PLASTIC RECYCLING IN MONTANA & FLATHEAD COUNTY

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Working Draft

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PLASTIC RECYCLING IN MONTANA
White Paper

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I. Overview

Although 84% of Americans view recycling as a valuable public service[i], recycling services in Flathead County, and Montana, are limited. In the fall of 2019, Climate Smart Glacier Country conducted a day-long symposium on the state of plastic recycling in Flathead County. Over 300 people attended the symposium and most expressed concerns with the recycling issues, specifically the lack of options for recycling plastic waste.

The purpose of this paper is to examine conditions necessary to economically recycle plastic waste. The paper includes a basic primer on the process of plastic recycling and a preliminary assessment of the existing infrastructure and potential markets necessary to support a sustainable plastic recycling program. This review identifies barriers for increasing recycling rates in Montana and suggest strategies to address such challenges. The paper is intended to provide the background information to attract partners and funding for a more detailed feasibility study.

II. Plastic Waste - Issues

A. Pollution

In its report on "Plastics and Sustainability", the American Chemistry Council describes the scope of plastic pollution as, "Land-based sources include storm water discharges, combined sewer overflows, littering, industrial activities, and solid waste disposal and landfills. Debris from such sources are often washed, blown, or discharged into waterways from rainfall, snowmelt, and wind. In the case of both land and ocean based sources, poor waste handling practices, both legal and illegal, contribute to marine debris. Plastic is the most common form of marine debris. Estimates have put the average proportion of plastic marine debris between 60 to 80% of all marine debris."[ii] According to the United States Environmental Protection Agency, "Plastics pose both physical (e.g., entanglement, gastrointestinal blockage, reef destruction) and chemical threats (e.g., bioaccumulation of the chemical ingredients of plastic or toxic chemicals absorbed from plastics) to wildlife and the marine ecosystem." [iii]

B. Sustainable Waste Management

The EPA waste management hierarchy places an emphasis on reducing, reusing, and recycling for sustainable materials management.[iv] The Montana Integrated Waste Management Act, (MCA Section 75-10-804) has adopted the same waste management priorities that acknowledge landfills are the least desirable waste management option.[v] As existing landfills reach capacity, local governments must contend with costs that are related to continued monitoring and potential brownfield issues. Difficulties with developing new or expanded landfills include, high land costs, permitting requirements, expensive construction costs and local opposition to these types of land uses. Due to complications in siting new solid waste facilities, extending the life of existing landfill operations by reducing waste and recycling is critically important.[vi]

Source: Environmental Protection Agency[vii] *https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials#GenerationTrends*

C. Carbon Footprint

Most plastic is derived from petroleum based resins. Consequently, plastic represents significant greenhouse gases emissions resulting from 1) extracting and distilling the petroleum into plastic resin, 2) manufacturing plastics products 3) transporting products to markets and 4) collecting and disposing of plastic waste. It is projected that the global demand for plastics will increase by some 22% over the next five years and will reach 17% of the global carbon budget by 2050.[viii] Recycling can reduce emissions by eliminating the need for virgin plastic and by using less energy to manufacturing products from recycled plastic resin.[ix]

III. Plastic Waste Opportunities

A. Economic Benefits

The U.S. Environmental Protection Agency's Recycling Economic Information Report found that "Recycling and reuse activities in the United States accounted for 757,000 jobs, $36.6 billion in wages and $6.7 billion in tax revenues. This equates to 1.57 jobs, $76,000 in wages and $14,101 in tax revenues for every 1,000 tons of material recycled."[x] While many of these jobs are located on in urban areas and near coastal shipping ports, the Scrap Recycling Industry Economic Impact Study" still estimates that the economic contributions specific to Montana are significant.[xi]

Direct Jobs = 359	Total Jobs (Direct & Indirect) = 1,210
Direct Wages = $20,868,000	Total Wages (Direct & Indirect) = $62,387,500
Direct Output = $80,797,400	Total Output (Direct & Indirect) = $236,003,500

The number of Montana jobs in the recycling industry, however, has not changed much over the last 15 years. According to a report from the Montana Department of Environmental Quality, in 2003 there were approximately 300-full time and 40 part time employees and gross revenue for the industry was almost $90 million dollars.[xii]

The stagnant growth in recycling jobs is consistent with the minimal growth in recycling rates for Montana. In 2004 the diversion rate for recycling in Montana was 15% while in 2016, the diversion rate was just

17%.[xiii] This compares to a national recycling rate of 25.1%.[xiv] Clearly, there is opportunity to increase the recycling rate in Montana and increase the number of jobs in the recycling industry. While most recycling jobs in Montana involve collection and sorting, other jobs could be developed related to processing and manufacturing. The appendix includes a list of such jobs along with average wages.

B. **Environmental Benefits**

As noted previously, increasing the rate of plastic recycling can reduce pollution and landfill costs. Energy savings are another potential benefit. According to the Washington Department of Ecology, "Recycling one ton of PET plastic results in a net savings of 32.1 million BTUs of energy and saves 62% of the total energy needed to make plastic from virgin materials (EPA WARM Model, 2015). Recycled HDPE saves 50.4 million BTUs and saves 75% of the total energy needed to manufacture new plastic, providing manufacturers with a reduction in operating expenses materials (EPA WARM Model, 2015)." [xv]

The American Chemistry Council concluded increasing the recycling of post-consumer plastics could reduce the environmental cost of plastics in Europe and North America by over $7.9 billion in net terms.[xvi] Furthermore, data from Recycling Montana indicates that recycling one ton of plastic can save 16.3 barrels of oil and 30 cubic yards of landfill space.[xvii]

C. Sustainability Benefits

More organizations are adopting sustainability programs that include goals for increasing recycling. Developing more local and regional opportunities for plastic recycling and reprocessing can help government and private industry achieve these sustainability goals. Examples include:

- The U.S Chamber of Commerce foundation has an initiative to help communities undertake efforts to increase recycling rates to exceed the national average. The effort represents a multi-stakeholder process between public and private partners and has received funding from corporations such as Walmart, Target, Coca-Cola, Republic Services, Walgreens, and Kroger. https://www.uschamberfoundation.org/beyond-34-recycling-and-recovery-new-economy

- S&P Global has a "Corporate Sustainability Assessment" tool to help investors determine which public listed companies are adopting sustainability practices. The tool also helps companies determine which sustainability factors are most likely to have an impact on their financial performance. https://www.robecosam.com/csa/csa-resources/

- American Sustainable Business Council has a sustainable procurement guide to help organizations choose goods and services that support sustainability from their supply chains. https://www.asbcouncil.org/sites/main/files/file-attachments/procurement_2018.pdf?1555084364

- United States General Services Administration has a green purchasing program to require that all new purchases contain a percentage of recycled content material in its manufacture and to consider materials that have a bio-based component. https://www.gsa.gov/about-us/regions/welcome-to-the-rocky-mountain-region-8/sustainability-in-action/green-purchasing

- Environmental Protection Agency's "Comprehensive Procurement Guidelines (CPG)" promotes the use of materials recovered from the municipal solid waste stream. By buying products made

with recovered materials the agency ensures that the materials collected in recycling programs will be used again in the manufacture of new products. https://www.epa.gov/smm/comprehensive-procurement-guideline-cpg-program

- National Association of State Procurement officers has a green purchasing guide to help states develop a green purchasing program. https://www.naspo.org/greenresources

- National Association of Counties recently conducted a webinar regarding best practices for improving county-wide recycling systems as well as supporting policies for green purchasing. https://www.naco.org/resources/conference-learning/rethinking-recycling-county-response-chinas-ban-recycling-imports

- Plastic Technology Magazine reports that, "Many brand owners aim to increase recycled content in packaging to an average of 25% by 2025." https://www.ptonline.com/blog/post/time-to-learn-more-about-the-real-world-of-recycling

IV. Plastics 101

A. Plastic Building Blocks

The raw materials for most plastics are derived from fossil fuels, primarily oil and gas. These raw materials are processed into hydrocarbon monomers that are then linked together to form polymers. Different types of plastic polymers have a wide range of properties resulting in an extremely versatile range of plastic materials that are used daily in every aspect of our lives.

To improve the physical or chemical properties of certain plastics, additives are incorporated into many finished products. Additives may protect plastics from the degradation due to light, heat, or bacteria; may change plastic properties such as melt flow or flame retardancy; and may provide color or other features related to surface appearance/texture. Plasticizers are materials that increase flexibility and are used in plastic film wraps and food packaging. All plastics used in food contact, including the additives and plasticizers, are regulated by the U.S. Food and Drug Administration (FDA) to ensure that these materials are safe.

Thermoplastics are the most common type of plastic. Thermoplastic typically start out as small pellets or sheets and are then are heated and formed into the desired shape using various manufacturing processes. Since there is no chemical bonding with the thermoplastic polymers, products made with thermoplastics can be remelted and recycled. Thermoset plastics uses a process that creates an irreversible chemical bond. These plastics cannot be recycled.

B. Type of Plastic and Recyclability

Preconsumer waste (manufacturing scrap) is recycled differently from *postconsumer waste* (recovered waste). Since there are limited plastic manufacturers in Montana, this paper focuses on postconsumer thermoplastic waste. Most such plastics are made from six different polymer resins, which are classified by a number, from 1 to 7. The chemical composition and resin properties determines the recycling rate and types of products that are created from the recycled plastic. The following table lists the resin codes, which are usually embossed on the bottom of the container, and the general recyclability and attributes for each type of plastic.

Table 1: Types of Plastic

Resin Symbol/Type	Characteristics Uses	Recyclability
1 PET or PETE Polyethylene Terephtalate	Clear, tough, heat resistant good gas and moisture barrier. Used for beverage bottles, food containers and microwave food trays.	Has the highest recycling rate of all resins. Bottled containers easy to identify and sort. Recycled uses include carpet, textiles (fleece), auto parts. Food contamination can be a problem. This type of plastic has established domestic markets for recycling.
2 HDPE High Density Polyethylene	Excellent moisture barrier and chemical resistance. Used for food packaging such as liner for milk/juice cartons, cereal box liners, detergent containers, household cleaners, plastic bags	Second most collected type of plastic for recycling. Recycled uses include fencing, lumber, lawn products & non-food bottles, …. Established domestic recycling markets
3 PVC Polyvinyl Chloride	Chemical resistance. Resistant to corrosion. Used for construction materials such as pipes, siding, flooring … Medical uses for tubing &IV bags. Clamshells, packaging…	Not typically collected. May be recycled from construction sites and recycled as part of construction material. Limited domestic market. Export market can be volatile.
4 LDPE Low Density Polyethylene	Flexible with a low melting point. Used for heat sealing such as shrink wrap. Common for shopping bags, beverage cup lids, ... Used in wire and cable applications for its stable electrical properties.	Not generally collected as part of municipal waste stream. Difficult to sort from waste stream. Major retailers collect bags. Can be recycled as shipping envelopes, floor tiles, landscape timber
5 PP Polypropylene	Chemical resistant. High melting point. Typical use for ketchup bottles, yogurt, straws, margarine tubs, medicine bottles.	Difficult to sort out of waste stream. Food contamination limits recyclability.
6 PS Polystyrene	Can be rigid or foam plastic. Foam has excellent thermal insulation. Used for medical and food packaging, plastic forks, egg cartons, take out containers.	Most recycling programs do not collect. Items like straws and forks are hard to sort from waste stream. Food contamination in take-out containers. Limited domestic market for recycling.
7 Other plastics not classified above	Mixed plastics – packaging	Not collected for recycling since mixed plastics have different melt points.

Source: Compiled from various sources

V. Plastic Waste and the Circular Economy

Throughout the 20th Century, the industrial economy was based on a linear approach which extracted raw materials, manufactured the material into products, and then disposed of the product after a single use. This model is costly in terms of energy use, pollution, cost of landfill space, depletion of natural resources and greenhouse gases. For these reasons, more communities and corporations are promoting the concept of a "Circular economy". In the circular economy, the emphasis is maximizing use of resources. Recycling is a major underlying principle in the circular economy as is minimizing waste in the manufacturing process. Better industrial design of products allows by-products and waste to be recovered as a resource for another industrial process

https://wasteadvantagemag.com/circular-economy/

More organizations are incorporating the concepts of the circular economy into manufacturing and recycling programs. Benefits of this approach include:

- U.S. Chamber of Commerce - "The circular economy represents a tremendous opportunity for business and the global economy. Shifting to the circular economy could unlock an estimated $4.5 trillion in additional economic growth by 2030 by turning current waste into wealth, according to research from Accenture, and could be the biggest economic revolution in 250 years." https://www.uschamberfoundation.org/beyond-34-recycling-and-recovery-new-economy/about-project

- American Chemistry Council - "An important principle of the circular economy is increasing the capture and recovery of materials in waste streams so that they can be recycled and reused in new products. Increasing the recycling of post-consumer plastics (to 55%) and minimizing landfilling (to a maximum of 10%) could deliver significant environmental benefits". https://plastics.americanchemistry.com/Plastics-and-Sustainability.pdf

- Financial Times – "Investor interest is certainly growing. In October, BlackRock, the world's largest asset manager, launched a fund seeded with $20m of its own money to buy stocks that could benefit from the circular economy." https://www.ft.com/reports/circular-economy

- New Plastics Economy - Signatories commit to three actions to realize this vision. **Eliminate** all problematic and unnecessary plastic items. **Innovate** to ensure that the plastics we do need are reusable, recyclable, or compostable. **Circulate** all the plastic items we use to keep them in the economy and out of the environment. https://www.newplasticseconomy.org/projects/global-commitment

VI. Plastic Recycling Process

A. Mechanical vs. Chemical Recycling

The recycling process for plastic can be classified as either "mechanical" or "chemical". In the mechanical process, the recovered plastic material is shredded, washed, and melted. This process is the most common type of recycling for plastic and is a relatively low-cost, reliable approach. Remelting the plastic causes degradation of the polymer so virgin plastic is often mixed with the recycled plastic to reduce the effects of degradation. Because of the degradation, however, plastic recycled through a mechanical process has a limited number of times that it can be recycled and reheated and will eventually end up in the waste stream.

The chemical process uses chemicals, or heat to convert the polymer chains to the original plastic monomer or other compounds that can then be recombined to generate new polymers or feedstock. Chemical processes use large amounts of energy and chemicals and are only economically or ecologically reasonable for a few types of polymers. Currently, there is limited infrastructure or markets to support chemical recycling and there are large up-front capital investments for these operations. For these reasons, this paper focuses on mechanical recycling. The figure below, illustrates the steps in the plastic recycling process.

B. Collection

Market prices and the ability to cover cost of operations for collecting recyclables typically dictate the type of materials that are collected in any specific region. The collection system is often operated by local governments as part of the solid waste services for the community. Often such services are provided in partnership with a non-profit or private business. Below is a review of the various systems to collect household recyclables:

- Community Drop-off Sites – Drop-off sites may include collection bins located as various locations in the community. Recycle bins typically require consumers to separate recyclables by material type. At unmanned sites, no fees are collected and there are typically high levels of contamination as non-recyclable trash is often mixed in with recyclable materials. Recycling drop-off sites that are staffed, have less contamination and may or may not collect fees to cover costs. Drop-off collection is more common in rural areas where curbside pick-up is not an option.

- Curbside Recycling - Single Stream vs. Source Separation – Curbside may be single (mixed) stream collection systems where all recyclables are mixed in in one container or source separation where recyclables are sorted by consumers and placed in separate bins before collection. While single stream waste collection increases overall household recycling rates, it also results in higher rates of contamination. The Recycling Partnership estimates that single stream recycling has a contamination rate of 17.6% compared to 12.6% for recyclables sorted in bins.[xviii] Excessive contamination results in low-quality outputs with low market values. In some cases, recyclables are sent to the landfill due to high levels of contamination.

- Buy-back/Refunds/Deposit – Private scrap recyclers will buy back high value materials such as metals and aluminum cans directly from consumers. Since the collapse of the China market, most scrap recyclers do not buy plastic. The most successful monetary incentives for "clean" plastic are deposit or redemption systems to encourage consumers to recycle their single-use plastic bottles. These return systems usually result in the best quality recovered plastic because bottles are kept separate from other types of plastic, paper, glass, and other contaminants.

C. Sorting & Bundling

Collected recyclables are sent to a material recovery facility (MRF) for sorting. Most facilities in the U.S. are mixed waste facilities that separate desired recyclable materials from non-recyclable materials. While manual sorting is still used in some facilities, it is becoming more common for sorting activities to rely on automated processes. Processes to separate plastic from the waste stream include use of air currents, magnetic pulleys, and optical sensors. Once plastic is separated from the waste stream, it is sold as a plastic bale. Bales are graded depending on the level of contamination.

> "If the sorting is minimal and residual waste is high, the bale price will be low. If the sorting entity reduces contamination, the bale price will be higher. ….For PET bales, there are different grades listed with 6 to 28% non-PET limits. For HDPE bales, the listed grades are limited to 5 to 21% non-HDPE. The 'not PET' can be water, aluminum cans or HDPE bottles. The 'not HDPE' can be water, aluminum cans or some other plastics. The Grade A bales, 94 or 95% indicated plastic, get the best price and are most sought after. Remember, shipping and sorting or disposing of trash in a bale is not a profit-making activity for the reclaimer. Quality matters."
> https://www.plasticstoday.com/recycling/unraveling-economics-plastics-recycling/55070110258784

Depending on the grade of the bale from the MRF[xix], there must be additional sorting to separate plastic types. Different types of plastics have different melting temperatures. If incompatible plastic resins mix, the plastic with a lower melting temperature will burn and the plastic pellets become discolored. This makes the pellets unsuitable for making new products. Also, pellets from a mix of plastic types will likely not meet performance standards for manufacturing new products. Fillers, dyes, and other additives in the waste plastic further complicates the recovery process. The more feasible sorting methods include:

- Float and Sink sorting – This inexpensive, common method, relies on density to separate plastics. With this technology, plastics are sent into tubs of water and lighter pieces that float are separated from heavier/denser pieces that sink. Since plastics of similar densities will not be separated, additional sorting is required after this initial stage.

- Froth – Flotation – Materials are first treated with a "surfactant" and then air is pumped into the water. Air bubbles adhere to some plastic resins making them float while other plastics sink to the bottom. This method can separate PET from PVC.

- Infrared Sorting – Automated sorting using infrared light is good for sorting clear PET bottles. Not suitable for dark-colored plastics or plastics with residues, adhesives, or additives

- X-Ray Fluorescence – Sorts plastic by creating spectral fingerprint based on plastics chemical composition. This is a more costly method and not widely used.

D. Grinding & Washing

After sorting, the plastic products are fed into a machine which has sets of blades that slice through the material and break the plastic into tiny bits or flakes. After this step, the flakes are washed to remove residue originally contained in the plastic items and various other "contaminants" (e.g. paper labels, dirt). A wash solution consisting of an alkaline, cationic detergent in water and a wash tank are used to making sure that all items are clean and ready for the next step in the recycling process.[xx]

E. Melting and Mixing

'Pellitize" is a term to describe the process of melting plastics back into a pellet form so it can be re-used in manufacturing new products. This involves melting down the flakes or chipped pieces of plastic and putting them through a machine called an "extruder". The extruder shapes the melted plastic into thin noodle-like tubes. The plastic tubes are then cut into small pellets by a set of rotating knives. The plastic can also be extruded as filament for 3-D printing.

Recycled pet pellets tend to be darker and more yellow than virgin PET. Some of the color comes from reheating, additives, and contaminants from foreign material. Larger contaminant particles can cause problems in injection molding. To control for the potential discoloration, and increase functionality of the plastic, the recycled PET pellets may be mixed, or blended, with virgin plastics. Blends with less than 25% recycled product usually only have a slight difference in appearance. Blends with higher percentages of recycled product will have a more noticeable discoloration. Some manufacturers will add a colorant to mask imperfections and maintain a consistent color from batch to batch.[xxi] In the Rocky Mountain West, Reaction Polymers in Salt Lake City is the largest company producing recycled pellets. https://www.reactionpolymers.com/

F. Manufacturing[xxii]

Pellets are used by manufactures to produce a variety of products. The most common processes for recycled plastics manufacturing include:

- Injection Molding - One of the most common methods that is used for mass production and small and large-scale products. This process involves melting resin pellets inside a heated barrel of an injection machine. The melted resin pellets are then pushed out, or injected, to fill a mold.

- Blow molding – Used for containers and bottles. Air pressure is blown into a hollow length of melted thermoplastic to expand plastic and the mold shape. The inside of the product hollow.

- Extrusion Molding - Plastic is melted and then pressed through an extrusion machine. This creates a fixed plastic shape. Some common items using this process include seals and pipes. This process can create filament for additive manufacturing processes such as 3-D printing.

- Vacuum Forming/Thermoforming – A plastic sheet is heated and forced against the mold resulting in a plastic sheet with the mold shape. The product is cut out the sheet causing residual waste.

- CNC Machining – A computer-controlled subtractive processes that starts with solid blocks or plastic sheets that are shaped by removing material through cutting, boring, drilling, and grinding. Results in residual manufacturing waste.

G. Transportation & Logistics (Applies to all steps)

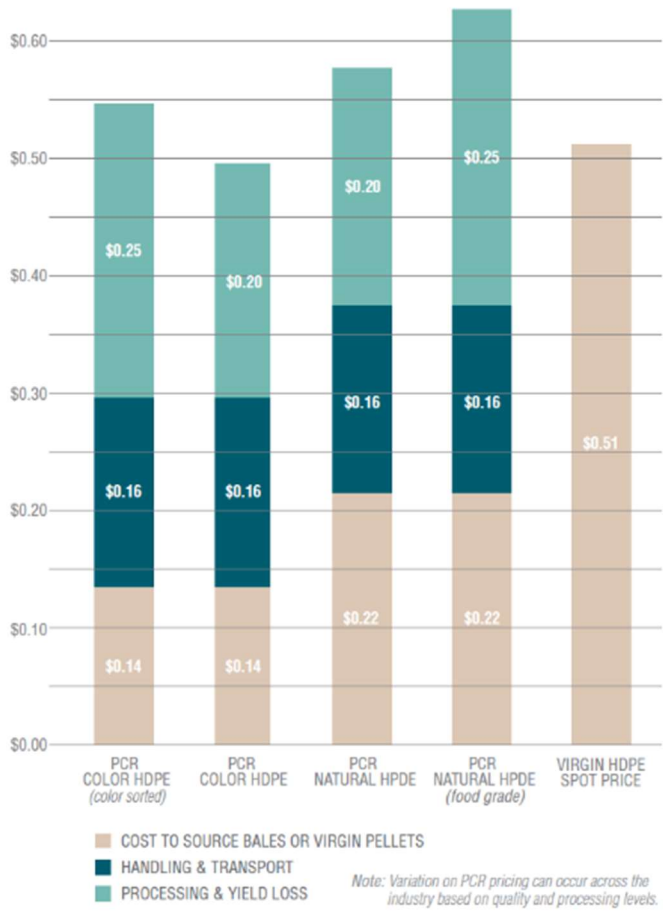
Transportation and other logistics are areas where there is potential to save costs in waste management and recycling processes. Web-based tools have been developed and employed to improve material waste management particularly for collection and waste diversion.[xxiii]

VII. Challenges to Recycling Plastic

A. Cost of recycled products vs. products made with virgin plastic

Prices for both virgin and scrap plastic fluctuates based on a variety of factors such as market demand, Production capacity, economic conditions, import/export markets, transportation costs, and the price of oil. Recycled plastic must compete with the cost of virgin plastic. If the price of virgin resin drops it becomes less feasible to use recycled content. Currently, the cost of oil is at a 30-year low making the cost of producing products with virgin feedstock cheaper than using recycled resin. As noted below:

> "Historically, companies have used post-consumer resin (PCR) because it was a lower cost feedstock than virgin. In recent years, however, pricing for virgin plastic (mostly "wide spec" resin) has fallen below that of PCR (mostly high quality PCR that is suitable for food contact). Developing PCR that can compete with virgin resin, in terms of performance or consistency in specifications, requires significant cost in handling and processing. The breakdown of those recycling costs for two common types of recycled plastic – color and natural HDPE – are shown in the bar graph.
>
> It is important to remember resin costs generally do not account for the environmental benefits from the use of PCR or the impacts of using virgin. For PCR to become a more attractive option, drivers beyond price will need to be taken into account by resin purchasers." *(Source:* https://resource-recycling.com/plastics/2019/09/09/data-sort-what-accounts-for-the-higher-cost-of-pcr/)



Improvements in the recycling system and supply chain can reduce the cost of recycled resin to make it more competitive with virgin plastics. The chart illustrates that most of the cost to produce post-consumer/recycled plastic are due to inefficiencies in handling, transportation, and processing of recycled plastics. Such inefficiencies include: [xxiv]

- Supply chain fragmentation: Infrastructure for reclaiming and reprocessing post-consumer PET is fragmented, with each stop in the chain adding incremental margins onto real processing costs.

- Logistics inefficiencies: Collecting and transporting plastic scrap between different locations along the supply chain adds cost compared to a more streamlined virgin logistics infrastructure.

- Contamination: Non-recyclable materials present in RPET bales will lead to yield loss and increase landfill costs at each step of the supply chain.

- Processing: Bottle-grade RPET buyers normally require additional processing steps to convert recycled PET bottles to quality RPET flake that meets the standards of the Food and Drug Administration.

B. Contamination

Contamination of post-consumer plastic is a primary challenge for recycling. The trend to move away from dual stream or source separation collection methods, to single-stream collection has increased the levels of contamination in the plastic waste stream. Additionally, consumers are confused about what types of plastic are recyclable and new composite plastics add to the difficulty of separating out viable plastics for recycling. Issues with such contamination are described below:

- "Quality of the baled plastic is the primary factor, which determines the value. A reduction in the contracted price of the material occurs if bales contain over 2% of unspecified materials. In addition to the reduction in contracted price, charges for disposal of the contaminants occur at times. Certain materials specified as "prohibited" and will render the bale "non-specification." When there is gross contamination or misrepresented materials, some customers may reject the entire shipment. These include plastic materials, which have a deleterious effect on each other when reprocessed, and materials such as agricultural chemicals, hazardous materials, flammable liquids and/or their containers, and medical waste."[xxv]

- "Also, in the U.S., the types of materials collected has expanded significantly, as have the types of packaging being put on the market – often leading to consumer confusion about what is and is not recyclable. Most confusion seems to be around plastics. Single-stream collection may reduce collection costs, but it increases contamination levels, which increases costs on the processing side and negatively impacts the marketability of resulting materials."[xxvi]

- "Different melting points of different plastics - There are so many kinds of plastic formed into clamshell-like packaging that even trained recycling techs have a tough time telling them apart. And if the item has an adhesive sticker, or a peel-off film, or one of those sanitary napkins that are put under steaks, it's not usable even if it's exactly the right kind of plastic." [xxvii]

- "The recycling rate of postconsumer waste, however, is low. This is due to technical limitations such as the limited availability of clean and unmixed postconsumer plastic waste. The rate can only be increased when the recycling process becomes an integral part of the product design process and both the manufacturer and consumer take a part in the improvement that process." [xxviii]

C. Markets

In 2017, China enacted a "National Sword Policy" that banned 24 types of material from being imported into the country. The list of materials included post-consumer recycled products with contamination levels above 0.5 percent. Since the level of contamination in the U.S. for recyclables typically falls between three and five percent, the policy had the effect of shutting down the China market for recycled plastics

With few markets available, and limited options for storage or stockpiling plastic materials, more plastics are being landfilled. The EPA, "National Framework for Advancing the U.S. Recycling System", states that domestic markets for recycled materials must be strengthened in the United States. Product and packaging designs should better integrate recycled materials and account for end-of-product management. EPA also recommends improving communication among the different sectors of the recycling industry to develop new innovative markets.[xxix]

D. Consumer Recycling Rates

Consumers express confusion about what to recycle, where to recycle, and how to recycle. Lack of reliable information often leads to consumers contaminating recyclables with trash. Lack of reliable information also results in consumers disposing of materials that could otherwise be recycled.[xxx]

Nationally, the percentage of recyclables diverted from the waste stream has plateaued. Although the per capita generation rate for overall recycling has remained steady at about 4.5 pounds per person per day, population growth results in higher volumes of waste that ultimately ends up in the landfill. Increasing recycling rates continues to be important to manage the waste stream at sustainable levels.

Effective means of increasing recycling rates and reducing contamination include education and improving the overall process to make recycling convenient. Some localities have instituted mandatory programs. Coordination between the various stakeholders to develop a local, integrated strategy for solid waste management and recycling has shown promising results.

E. Rural Recycling Issues

Although there is general support for recycling programs, geography and economics create unique challenges in operating recycling programs in rural areas. Montana counties have low population densities and are located far from markets. Strategies that work in urban areas are not viable in rural regions. Rural recycling programs must consider the following factors:

- Economy of Scale - There is significant cost to collect, sort and process recycled plastic. Since only certain types of plastic are suitable for recycling, rural areas with low population bases often do not generate enough plastic waste to offset the costs associated with the recycling operation. According to DEQ, "….rural communities do not generate enough recyclables to lure large recyclers to their areas, nor do they produce enough recyclables to effectively start a full-scale recycling program of their own [xxxi]

- Inexpensive landfilling - According to the Recycling Partnership, "Many communities are increasingly paying more to send materials to a Material Recover Facility (MRF) than the landfill."[xxxii] Recycling operations must address inexpensive landfill tipping fees that make disposal options significantly cheaper than recycling.

- Transportation costs – Once recycled materials are collected and sorted, they are exported out-of-state for further processing. Due to distances from these markets, transportation costs for recycling operations are high and reduce potential profit margins for selling recycled materials. Often, the value of the recyclables is not enough to pay for the fuel to haul it to market.

Table: Distance to Major Metropolitan Areas

	Salt Lake	Seattle	Los Angeles	Denver	Minneapolis
Billings	562	821	1,249	554	839
Bozeman	409	681	1,096	696	981
Butte	417	594	1,104	781	1,066
Great Falls	571	643	1,248	976	969
Helena	483	588	1,170	793	1,078
Kalispell	646	525	1,334	1,020	1,188
Missoula	523	476	1,211	897	1,182

- Low tax base – Many rural areas have a small tax base and tax receipts are already earmarked for essential services. Recycling programs typically do not receive allocations from the local

government general funds and consequently these programs must generate sufficient revenue from fees and commodity sales to cover the cost of the recycling services.

Even if revenues are adequate to pay for basic collection, sorting and shipping services, they are often insufficient to pay for public education, equipment upgrades, capital reserves or adequate staffing. These types of investments are necessary for the long-term sustainability of a recycling operation. A partnership or cooperative may be one way to pool funds and share the costs for such investments.

F. Covid-19 & Economic Downturns

The initial impacts of the Covid-19 crisis on the recycling industry is a reduction in collection services. This is due to suspension of services until communities institute safety procedures in solid waste management to respond to the outbreak. Reduced industrial output and a decrease in tax collections from an economic slow-down, may also result in service cuts for recycling programs. According to an article in Forbes magazine, "The consequence of less overall recycling is that there are fewer recyclables in the supply chain to make products while also temporarily pausing sustainability, corporate social responsibility (CSR) and environmental, social, governance (ESG) goals."

Despite these challenges, the article notes that the crisis, "…emphasizes the value life cycle assessments have in helping us make informed, sustainable decisions regarding the full spectrum of environmental, social, and economic impacts associated with every stage of a product (plastic, bioplastic, metal, paper, etc.), service, or activity from cradle to grave, i.e., raw material extraction, materials processing, manufacture, distribution, use, transportation, and disposal. Conducting this assessment prioritizes resources and redirects investments, stimulates innovation in enterprises and value chain actors, and helps decision-makers and consumers take informed actions."
https://www.forbes.com/sites/thebakersinstitute/2020/04/14/pandemic-plastics-and-the-continuing-quest-for-sustainability/#2cfbdb0777b4

It is also worthwhile to note that consumers are continuing to demand products with recycled content. As a result, major brands such as PepsiCo, Nestle, Hewlett Packard and Wal-Mart have renewed their commitments to recycling goals thereby creating a steady market for recycled plastic feedstock even during economic downturns. https://pt.mydigitalpublication.com/publication/?i=659347&p=&pn=

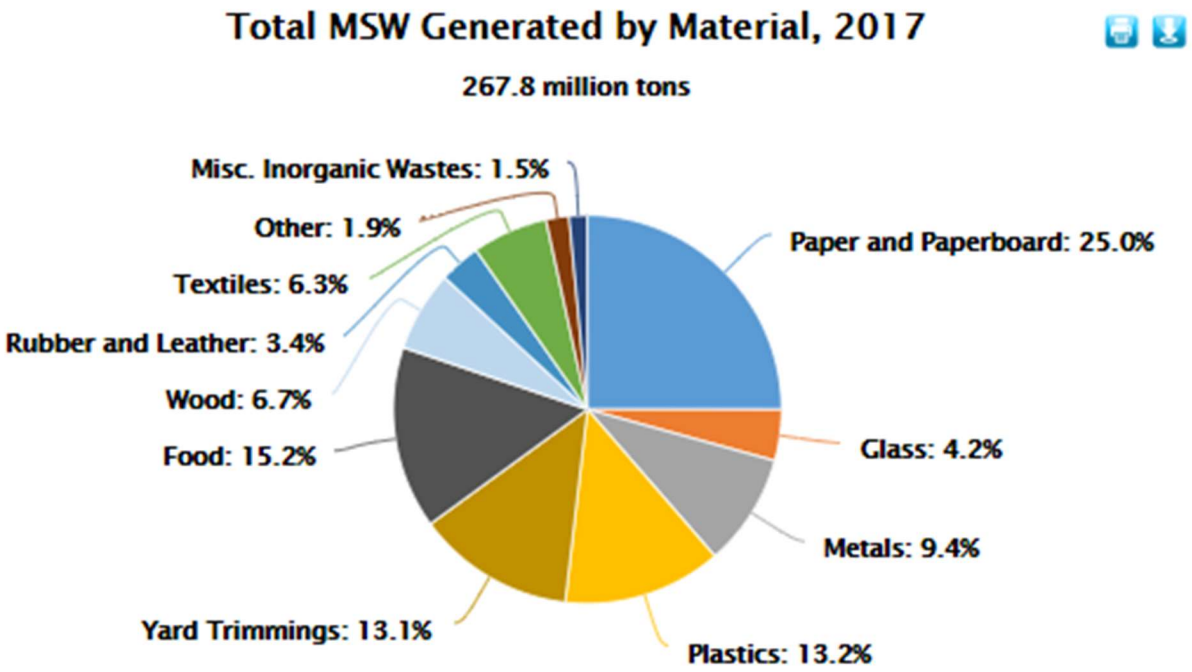
VIII. Solid Waste Management & Recycling Trends

An analysis of the waste stream is the foundation for solid waste planning. Such analysis provides benchmarks to make projections, measure progress and identify potential improvements to the recycling system. A comprehensive waste stream analysis will determine how much waste is generated, the type of waste, major waste generators, how much is diverted from the landfill and projected volumes of waste. Waste stream data is derived from landfill samples, landfill permitting information, national or regional data, or surveys of solid waste/recycling businesses. The following data is compiled from published reports and provides an indication of current trends.

A. National Solid Waste Overview

1. Waste generation[xxxiii]

Per capita MSW generation increased from 4.48 pounds per person per day in 2015 to 4.51 pounds per person per day in 2017. MSW generation per person per day peaked in 2000. In 2017, plastic products generation was 35.4 million tons, or 13.2 percent of generation. This was an increase of four million tons from 2010 to 2017, and it came from durable goods and the containers and packaging categories. Plastic waste generation has grown from 8.2 percent of the waste stream in 1990 to 13.2 percent in 2017.



https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials#GenerationTrends

2. Recycling

Nationally, the 2017 recycling rate for all materials was 25.1% percent. The amount of food/yard waste that was composted comprised an additional 10% of the waste stream. Combined waste diverted from landfills amounted to 1.58 pounds per person per day. Recycling accounted for 1.13 pounds per person per day for recycling and composting accounted for 0.45 pounds per person per day. [xxxiv] Only about 9% of all plastic materials are recycled compared to 66% for paper/cardboard products. The collection rate for just PET plastic bottles is 28.9%.[xxxv].

B. Montana Solid Waste Overview [xxxvi]

Records from waste management facilities evaluated by DEQ indicate the generation of MSW in Montana increased from 1,697,085 tons in 2011 to 1,803,435 tons in 2016. Per-capita waste generation increased from 9.3 pounds/day/person in 2011 to 9.7 pounds in 2016. (Note: In Montana, significant quantities of construction waste are discarded in the municipal waste stream and accounts for some of the higher per capita waste generation over national averages.)

Source: http://deq.mt.gov/Land/Recycle

The graphic illustrates that paper comprises the largest percentage of the mix of materials in the waste stream in Montana. Plastics comprise 7.2% of the waste stream and represents a smaller portion of waste compared to national averages. Food waste comprises just 6.6% of the waste stream in Montana compared to a rate of 15.2% nationally.

The Montana Code Annotated establishes recycling goals:

> **75-10-803. Solid waste reduction goal and targets.** (1) It is the goal of the state to reduce, through source reduction, reuse, recycling, and composting, the amount of solid waste that is generated by households, businesses, and governments and that is either disposed of in landfills or burned in an incinerator, as defined in **75-2-103**.
>
> (2) Targets for the rate of recycling and composting are: "22% of the state's solid waste referenced in subsection (1) by 2015."

Montana Department of Environmental Quality (DEQ) relies on yearly facility reports and voluntary surveys to calculate yearly diversion rates due to recycling. In 2016, the diversion rate was 17.6%. Diversion rates reached a high of 22.2% in 2014.

Currently, there are 30 licensed Class II landfills in Montana, compared to 29 in 2011, 31 in 2006, 59 in 1993, and 87 in 1979. Landfills must meet federal Subtitle D and Montana requirements for liner design, leachate collection, methane monitoring, and other criteria. Overall, the average life of these facilities is about 43 years. However, because of the population growth occurring in Montana, landfill space is being used at a higher rate than anticipated. (MT Integrated Waste Management Plan) Recycling is an important strategy to conserve landfill space and extend the useful life of these facilities.

C. Flathead County Solid Waste System [xxxvii]

1. Flathead County Landfill

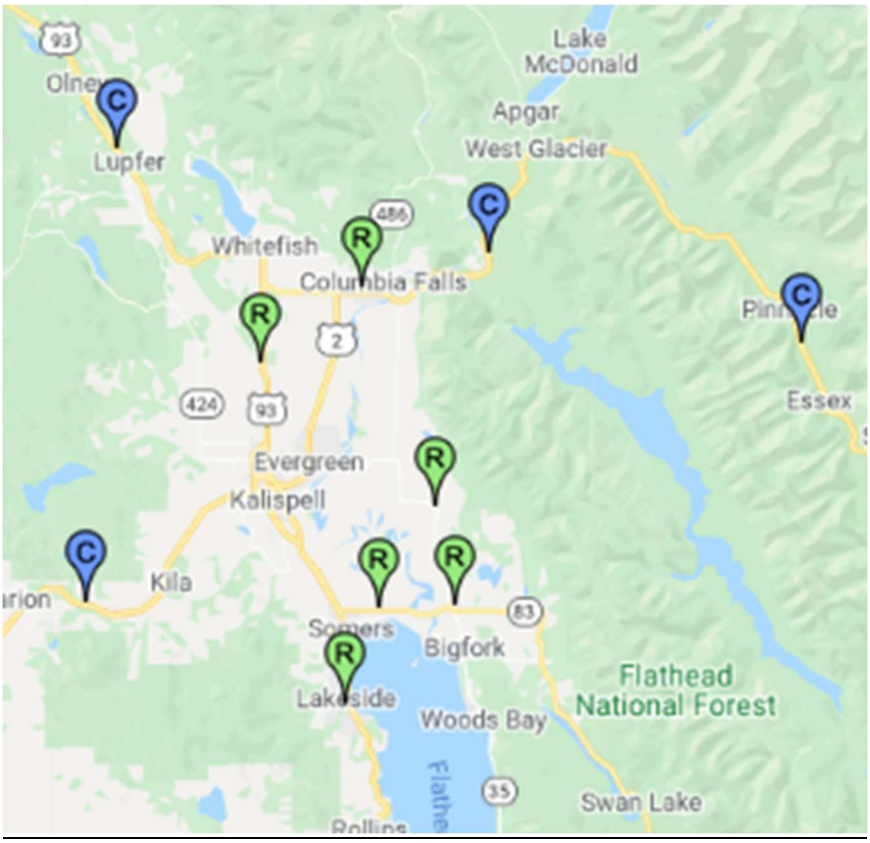
Total tonnage disposed of at the Flathead County landfill in Fiscal Year (FY) 2018 was 144,211 tons, an increase of almost 24% compared to FY17. The increase was attributed to several major projects, the largest of which was the demolition of the Columbia Falls Aluminum Company. The contractor for the project, Calbag Resources, deposited 12,711.23 tons of debris in the landfill (54% of the increase). https://flathead.mt.gov/waste/

In FY18, 83,300.12 tons of mixed waste (does not include construction debris) was landfilled, of which 51% was disposed of by commercial haulers, 12% by municipal haulers, 8% by private citizens and 29% hauled by Flathead County Solid Waste (FCSW) from the green box container sites. Per capita average for mixed waste was 4.47 pounds which is comparable to the national average.

2. County Green Box Collection Sites

The Flathead County Solid Waste Board operates green box container sites for residential solid waste collection. The sites are only open during posted hours when staff is present. Magazines and aluminum cans are accepted for recycling at the Bigfork, Columbia Falls, Creston, Lakeside, and Somers sites. Commercial recycling must be taken to the landfill. Effective in February, 2020 plastic, steel and tin cans were no longer accepted for recycling due to a change in the global market for these commodities. The total amount of recycled material for the FY2018 for this program was 766 tons. The county contracts with Valley Recycling to provide hauling and processing of the recyclable materials. https://flathead.mt.gov/waste/

Location of County Green Box Container Sites (R=Recycled materials accepted)



3. Private waste and recycling services in Flathead County

Name	Description
Republic Services	Headquarters in Phoenix provides commercial and residential waste hauling services. Maintains a recycling drop-off site in Whitefish. Collects aluminum, plastic bottles, paper, and cardboard. Compresses and bales recyclables into shipping units. https://www.republicservices.com/ (Formerly North Valley Refuse.)
Valley Recycling	In addition to providing hauling services for recycling at the county green box sites, accepts aluminum, plastic bottles, paper, and cardboard at material recovering facility. Compresses and bales recyclables into shipping units. Diverts and average of 7.5 million pounds of material annually. https://www.valleyrecycling.com/
Evergreen Disposal	Commercial and residential waste hauling. Collects corrugated cardboard from commercial customers. https://www.evergreengarbage.com/commercial-recycling
Green Machines	Curbside recycling. Collects paper, aluminum cans, plastic bottles, and cardboard. Residential and commercial. http://valleygreenmachines.com/
Flathead Recon	Glass recycling for businesses and some collection events. https://flatheadrecon.com/
Pacific Steel & Recycling	Based in Great Falls with location in Kalispell. Multiple locations in region. Primarily scrap metal. Accepts aluminum cans and cardboard at material recovery facility. Plastic collection dependent on market. Compresses and bales recyclables into shipping units. https://www.pacific-steel.com/recycling/
Waste Not	Recycling Education sponsored by Flathead County Solid Waste Board. https://www.wastenotproject.org/
Dirt Rich	Food waste and yard waste composting. Collects from commercial and residential customers. https://www.dirtrichcompost.com/
Grocery Stores	Most grocery stores have receptacles for recycling of plastic bags. A common use for plastic film is composite lumber products. (i.e. Trex decking…) https://www.plasticfilmrecycling.org/recycling-bags-and-wraps/find-drop-off-location/

IX. Recycling Business Best Practices

A. Education

Education can increase recycling rates by raising awareness about recycling benefits as well as local recycling opportunities. Education is also recommended to promote best practices and decrease overall contamination of collected recyclables. The "Montana Integrated Waste Management Plan" recommends that local governments implement aggressive public education campaigns to spread awareness and encourage the public to adopt best practices. Recycle Montana has educational resources on their website and the Flathead County Solid Waste Board contacts with a local non-profit to conduct consumer education.[xxxviii] The Flathead County WasteNot Project conducts outreach in local schools, host recycling events and publishes guides on recycling.

B. Hub and Spoke

As noted below, the Montana Department of Environmental Quality, "Integrated Waste Management Plan", promotes the "Hub and Spoke" concept to address the logistics of rural recycling. [xxxix]

> "The Hub and Spoke concept is dependent on several communities working in partnership to collect and aggregate materials for recycling. For example, five communities all collect recyclables and ship the material to one central community, establishing a volume that economically supports hauling to a recycling business. ….. A regional recycling approach helps to overcome the obstacles encountered by individual rural governments. Benefits of this type of approach include increased volumes of recyclables and increased marketing opportunities, as well as:
>
> • Potential for cooperative marketing, which can substantially increase revenues
> • Conserved landfill capacity and avoided tipping fees to citizens
> • Regional economic stimulus from new collection and processing jobs
> • Shared costs for equipment, personnel, processing, transportation, marketing, and facility capital and operating costs"

C. Target End Markets for Recyclables

Collection and processing of waste streams can be designed for specifically for markets that use recycled content. The value of recyclables is predicated on meeting certain market standards or specifications. End-user markets have different specifications. Determining in advance the actual manufacturers who will purchase recyclables and instituting processes to meet their latest specifications is advantageous.[xl] Focusing on high-value end uses can bring premium prices for recycled materials. Some examples include:

- The construction industry has been increasing its use of recycled materials. Some cities are using recycled materials in road construction, piping, landscaping, and other projects. The U.S. Green Building Council LEED program encourages the use of recycled materials in building construction.[xli]

- To create more end markets for recyclables, the Colorado Department of Public Health and Environment funds an incentive programs to encourage businesses to make products from recycled materials. [xlii]

D. Improve Collection Systems

Improvements in the collection system can increase recycling rates and reduce contamination. Providing more convenient options to recycle through drop-off sites or curbside recycling is proven to increase recycling rates for consumers. Working with large industrial and commercial waste generators to develop "green teams" or adopt new waste management strategies can increase recycling rates in the business sector. Localities have adopted a range of strategies to reduce contamination such as staffing of drop-off sites, right-size containers, incentives for source separation incentives and training.[xliii]

E. Mandates or Incentives to Increase Recycling Rates

Localities have adopted a combination of carrot (incentives) and stick (mandates) to increase participation in recycling programs. Incentives may include reduced fee structures, rebates, public recognition programs or direct subsidies to large recyclers. Mandates establish a goal for recycled content and may be implemented through regulatory or purchasing requirements. Landfill bans, surcharges, audits, mandatory curbside programs, and other measures are used to enforce mandates. The EPA has compiled a database of communities that have adopted such measures. https://www.epa.gov/transforming-waste-tool/managing-and-transforming-waste-streams-tool

F. Community Support & Partnerships

Engaging a wide variety of stakeholders can bring more resources to recycling efforts, increase the visibility of recycling programs and create a constituency for expanding recycling programs. Fostering recycling partnerships helps identify potential areas of coordination and expands the pool of experts that can contribute to successful efforts. Establishing a task force or advisory committee with widespread representation from the community is useful to help develop long-range goals and on-going oversight. The committee can draft a local integrated solid waste management plan to reflect local circumstances. Other successful avenues of building community support include, conducting public outreach, surveying community members on preferences for programs and direct engagement through collection events, waste exchanges, contests, social media, and other similar activities. Advocating for recycling policies in local and state sustainability/climate plans, purchasing programs and legislation is another means of building support for recycling programs.

X. Cooperative Business Model

As noted in this white paper, individual recycling operations in rural areas have unique challenges that make it difficult to achieve a long-term financial success. Additionally, many of the best practices for sustainable recycling businesses are difficult for small scale operations to implement. A successful approach to address these issues is the rural recycling cooperative model. "A recycling cooperative consists of a group of individuals, communities or businesses of varying sizes and types, organized around a desire to maximize recycling efforts and improve local and regional solid waste management systems by creating greater opportunities with economics of scale."[xliv]

The Montana Integrated Waste Management Plan acknowledges the potential for cooperative marketing, which can substantially increase revenues for rural recyclers. For some areas, solid waste volumes fluctuate due to seasonal residents or tourism. Small communities have difficulty accumulating enough processed materials to offset costs. A regional rural recycling cooperative can achieve economies of scale and access large markets to overcome these obstacles.

Cooperatives can share equipment and expand into processing and storage that would be cost prohibitive for small operations. A regional sellers cooperative can collect and process recyclables from multiple communities to achieve economies of scales and access higher paying commodity markets. A buyer's cooperative can enter joint purchasing contracts that benefit from volume discounts. Other advantages include shared marketing, training, and negotiation of more advantageous employment contracts to staff operations. Cooperatives can provide resources for community outreach and education. An organization that represents multiple statewide members is also more effective at advocacy. The following table describes the next steps in determining the feasibility of a cooperative.

Action	Description
1. Determine Interest	Exploratory meetings. Presentations to key agencies. Identify existing efforts and potential collaborations.
2. Define project	Timeframe. Issue identifications. Partners. Study area. Project management. Project budget.
3. Market Research	Industry overview. Population/economic data. Potential markets. Suppliers.
4. Stakeholder Involvement	Identify stakeholders (See appendix). Conduct surveys. Focus groups.
5. Feasibility Study	Evaluate alternatives. Analysis of waste stream/diversion rates, capital start-up costs, operating costs, revenue projections, transportation alternatives, regulatory analysis, risks analysis, ….
6. Cooperative formation	Business plan, site analysis, Legal documents, cooperative membership recruitment, staffing needs, budges/financials, …

Appendix 1: On-line Resources

Agencies

Montana Dept. of Environmental Quality - http://deq.mt.gov/Land/recycle/plastics

U.S. Environmental Protection Agency - https://www.epa.gov/trash-free-waters/frequently-asked-questions-about-plastic-recycling-and-composting

U.S. Department of Energy - https://www.energy.gov/articles/department-energy-launches-plastics-innovation-challenge

Trade Organizations

Name	Web Sites
American Chemistry Association	https://plastics.americanchemistry.com/
Association of Plastic Recyclers	https://plasticsrecycling.org/
Plastic Industry Organization	https://www.plasticsindustry.org/
Sustainable Package Coalition	https://sustainablepackaging.org/
Recycle Montana	https://recyclemontana.org/
Institute of Scrap Recycling Industries,	https://www.isri.org/
Solid Waste Association of North America	https://swana.org/
Recycling Partnership	https://recyclingpartnership.org/
National Recycling Coalition	https://nrcrecycles.org/
Montana Solid Waste Contractors	http://www.mswc.org/

Web Sites

https://resource-recycling.com/

https://recyclemoreplastic.org

https://www.3rinitiative.org/about

https://www.recyclingtoday.com/

https://recyclenation.com/about/

https://www.waste360.com/mag/waste_steps_planning_rural

https://www.newplasticseconomy.org/

https://wasteadvantagemag.com/

https://www.ptonline.com/ (Plastic Technology On-line magazine)

https://sustainablepackaging.org/

https://environmentmontanacenter.org/

Appendix 2: Stakeholders

Name	Web site
Valley Recycling	https://www.valleyrecycling.com/
Citizens for a Better Flathead	https://www.wastenotproject.org/
Evergreen Garbage	https://www.evergreengarbage.com/
Republic Services	https://www.republicservices.com/recycling?tab=local
Valley Green Machines	http://www.valleygreenmachines.com/
Pacific Steel & Recycling	https://www.pacific-steel.com/recycling/
Flathead County Solid Waste Board	https://flathead.mt.gov/waste/
Flathead Recon - Glass Recycling	https://flatheadrecon.com/
Dirt Rich Compost	https://www.dirtrichcompost.com/
Lake County Transfer Station	https://www.lakemt.gov/SolidWaste/recycle.html
MT Dept. of Agriculture	https://agr.mt.gov/Pesticide-Container-Recycling
Flathead Valley Community College	https://www.fvcc.edu/
Northern Plastics	https://northernplastics.com/
Creative Sales Products	http://www.creativesalescompany.com/

Appendix 3: Funding & Business Resources US Small Business Association	https://www.sba.gov/funding-programs/
Small Business Dev. Center	https://sbdc.mt.gov/kalispell
Montana West Economic Development	https://dobusinessinmontana.com/
Montana Manufacturing Extension Center	http://www.montana.edu/mmec/
USDA	https://www.rd.usda.gov/programs-services/rural-business-development-grants/mt
Montana Dept. of Commerce	https://commerce.mt.gov
University of Montana	http://acceleratemontana.umt.edu/departments/amrii/default.php
Montana Dept. of Agriculture	https://agr.mt.gov/GTA
Economic Dev. Administration	https://www.eda.gov/oie/buildtoscale/
Small Business Innovation Research Grants	https://www.sbir.gov/
Montana High Tech Alliance	https://mthightech.org/
Montana Cooperative Development Center	https://www.mcdc.coop/
MT Governor's Office of Economic Development	http://business.mt.gov/ (Site Selector/Esri data)

Appendix 4 : Rural and Small-Scale Case Studies

A. Mobile Collection, Compacting & Grinding -
   - Montana Dept. of Agriculture, Pesticide Container Recycling, https://agr.mt.gov/Pesticide-Container-Recycling
   - Republic - https://www.republicservices.com/compactor-rental

B. Recycled Filament for 3D Printing
   - Closed Loop Plastics - https://www.closedloopplastics.com/about-us (California)
   - Equipment to Purchase - https://www.filabot.com/products/ex2-bundle
   - Equipment to Rent - https://greenpathrecovery.com/about/

C. 3d Printing - University - https://www.montana.edu/makerspace/Printing.html
   Business - http://www.3dprintingcolor.com/ (Kalispell, MT)
   Business - https://www.print3dmt.com/ (Joliet, MT)

D. Injection Molding – Fabrication using recycled plastic
   - Missoula DPA Plastics - https://www.dpiplastics.com/about-us/

E. Recycling Cooperative –
   - Northeast Recycling Cooperative - https://nerc.org/documents/coop/nerc.pdf (Massachusetts)
   - Oregon Beverage Recycling Cooperative - https://www.obrc.com/About

F. Consulting - https://greenpathrecovery.com/about/ (Nevada)

G. Design & Testing –
   - Make It Plastic - https://makeitplastic.com/ (Montana)
   - http://www.recyclinggrinding.com/testing.html (Iowa)

H. All-in-one services - http://www.recyclinggrinding.com/washing.html (Iowa)

Appendix 5: Occupation & Wages for Plastic Recycling Processing Plant

Potential Job Titles (Depending on Type & Size of Operations)

Job Title	**Hourly (1)**	**Mean Annual**
Industrial/Plant Manager	$31.27 - $50.71	$75,592 (2) - $105,408 (3)
Administrative Office Support	$14.47 - $18.84	$34,060 (2)
Machine Operator – Extruding Machine Operator, Grinding Machine Operator, Plastic Injection Molding Operator	$14.16 – 18.12	$37,860 (1)
Modeling – Production Design	$20.14 - $24.41	$57,420 (3)
Lab Tech – Chemical Analysis – Quality Control	$18.13 - $23.68	$49,260 (3)
Property Maintenance – Warehouse - General labor	$11.24 - $15.54	$31,250 (3)
Sales & Marketing	$18.00 – $32.10	$56,130 (3)

Notes:

(1) U.S. Bureau of Labor Statistics - (Hourly wage range based on 25% of national average to mean national average) https://www.bls.gov/oes/current/oes_stru.htm#51-0000

(2) Montana Dept. of Labor and Industry – (Mean Annual Wage for Montana) http://lmi.mt.gov/Industry/WageEmploymentByIndustryQCEW

(3) U.S. Bureau of Labor Statistics - (Hourly wage range based on mean national average) https://www.bls.gov/oes/current/oes_stru.htm#51-0000

Appendix 6: Problems with Collection of Plastic

There are several key issues with plastic containers delivered to Material Recovery Facilities (MRFs): • Container Size and Shape: As most of the equipment at the MRF sort containers by shape of the container, anything that is not three-dimensional has the potential of causing problems. Flat plastics often "behave" as paper in the sorting machines and end up being sorted into paper bales and contaminating the bale.

• Non-Program Plastics: Non-program plastic materials, such as plastic trays, are often difficult to sort from 'program' plastics, can contaminate other recyclables, and often lack a market. There are often labor and disposal costs associated with removing this material. . In King County, 16% of plastics collected are non-program/non-conforming which equates to about one out of every six pounds of plastic collected.

• Plastic Bags and Film: Plastic bags and film make up a small percentage of incoming material by weight (.2%, which is approximately a bale a day) but has a big impact. Plastic film (such as, grocery bags) tangles in the gears of the processing equipment. This regularly requires stopping the machines at the MRF to remove the film. The exact MRF operators can usually remove 30-40% of the plastic bags during the pre-sort process, but the rest tangle in the machinery. It costs $700-$1000 a ton to remove this material. Overall, 20-30% of recycling center labor entails dealing with film. Curbside collected bags are highly contaminated, dirty, and gritty. According to Moore Recycling, MRFs are typically unable to create bales of film from curbside programs that meet domestic quality standards. The film that is successfully sorted at the MRF is only suitable for export markets. In today's (2016) down market, the export market does not want curbside film. When residents told to take bags, film and wraps to retail collection, the material has a much higher value. The City of Vancouver Washington in conjunction with Clark County, Waste Connections of Washington and other partners conducted a study that showed a 75% decrease in plastic bag contamination within recycling carts of consumers who had received informational notices of where to recycle the bags. (City of Vancouver, 2016)

• Food or Liquid Soiled Plastic Containers: Liquid left in plastic containers results in three issues:
  • Sorting machinery fails to separate plastic bottles with significant liquid correctly, due to their weight.
  • Plastic bottles and containers containing liquid or food contaminates other recyclables like paper and cardboard
  • Food and liquid often weigh more than the plastic, and this can affect bale yields.
  • Food and liquid residue stuck on plastic recyclables impact the quality of the plastic used for re-manufacturing.

• Screw-on Caps: There is ongoing discussion about the best way to handle screw-on caps. Loose caps placed in the recycling container fall through screens at the MRF and become part of the residual and are therefore lost to recycling. A new opportunity has emerged to recycle plastic screw-on caps. Caps screwed back onto empty plastic bottles by the consumer before placing in the recycling container will move with the bottle through the MRF. After the MRF, a secondary processor receives the caps and plastic bottles. Plastic processors are now able to separate the cap resins from the bottle resins and sell cap resins for making new products. Caps make up 6 to 12% of the weight of many bottles. Capturing caps for recycling actually results in a significant increase in plastic available for recycling.

• Flexible packaging: This type of packaging is often comprised of multiple plastic resins and foil. Flexible packaging is not currently recyclable and unacceptable in curbside by municipalities. However, consumers are putting flexible packaging into their curbside recycling bin. Due to its flat shape and light weight this packaging material tends to behave like paper and flows through a MRF with the paper stream. This practice allows the flexible packaging to potentially contaminate the paper stream. It requires manual sorting to remove the laminated plastics. Today's optical sorting technologies are unproven in removing all contaminants from the fiber stream. When removed at the MRF, flexible packaging typically ends up disposed. There is no large-scale end market for this packaging type at this time. 67 Photo 12: PET flake. Photo credit: Pinnacle Recycling Private Ltd.

• Full-Wrap Bottles: Bottles wrapped in a sleeve, made from a different plastic resin than the bottle. In an optical sorter, the bottles may be missorted.

Other

*Compostable Plastics: Compostable plastics, such as PLA, are sorted with near infrared (NIR) optical sortation. Any of the major brands of NIR optical sorters can read the unique light wavelength signature of PLA in use today. MRFs (usually into a mixed plastic stream), secondary MRFs, plastic recovery facilities (PRFs) and PET reclaimers sort out PLA. Compostable plastics, though technically recyclable, are not currently commercially recyclable in the U.S. due to the low volumes in the recycling stream and limited markets. However, as volumes grow and markets for recycled PLA develop, the recovery of this material will also grow. At least one secondary MRF located in Los Angeles is proving this concept out, and other PRFs around the country are showing interest in this concept. In Taiwan, the recycling of PLA at a number of PRFs in the country has been ongoing for years. Photo 11: Plastic pellets. Photo credit: Moore Recycling 68 Operation Green Fence For over 20 years, the United States has shipped much of its plastic to China for recycling. In 2013, China launched Operation Green Fence, which implemented strict quality standards on imports of recycled material. It restricted the amount of allowable contaminants, raising the bale specs and cause rejected bales. This led to a temporary glut of plastic materials that MRFs were unable to move and forced MRFs to reduce contamination in their bales. This primarily affected bales of mixed plastic resins.

* Degradable Plastics: Optical sorters cannot tell the difference between a plastic cup with a degradable additive and a traditional plastic cup. Plastics with degradable additives are being sorted into the same bale as traditional plastics, which degrades the quality of the bale.

* Full-Wrap Bottles: Bottles wrapped in a sleeve that made from a different plastic resin than the bottle. In an optical sorter, the bottles may be missorted.

*Calcium carbonate loaded HDPE and PP: A 'sink/float' technology divides HDPE and PP by plastic resin. Adding calcium carbonate into the HDPE or PP, causes the flake to sink instead of float. This reduces the amount of material captured for recycling.

(*Source: Washington Department of Ecology – Northwest Region Report, " Optimizing the Commingled Residential Curbside Recycling Systems in Northwest Washington", 2016* https://fortress.wa.gov/ecy/publications/documents/1607028.pdf)

End notes:

[i] Recycling Partnership, https://recyclingpartnership.org/stateofcurbside/

[ii] American Chemistry Council, https://plastics.americanchemistry.com/Plastics-and-Sustainability.pdf

[iii] United States Environmental Protection Agency, https://www.epa.gov/trash-free-waters/toxicological-threats-plastic

[iv] United States Environmental Protection Agency, https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials#GenerationTrends

[v] IBID

[vi] Montana Department of Environmental Quality, "Integrated Waste Management Plan-2018", https://deq.mt.gov/Portals/112/Land/SolidWaste/Documents/docs/IWMP2018.pdf

[vii] Recycle Montana, https://recyclemontana.org/

[viii] University of California Santa Barbara, https://www.news.ucsb.edu/2019/019424/plastic-s-carbon-footprint

[ix] Montana Department of Environmental Quality, http://deq.mt.gov/Land/recycle/plastics

[x] *EPA, "National Framework for Advancing the U.S. Recycling System", 2019.* https://www.epa.gov/americarecycles/national-framework-advancing-us-recycling-system

[xi] https://www.isri.org/docs/default-source/recycling-analysis-(reports-studies)/economic-impact-2017_updatedfinal.pdf?sfvrsn=4&sfvrsn=4

[xii] *"The Economic and Ecological Impacts of Recycling in Montana", (Source: MT DEQ) https://deq.mt.gov/Portals/112/Land/Recycle/Documents/docs/EEIRinMT.pdf*

[xiii] Montana Department of Environmental Quality, http://deq.mt.gov/Land/recycle/recycling_statistics_page

[xiv] US Environmental Protection Agency, https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials#GenerationTrends

[xv] *Washington Dept. of Ecology, "Optimizing the Commingled Residential Curbside Recycling Systems in Northwest Washington", 2016,* https://fortress.wa.gov/ecy/publications/documents/1607028.pdf

[xvi] American Chemistry Council, https://plastics.americanchemistry.com/Plastics-and-Sustainability.pdf

[xvii] Recycle Montana, https://recyclemontana.org/wp-content/uploads/2018/01/Plastic-Fact-Sheet.pdf

[xviii] Recycling Partnership, https://recyclingpartnership.org/stateofcurbside/

[xix] The Association of Plastics Recyclers, https://plasticsrecycling.org/resources/model-bale-specs

[xx] Greenpath Recovery, https://greenpathrecovery.com/wp-content/uploads/2017/03/Greenpath-Whitepaper-v1.pdf

[xxi] Plastics Technology, https://www.ptonline.com/articles/processing-pcr-how-its-done-at-a-leading-pet-bottle-maker

[xxii] http://www.starmould.com/the-main-methods-of-manufacturing-plastic-products/
https://formlabs.com/blog/guide-to-manufacturing-processes-for-plastics/
https://plastics.americanchemistry.com/Life-Cycle/

[xxiii] US Environmental Protection Agency, https://www.epa.gov/transforming-waste-tool
Smart Cities Council, https://smartcitiescouncil.com/smart-cities-information-center/waste-management
Waste 360, https://www.waste360.com/waste-reduction/10-innovative-and-informative-waste-and-recycling-apps

[xxiv] Recycling Partnership, https://recyclingpartnership.org/circularity/

[xxv] *Washington Dept. of Ecology, "Optimizing the Commingled Residential Curbside Recycling Systems in Northwest Washington", 2016,* https://fortress.wa.gov/ecy/publications/documents/1607028.pdf

[xxvi] RES USA, "Recycling Market Development in the United States",
https://www.oregon.gov/deq/FilterDocs/recMarketDevReport.pdf

[xxvii] https://earth911.com/general/360-recycling-plastic-containers/

[xxviii] Understanding Plastics Recycling, Natalie Rudolph, Raphael Kiesel, Chuachom Aumnate - Hanser Publications, 2017)

[xxix] US *Environmental Protection Agency, "National Framework for Advancing the U.S. Recycling System", 2019,*
https://www.epa.gov/americarecycles/national-framework-advancing-us-recycling-system

[xxx] *IBID*

[xxxi]Montana Department of Environmental Quality, "Integrated Waste Management Plan-2018",
https://deq.mt.gov/Portals/112/Land/SolidWaste/Documents/docs/IWMP2018.pdf

[xxxii] Recycling Partnership, https://recyclingpartnership.org/wp-content/uploads/dlm_uploads/2020/02/2020-State-of-Curbside-Recycling.pdf

[xxxiii] https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials#GenerationTrends

[xxxiv] IBID

[xxxv] IBID

[xxxvi] Montana Department of Environmental Quality, "Integrated Waste Management Plan-2018",
https://deq.mt.gov/Portals/112/Land/SolidWaste/Documents/docs/IWMP2018.pdf

[xxxvii] Flathead County Solid Waste Board, "2018 Solid Waste Report",
https://flathead.mt.gov/waste/downloads.php

[xxxviii] Recycle Montana, https://recyclemontana.org/ & Waste Not Project, https://www.wastenotproject.org/

[xxxix] Montana Dept. of Environmental Quality, http://deq.mt.gov/Land/Recycle/Publications_homepage_new

[xl] Waste, 360, *"Ten steps to a Rural Recycling Strategy", https://www.waste360.com/*

[xli] RES USA web link, EPA tools web link and US Green Building Council web link
[xlii] https://www.colorado.gov/pacific/cdphe/news/nextcycle-grants

[xliii] US Environmental Protection Agency, https://www.epa.gov/transforming-waste-tool/managing-and-transforming-waste-streams-tool

[xliv] Nebraska Recycling Council, "Rural Recycling Cooperative Toolkit", https://nrcne.org/a-rural-cooperative-recycling-toolkit-regional-purchasing-recover-processing-and-market-development/