as 1,500 pounds or more depending on the material and the size and type of baler. These bales of materials are loaded onto trucks or placed in containers to ship to local mills or to overseas markets.

Step 7. Residue Disposal

When processing commingled materials, there is always a residue: materials that either are contaminated or do not have market value. The amount of residue can vary greatly depending on the community and city. Programs that have been in place for many years and are supported by a well-managed education and promotional information base tend to have fewer residues. This is true for most cities in the Pacific Northwest, like Tacoma where the amount of residue averages less than 7% of incoming recyclables overall. Other cities can see as much as 25% to 30% residue in the residential commingled recyclables stream. The national average is 15%, as reported by the United States Environmental Protection Agency. This residue is loaded into trucks or containers and is transported to a solid waste disposal site.

2.1.2 Equipment and Cost

The cost for equipment and installation for a typical single stream or commingled process line is estimated to range from $5.5 M to $7.5 M for the processing equipment. The difference in the cost depends on several factors, including throughput requirements and unit processes, such as screens, air separators, and optical sorters. The decision of how much equipment is installed includes weighing the benefits of added capital cost against the cost of operations and how much labor is needed. For instance, if the MRF is designed to process 35 to 40 tons per hour, there will need to be more equipment and therefore added capital cost. If the MRF is designed to process 20 to 30 tons per hour, the initial capital cost may be less, but labor cost may be more. Owners and operators need to evaluate these factors to decide what system is best suited for their situation.

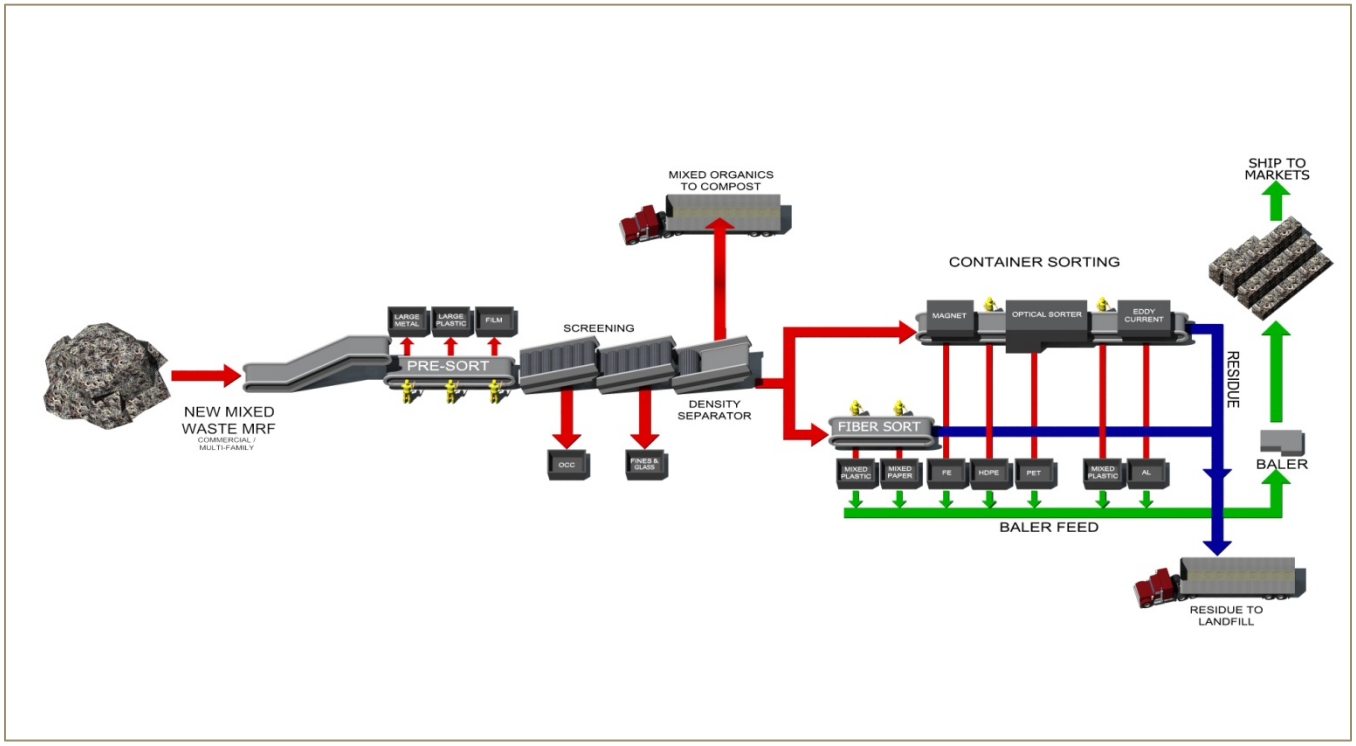
2.2 Mixed Waste MRF Equipment

The following provides an overview of the equipment that might be used for an integrated mixed waste MRF.

2.2.1 Conceptual Plan for Integrated Mixed Waste MRF

An integrated MRF system is designed to process both commingled and mixed waste. The integrated MRF system would use many of the same components as does a commingled or single stream recovery system. The main difference between the two is that the integrated line would include additional screening in the initial phase or would be front end designed to remove the wet organics fraction from the mixed waste stream. In a typical commingled waste stream, the amount of organics in the waste stream is minimal or none, so including screens to remove organics is unnecessary. However, in a mixed waste MRF, the waste streams have a significant amount of organics (estimated to be between 25% and 35%) that must be removed in the initial screening process to avoid contamination to fibers and containers that have a higher market value. Glass that is mixed with the organics can be removed with additional equipment or can be further processed at the compost site. **Figure 2** shows a typical mixed waste MRF with organics being removed immediately after the pre-sort screen. Some mixed waste MRFs are designed to remove the dense fines made up of food waste and wet mixed organic materials prior to the pre-sort. By removing the heavy organic fraction first, the material on the sort line is less dense, making it easier for sorters to remove larger items such metal, wood, or other bulky items. Mixed waste MRFs are common and are in operation across the United States.

Figure 2. Typical Mixed Waste Process Equipment



As shown in **Figure 2**, after the front-end screening and pre-sort operations, the back end of the equipment line is similar to that of a commingled sort line. The process line would typically include additional air separation and optical sorters to separate the various commodities for sale to markets. Because most of the

equipment is interchangeable for processing different waste streams, there is a trend to build integrated MRF equipment to process mixed waste or commingled materials on a single system.

2.2.2 Equipment and Cost

The cost for equipment and installation for an integrated MRF processing line is estimated to range from $13 M to $16 M (2016 dollars). The difference in the cost depends on several factors, including throughput requirements and unit processes, such as screens, air separators, and optical sorters. The decision of how much equipment is installed includes weighing the benefits of added capital cost against the cost of operations and how much labor is needed. However, with the increasing pressure from markets to produce higher quality materials, more technology is desirable. In this case, a system that costs $13 M will have much of the equipment needed to meet the demand for high quality materials. However, if the process line needs to operate with higher throughput, then additional equipment would be needed, increasing the cost. The equipment line to process both commingled and mixed waste must include technology that is effective in removing the organics in the early stages of the process to prevent contamination.

Chapter 3. Material Recovery Facility Options

Chapter 1 listed four MRF options that would provide the highest potential for recovering recyclable materials from various waste streams. An important consideration when developing these options was to maintain the quality of the recovered material to increase its marketability. Using the advanced MRF technology available in 2016, the project team analyzed the potential recovery of materials from each waste stream or a combination of waste streams considering an integrated processing equipment line. This chapter summarizes the results of that analysis.

The summary focuses on the system performance and the estimated amount of materials recovered. It also includes the financial performance of each MRF option. The buildings and the equipment to be used for each MRF option would be similar, but the amount of materials processed and recovered would vary. Therefore, the operating parameters for each option would be different, as would the cost and revenue. The operating parameters and assumptions as well as financial information for each MRF option are presented in the *Basis of MRF Design Technical Memorandum* in **Appendix A**.

The results for each MRF option are used in conjunction with material recovery estimates from the sustainability plan scenarios to inform the decision as to the most feasible and practical approach for meeting the City's goals.

3.1 Waste Composition Analysis

The four MRF options were evaluated using the waste composition data from the spring and fall sampling events conducted in 2015. Waste data were compiled and analyzed from each of the major waste streams collected by SWM, including the following:

1. Commingled / single stream from residential, multifamily, and commercial accounts as reported by Waste Management
2. Commercial non-C&D waste as collected by SWM
3. Multifamily waste streams as collected by SWM
4. Self-haul waste delivered by public vehicles to the TRTC

The raw data were combined from the two sampling periods for 84 different material classifications. These data were then compressed into 31 materials in the following six categories:

- Traditional recyclables – mostly commodities with higher market values
- Other recyclables – materials that also are marketable but at less value
- Organics / food waste
- Organics – Yard waste, green waste, and compostables
- Construction and demolition – mostly wood and inerts
- Non-recyclables

Once the data were compressed into these primary categories, the data were used to evaluate different MRF options.

The waste composition data from the 2015 spring and fall sampling programs were combined with recovery rates reported from industry experience to evaluate the estimated quantities of potential recyclable materials from each of the waste streams. The main categories addressed were paper, plastics, glass, metals, wood, and organics including food waste, mixed organics, compostable paper, and yard waste.

The analysis of the waste composition also provides a potential range of recovery with different options. It is assumed that due to a combination of load selection and contamination, a portion of the material in both waste streams will not be fully recoverable. The detailed tables for the waste composition and estimated recovery rates are presented in **Appendix A**.

3.2 Option 1: Commingled Residential Recyclables

The initial feasibility evaluation for Option 1 was completed on June 30, 2015. It is based on previous waste data and analysis of the City's current collection practices. Factors that may contribute to increases in residential commingled materials, such as new programs or services identified in the City's sustainability plan, can be taken into account in Option 1 if needed.

3.2.1 Potential Material Recovery

SWM collects just over 17,000 tons of commingled materials from residential and commercial customers. In addition, SWM receives another 5,000 tons of recyclable materials at the TRTC. Glass from residences, which is currently collected separately, represents almost 3,000 tons per year. As indicated in a *MRF Feasibility Report* prepared for the Department of Ecology in June 2015, it is possible to install equipment to effectively remove glass from the commingled stream without causing a significant impact on the price of the

commodities. SWM can elect to continue to collect glass separately, but for this analysis, it is assumed that glass would be processed and recovered in the MRF.

Assuming that all materials are processed, the MRF would have a nominal capacity to process 25,000 tons per year. If the MRF operates 5 days per week, then it would process 92 tons per day. The process rate can vary depending on the technology used and level of sorting labor. For instance, MRFs using high levels of technology can operate at a throughput of 35 to 40 tons per hour, while a MRF operating at a smaller scale with less material could range from 20 to 30 tons per hour. For this analysis, it is assumed that the MRF throughput would be 25 tons per hour.

Currently, SWM delivers collected residential and commercial commingled recyclables to Waste Management's JMK MRF. Recyclable materials that the City recovered in 2014 are summarized in **Table 2**. These amounts include both material the City collected from residential and commercial curbside customers, and material dropped off at the TRTC. The residential and commercial curbside recycling tons are based on reports from Waste Management's JMK MRF provided to SWM. For this feasibility study, these quantities were modified using recovery rates for a typical MRF, so only the estimated recovered and residual amounts are reported below. The TRTC sends mixed fibers and containers to Waste Management's JMK MRF to bale and ship, whereas the TRTC markets other materials, like metal, directly to recyclers.

As shown in **Table 2**, cardboard, mixed paper, and ONP made up almost 70% of the tons collected for recycling in 2014. Glass also made up a large portion (13%) of the total.

Table 2. Recycling Material Recovered by the City of Tacoma in 2014

Recyclables	Tons	% of Total
Cardboard	2,273	9
Mixed Paper	11,424	46
ONP	3,455	14
Glass Containers in Commingled	191	1
Glass Collected Separately	2,954	12
PET Plastics	329	1
HDPE Plastics	199	1
Ferrous Metal	1,392	6
Aluminum	209	1
Wood/Lumber	0	0
Mixed Plastics #3–#7	284	1
Plastic Film	259	1
Other	0	0
Mixed Plastics	279	1
Residue	1,651	7
Total	**24,900**	**100**

As shown, the current JMK MRF is recovering about 93% of the materials being collected by SWM. With only 7% residue in the commingled stream, the level of contamination is well below the national average of 16% for residential single streams processed at MRFs nationwide. If a new MRF is constructed, it stands to reason that the recovery of materials would be similar or even slightly improved over the current MRF provided that the condition of the materials delivered are comparable.

3.2.2 Financial Results

For Option 1, where commingled residential recyclable materials would be processed, the estimated diversion rate is 94%, with 20,267 tons of material being recycled. The market value of the materials recovered could range from $80 to $116 per ton based on the 10-year average of all commodity prices in the Pacific Northwest. The lower price in the range reflects the average over this same period but discounts the 3 years with the highest market prices. The reason is that periods of recessionary prices do occur and should be recognized when considering the financial risk associated with operating a MRF.

Table 3 shows the estimated cost of Option 1.

Table 3. Option 1 Revenue Summary

	Option 1
Material Recovery	
Tons Recycled	20,267
Tons Composted	0
Tons Landfilled	1,267
Total Tons Processed	**21,534**
Diversion Rate	94%
Revenue Requirements	
MRF Operations	$1,578,508
Debt Services	$1,492,794
Total Expenses	**$3,071,302**
Expenses per Ton	$143
Revenue	
Tip Fee Revenue	$0
Material Sales	$2,270,109
Average Net Sale Price	$112
Organics to Compost	$0
Total Revenue	**$2,270,109**
Revenue per Ton Processed	$105
Net Revenue	**$ (801,193)**
Per Ton	$ (37)

For Option 1, the cost to build a new MRF to process commingled residential recyclables is estimated to be over $800,000 per year or $37 per ton. Currently, the City has a contract with Waste Management to process at the JMK MRF for about $41 per ton. However, the City has a revenue sharing agreement that in 2014 provided a return of $24 per ton. Thus, the net revenue to the City historically has been about $300,000 per year or $17 per ton. Unless the business terms of this arrangement change or services are discontinued, Option 1 is not practical to implement. It does not offer opportunity to increase recovery over present recycling rates.

3.3 Option 2: Commingled Residential Recyclables, Non-C&D Commercial Waste, and Multifamily Waste

Option 2 considers processing the non-C&D commercial and multifamily waste stream in addition to commingled residential recyclables using an integrated material recovery equipment line. The analysis considers waste from multifamily and commercial/institutional customers that is primarily delivered by automated front loaders.

3.3.1 Potential Material Recovery

Under Option 2, SWM would process all of the commingled residential, multifamily, and non-C&D commercial material currently disposed of. SWM collects about 58,000 tons of mixed commercial waste generated by businesses and institutional customers. These results represent data from two quarters of the year. Based on waste composition data, this waste stream was found to contain between 25% and 30% of traditional and other recyclable materials, including wood waste. (Note: This does not include C&D waste.) In addition to the traditional and other recyclable material, the commercial waste contains over 30% of food waste, compostable paper, and green waste. This material can be separated by processing on a mixed waste MRF line. Assuming a market can be developed for the food waste and mixed organics, then between 55% and 64% of the commercial waste could be diverted from landfill disposal. Likewise, the composition of the waste collected from multifamily residences shows similar opportunities.

Using these data, the analysis evaluated processing both the non-C&D commercial waste and multifamily waste streams. This is a practical assumption because many of SWM's automated front load routes collect from both commercial and multifamily units in the same trucks.

Table 4 presents the estimated amount of materials to be recovered from the mixed commercial and multifamily waste stream.

Table 4. Non-C&D Commercial and Multifamily Waste Stream Summary

Recovery of Recyclables	**Tons**	**% Recyclables**
Newspaper	524	0.9
OCC/Cardboard	1,848	2.9
Paper (Mixed)	3,791	6.3
#1 and #2 Bottles	956	1.5
#1–#7 Other Containers	319	0.5
Clean Bags and Film	637	1.0
Durable Plastics (Rigids)	1,338	2.1
Recyclable Glass (Containers)	1,147	1.8
Aluminum/Beverage Cans	202	0.3
Other Aluminum	67	0.1
Other Non-Ferrous	64	0.1
Tin Food Cans	336	0.5
Other Ferrous	1,479	2.2
Metals	0	0.0
Wood/Lumber	5,210	9.2
Total Commodities	**12,724**	**71**
Total Recyclables	**17,934**	**100**
Recovery of Organics/Compostables	**Tons**	**% Compostables**
Food Waste	13,138	68%
Mixed Organic	4,587	24
Green Waste / Yard Waste	1,586	82
Total Compostables	**19,310**	**100**
Non-Recoverable/Trash	33,542	47
Total	**70,786**	**100**

Of the recovered material, almost 19,000 tons (27%) would be compostable organics, and higher-value commodities would make up about 13,000 tons (19%). The waste data show that potentially 5,000 tons of clean wood waste could also be recovered. This represents untreated woody debris that can be ground up for mulch. Total potential diversion is estimated to be about 53% of the commercial material.

In addition to processing mixed waste, the MRF is designed to process the commingled materials. Therefore, in total, the MRF would have the capacity to process 100,000 tons of waste per year or 380 tons per day. In order to process this waste stream, the MRF would need to operate over 16 hours or in two 8-hour shifts.

3.3.2 Financial Results

For Option 2, the MRF would be an integrated equipment line that would process over 90,000 tons per year. The MRF equipment needed to process these materials are estimated to cost between $13 M and $16 M. The building and other facility capital costs are estimated at $26 M. These initial capital costs are amortized (debt service expenditures) over the operating life and included in the financial analysis.

The integrated MRF process line for Option 2 would be capable of processing 400 tons per day over two shifts. The annual labor and operating expenditures are shown in **Table 5**.

Table 5. Option 2 Revenue Summary

	Option 2
Material Recovery	
Tons Recycled	38,201
Tons Composted	19,310
Tons Landfilled	34,809
Total Tons Processed	**92,320**
Diversion Rate	62%
Revenue Requirements	
MRF Operations	$5,212,583
Debt Services	$3,338,757
Total Expenses	**$8,551,340**
Expenses per Ton	$93
Revenue	
Tip Fee Revenue	$0
Material Sales	$4,039,511
Average Net Sale Price	$106
Organics to Compost	$0
Total Revenue	**$4,039,511**
Revenue per Ton Processed	$44
Net Revenue	**$(4,511,829)**
Per Ton	$ (49)

The total gross operating expenses for Option 2 would be $8.5 M or $93 per ton for processing 92,000 tons per year.

Because Option 2 would process both commingled recyclables and mixed waste, an estimated 38,000 tons or 41% of marketable commodities are estimated to be recovered from the process line. This includes commingled materials collected from the City's residential recycling program. Assuming a 10-year average market value for these materials, revenues are estimated to be $4 M per year.

The integrated MRF system is expected to recover 19,000 tons per year or 21% of food waste and mixed organics that could potentially be composted or processed in an anaerobic digester (AD) system to recover renewable energy. This is a common practice in Europe, and several AD facilities are being developed in California. In this financial analysis, no cost or revenue is assigned to processing the mixed organic stream. However, this material has the potential to be processed and to increase the overall recycling rate for the City.

In summary, it is estimated that it would cost the City about $50 per ton to recycle an additional 18,000 tons of recyclables from the commercial and multifamily waste streams. (Note that 20,000 tons are already recycled from the commingled waste stream.) If the organics can be recycled, then this would increase to almost 40,000 tons. This cost is net of revenue from the sale of recovered commodities.

The financial analysis does not account for any expected avoided cost the City might experience under Option 2. Currently, the 70,000 tons of mixed waste processed at the MRF is being accepted at the TRTC and transported to a landfill. If this material were to be processed at the MRF, then the total tons transported to the landfill would about 35,000 tons per year or half that without the MRF. The financial analysis did not include this potential savings. However, if the City would actually avoid transporting and paying the disposal cost for the estimated 35,000 tons per year, then this would present an additional cost benefit that should be considered.

3.4 Option 3: Commingled Residential Recyclables and High-Grade Non-C&D Commercial Waste

Option 3 is similar to Option 2 in that it is designed to process both the commingled residential and non-C&D commercial waste currently disposed of. However, Option 3 assumes that the City would alter commercial collection routes to generate commodity-rich or dry loads that would contain less food waste. An example would be for a front load truck to be scheduled to collect waste from businesses such as banks and office complexes, which generate waste with less food waste, separate from restaurants or places with cafeteria waste. The result would be a higher graded load that would contain a higher percentage of recoverable materials and less wet or organic waste.

3.4.1 Potential Material Recovery

3.4.1.1 HIGH-GRADE GENERATOR BACKGROUND

Certain business sectors generate waste that contains higher percentages of recyclable materials. Waste from generator types such as education, hotel/motel, manufacturing, office, and retail contains higher proportions of recyclable commodities like paper, metal, and plastics, while waste from generators like healthcare and restaurants contains larger proportions of food waste and other organics. Collection trucks could be encouraged to collect loads with high percentages of recyclable content separate from those containing large amounts of food waste or wet waste. These high-grade loads could be delivered to a MRF for processing. This material would be of higher value due to the reduced volume of organic waste.

For Option 3, the waste composition for the high-grade non-C&D commercial waste stream was estimated using non-C&D commercial waste generator data from Seattle Public Utility. As shown in **Table 6**, the data

retrieved from the Seattle Public Utility present the breakdown of the waste stream by commercial generator types. The waste composition of the high-grade material waste stream was based on six of these generators whose waste might be collected on separate routes due to their higher percentage of commodities and lower portion of food waste.

Table 6. Non-C&D Commercial Generator Data[1]

Generator	Samples	Paper (%)	Plastic (%)	Metal (%)	Commodities (%)	Food (%)
CDL	2	13	23	0	36	1.20
Education	4	31	9	1	41	20.60
Healthcare	21	16	7	1	24	15.80
Hotel/Motel	6	41	9	3	52	17.50
Manufacturing	7	15	26	5	46	12.30
Office	15	44	15	3	62	21.80
Other Service	19	34	13	3	50	18.50
Restaurants	3	28	14	2	44	53.40
Retail	38	25	15	5	46	30.50
Transportation	8	29	10	5	44	11.70
Wholesale	6	23	18	1	41	55.40
Mixed Commercial Generators	128	24	11	3	38	35.80
Total	**257**					

Note:

1. Obtained from Seattle Public Utility

By selecting the high-grade generators based on a percentage of commodities (>40%) and low percentages of food waste (<25%), the portion that each commodity and the residual food waste would contribute to the high-grade commercial waste stream was estimated. This was obtained by averaging each commodity and food waste portion from all the values of the selected high-grade generators. As shown in **Table 6**, the generators that were selected as high-grade generators were education, hotel/motel, manufacturing, office, transportation, and other service facilities (highlighted in green). The addition and omission of the retail facilities generator was compared due to the large portion of possibly viable commodities generated from retail facilities. **Table 7** compares the results from including or omitting the retail generator to determine if it would significantly increase the percentage of commodity materials while insignificantly changing the portion of food waste in the high-grade commercial waste stream.

Table 7. Comparison of Results from adding or omitting Retail Generator

Select High-Grade Generator	Paper (%)	Plastic (%)	Metal (%)	Commodities (%)	Food (%)
Without Retail Generator	32	14	3	49	17
With Retail Generator	31	14	4	49	19

As shown in **Table 7**, the addition of the retail generator did not offer any significant increase in commodities, but it did increase the portion of food waste. Although the retail facilities can provide additional commodity tonnage as a generator, it was omitted from the selected high-grade generators due to its fairly large portion of food waste that may cause a significant decrease in material grade by contaminating commodity materials. The large portion of food waste from the retail generator may be indicative of retail employee and customer food waste generation in malls and other large retail establishments that are in close proximity to restaurants.

3.4.1.2 HIGH-GRADE POTENTIAL MATERIAL RECOVERY

For Option 3, an assumption was made that 50% of the commercial waste stream could be collected by systematically modifying routes to produce higher-value loads. The reason is that commercial routes, like residential routes, need to involve the least travel distance to fill the truck to be efficient. Whereas, it is possible to set up certain routes to pass by customers to pick up loads from select generators, it may not always be most cost effective to do so. More analysis is needed to evaluate how adjustments could be implemented to generate high-grade loads in the City. Assuming that 50% of the commercial waste would be high-grade through modified collection, 34,000 tons per year would be processed at an integrated MRF. **Table 8** presents the estimated amount of materials to be recovered from the high-grade non-C&D commercial waste stream.

Table 8. High-Grade Non-C&D Commercial Waste Stream Summary

Recovery of Recyclables	Tons	% Recyclables
Newspaper	289	1.0
OCC/Cardboard	1,836	6.0
Paper (Mixed)	3,468	12.0
#1 and #2 Bottles	428	1.4
#1–#7 Other Containers	306	1.0
Clean Bags and Film	367	1.2
Durable Plastics (Rigids)	1,224	4.0
Recyclable Glass (Containers)	612	2.0
Aluminum/Beverage Cans	97	0.3
Other Aluminum	39	0.1
Other Non-Ferrous	0	0.0
Tin Food Cans	162	0.5

Other Ferrous	485	1.5
Metals	0	0.0
Wood/Lumber	3,101	11.4
Total Commodities	**9,312**	**75**
Total Recyclables	**12,413**	**100**
Recovery of Organics/Compostables	**Tons**	**% Compostables**
Food Waste	5,440	20.0
Mixed Organic	2,448	9.0
Green Waste / Yard Waste	408	1.5
Total Compostables	**8,296**	**100**
Non-Recoverable/Trash	13,291	39
Total	**34,000**	**100%**

Based on waste composition data, the high-grade waste stream was found to contain about 40% of traditional and other recyclable materials, including wood waste. (Note: This does not include C&D waste.) Of this 40%, 12% is paper, which remains less contaminated in dry loads and returns a higher value in the market. As discussed above, collection of commingled and high-grade materials reduces the amount of organics and thus wet contamination of all the recoverable materials. Because both loads are dry, they would be processed on the same MRF equipment.

3.4.2 Financial Results

For Option 3, the MRF would have an integrated equipment line that would process a high-grade non-C&D commercial waste stream along with the residential commingled recyclables stream. Option 3 assumes that the City would alter collection routes to generate commodity-rich dry loads. In this case, the process line would optimize recovery of fibers from high-grade non-C&D commercial loads. The MRF would process an estimated one-third to one-half of the City's commercial waste stream. The design capacity for processing residential commingled recyclables would be 25,000 tons per year or 100 tons per day, unchanged from Option 2, Commingled Residential Recyclables, Non-C&D Commercial Waste, and Multifamily Waste.

The MRF equipment needed to process these materials would be similar to Option 2 and therefore is estimated to cost between $13 M and $16 M. The front end of the process line would be designed to remove food waste and heavy fines as it would in any mixed waste processing system. The building and other facility capital costs are estimated at $26 M. These initial capital costs are amortized (debt service expenditures) over the operating life and included in the financial analysis.

The integrated MRF process line for Option 3 would be capable of processing 225 tons per day over a single shift. Because less material would be processed each day, the annual operating expenses would be lower than in Option 2. The annual labor and operating expenditures are shown in **Table 9**.

Table 9. Option 3 Revenue Summary

	Option 3
Material Recovery	
Tons Recycled	32,680
Tons Composted	8,296
Tons Landfilled	14,558
Total Tons Processed	**55,534**
Diversion Rate	74%
Revenue Requirements	
MRF Operations	$3,704,583
Debt Services	$3,338,757
Total Expenses	**$7,043,340**
Expenses per Ton	$127
Revenue	
Tip Fee Revenue	$0
Material Sales	$3,363,328
Average Net Sale Price	$103
Organics to Compost	$0
Total Revenue	**$3,363,328**
Revenue per Ton Processed	$61
Net Revenue	**$(3,680,012)**
Per Ton	$ (66)

The net cost to the City for Option 3 would be $3.6 M or $66 per ton. Although the net unit cost is higher than the other options, the amount of materials recycled as a percentage processed is 74%, which is higher than the other options. The amount recycled and diverted does assume that mixed organics are processed and recycled.

As with Option 2, the financial analysis does not account for any expected avoided cost the City might experience under Option 3. If Option 3 is considered, then an evaluation of the potential of avoided cost to the solid waste system should be conducted.

3.5 Option 4: Commingled Residential Recyclables, High-Grade Non-C&D Commercial Waste, and High-Grade Non-C&D Self-Haul Waste

Option 4 builds on Option 3, which includes commingled residential recyclables and select high-grade non-C&D commercial waste, with the addition of high-grade non-C&D self-haul waste. Self-haul loads include

those taken to the TRTC and unloaded from cars, pickups, and vehicles with trailers. This waste stream contains many recyclable materials that are processed in a MRF and could be recovered.

3.5.1 Potential Material Recovery

Waste composition data from two quarters of the year has shown that the self-haul waste stream contains a relatively high percentage of paper, cardboard, metals, and plastics as well as other materials that could be diverted from the landfill. Of these materials, wood, yard waste, and metal together represented between 30% and 40% of the total waste stream. It is assumed that because these materials are not as desirable to process in a MRF, nor is it the most effective way to recover the materials, the City will embark on a program to reduce the amount of wood and metal at the TRTC. This is a way to improve the quality of the self-haul waste stream. Currently, SWM does floor sorting to remove OCC and wood, so this program could be expanded. When removed, a majority of the remaining materials could be delivered to the MRF to be processed.

For Option 4, commingled residential recyclables, high-grade non-C&D commercial waste, and selected high-grade non-C&D self-haul waste were analyzed. This reflects a scenario in which all possible clean recyclable materials from each waste stream would undergo processing, resulting in a higher waste volume as well as higher recovery potential. Adding high-grade non-C&D self-haul waste to the recovery stream of the other options would result in an additional 6,781 tons of recoverable recyclables. **Table 10** shows the breakout of recyclable materials in the high-grade non-C&D self-haul waste stream.

Table 10. High-Grade Non-C&D Self-Haul Waste Stream Summary

Recovery of Recyclables	Tons	% Recyclables
OCC/Cardboard	924	4.2
Paper (Mixed)	242	1.1
Newspaper	176	0.8
Recyclable Glass Containers	308	1.4
#1 and #2 Bottles	46	0.2
#1–#7 Other Containers	23	0.1
Clean Bags and Film	0	0.0
Tin Food Cans	46	0.2
Other Ferrous	3,461	14.9
Aluminum Cans	23	0.1
Other Aluminum	0	0.0
Other Non-Ferrous	395	1.9
Wood/Lumber	782	4.0
Durable Plastics	353	1.7
Total Commodities	**5,999**	**88**
Total Recyclables	**6,781**	**100**
Recovery of Organics/Compostables	**Tons**	**% Compostables**
Food Waste	724	96.0
Mixed Organic	0	0.0
Green Waste / Yard Waste	27	4.0
Total Compostables	**751**	**100**
Non-Recoverable/Trash	16,918	69
Total	**24,451**	**100**

As **Table 10** shows, of the total 24,000 tons that would be processed, roughly 30% would be recovered. Although the total amount of commodities recovered would be minimal, the material itself would be relatively high in value because the organics/food waste would be very low. **Table 11** shows the total waste stream summary for Option 4, which includes commingled residential recyclables, high-grade non-C&D commercial waste, and high-grade non-C&D self-haul waste.

Table 11. Option 4 Waste Stream Summary

Recovery of Recyclables	Tons	% Recyclables
Newspaper	3,816	9.7
OCC/Cardboard	4,964	12.6

Paper (Mixed)	14,893	37.7
#1 and #2 Bottles	1,044	2.6
#1–#7 Other Containers	823	2.1
Clean Bags and Film	629	1.6
Durable Plastics (Rigids)	1,577	4.0
Recyclable Glass (Containers)	1,106	2.8
Aluminum/Beverage Cans	348	0.1
Other Aluminum	71	0.2
Other Non-Ferrous	671	1.7
Tin Food Cans	266	0.7
Other Ferrous	5,369	13.6
Wood/Lumber	3,883	9.8
Total Commodities	**35,579**	**90.2**
Total Recyclables	**39,462**	**100**
Recovery of Organics/Compostables	**Tons**	**% Compostables**
Food Waste	6,164	68
Mixed Organic	2,448	27
Green Waste / Yard Waste	435	5
Total Compostables	**9,047**	**100**
Non-Recoverable/Trash	31,477	38
Total	**79,985**	**100**

Processing the high-grade non-C&D commercial and self-haul waste streams would produce over 15,000 tons of high-quality materials while processing less than 60,000 tons per year. When accounting for the commingled residential recyclables, the amount of recovered materials increases. Under Option 4, the estimated diversion rate is 61%, with 39,462 tons of material being recycled and an additional 9,047 tons of compostable organics, as shown in **Table 11**. The effect of implementing the high-grade non-C&D commercial waste collection in combination with removing the wood and yard waste from the self-haul would result in a much higher percentage of recoverable commodities. While total recovery under Option 4 would be less than under Option 3, it is important to note that quality of recoverable materials would be higher.

3.5.2 Financial Results

For Option 4, the MRF would have an integrated equipment line that would process the residential commingled recyclables stream, a high-grade non-C&D commercial waste stream, and a high-grade non-C&D self-haul waste stream. As in Option 3, Option 4 assumes that the City would alter collection routes to generate commodity-rich dry loads. In this case, the process line would optimize recovery of fibers from high-grade non-C&D commercial loads, and the large wood and metal would be removed on the tipping floor prior to delivery at the MRF. The MRF would process an estimated one-third to one-half of the City's commercial

waste stream. The design capacity for processing residential commingled recyclables would be 25,000 tons per year or 100 tons per day, unchanged from Option 2, Commingled Residential Recyclables, Non-C&D Commercial Waste, and Multifamily Waste.

The MRF equipment needed to process these materials would be similar to Option 2 and therefore is estimated to cost between $13 M and $16 M. The building and other facility capital costs are estimated at $26 M. These initial capital costs are amortized (debt service expenditures) over the operating life and included in the financial analysis.

The integrated MRF process line for Option 4 would be capable of processing 300 tons per day over a single shift. The annual labor and operating expenditures are shown in **Table 12**.

Table 12. Option 4 Revenue Summary

	Option 4
Material Recovery	
Tons Recycled	39,462
Tons Composted	9,047
Tons Landfilled	31,477
Total Tons Processed	**79,985**
Diversion Rate	61%
Revenue Requirements	
MRF Operations	$4,206,083
Debt Services	$3,338,757
Total Expenses	**$7,544,840**
Expenses per Ton	$94
Revenue	
Tip Fee Revenue	$0
Material Sales	$3,438,492
Average Net Sale Price	$87
Organics to Compost	$0
Total Revenue	**$3,438,492**
Revenue per Ton Processed	$43
Net Revenue	**$(4,106,349)**
Per Ton	$ (51)

The net cost to the City for Option 4 is estimated to be slightly more than $4.0 M per year or $51 per ton of waste processed.

As with Options 2 and 3, the financial analysis does not account for any expected avoided cost the City might experience under Option 4. If Option 4 is considered, then an evaluation of the potential of avoided cost to the solid waste system should be conducted.

3.6 Summary of Financial Results

The financial results for Options 1 through 4 are influenced by two main factors. The first factor is throughput, which determines the amount of material being processed in the MRF. As explained in Chapter 2, MRFs using a high level of technology can operate a throughput of 35 to 40 tons per hour. A MRF operating at a smaller scale with less material could range from 20 to 30 tons per hour. Thus the MRF processing the same quantity and quality of material that has a larger throughput per hour will have fewer operating hours. The second factor influencing financial results is the amount of commodities recovered. Recovering and selling more high-quality recyclable material would lead to increased revenues. Of course this can be influenced by market prices, but in the end, the more materials that are recovered, the more revenue that is generated. **Table 13** summarizes revenue for each of the MRF options.

Table 13. Revenue Summary for All MRF Options

	Option 1	Option 2	Option 3	Option 4
Material Recovery				
Tons Recycled	20,267	38,201	32,680	39,462
Tons Composted	0	19,310	8,296	9,047
Tons Landfilled	1,267	34,809	14,558	31,477
Total Tons Processed	**21,534**	**92,320**	**55,534**	**79,985**
Diversion Rate	94%	62%	74%	61%
Revenue Requirements				
MRF Operations	$1,578,508	$5,212,583	$3,704,583	$4,206,083
Debt Services	$1,492,794	$3,338,757	$3,338,757	$3,338,757
Total Expenses	**$3,071,302**	**$8,551,340**	**$7,043,340**	**$7,544,840**
Expenses per Ton	$143	$93	$127	$94
Revenue				
Tip Fee Revenue	$0	$0	$0	$0
Material Sales	$2,270,109	$4,039,511	$3,363,328	$3,438,492
Average Net Sale Price	$112	$106	$103	$87
Organics to Compost	$0	$0	$0	$0
Total Revenue	**$2,270,109**	**$4,039,511**	**$3,363,328**	**$3,438,492**
Revenue per Ton Processed	$105	$44	$61	$43
Net Revenue	**$ (801,193)**	**$ (4,511,829)**	**$ (3,680,012)**	**$ (4,106,349)**
Per Ton	$ (37)	$ (49)	$ (66)	$ (51)

As mentioned for Option 1, the cost to build a MRF for the purposes of processing only the commingled residential recyclables is not feasible as long as the City has the ability to have materials processed at a local privately operated MRF. Construction of a single-purpose MRF may make sense if the financial arrangement with local processors is changed or relocated and the City has to transport materials further, or if the City is able to divert more materials to the MRF. This could be a result of getting more materials from the City or attracting materials from other jurisdictions.

Comparing Options 2, 3, and 4 allows the City to consider a variety of strategies for meeting its recycling goals. Option 3 would recover a higher percentage of the materials processed than other options. However, Options 2 and 4 would recover more materials because a higher volume waste would be processed at the integrated MRF. The unit cost to operate either Option 2 or 4 is similar, but the net annual operating expenses for Option 4 are 10% less.

Chapter 4. Sustainability Programs and MRF Option 4

The City of Tacoma is implementing a variety of sustainability programs, and expects these programs to divert additional materials from landfill through recycling and composting, including wood and yard waste. However, even if these programs reach maximum success, projections indicate that an appreciable quantity of recyclable materials will remain in the waste stream. A MRF could recover a large portion of these remaining recyclable materials from the waste stream.

Rather than investing in building additional MRF capacity at this time, the City's preferred approach to increasing diversion is to implement a series of diversion and sustainability programs targeting different waste generation sectors. Since implementing new programs and changing behavior takes time, Tacoma will monitor the impacts of these programs over the next 5 or 6 years to determine their effectiveness. The results of this program monitoring will contribute to Tacoma's decision to invest in a MRF.

This chapter presents the projected diversion results of implementing selected sustainability programs over the next 5 to 6 years, and the associated impact on the amount of MRF capacity needed in 2028. Section 4.1 quantifies projected sustainability program impacts on waste diversion and disposal through 2028. Section 4.2 presents costs and other considerations related to investing in additional MRF capacity in 2028, along with projected diversion that would result from this increased capacity.

The project team modeled anticipated 2028 material recovery resulting from the selected planned sustainability programs. In addition, the modeling estimated the amount of recoverable materials that would remain in the landfilled waste stream in 2028. This section presents modeling results.

4.1 Expansion of Commingled Collection Programs

The City's sustainability plan indicates that Tacoma will target expansion of its commingled collection programs to multifamily residences and commercial customers. Although commingled collection is currently available to these customers, the participation rate is low. Tacoma predicts that expanding commingled collection programs for multifamily and commercial customers will also encourage increased commingled

collection program participation among single-family residences. **Table 14** shows the estimated additional materials that expanded commingled collection programs would collect and recover.

Table 14. Estimated New Commingled Materials in Year 2028

Source	Collected	Commodities Recovered
Residential SF	2,590	1,616
Residential MF	1,510	1,418
Commercial	2,802	1,055
Self-Haul	NA	NA
Total	**6,902**	**4,089**

Tacoma's sustainability plan also suggests targeting self-haul customers to reduce the amount of recyclable items that these customers delivered to the TRTC for disposal. The plan estimates that as many as 2,000 tons of material could be diverted from the landfill by encouraging self-haul customers to recycle those materials rather than delivering them to the TRTC for disposal.

Table 15 considers the impact that expanded commingled collection programs and outreach to self-haul customers would have on the commingled waste stream, and estimates the composition of this new waste stream. This stream would be processed at the advanced MRF in 2028, when the system would go into service.

Table 15. Total Commingled Materials in the Year 2028

Material Processing	**Tons**
Current Residential Commingled	24,266
Commingled + Sustainability Program	**31,177**
Recovery of Recyclables	**Tons**
OCC/Cardboard	2,946
Paper (Mixed)	13,674
Newspaper	4,050
Recyclable Glass (Containers)	666
#1 and #2 Bottles	968
#1–#7 Other Containers	751
Clean Bags and Film	795
Tin Food Cans	177
Other Ferrous	1,857
Aluminum/Beverage Cans	338
Other Aluminum	82

Other Non-Ferrous	336
Wood/Lumber	85
Durable Plastics (Rigids)	287
Total Commodities	**26,926**
Total Recyclables	**27,011**
Recovery of Organics/Compostables	**Tons**
Food Waste	1,208
Mixed Organic	215
Green Waste / Yard Waste	161
Total AD/Compostables	**1,584**
Landfilled Material	2,582

The amount of materials available for processing at the new MRF is expected to increase to 31,000 tons per year in 2028. Because of the new sustainability programs, 86% of this material is estimated to be recyclable commodities, and about 1,500 tons is projected to be compostable organics.

4.2 Recoverable Materials in Disposed Waste

This modeling effort also produced a projection that identifies what materials will still remain in the disposed waste stream in 2028. A substantial amount of these materials could be targeted for recovery by building or acquiring new integrated MRF capacity.

Table 16 shows the estimated quantities of materials that might be processed and recovered from the high-grade non-C&D commercial waste stream in 2028.

Table 16. High-Grade Non-C&D Commercial Materials in the Year 2028

Material Processing	**Tons**
High-Grade Commercial	33,237
Recovery of Recyclables	**Tons**
OCC/Cardboard	1,538
Paper (Mixed)	2,202
Newspaper	502
Recyclable Glass (Containers)	1,133
#1 and #2 Bottles	775
#1–#7 Other Containers	290
Clean Bags and Film	698
Tin Food Cans	148

Other Ferrous	1,218
Aluminum/Beverage Cans	164
Other Aluminum	42
Other Non-Ferrous	41
Wood/Lumber	2,552
Durable Plastics (Rigids)	770
Total Commodities	**9,520**
Total Recyclables	**12,072**
Recovery of Organics/Compostables	**Tons**
Food Waste	5,113
Mixed Organic	1,916
Green Waste / Yard Waste	2,121
Total AD/Compostables	**9,149**
Landfilled Material	12,015

The amount of high-grade commercial waste is estimated to be about the same as shown previously for Option 4. However, the model indicates that about 20% of this waste stream will be marketable commodities in 2028, which is down from 28% in 2016. The reason for this decrease is that new sustainability programs would drive more recyclables into the commercial commingled collection system.

Table 17 shows the estimated quantities of materials that might be recovered from self-haul waste in 2028. The model that generated these estimates considers new sustainability programs in its estimates. By the model's predictions, many of the higher value materials would be recycled prior to arriving at the MRF, and a large portion of the wood waste and yard debris generated would be diverted through financial incentives and tip floor sorts.

Table 17. Non-C&D Self-Haul Materials in the Year 2028

Material Processing	**Tons**
Self-Haul Mixed Waste	24,327
Recovery of Recyclables	**Tons**
OCC/Cardboard	759
Paper (Mixed)	194
Newspaper	110
Recyclable Glass (Containers)	49
#1 and #2 Bottles	30
#1–#7 Other Containers	17
Clean Bags and Film	1

Tin Food Cans	21
Other Ferrous	715
Aluminum/Beverage Cans	7
Other Aluminum	1
Other Non-Ferrous	268
Wood/Lumber	0
Durable Plastics (Rigids)	439
Total Commodities	**2,611**
Total Recyclables	**2,611**
Recovery of Organics/Compostables	**Tons**
Food Waste	163
Mixed Organic	114
Green Waste / Yard Waste	1,687
Total AD/Compostables	**1,963**
Landfilled Material	19,753

4.3 Analysis of MRF Option 4 in the Year 2028

This analysis assumes that the City of Tacoma will pursue the concept described in Section 3.5 (Option 4: Commingled Residential Recyclables, High-Grade Non-C&D Commercial Waste, and High-Grade Non-C&D Self-Haul Waste). The process to site, design, and construct the advanced MRF is expected to take several years, with the goal to have the plant operational by 2028. This date is consistent with the City's goals: full operation of an integrated MRF by 2028 would support the City's progress towards meeting the 70% diversion by 2028 goal.

The City would embark on developing an advanced MRF that could either be publically owned and operated or be constructed and operated through a public-private partnership. The analysis in this section assumes an integrated MRF capable of processing commingled materials and high-grade non-C&D commercial and self-haul waste. The MRF would not have the capacity to process wood and yard waste: although some wood would remain in the waste stream, the model assumes that new programs would greatly reduce the amount in the mixed waste streams. The MRF would also process commingled materials collected from all generators, including single-family residences, multifamily residences, and commercial customers.

Using the waste data from the *Volume 2 Municipal Waste Composition Study* and performance information from recently operational advanced MRFs in other North American locations, it is estimated that an additional 41,700 tons of commodities and 12,700 tons of compostables may be recovered in 2028 using the MRF described in Option 4. This represents 61% of the total waste processed at the MRF.

The cost to operate the MRF in 2028 is estimated to be $136 per ton, with revenue estimated to be $63 per ton. Therefore, the net cost to operate the MRF in 2028 is estimated to be $72 per ton. **Table 18** summarizes the amount of material processed and the associated costs projected for the year 2028.

Table 18. Option 4 Costs in the Year 2028

	Option 4
Material Recovery	
Tons Recycled	41,695
Tons Composted	12,696
Tons Landfilled	34,350
Total Tons Processed	**88,740**
Diversion Rate	61%
Revenue Requirements	
MRF Operations	$7,473,319
Debt Services	$4,574,540
Total Expenses	**$12,047,858**
Expenses per Ton	$136
Revenue	
Tip Fee Revenue	$0
Material Sales	$5,621,935
Average Net Sale Price	$135
Organics to Compost	$0
Total Revenue	**$5,621,935**
Revenue per Ton Processed	$63
Net Revenue	**$(6,425,924)**
Per Ton	$ ($72)

This analysis is based on current composition data and current advanced MRF technology. The composition of the waste that the City of Tacoma generates will change over time as consumer habits and packaging innovations evolve. For example, in recent years, the amount of newspaper has decreased while the amount of plastics has increased. Sustainability program implementation will also influence changes in composition. The technology used to recover materials from the waste stream is also constantly evolving. In the past 5 years alone, advances in screening technology, air density separation, and optics have vastly improved the ability of MRFs to recover clean marketable materials from the mixed waste stream.

This MRF feasibility analysis provides the City with information to help plan for the future. Prior to moving forward with any investment in an advanced MRF, it is recommended that the City complete an updated feasibility analysis using new waste composition data and consider evaluating the latest processing technology.

Appendices

Appendix A: Basis of MRF Design Technical Memorandum

Appendix A: Basis of MRF Design Technical Memorandum

In the course of evaluating approaches to increase the recycling rate for the City of Tacoma, four material recovery facility (MRF) options were examined. The amounts of materials are based on sampling events conducted in May 2015 and are used to define the overall parameters for building a MRF(s). Additional waste sampling events will be conducted that will be used to evaluate the overall feasibility for different options. But the data from spring 2015 is used to establish the primary capital and operating parameters for this basis of design (BOD). These parameters are then used to develop the capital and operating cost for completing the feasibility analysis.

The analysis takes into account cost and operational elements (e.g., number of sorters) from recent MRF proposals of similar systems, operations, capacities, and waste streams. The MRF assumes that an equipment line may consist of trommels, a variety of screens, manual sort stations, a ferrous magnet, an eddy current separator, and several optical sorters placed on the both the fiber and plastics lines to enhance quality and throughput that is experienced in the latest facilities. The process lines shown are similar to MRF equipment installed in recent facilities processing similar types of materials. However, the equipment shown and the cost estimates are planning-level schematics, and the actual equipment used may be different depending on the final waste stream to be processed and the selected vendor**.** Technology advances will continue, and vendors are expected to provide the latest technology appropriate for the anticipated material mix determined at the time the project advances.

Recovery rates for the sort lines are included in the model and are based on performance information for mixed waste and commingled MRFs installed and operating over the past few years. The latest technology using a series of optical sorting provides higher throughput rates, lower labor, and enhanced quality of recovered materials.

MRF Options

Option 1: Commingled Residential Recyclables

The initial feasibility evaluation was completed on June 30, 2015. It is based on previous waste data and analysis of the City's current collection practices. This option was updated as necessary to consider factors that may contribute to increasing the amount of source-separated materials from residential or other customers resulting from new programs or additional services identified in preparing the sustainability plan.

See **Attachment A, Figure 1**, for a process flow diagram.

Table 1 presents estimates of the potential material recovery quantities for Option 1. The estimated quantities reflect the current recovery rates of over 90% for the materials as reported by Waste Management for processing at the JMK MRF. This plant was upgraded with additional equipment by Waste Management recently. A new MRF constructed to handle the material would be expected to achieve similar or perhaps better recovery, but the BOD will use the current data. Note that 2,954 tons of glass is currently collected separately based on the information provided.

Table 1. Option 1 Potential Recovery Range

Commingled Residential	**Year 1**
Material Processing	
Commingled Materials	17,125
Other Recyclables	4,409
Recovery of Recyclables	
OCC/Cardboard	2,204
Paper	11,183
Newspaper	3,351
Recyclable Glass Containers	186
#1 and #2 Bottles	569
#1–#7 Other Containers	493
Clean Bags and Film	262
Tin Food Cans	58
Other Ferrous	1,423
Aluminum Cans	228
Other Aluminum	33
Other Non-Ferrous	277
Wood/Lumber	0
Durable Plastics (Rigids)	0
Total Commodities	**20,267**
Total Recyclables	**20,267**
Recovery of Compostables	
Food Waste	0
Mixed Organic	0
Yard Waste / Green Waste	0
Total AD/Compostables	**0**
Landfilled Material	**1,267**
Commingled Residential	
Recovery Rate Range	

Recyclables Recovery Rate (of Overall Tons)	94%
Recyclables Recovery Rate (of Recyclable Tons)	100%

BOD INFORMATION

Table 2 and **Table 3** summarize the potential processing rate as well as anticipated labor requirements for the processing line.

Table 2. Option 1 Material Process Rate

Option 1 Process Rate	Material Processed (Tons per Year) [1]	Process Rate (Tons per Day) [2]
Commingled Residential Recyclables	17,000	
Recycle Drop Off	4,800	
Glass	3,000	
Total	**25,000**	**100**

Notes:
1. Values are rounded.
2. Assumes operation 5 days per week.

Option 1 Operation Duration	Typical Equipment Processing Rate (Tons per Hr)	System Availability	Operation Duration (Hrs per Day)
Commingled Line	25	90%	5

Table 3. Option 1 Process Line Labor Requirements

Option 1 Labor Requirements	Full Time Equivalents (FTE)	Notes
Supervisor	0.5	
Operators	0.75	Includes forklift, baling
Sort Labor		
Laborer 1	12	
Laborer 2	8	
Total Sort Laborers	20	
MRF Maintenance	1.5	

Note:
1. Labor totals do not include material resale, product delivery, or building maintenance.

Option 2: Commingled Residential Recyclables, Non-C&D Commercial Waste, and Multi-Family Waste

Option 2 includes installation of an integrated equipment line with capabilities to process a mixed waste stream and commingled. These materials would be processed at separate times to maximize recovery efficiency of the single stream material. The analysis considers waste delivered primarily with automated front loaders that typically collect from commercial/institutional and multi-family customers. Based on the spring sort data, there are about 56,000 tons of commercial waste and 14,000 tons of multi-family waste per year. The capacity of the facility might be about 92,000 tpy or 354 tpd. Further evaluation of the waste streams will determine what materials would be processed.

The equipment would likewise be capable of processing about 25,000 tpy or 100 tpd of single stream. At other times, select loads from non-C&D commercial routes and multi-family routes would be processed.

See **Attachment A, Figure 2**, for a process flow diagram.

System recovery rates would vary depending on several factors, such as the final equipment arrangement/selection, number of sorts, composition of waste, and quality of waste/recyclables. **Table 4** provides a range of potential material recovery for the non-C&D commercial and multi-family waste line. See Option 1 for commingled potential material recovery.

Table 4. Option 2 Potential Recovery Range

Non-CD Commercial and Multifamily	**Year 1**	
Material Processing		
Commercial Waste	70,786	
Recovery of Recyclables	**High**	**Low**
OCC/Cardboard	1,848	1,756
Paper	3,791	3,601
Newspaper	542	515
Recyclable Glass Containers	1,147	1,090
#1 and #2 Bottles	956	908
#1–#7 Other Containers	319	303
Clean Bags and Film	637	605
Tin Food Cans	336	319
Other Ferrous	1,479	1,405
Aluminum Cans	202	192
Other Aluminum	67	64
Other Non-Ferrous	64	61
Wood/Lumber	5,210	4,950
Durable Plastics (Rigids)	1,338	1,271
Total Commodities	**12,724**	**12,088**

Total Recyclables	**17,934**	**17,037**
Recovery of Compostables		
Food Waste	13,138	12,481
Mixed Organic	4,587	4,358
Yard Waste / Green Waste	1,586	1,507
Total AD/Compostables	**19,310**	**18,345**
Landfilled Material	**33,542**	**31,865**
Non-CD Commercial and Multi-Family		
Recovery Rate Range	**High**	**Low**
Recyclables/Organics Recovery Rate (of Overall Tons)	53%	50%
Recyclables/Organics Recovery Rate (of Rec/Org Tons)	86%	82%
Commodities Recovery Rate (of Overall Tons)	18%	17%
Commodities Recovery Rate (of Commodity Tons)	89%	85%
Recyclables Recovery Rate (of Overall Tons)	25%	24%
Recyclables Recovery Rate (of Recyclable Tons)	88%	69%
Compostables Recovery Rate (of Overall Tons)	18%	17%
Compostables Recovery Rate (of Compostables Tons)	80%	78%

BOD INFORMATION

Table 5 and **Table 6** summarize the potential processing rate as well as anticipated labor requirements for the processing line.

Table 5. Option 2 Material Process Rate

Option 2 Process Rate	Material Processed (Tons per Year) [1]	Process Rate (Tons per Day) [2]
Option 1 Material	25,000	100
Non-C&D Commercial & Multi-Family	76,000	300
Total	**101,000**	**400**

Notes:
1. Values are rounded.
2. Assumes operation 5 days per week.

Option 2 Operation Duration	Typical Equipment Processing Rate (Tons per Hr)	System Availability	Operation Duration (Hrs per Day) [1]
Commingled Line	30	90%	3.8
Commercial Stream Line	35	90%	9.6
Total			**14.4**

Notes:
1. Includes 1 hour break time.
2. Assume 2 shifts.

Table 6. Option 2 Process Line Labor Requirements

Option 2 Labor Requirements	Full Time Equivalents (FTE)	Notes
Supervisor	1.5	
Operators	4	Includes 3 loaders & forklift + 1 baling. Does not include drivers for organics/residue.
Sort Labor		
Laborer 1	12	
Laborer 2	8	
Total Sort Laborers (Per Shift)	20	
Pre-Sort	*6*	
Fibers Post-Sort	*6*	
Containers Line	*6*	
Floaters (QA)	*2*	
MRF Maintenance	5	
MRF Maintenance Sup	*1*	
Mechanical/Electrical	*2*	
Laborers	*2*	

Note:
1. Labor totals do not include material resale, product delivery, or building maintenance.

As shown in **Table 5** and **Table 6**, in order for the MRF to process the amount of materials under Option 2, it would need to operate over two shifts. The financial analysis will account for these labor requirements.

FACILITY PARAMETERS

The facility would require systems to support the material recovery line. These systems may include thickened floor slab or enhanced foundations, power, lighting, compressed air, HVAC, etc. Sort station areas may also require focused lighting and HVAC systems.

A new MRF would require an overall footprint of approximately 400 FT x 200 FT plus office and other employee space (e.g., lockers, restrooms, and break area) of approximately 40 FT x 80 FT. Based on the waste stream projections for Option 2, the MRF would require areas for the following:

- Exterior vehicle maneuvering – 10,000 – 15,000 SF

- Infeed – ~2,000 SF
- Processing equipment line and bin storage – ~15,000 – 25,000 SF
- Tipping floor for commingled (not including exterior maneuvering) – ~3,000 SF
- Tipping floor for commercial/multi-family (not including exterior maneuvering) – ~4,000 SF
- Storage space for commingled – ~3,000 SF
- Storage space for commercial/multi-family – ~6,700 SF
- Bale loading dock / shipping (not including exterior maneuvering) – ~2,500 SF
- Bale storage – ~6,000 SF
- Interior forklift / front loader maneuvering

See **Attachment B, Figure 1**, for a Generic Conceptual Level Floor Plan.

Option 3: Commingled Residential Recyclables and High-Grade Non-C&D Commercial Waste

Option 3 includes installation of an integrated equipment line with capabilities to process mixed waste and commingled materials. Under this Option 3, it is expected that the City would implement a means to alter collection routes to generate commodity-rich loads. This assumes that waste from commercial customers that might generate a higher percentage of paper, plastics, metals, etc., could be picked up by selectively routing trucks. Waste from customers that generate a higher percentage of food waste or less desirable materials would be collected in separate trucks. Although the commercial waste stream is expected to have less organics and more commodities, the equipment used to process the waste streams under Option 3 are similar to the equipment used under Option 2.

The amount of material that could be collected assuming the City implements a high-grade collection strategy was developed using data from the City of Seattle waste composition study. In this study, Cascadia sampled various commercial generators and found that manufacturing, office, retail, education, and hotel/motel facilities contain a higher percentage of paper on average than health care, restaurants, and wholesale outlets. The result of selecting certain customers that generate higher amounts of paper, plastics, cardboard, etc., means less food waste and less contamination.

For Option 3, it is assumed that the City would collect 50% of commercial customers to generate high-grade loads to process. In this case, the process line would focus on recovery of fibers from commodity-rich loads. Therefore, 34,000 tons per year (130 tons per day) would be delivered to the mixed waste MRF to process. The equipment would likewise be capable of processing about 25,000 tpy (100 tpd) of commingled. These materials would be processed at different times, therefore allowing staffing adjustments to be made to optimize recovery.

The equipment line would be the same as in Option 2; however, the process line operation duration would be reduced due to reduced tonnage. See **Attachment A, Figure 2**, for a process flow diagram.

System recovery rates would vary depending on several factors, such as the final equipment arrangement/selection, number of sorts, composition of waste, and quality of waste/recyclables. **Table 7** provides a range of potential material recovery for the select high-grade non-C&D commercial waste line. See Option 1 for commingled potential material recovery.

Table 7. Option 3 Potential Recovery Range

High-Grade Non-C&D Commercial	**Year 1**	
Material Processing		
High-Grade Commercial	34,000	
Recovery of Recyclables	**High**	**Low**
OCC/Cardboard	1,836	1,744
Paper	3,468	3,294
Newspaper	289	275
Recyclable Glass Containers	612	581
#1 and #2 Bottles	428	407
#1–#7 Other Containers	306	291
Clean Bags and Film	367	349
Tin Food Cans	162	153
Other Ferrous	485	460
Aluminum Cans	97	92
Other Aluminum	39	37
Other Non-Ferrous	0	0
Wood/Lumber	3,101	2,946
Durable Plastics (Rigids)	1,224	1,163
Total Commodities	**9,312**	**8,847**
Total Recyclables	**12,413**	**11,792**
Recovery of Compostables		
Food Waste	5,440	5,168
Mixed Organic	2,448	2,326
Yard Waste / Green Waste	408	388
Total AD/Compostables	**8,296**	**7,881**
Landfilled Material	**13,291**	**12,626**
High-Grade Non-C&D Commercial		
Recovery Rate Range	**High**	**Low**
Recyclables/Organics Recovery Rate (of Overall Tons)	60%	58%
Recyclables/Organics Recovery Rate (of Rec/Org Tons)	84%	79%

Commodities Recovery Rate (of Overall Tons)	27%	26%
Commodities Recovery Rate (of Commodity Tons)	88%	80%
Recyclables Recovery Rate (of Overall Tons)	36%	35%
Recyclables Recovery Rate (of Recyclable Tons)	86%	81%
Compostables Recovery Rate (of Overall Tons)	27%	26%
Compostables Recovery Rate (of Compostables Tons)	80%	76%

BOD INFORMATION

Table 8 and **Table 9** summarize the potential processing rate as well as anticipated labor requirements for the processing line.

Table 8. Option 3 Material Process Rate

Option 3 Process Rate	Material Processed (Tons per Year) [1]	Process Rate (Tons per Day) [2]
Option 1 Material	25,000	100
High-Grade Non-C&D Commercial	34,000	130
Total	**59,000**	**230**

Note:
1. Values are rounded.
2. Assumes operation 5 days per week.

Option 3 Operation Duration	Typical Equipment Processing Rate (Tons per Hr)	System Availability	Operation Duration (Hrs per Day) [1]
Commingled Line	30	90%	3.8
Commercial Stream Line	35	90%	4.2
Total			**9.0**

Note:
1. Includes 1 hour break time.

Table 9. Option 3 Process Line Labor Requirements

Option 3 Labor Requirements	Full Time Equivalents (FTE)	Notes
Supervisor	1.5	
Operators	4	Includes 3 loaders & forklift + 1 baling. Does not include drivers for organics/residue.
Sort Labor		

Laborer 1	12
Laborer 2	8
Total Sort Laborers	20
Pre-Sort	*6*
Fibers Post-Sort	*6*
Containers Line	*6*
Floaters (QA)	*2*
MRF Maintenance	5
MRF Maintenance Sup	*1*
Mechanical/Electrical	*2*
Laborers	*2*

Note:

1. Labor totals do not include material resale, product delivery, or building maintenance.

FACILITY PARAMETERS

The facility would require systems to support the material recovery line. These systems may include thickened floor slab or enhanced foundations, power, lighting, compressed air, HVAC, etc. Sort station areas may also require focused lighting and HVAC systems.

A new MRF would require an overall footprint of approximately 400 FT x 200 FT plus office and other employee space (e.g., lockers, restrooms, and break area) of approximately 40 FT x 80 FT. Based on the waste stream projections for Option 3, the MRF would require areas for the following:

- Exterior vehicle maneuvering – ~10,000 – 15,000 SF
- Infeed - ~2,000 SF
- Processing equipment line and bin storage – ~25,000 SF
- Tipping floor for commingled (not including exterior maneuvering) – ~3,000 SF
- Tipping floor for commercial/multi-family (not including exterior maneuvering) – ~4,000 SF
- Storage space for commingled – ~3,000 SF
- Storage space for high-grade commercial – ~3,000 SF
- Bale loading dock / shipping (not including exterior maneuvering) – ~2,500 SF
- Bale storage – ~6,000 SF
- Interior forklift / front loader maneuvering

See Attachment B, Figure 1, for a Generic Conceptual Level Floor Plan.

Option 4: Commingled Residential Recyclables, High-Grade Non-C&D Commercial Waste, and High-Grade Non-C&D Self-Haul Waste

Option 4 is similar to Option 3 but would also process select materials received from self-haul customers. Waste composition data show that the self-haul waste stream contains a high percentage of wood and metal. These items represent a high percentage of recoverable materials; however, it is not desirable to process over a mixed waste sort line. Based on discussions with Cascadia, it was assumed that 80% of the yard debris and wood waste would be removed from self-haul waste through a variety of efforts. This might include rate incentives, more education and promotion, or other programs. When excluding this material and balancing the percentage of discards, the MRF line is assumed to process 24,000 tons per year of the total 34,000 tons.

The 24,000-ton waste stream is somewhat high-grade material without most wood and yard waste. The material can be processed over the integrated mixed waste and commingled processing equipment. Because most of the waste is largely dry materials, it can be processed along with commingled materials and separate from processing the mixed high-grade commercial wastes.

The equipment line would be the same as in Option 2; however, the process line operation duration would be minimized due to reduced tonnage. See **Attachment A, Figure 2**, for a process flow diagram.

System recovery rates would vary depending on several factors, such as the final equipment arrangement/selection, number of sorts, composition of waste, and quality of waste/recyclables. **Table 10** provides a range of potential material recovery for the high-grade non-C&D commercial and high-grade self-haul waste line. See Option 1 for commingled potential material recovery.

Table 10. Option 4 Potential Recovery Range

Commingled Residential Recyclables, High-Grade Non-C&D Commercial Waste, and High-Grade Non-C&D Self Haul Waste	**Year 1**	
Material Processing		
Commingled, Commercial, and Self-Haul	75,576	
Recovery of Recyclables	**High**	**Low**
OCC/Cardboard	4,964	4,716
Paper	14,893	14,148
Newspaper	3,816	3,625
Recyclable Glass Containers	1,106	1,051
#1 and #2 Bottles	1,044	992
#1–#7 Other Containers	823	781
Clean Bags and Film	629	598
Tin Food Cans	266	253
Other Ferrous	5,369	5,101
Aluminum Cans	348	330
Other Aluminum	71	68
Other Non-Ferrous	671	638
Wood/Lumber	3,883	3,689
Durable Plastics (Rigids)	1,577	1,498
Total Commodities	**35,579**	**33,800**
Total Recyclables	**39,462**	**37,489**
Recovery of Compostables		
Food Waste	6,164	5,856
Mixed Organic	2,448	2,326
Yard Waste / Green Waste	435	414
Total AD/Compostables	**9,047**	**8,595**
Landfilled Material	**31,477**	**29,903**
Commingled, Commercial, and Self Haul		
Recovery Rate Range	**High**	**Low**
Recyclables/Organics Recovery Rate (of Overall Tons)	64%	61%
Recyclables/Organics Recovery Rate (of Rec/Org Tons)	91%	86%
Commodities Recovery Rate (of Overall Tons)	47%	45%
Commodities Recovery Rate (of Commodity Tons)	92%	87%
Recyclables Recovery Rate (of Overall Tons)	52%	50%

Recyclables Recovery Rate (of Recyclable Tons)	91%	86%
Compostables Recovery Rate (of Overall Tons)	47%	45%
Compostables Recovery Rate (of Compostables Tons)	80%	76%

BOD INFORMATION

Table 11 and **Table 12** summarize the potential processing rate as well as anticipated labor requirements for the processing line.

Table 11. Option 4 Material Process Rate

Option 4 Process Rate	Material Processed (Tons per Year) [1]	Process Rate (Tons per Day) [2]
Option 1 Material	25,000	100
High-Grade Non-C&D Commercial	34,000	130
High-Grade Non-C&D Self Haul	24,000	90
Total	**83,000**	**320**

Note:

1. Values are rounded.

2. Assumes operation 5 days per week.

Option 4 Operation Duration	Typical Equipment Processing Rate (Tons per Hr)	System Availability	Operation Duration (Hrs per Day) [1]
Commingled Line	30	90%	3.8
Commercial Stream Line	35	90%	4.2
Self-Haul Stream Line	30	90%	2.5
Total			**11.5**

Note:

1. Includes 1 hour break time.

2. Assume staggered 8-hour shift for sorters. Therefore, total labor is based on 1.4 operating times to account for additional labor hours per day.

Table 12. Option 4 Process Line Labor Requirements

Option 4 Labor Requirements	Full Time Equivalents (FTE)	Notes
Supervisor	1.5	
Operators	4	Includes 3 loaders & forklift + 1 baling. Does not include drivers for organics/residue.
Sort Labor		
Laborer 1	12	
Laborer 2	8	
Total Sort Laborers (Per Shift)	20	
Pre-Sort	*6*	
Fibers Post-Sort	*6*	
Containers Line	*6*	
Floaters (QA)	*2*	
MRF Maintenance	5	
MRF Maintenance Sup	*1*	
Mechanical/Electrical	*2*	
Laborers	*2*	

Note:
1. Labor totals do not include material resale, product delivery, or building maintenance.

The amount of labor required to process the materials under Option 4 is similar to the amount of labor required under Option 3. However, because an additional 65 tons of self-haul waste would be processed, the line would need to operate for an additional 2 hours. This will be accounted for in the financial analysis.

FACILITY PARAMETERS

The facility would require systems to support the material recovery line. These systems may include thickened floor slab or piles under major equipment, power, lighting, compressed air, HVAC, etc. Sort station areas may also require focused lighting and HVAC systems.

A new MRF would require an overall footprint of approximately 400 FT x 200 FT plus office and other employee space (e.g., lockers, restrooms, and break area) of approximately 40 FT x 80 FT. Based on the waste stream projections for Option 3, the MRF would require areas for the following:

- Exterior vehicle maneuvering – ~10,000 – 15,000 SF
- Infeed - ~2,000 SF
- Processing equipment line and bin storage – ~25,000 SF
- Tipping floor for commingled (not including exterior maneuvering) – ~3,000 SF

- Tipping floor for commercial/multi-family (not including exterior maneuvering) – ~4,000 SF
- Storage space for commingled – ~3,000 SF
- Storage space for high grade commercial/self-haul – ~4,800 SF
- Bale loading dock / shipping (not including exterior maneuvering) – ~2,500 SF
- Bale storage – ~6,000 SF
- Interior forklift / front loader maneuvering

See **Attachment B, Figure 1**, for a Generic Conceptual Level Floor Plan and building plan. This plan depicts an integrated mixed waste and commingled MRF that might be constructed on a new site. The concept plan would be similar for Options 2, 3, and 4.

Capital Cost Estimates

Equipment Cost

The capital cost for equipment can vary depending on the waste stream being processed and other factors that are related to a specific waste stream, system performance requirements, the level of technology selected, and general requirements of individual projects.

Under Option 1, based on recent projects, the cost of equipment for commingled or clean commingled recycled materials from residential customers may range from $5,500,000 to $7,500,000. The differences in cost may be how much technology is employed versus the labor cost. For instance, sort lines may incorporate more optical sorters to reduce the number of manual sorters on the line. Another example is that additional screens could be used to provide flexibility in sorting a wider range of materials. However, adding different unit processes would cost capital, and the number of units required would vary depending on the waste composition.

The City's commingled stream is fairly clean, with 10% or less residue. Therefore, due to the quantity of material to be processed, the equipment cost used in Option 1 is assumed to be $5,500,000.

For Options 2 through 4, the equipment line would process a mixture of mixed waste collected from primarily commercial accounts and commingled on the same line in batches. The different material streams would not be processed at the same time. The arrangement of the sorters and other adjustments may be completed as needed to adjust operations for the period when the commingled material is processed and the period when the selected mixed waste is processed. This approach uses an integrated equipment line that would allow both dry and clean recyclables on the same process line as a mixed waste stream. This is a more recent development in MRF equipment lines. Currently, there are several lines operating in the United States (primarily California) that have been installed in recent years to successfully process multiple types of materials.

The cost of installing a process system that can operate at throughput rates of 30 to 40 tons per hour ranges from $13,000,000 to $16,000,000. Similar to the comingled MRF processing equipment, the cost varies depending on the number of unit processes such screens, air separators and optical sorters that are installed. For the purposes of the feasibility study, the cost of $13,000,000 was assumed. This estimate is based on a recent system installed that requires processing similar waste streams and quantities of material as Option 2, which processes the greatest amount of waste. Because Options 3 and 4 would operate with less material, this is a reasonable assumption. Equipment costs may be higher if operating parameters are different.

Capital Cost of MRF Building

The options for constructing a new MRF can range from expanding the current transfer station to retrofitting an existing structure to building a new structure to house the new equipment.

For Option 1, it is possible to expand the existing transfer station. This is shown in **Attachment B, Figure 1**. However, expanding the transfer station makes several assumptions as to whether the City would want to co-locate the MRF or even wish to operate the facility. For the feasibility study, it is assumed a separate MRF will be built. Cost of construction is estimated to be $12,000,000. This would include a 60,000 SF building, scalehouse, and scale system.

For Options 2 through 4, the MRF building would need to be expanded to provide more tip floor space to receive more materials. Similarly, the equipment line would also need to be larger. The MRF building for the integrated MRF would be 80,000 SF. It would also include a scale complex. The estimated cost of the building is $26,000,000.

The construction costs are planning-level estimates and carry accuracy of +30% and -15%. The estimates are provided in **Attachment C**.

Revenue - Market Prices for Recovered Materials

Recycling programs throughout the Pacific Northwest have been in place for over 20 years. As such, markets for most materials from local MRFs are established. Some of these markets are local, and others are overseas. Although these markets are fairly stable, the value varies considering both domestic and international commodity prices. To estimate the potential revenue from materials recovered, the feasibility analysis used the average price for materials over the past 10 years. The prices were reported to the City of Seattle from local processers.

Considering the data from the last 10 years provides a longer period, but is not necessarily reflective of current trends. To more accurately portray current trends in commodity prices, spot prices reported from Northwest brokers for 2015 were added to the data. To reflect potential impacts of lower prices, the years of the highest prices were not included. The result is that the low price is an average of the lowest prices for each commodity. This approach demonstrates what effect the market has on the total revenue. While prices do fluctuate, it is important to note that down periods or recessionary prices will rebound with the economy. Table 13 shows the average commodity prices used in the financial analysis.

Table 13. SPU Residential Survey Market Prices

				SPU Residential Survey Market Prices						
				10- Year Average - 2006- 2015						
Year	Baled Aluminum	OCC	Mixed Paper	Baled ONP	Plastic	Tin	Brown Glass	Clear Glass	Green Glass	Average Glass
2015	$1,380.00	$110.00	$65.00	$73.00	$560.00	$236.67	$17.50	$17.50	$2.50	
2014	$1,670.00	$117.08	$72.50	$77.50	$467.00	$352.92	$17.50	$17.50	$2.50	
2013	$1,550.50	$130.00	$85.00	$97.50	$420.00	$345.00	$17.50	$17.50	$2.50	$12.50
2012	$1,510.00	$143.54	$105.63	$99.58	$463.33	$379.50	$17.50	$17.50	$2.92	$12.64
2011	$1,730.00	$182.50	$143.33	$133.96	$473.33	$415.42	$17.50	$17.50	$2.50	$12.50
2010	$1,515.83	$164.17	$111.46	$105.21	$383.33	$328.75	$17.50	$17.50	$2.50	$12.50
2009	$1,113.13	$102.22	$61.04	$63.33	$300.83	$190.00	$18.33	$20.83	$4.17	$14.44
2008	$1,587.50	na	$97.92	$86.25	$297.50	$71.88	$25.00	$37.50	na	$20.83
2007	$1,700.00	na	$63.75	$60.00	$319.17	$78.33	$25.00	$37.50	na	$20.83
2006	$1,701.67	na	$26.25	$27.50	$259.17	$77.92	$23.00	$33.88	na	$18.96
2005	$1,306.67	na	$27.92	$34.17	$486.67	$87.29	$17.00	$23.00	na	$13.33
2004	$1,227.92	na	$12.50	$30.42	$193.33	$67.50	$17.00	$23.00	na	$13.33
Total - 10 yrs	$15,458.63	$832.43	$831.88	$823.83	$3,943.66	$2,476.39	$196.33	$234.71	$14.59	$151.88
10 Yr - Ave. Price (2006-2015)	$1,545.86	$118.92	$83.19	$82.38	$394.37	$247.64	$19.63	$23.47	$2.92	$15.19
USE 10 YR Ave Scenario	**$1,540.00**	**$115.00**	**$80.00**	**$80.00**	**$390.00**	**$215.00**	**$20.00**	**$23.00**	**$2.50**	**$16.00**
Low Prices	$1,269.62	$102.33	$62.42	$64.91	$258.17	$116.63				
Low Price Scenario	**$1,200.00**	**$100.00**	**$60.00**	**$65.00**	**$260.00**	**$110.00**	**$17.50**	**$17.50**	**$2.50**	

In the feasibility study, the 10-year average was used because it portrays the most accurate account of commodity prices over the past 10 years.

Financial Model

Using the information presented above, JRMA prepared a financial model to evaluate various options. The analysis uses a building block approach that considers each element of the financial aspects of operating a MRF. These include the following steps:

Step 1. Estimate recovery of materials from various waste streams. Waste composition data are from the 1st and 2nd quarter sampling events in 2015. Waste streams include:

- Commingled residential/commercial
- Non-C&D commercial – mixed waste
- Non-C&D commercial – high-grade
- Self-haul waste

Step 2. Estimate the quantity of materials recovered using MRF performance information from the most recent technology being applied to processing waste to recover materials.

Step 3. Estimate revenue from the sale of recovered materials using the average 10-year market price for each commodity.

Step 4. Estimate operational expenses associated with various options. **Table 3, Table 6, Table 9, and Table 12** presented the estimated labor requirements for each option. Current labor rates for the City of Tacoma were used to arrive at annual costs. The operating hours for each option were adjusted based on the throughput for each option.

Other operating expenses for maintenance, parts, power, etc., were estimated based on similar operations.

Step 5. Estimate capital costs for the two MRF systems that are used in the feasibility analysis. It is assumed these would be financed with bonds and the debt retired over 15 years for the equipment and 20 years for the buildings.

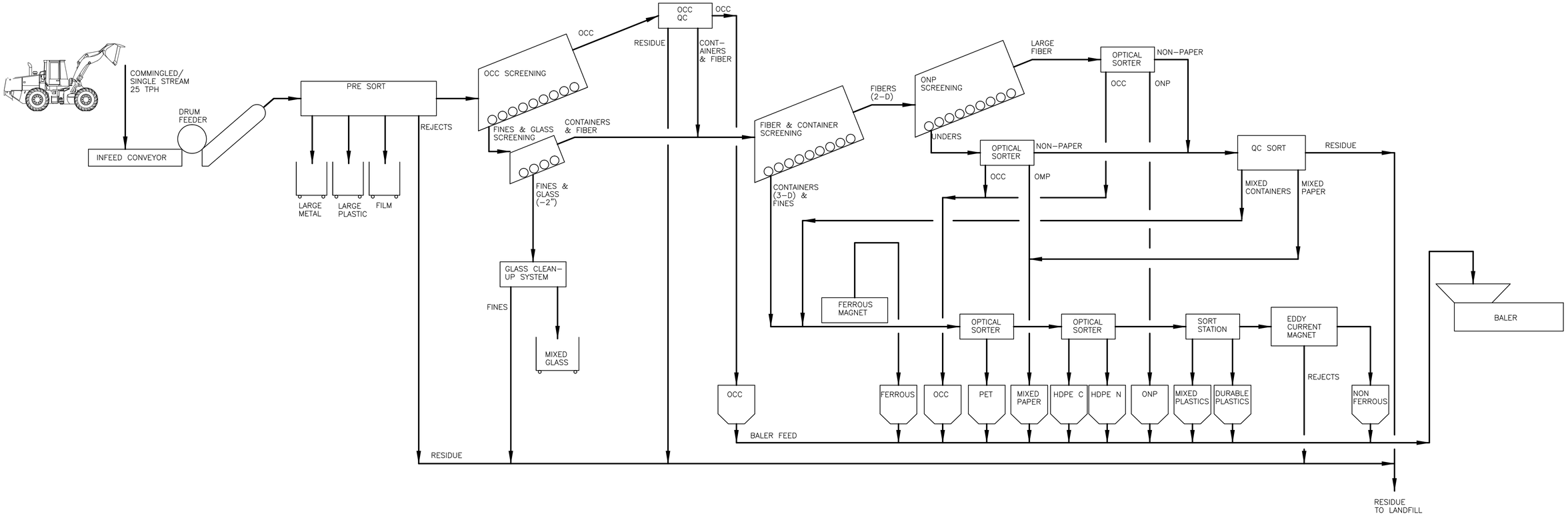
Step 6. Determine the unit operating cost for each option. This step uses all of the capital and operating expenses and the total waste processed to arrive at the unit operating cost for the different options and excludes revenues.

Step 7. Prepare a Summary of Financial Performance, which is a composite of the all information that shows the total materials being processed, the estimated recovery rate, the estimated annual expenses and revenues, and the net unit cost of each option.

The financial results are presented in the feasibility report.

ATTACHMENT A – FLOW DIAGRAMS

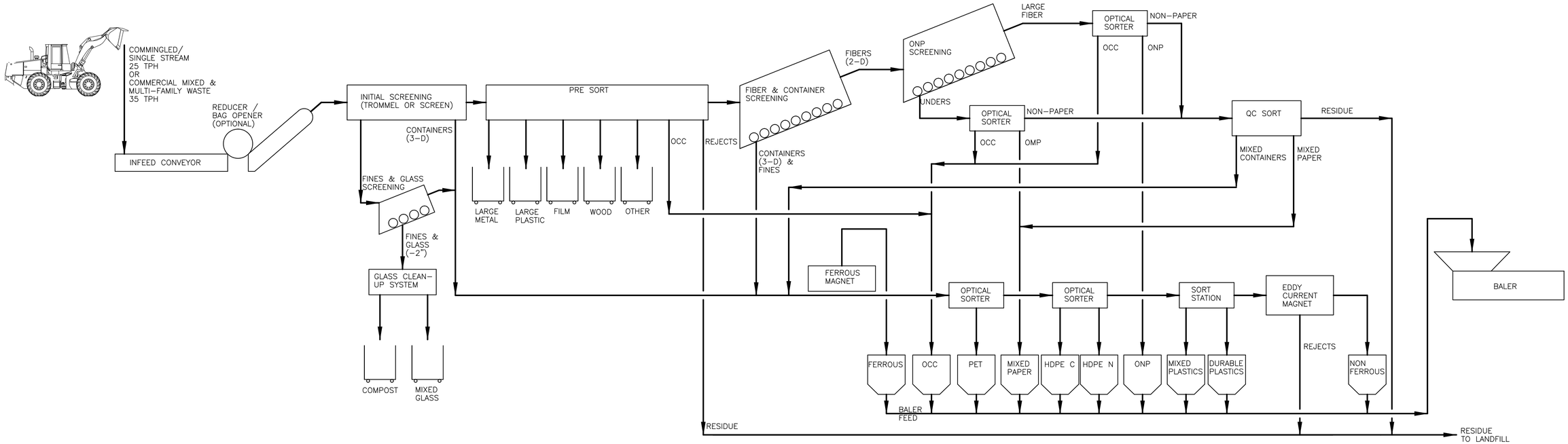
Attachment A, Figure 1



OPTION 1
FLOW DIAGRAM

MATERIAL RECOVERY FACILITY

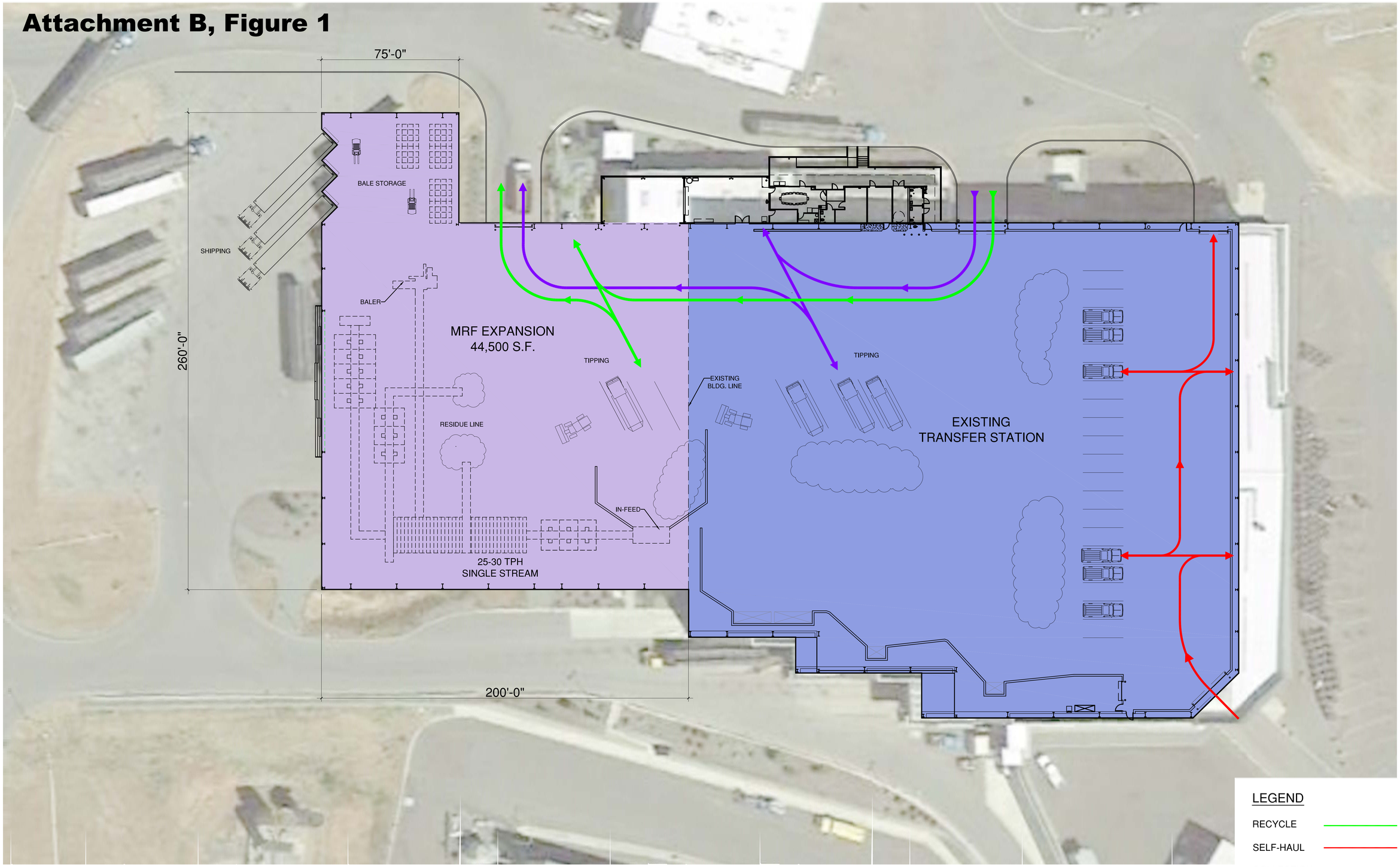
Attachment A, Figure 2



OPTION 2
FLOW DIAGRAM

ATTACHMENT B – CONCEPTUAL PLAN

Attachment B, Figure 1



N

SCALE: 1"=20'-0"

0' 10' 20' 40' 80'

Option 1

TACOMA Materials Recovery Facility (MRF)

ARCHITECTS
ENGINEERS
PLANNERS

JOB # 4980-0

JUNE 25, 2015

Attachment B, Figure 2

Option 2

1. COMMERCIAL + MF - 76,000 TPY
   300 TPD @ 18 lb/ft³ @ 10' HEIGHT = 3,300 S.F.
   2 DAY STORAGE ≈ 6,700 S.F.

2. COMMINGLED
   100 TPD @ 14lb/ft³ @ 10' HEIGHT ≈ 1,500 S.F.
   2 DAY STORAGE ≈ 3,000 S.F.

Option 3

1. SELECT MIXED COMMERCIAL - 34,000 TPY
   130 TPD @ 18 lb/ft³ @ 10' HEIGHT ≈ 1,500 S.F.
   2 DAY STORAGE ≈ 3,000 S.F.

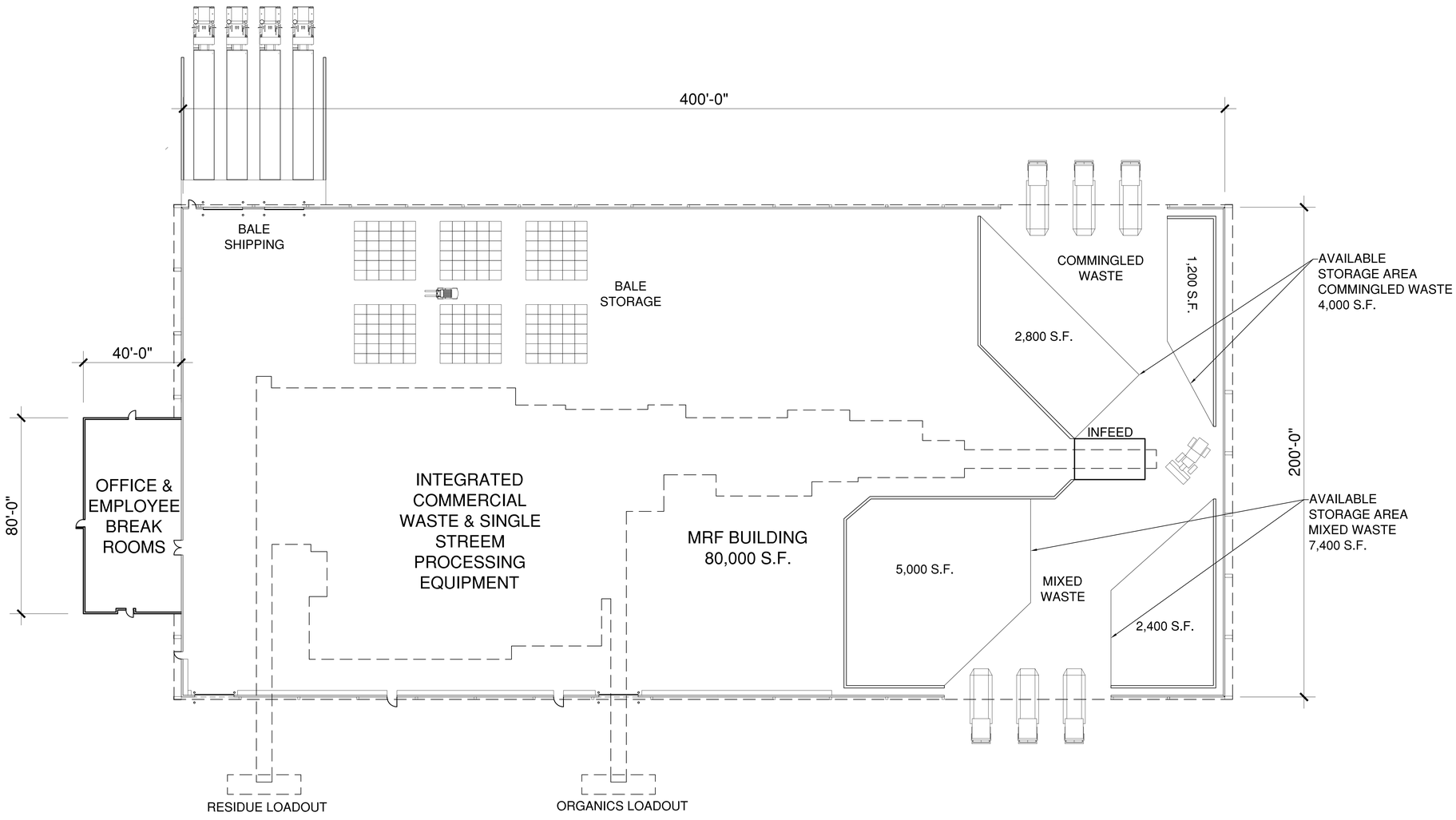
2. COMMINGLED
   100 TPD @ 14lb/ft³ @ 10' HEIGHT ≈ 1,500 S.F.
   2 DAY STORAGE ≈ 3,000 S.F.

Option 4

1. MIXED WASTE - 34,000 TPY
   130 TPD @ 18 lb/ft³ @ 10' HEIGHT ≈ 1,500 S.F.
   2 DAY STORAGE ≈ 3,000 S.F.

2. SELF HAUL - 17,000 TPY
   65 TPD @ 15 lb/ft³ @ 10' HEIGHT = 900 S.F.
   2 DAY STORAGE = 1,800 S.F.

3. COMMINGLED
   100 TPD @ 14lb/ft³ @ 10' HEIGHT ≈ 1,500 S.F.
   2 DAY STORAGE ≈ 3,000 S.F.



N

0' 10' 20' 40' 80'

Generic Concept Plan
Integrated Mixed Waste & SS/Commingled MRF
Materials Recovery Facility (MRF)

ARCHITECTS
ENGINEERS
PLANNERS

JOB # 4980-0

NOVEMBER 6, 2015

ATTACHMENT C – CAPITAL COSTS

Attachment C, Table 1

City of Tacoma

COMMINGLED MRF

Planning Level Construction Costs Estimate

Note: Planning Level cost estimates carry a +30 / -15 range of accuracy. Cost estimates should be used for evaluating and planning options.

EXPANSION OF TACOMA TRANSFER AND RECYCLING CENTER						
BUILDING/ SITE AREA		**DESCRIPTION OF WORK**	**QUANTITY**	**SF / LF**	**UNIT COST**	**EXTENDED VALUE**
SITE GRADING AND UTILITIES						
	Site work	Site Demolition	1	LS	$30,000	$30,000
		Site grading	20,000	SF	$0.50	$10,000
		Paving Roadway and Drive Areas	20,000	SF	$6.00	$120,000
		Paving Roadway and Drive Areas	1	LS	$30,000.00	$30,000
		Misc Expenses	1	LS	$50,000.00	$50,000
		Power/ Electrical	1	LS	$100,000.00	$100,000
TOTAL SITE GRADING AND UTILITIES						**$310,000**
MRF EXPANSION						
	New MRF Building	New MRF	60,000	SF	$120.00	$7,200,000
		Office/employee	5,000	SF	$200.00	$1,000,000
	Scalehouse	8'x20'	160	SF	$250.00	$40,000
	Scales	2 @ 70"	2	Ea	$80,000.00	$160,000
SUBTOTAL						**$8,400,000**
TOTAL NEW MRF BUILDING						**$8,400,000**
SUBTOTAL CONSTRUCTION COST						
	General				12%	$1,008,000
	Permitting and Entitlements					$300,000
	Engineering and Construction Support				12%	$1,008,000
	Sales /Service Tax				5%	$420,000
	Contingency				10%	$840,000
SUBTOTAL CONSTRUCTION COST						**$3,576,000**
TOTAL ESTIMATED CONSTRUCTION COST						**$11,976,000**
MRF EQUIPMENT						
TOTAL CONSTRUCTION COST						**$11,976,000**
					USE	**$12,000,000**

JRMA ***March 2016***

Attachment C, Table 2 — City of Tacoma

INTEGRATED MIXED WASTE + COMMINGLED MRF - 35 TPH

Planning Level Construction Costs Estimate

Note: Planning Level cost estimates carry a +30 / -15 range of accuracy. Cost estimates should be used for evaluating and planning options.

New Mixed Waste /Commingled MRF							
BUILDING/ SITE AREA		DESCRIPTION OF WORK	QUANTITY	SF / LF	UNIT COST	EXTENDED VALUE	COMMENTS/ASSUMPTIONS
SITE GRADING AND UTILITIES							
	Site work						
		Site grading	100,000	SF	$5.00	$500,000	
		Paving Roadway and Drive Areas	80,000	SF	$7.00	$560,000	
		Utilities	1	LS	$300,000.00	$300,000	Utilies are in street (Water/ Sewer/Fire)
		Power/ Electrical	1	LS	$200,000.00	$200,000	Power in available locally
		Stormwater	1	LS	$100,000.00	$100,000	
TOTAL SITE GRADING AND UTILITIES						**$1,660,000**	
MRF BUILDING AND OFICCE							
	New MRF Building	200'x 400' PEMB	80,000	SF	$175.00	$14,000,000	Includes: Foundations, Push walls, HVAC, Electrical
	Office Employee	2 -Sty 40' x 80' -	6,400	SF	$250.00	$1,600,000	2 sty office with Employee space for 50 staff
	Scalehouse	8'x20'	160	SF	$250.00	$40,000	2 sty office with Employee space for 50 staff
	Scales	2 @ 70"	2	Ea	$80,000.00	$160,000	
SUBTOTAL						**$15,800,000**	
TOTAL NEW MRF BUILDING						**$15,800,000**	
SUBTOTAL CONSTRUCTION COST						**$17,460,000**	
	General				12%	$2,095,200	
	Permitting and Entitlements					$300,000	
	Engineering and Construction Support				12%	$2,095,200	
	Sales /Service Tax				7%	$1,222,200	
	Contingency				15%	$2,619,000	
SUBTOTAL CONSTRUCTION COST						**$8,331,600**	
TOTAL ESTIMATED CONSTRUCTION COST						**$25,791,600**	
MRF EQUIPMENT							
Total CONSTRUCTION COST W/ MRF EQUIPMENT						**$25,791,600**	
						USE	**$26,000,000**

JRMA ***March 2016***

ATTACHMENT D – FINANCIAL MODEL

Summary of MRF Options

10/20/2015

(Option 1)- Commingled Residential Recyclables

100%

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Material Recovery																
Tons Recycled	20,267	20,470	20,675	20,881	21,090	21,301	21,514	21,729	21,947	22,166	22,388	22,612	22,838	23,066	23,297	23,530
Tons Composted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tons Landfilled	1,267	1,280	1,293	1,306	1,319	1,332	1,345	1,359	1,372	1,386	1,400	1,414	1,428	1,442	1,457	1,471
Total Tons Processed	**21,534**	**21,750**	**21,967**	**22,187**	**22,409**	**22,633**	**22,859**	**23,088**	**23,319**	**23,552**	**23,787**	**24,025**	**24,266**	**24,508**	**24,753**	**25,001**
Diversion Rate	*94%*	*94%*	*94%*	*94%*	*94%*	*94%*	*94%*	*94%*	*94%*	*94%*	*94%*	*94%*	*94%*	*94%*	*94%*	*94%*
Revenue Requirements																
MRF Operations	$ 1,578,508	$ 1,603,662	$ 1,629,318	$ 1,655,488	$ 1,682,181	$ 1,709,408	$ 1,737,180	$ 1,765,507	$ 1,794,400	$ 1,823,871	$ 1,853,932	$ 1,884,594	$ 1,915,869	$ 1,947,770	$ 1,980,309	$ 2,013,498
Debt Services	$ 1,492,794	$ 1,492,794	$ 1,492,794	$ 1,492,794	$ 1,492,794	$ 1,492,794	$ 1,492,794	$ 1,492,794	$ 1,492,794	$ 1,492,794	$ 1,492,794	$ 1,492,794	$ 1,492,794	$ 1,492,794	$ 1,492,794	$ 1,492,794
Total Expenses	**$ 3,071,302**	**$ 3,096,455**	**$ 3,122,112**	**$ 3,148,282**	**$ 3,174,975**	**$ 3,202,202**	**$ 3,229,973**	**$ 3,258,300**	**$ 3,287,194**	**$ 3,316,665**	**$ 3,346,726**	**$ 3,377,388**	**$ 3,408,663**	**$ 3,440,564**	**$ 3,473,102**	**$ 3,506,292**
Expenses per Ton	*$ 143*	*$ 142*	*$ 142*	*$ 142*	*$ 142*	*$ 141*	*$ 141*	*$ 141*	*$ 141*	*$ 141*	*$ 141*	*$ 141*	*$ 140*	*$ 140*	*$ 140*	*$ 140*
Revenue																
Tip Fee Revenue	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Material Sales	$ 2,270,109	$ 2,315,738	$ 2,362,285	$ 2,409,766	$ 2,458,203	$ 2,507,613	$ 2,558,016	$ 2,609,432	$ 2,661,881	$ 2,715,385	$ 2,769,964	$ 2,825,641	$ 2,882,436	$ 2,940,373	$ 2,999,474	$ 3,059,764
Average Net Sale Price	*$ 112*	*$ 113*	*$ 114*	*$ 115*	*$ 117*	*$ 118*	*$ 119*	*$ 120*	*$ 121*	*$ 123*	*$ 124*	*$ 125*	*$ 126*	*$ 127*	*$ 129*	*$ 130*
Organics to Compost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Revenue	**$ 2,270,109**	**$ 2,315,738**	**$ 2,362,285**	**$ 2,409,766**	**$ 2,458,203**	**$ 2,507,613**	**$ 2,558,016**	**$ 2,609,432**	**$ 2,661,881**	**$ 2,715,385**	**$ 2,769,964**	**$ 2,825,641**	**$ 2,882,436**	**$ 2,940,373**	**$ 2,999,474**	**$ 3,059,764**
Revenue per Ton Processed	*$ 105*	*$ 106*	*$ 108*	*$ 109*	*$ 110*	*$ 111*	*$ 112*	*$ 113*	*$ 114*	*$ 115*	*$ 116*	*$ 118*	*$ 119*	*$ 120*	*$ 121*	*$ 122*
Net Revenue	**$ (801,193)**	**$ (780,717)**	**$ (759,828)**	**$ (738,515)**	**$ (716,772)**	**$ (694,589)**	**$ (671,958)**	**$ (648,868)**	**$ (625,312)**	**$ (601,280)**	**$ (576,761)**	**$ (551,747)**	**$ (526,227)**	**$ (500,191)**	**$ (473,628)**	**$ (446,528)**
Per Ton	*$ (37)*	*$ (36)*	*$ (35)*	*$ (33)*	*$ (32)*	*$ (31)*	*$ (29)*	*$ (28)*	*$ (27)*	*$ (26)*	*$ (24)*	*$ (23)*	*$ (22)*	*$ (20)*	*$ (19)*	*$ (18)*

(Option 2) - Commingled Residental and Non-C&D Commercial and Multifamily

100%

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Material Recovery																
Tons Recycled	38,201	38,583	38,969	39,358	39,752	40,150	40,551	40,957	41,366	41,780	42,198	42,620	43,046	43,476	43,911	44,350
Tons Composted	19,310	19,504	19,699	19,896	20,095	20,295	20,498	20,703	20,910	21,120	21,331	21,544	21,759	21,977	22,197	22,419
Tons Landfilled	34,809	35,157	35,509	35,864	36,223	36,585	36,951	37,320	37,693	38,070	38,451	38,836	39,224	39,616	40,012	40,412
Total Tons Processed	**92,320**	**93,244**	**94,176**	**95,118**	**96,069**	**97,030**	**98,000**	**98,980**	**99,970**	**100,970**	**101,979**	**102,999**	**104,029**	**105,069**	**106,120**	**107,181**
Diversion Rate	*62%*	*62%*	*62%*	*62%*	*62%*	*62%*	*62%*	*62%*	*62%*	*62%*	*62%*	*62%*	*62%*	*62%*	*62%*	*62%*
Revenue Requirements																
MRF Operations	$ 5,212,583	$ 5,301,668	$ 5,392,535	$ 5,485,219	$ 5,579,757	$ 5,676,185	$ 5,774,542	$ 5,874,866	$ 5,977,197	$ 6,081,574	$ 6,188,039	$ 6,296,633	$ 6,407,399	$ 6,520,381	$ 6,635,622	$ 6,753,167
Debt Services	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757
Total Expenses	**$ 8,551,340**	**$ 8,640,425**	**$ 8,731,292**	**$ 8,823,976**	**$ 8,918,514**	**$ 9,014,942**	**$ 9,113,299**	**$ 9,213,623**	**$ 9,315,954**	**$ 9,420,331**	**$ 9,526,796**	**$ 9,635,390**	**$ 9,746,156**	**$ 9,859,138**	**$ 9,974,379**	**$ 10,091,924**
Expenses per Ton	*$ 93*	*$ 93*	*$ 93*	*$ 93*	*$ 93*	*$ 93*	*$ 93*	*$ 93*	*$ 93*	*$ 93*	*$ 93*	*$ 94*	*$ 94*	*$ 94*	*$ 94*	*$ 94*
Revenue																
Tip Fee Revenue	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Material Sales	$ 4,039,511	$ 4,126,493	$ 4,215,281	$ 4,305,912	$ 4,398,423	$ 4,492,854	$ 4,589,243	$ 4,687,630	$ 4,788,056	$ 4,890,563	$ 4,995,193	$ 5,101,990	$ 5,210,996	$ 5,322,259	$ 5,435,823	$ 5,551,736
Average Net Sale Price	*$ 106*	*$ 107*	*$ 108*	*$ 109*	*$ 111*	*$ 112*	*$ 113*	*$ 114*	*$ 116*	*$ 117*	*$ 118*	*$ 120*	*$ 121*	*$ 122*	*$ 124*	*$ 125*
Organics to Compost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Revenue	**$ 4,039,511**	**$ 4,126,493**	**$ 4,215,281**	**$ 4,305,912**	**$ 4,398,423**	**$ 4,492,854**	**$ 4,589,243**	**$ 4,687,630**	**$ 4,788,056**	**$ 4,890,563**	**$ 4,995,193**	**$ 5,101,990**	**$ 5,210,996**	**$ 5,322,259**	**$ 5,435,823**	**$ 5,551,736**
Revenue per Ton Processed	*$ 44*	*$ 44*	*$ 45*	*$ 45*	*$ 46*	*$ 46*	*$ 47*	*$ 47*	*$ 48*	*$ 48*	*$ 49*	*$ 50*	*$ 50*	*$ 51*	*$ 51*	*$ 52*
Net Revenue	**$ (4,511,829)**	**$ (4,513,932)**	**$ (4,516,011)**	**$ (4,518,065)**	**$ (4,520,091)**	**$ (4,522,088)**	**$ (4,524,056)**	**$ (4,525,993)**	**$ (4,527,898)**	**$ (4,529,768)**	**$ (4,531,603)**	**$ (4,533,401)**	**$ (4,535,160)**	**$ (4,536,879)**	**$ (4,538,556)**	**$ (4,540,189)**
Per Ton	*$ (49)*	*$ (48)*	*$ (48)*	*$ (47)*	*$ (47)*	*$ (47)*	*$ (46)*	*$ (46)*	*$ (45)*	*$ (45)*	*$ (44)*	*$ (44)*	*$ (44)*	*$ (43)*	*$ (43)*	*$ (42)*

(Option 3) - Commingled Residential and Select High-Grade Non-C&D Commercial Waste

100%

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Material Recovery																
Tons Recycled	32,680	33,007	33,337	33,671	34,007	34,347	34,691	35,038	35,388	35,742	36,099	36,460	36,825	37,193	37,565	37,941
Tons Composted	8,296	8,379	8,463	8,547	8,633	8,719	8,806	8,894	8,983	9,073	9,164	9,256	9,348	9,442	9,536	9,631
Tons Landfilled	14,558	14,704	14,851	14,999	15,149	15,301	15,454	15,608	15,764	15,922	16,081	16,242	16,405	16,569	16,734	16,902
Total Tons Processed	**55,534**	**56,090**	**56,651**	**57,217**	**57,789**	**58,367**	**58,951**	**59,540**	**60,136**	**60,737**	**61,345**	**61,958**	**62,578**	**63,203**	**63,835**	**64,474**
Diversion Rate	*74%*	*74%*	*74%*	*74%*	*74%*	*74%*	*74%*	*74%*	*74%*	*74%*	*74%*	*74%*	*74%*	*74%*	*74%*	*74%*
Revenue Requirements																
MRF Operations	$ 3,704,583	$ 3,763,508	$ 3,823,612	$ 3,884,917	$ 3,947,449	$ 4,011,231	$ 4,076,289	$ 4,142,648	$ 4,210,335	$ 4,279,375	$ 4,349,796	$ 4,421,625	$ 4,494,891	$ 4,569,622	$ 4,645,848	$ 4,723,598
Debt Services	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757
Total Expenses	**$ 7,043,340**	**$ 7,102,265**	**$ 7,162,369**	**$ 7,223,674**	**$ 7,286,206**	**$ 7,349,988**	**$ 7,415,046**	**$ 7,481,405**	**$ 7,549,092**	**$ 7,618,132**	**$ 7,688,553**	**$ 7,760,382**	**$ 7,833,648**	**$ 7,908,379**	**$ 7,984,605**	**$ 8,062,355**
Expenses per Ton	*$ 127*	*$ 127*	*$ 126*	*$ 126*	*$ 126*	*$ 126*	*$ 126*	*$ 126*	*$ 126*	*$ 125*	*$ 125*	*$ 125*	*$ 125*	*$ 125*	*$ 125*	*$ 125*
Revenue																
Tip Fee Revenue	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Material Sales	$ 3,363,328	$ 3,430,931	$ 3,499,893	$ 3,570,240	$ 3,642,002	$ 3,715,207	$ 3,789,882	$ 3,866,059	$ 3,943,767	$ 4,023,036	$ 4,103,899	$ 4,186,388	$ 4,270,534	$ 4,356,372	$ 4,443,935	$ 4,533,258
Average Net Sale Price	*$ 103*	*$ 104*	*$ 105*	*$ 106*	*$ 107*	*$ 108*	*$ 109*	*$ 110*	*$ 111*	*$ 113*	*$ 114*	*$ 115*	*$ 116*	*$ 117*	*$ 118*	*$ 119*
Organics to Compost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Revenue	**$ 3,363,328**	**$ 3,430,931**	**$ 3,499,893**	**$ 3,570,240**	**$ 3,642,002**	**$ 3,715,207**	**$ 3,789,882**	**$ 3,866,059**	**$ 3,943,767**	**$ 4,023,036**	**$ 4,103,899**	**$ 4,186,388**	**$ 4,270,534**	**$ 4,356,372**	**$ 4,443,935**	**$ 4,533,258**
Revenue per Ton Processed	*$ 61*	*$ 61*	*$ 62*	*$ 62*	*$ 63*	*$ 64*	*$ 64*	*$ 65*	*$ 66*	*$ 66*	*$ 67*	*$ 68*	*$ 68*	*$ 69*	*$ 70*	*$ 70*
Net Revenue	**$ (3,680,012)**	**$ (3,671,334)**	**$ (3,662,476)**	**$ (3,653,434)**	**$ (3,644,204)**	**$ (3,634,782)**	**$ (3,625,164)**	**$ (3,615,347)**	**$ (3,605,325)**	**$ (3,595,096)**	**$ (3,584,653)**	**$ (3,573,994)**	**$ (3,563,114)**	**$ (3,552,007)**	**$ (3,540,670)**	**$ (3,529,097)**
Per Ton	*$ (66)*	*$ (65)*	*$ (65)*	*$ (64)*	*$ (63)*	*$ (62)*	*$ (61)*	*$ (61)*	*$ (60)*	*$ (59)*	*$ (58)*	*$ (58)*	*$ (57)*	*$ (56)*	*$ (55)*	*$ (55)*

(Option 4) - Commingled Residential Recyclables, High-Grade Non-C&D Commercial Waste, and High-Grade Non-C&D Self-Haul Waste

100%

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Material Recovery																
Tons Recycled	39,462	39,856	40,255	40,658	41,064	41,475	41,889	42,308	42,731	43,159	43,590	44,026	44,467	44,911	45,360	45,814
Tons Composted	9,047	9,138	9,229	9,321	9,414	9,509	9,604	9,700	9,797	9,895	9,994	10,094	10,195	10,296	10,399	10,503
Tons Landfilled	31,477	31,791	32,109	32,430	32,755	33,082	33,413	33,747	34,085	34,425	34,770	35,117	35,469	35,823	36,182	36,543
Total Tons Processed	**79,985**	**80,785**	**81,593**	**82,409**	**83,233**	**84,066**	**84,906**	**85,755**	**86,613**	**87,479**	**88,354**	**89,237**	**90,130**	**91,031**	**91,941**	**92,861**
Diversion Rate	*61%*	*61%*	*61%*	*61%*	*61%*	*61%*	*61%*	*61%*	*61%*	*61%*	*61%*	*61%*	*61%*	*61%*	*61%*	*61%*
Revenue Requirements																
MRF Operations	$ 4,206,083	$ 4,275,038	$ 4,345,372	$ 4,417,113	$ 4,490,289	$ 4,564,928	$ 4,641,060	$ 4,718,714	$ 4,797,922	$ 4,878,714	$ 4,961,121	$ 5,045,177	$ 5,130,914	$ 5,218,366	$ 5,307,566	$ 5,398,551
Debt Services	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757	$ 3,338,757
Total Expenses	**$ 7,544,840**	**$ 7,613,795**	**$ 7,684,129**	**$ 7,755,870**	**$ 7,829,046**	**$ 7,903,685**	**$ 7,979,817**	**$ 8,057,471**	**$ 8,136,679**	**$ 8,217,471**	**$ 8,299,878**	**$ 8,383,934**	**$ 8,469,671**	**$ 8,557,123**	**$ 8,646,323**	**$ 8,737,308**
Expenses per Ton	*$ 94*	*$ 94*	*$ 94*	*$ 94*	*$ 94*	*$ 94*	*$ 94*	*$ 94*	*$ 94*	*$ 94*	*$ 94*	*$ 94*	*$ 94*	*$ 94*	*$ 94*	*$ 94*
Revenue																
Tip Fee Revenue	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Material Sales	$ 3,438,492	$ 3,507,605	$ 3,578,108	$ 3,650,028	$ 3,723,394	$ 3,798,234	$ 3,874,578	$ 3,952,457	$ 4,031,902	$ 4,112,943	$ 4,195,613	$ 4,279,945	$ 4,365,972	$ 4,453,728	$ 4,543,248	$ 4,634,567
Average Net Sale Price	*$ 87*	*$ 88*	*$ 89*	*$ 90*	*$ 91*	*$ 92*	*$ 92*	*$ 93*	*$ 94*	*$ 95*	*$ 96*	*$ 97*	*$ 98*	*$ 99*	*$ 100*	*$ 101*
Organics to Compost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Revenue	**$ 3,438,492**	**$ 3,507,605**	**$ 3,578,108**	**$ 3,650,028**	**$ 3,723,394**	**$ 3,798,234**	**$ 3,874,578**	**$ 3,952,457**	**$ 4,031,902**	**$ 4,112,943**	**$ 4,195,613**	**$ 4,279,945**	**$ 4,365,972**	**$ 4,453,728**	**$ 4,543,248**	**$ 4,634,567**
Revenue per Ton Processed	*$ 43*	*$ 43*	*$ 44*	*$ 44*	*$ 45*	*$ 45*	*$ 46*	*$ 46*	*$ 47*	*$ 47*	*$ 47*	*$ 48*	*$ 48*	*$ 49*	*$ 49*	*$ 50*
Net Revenue	**$ (4,106,349)**	**$ (4,106,190)**	**$ (4,106,021)**	**$ (4,105,842)**	**$ (4,105,652)**	**$ (4,105,451)**	**$ (4,105,239)**	**$ (4,105,014)**	**$ (4,104,777)**	**$ (4,104,528)**	**$ (4,104,265)**	**$ (4,103,989)**	**$ (4,103,699)**	**$ (4,103,395)**	**$ (4,103,075)**	**$ (4,102,741)**
Per Ton	*$ (51)*	*$ (51)*	*$ (50)*	*$ (50)*	*$ (49)*	*$ (49)*	*$ (48)*	*$ (48)*	*$ (47)*	*$ (47)*	*$ (46)*	*$ (46)*	*$ (46)*	*$ (45)*	*$ (45)*	*$ (44)*