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Deschutes County Landfill Alternative Analysis

Project Background

JRMA was hired by Deschutes County in October 2023 to complete a Landfill Alternative Analysis. The scope of work was focused on updating certain analyses and findings from the adopted 2019 Solid Waste Management Plan related to Alternative Technologies and Solid Waste Disposal (Chapter 6 of SWMP) and Landfill Disposal Options (Chapter 7 of SWMP). The goal was not to reassess and update all the work from Chapters 6 and 7, rather the focus was to revisit long-haul transport (rail and trucking) and disposal and alternative technology options.

A virtual project kickoff meeting was held on October 12, 2023, and various virtual meetings (e.g., 11/30/23) and email check-ins were held thereafter to review draft work products. An in-person meeting was held at the County offices at the Knott Landfill on March 13, 2024, to review all deliverables and get final direction from County staff.

Project Objective and Approach

JRMA has prepared this technical memorandum which documents long haul and rail transport and disposal options and potentially viable landfill alternatives for consideration by the County. This information will be considered in the context of the County's future decision regarding: landfill siting for a local (within Deschutes County) new landfill. While implementing the project opportunities analyzed in the recently completed Diversion Master Plan and potentially implementing a waste conversion project (processing and treatment of MSW or some segment thereof) will decrease future disposed tons, the County is still faced with a replacement option for the Knott Landfill.

This technical memorandum (TM) incorporates an assessment of options, updating applicable waste stream projections, and a limited financial analysis. Our work was based on the following project assumptions:

1. JRMA and the County reviewed the 2019 Solid Waste Management Plan and any other related documents to confirm the findings and data to update.
2. JRMA updated transfer costs compiled in the 2021 Solid Waste Transfer System Analysis Study – Report Findings (Task 4) document prepared for the County.
3. Research was conducted on long-haul trucking and disposal of municipal solid waste (MSW) using data from other long-haul projects in the Pacific Northwest in terms of publicly known costs, constraints, and opportunities associated with long-haul trucking. For disposal locations, we assumed taking MSW from the Deschutes transfer station(s) to one of three landfills (i.e., WM Columbia Ridge Landfill, Waste Connections Finley Buttes Landfill, and Republic Services Roosevelt Landfill).
4. JRMA compiled data from other rail projects in the Pacific Northwest in terms of publicly known costs, constraints, and opportunities. JRMA also assumed a hypothetical new intermodal facility, however, no conceptual design work was done for an actual intermodal facility. An assumption was made that the intermodal facility would be located

along the rail line that generally runs parallel to Hwy. 97 in an area east of the solar array (east side of highway) approximately halfway between Bend and Redmond.

Summary of Findings

Key findings from our landfill disposal alternatives analysis are as follows:

- The County expects to achieve an overall recovery rate of 45% by 2030. ORS 459A established a wasteshed recovery rate target of 45%.
- All long-haul trucking and rail haul options are far more expensive than the current transfer and disposal costs of $36.50/ton for Deschutes County.
- None of the alternative disposal technologies are viable for the County at this time for reasons documented in **Appendix A, Task 5: Assess Commercially Operating and Viable Conversion Technologies Technical Memorandum.**

Updated Waste Projections

JRMA updated the current waste tonnage received at the Knott Landfill since the completion of the 2019 SWMP and future waste projections. **Table 1** below shows historical waste stream tonnage from 2015 through 2022 with the actual percentage change shown for each year.

Table 1: Deschutes County Historical Waste Stream Tonnage[1]

Year	2015	2016	2017	2018	2019	2020	2021	2022
Annual Waste Disposed (tons)	**143,952**	**161,087**	**182,905**	**179,991**	**183,593**	**197,979**	**220,125**	**223,924**
% Change		**11.9%**	**13.5%**	**-0.7%**	**2.0%**	**7.8%**	**11.2%**	**1.7%**

[1] Disposed tonnage figures are taken from the data request file provided by Deschutes County, "Historical Waste Stream Data." These same disposal figures are used for the waste disposal projection figures below in Table 2 for 2021-2022. Please note in the data set provided by the County there's a slightly different figure of 144,067 shown in 2015 in the "Tonnage to Disposal Operation" table.

Table 2 shows waste disposal, recycled tons, and total waste generation projections through 2030. Assumptions for the projections are included as footnotes to the table. Notably, the County is expected to reach the state recovery rate target of 45% by 2030.

Table 2: Deschutes County Waste Disposal Projections[2]

Year	Population Projections	Per Capita Generated (lbs.)	Waste Generated (tons)	Waste Recycled (tons)	Recovery Rate	Waste Disposed (tons)
2021	202,813	3,051	309,429	86,640	28%	222,789
2022	207,921	3,000	311,882	87,327	28%	224,555
2023	212,495	3,000	318,743	89,248	28%	229,495
2024	217,170	2,950	320,326	89,691	28%	230,635
2025	220,678	2,950	325,500	100,905	31%	224,595

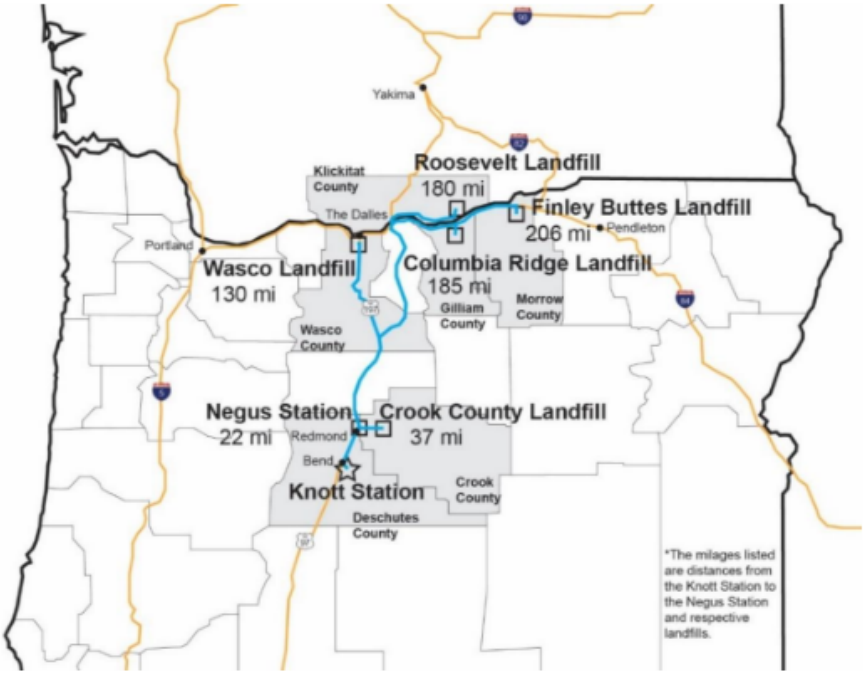
2026	225,092	2,900	326,383	110,970	34%	215,413
2027	229,594	2,900	332,911	123,177	37%	209,734
2028	233,956	2,850	333,387	133,355	40%	200,032
2029	238,167	2,850	339,388	145,937	43%	193,451
2030	240,446	2,800	336,624	151,481	45%	185,143

[2] Population estimates are based on the 2022-2072 Deschutes County Coordinated Population Forecast, with 1.1% AAGR continuing through the fifty-year period.
Waste disposal projections assume an incremental reduction to 2,800 lbs./capita by 2030.

Waste disposal projections assume a flat recovery rate through 2024 until the Recycling Modernization Act takes effect and new composting capacity comes online. Then an incremental increase of the recovery rate to 45% by 2030 is projected.

Long Haul Trucking, Rail Haul, and Landfill Disposal Costs to Select Landfill Facilities

JRMA researched and compiled transfer (via truck) and disposal costs/ton to three landfills (i.e., WM Columbia Ridge Landfill, Waste Connections Finley Buttes Landfill, and Republic Services Roosevelt Landfill) which are shown in the figure below. **Our cost analysis was limited to quantifying transportation expenses and landfill tipping fees and does not include environmental costs such as the impact of greenhouse gas emissions from hauling the waste a further distance than an in-county landfill**. Data was gathered from known public sources of information, interviews with landfill operators, and the use of industry benchmark data (e.g., cost per ton mile) as applicable.



JRMA also researched and compiled rail haul and disposal costs/ton to one viable location, Republic Services Roosevelt Landfill. Roosevelt Landfill is the only rail option due to the rail configuration at the Columbia River where the BNSF line crosses over the UP lines on a bridge, eliminating the other two landfills as options.

Table 3 below shows a comparison of the long-haul trucking and rail haul costs.

Table 3: Comparable Transportation and Disposal Costs[3]

Landfill:	Columbia Ridge Landfill	Finley Buttes Landfill	Roosevelt Landfill	Roosevelt Landfill
Landfill Owner	WM	Waste Connections	Republic	Republic
Destination	Arlington, OR	Boardman, OR	Roosevelt, WA	Roosevelt, WA
Roundtrip Miles (Knott TS)[3]	360	440	356	334
Transport Mode	Truck	Truck	Truck	**Rail[4]**
Ave. Payload (Tons)[5]	25	25	25	28
Transport Cost/ Ton[6]	$52.21	$59.31	$47.75	**$44.85[7]**
Disposal Cost/ Ton[8]	$23.00	$23.00	$23.00	**$24.02**
Transport Cost/ Trip	$1,305.32	$1,482.85	$1,193.79	$1,255.90
Total Transport and Disposal Cost/Ton	$75.21	$82.31	$70.75	**$68.87**

[3] Roundtrip miles are from the Knott Transfer Station. Transportation costs are not differentiated between Negus TS and Knott TS; assume roundtrip miles and times from Knott TS which does slightly overstate the transportation costs as future Negus TS haul is shorter than from Knott TS. The tonnage assumption was 223,924 tons combined for Negus and Knott.

[4] Roosevelt Landfill is the only rail option due to the rail configuration at the Columbia River where the BNSF line crosses over the UP lines on a bridge, eliminating the other two landfills as options.

[5] Payload assumes industry standards for top load.

[6] Transportation costs include an embedded assumption re: a haul cost per hour of $150.

[7] Rail costs do not include costs associated with developing or operating an intermodal yard.

[8] Disposal rates at landfills were established by reviewing public contract rates available. Public contacts reviewed included Clark County, WA; Kitsap County, WA; Metro, OR; Snohomish County, WA; and Thurston County, WA. Variables such as fuel, tipper charges, host fees, Ecology, and DEQ fees were not included due to the variability of contracts.

Please note the rail costs are significantly higher than shown in the table above. These costs don't reflect the actual higher collection costs for commercial (franchise) loads that will have to travel further than they currently do; overall it will cost more money to haul to the intermodal facility then to the Knott Transfer Station.

Further, as the intermodal facility will not be designed to receive self-haul customers, these customers will continue to tip/unload at the Knott Transfer Station. The self-haul loads will then have to be transferred to the intermodal facility, costly double handling of this tonnage which represents about 40% of the total tonnage. The estimated handling and transfer costs for these loads is estimated at $10-15/ton.

Finally, the total transport and disposal cost/ton doesn't include facility capital costs for permitting, designing, and construction. While no rough order of magnitude cost estimates have been prepared for the intermodal facility, some assumptions can be made considering the Negus Transfer Station capital costs. Assuming the Negus cost of $21.3M is adjusted for a future timeframe of 2029 and using debt financing assumptions of 4.75% interest at 20 year depreciation period, the costs would be as follows:

$26M capital costs

Annual depreciation expense of $1.3M (rounded from $1,299,950)

223,924 annual tons at Knott Landfill

Depreciation cost/ton/year: $1,300,000/223924 tons = $5.81/ton

Total Interest paid over 20 years = $14,324,354

Assess Commercially Operating and Viable Conversion Technologies

In updating the SWMP assessment of landfill alternatives, JRMA focused on updating the Waste Conversion Technologies Report (December 14, 2021) prepared by GBB. The GBB Report summarized research and specific information related to technologies that can process municipal solid waste (MSW) and convert the material into a useful by-product. These processes must be proven technologies that are commercially operating and therefore, represent a feasible alternative to reliably transform solid waste into a marketable product to avoid landfill disposal.

The policy driver for the GBB Report and our update was the adopted SWMP policy which stated, "The County should only consider those technologies/vendors that have a proven record of successfully operating a commercial scale facility."

For the JRMA work, a Viable Conversion Technology was defined as follows:

1. Facilities that have successfully operated with MSW for a minimum of three (3) years. They must have accepted and processed a minimum of 500 TPD and 200,000 TPY.
2. Technologies must provide a feasible alternative compared to the cost of landfilling. Specifically, it shall not require a significant increase in the rates charged to residences and businesses excluding vendor's financial subsidies as these are not considered guaranteed.
3. The technology shall significantly reduce by 80% the amount of MSW to be disposed of in a landfill.

The JRMA analysis also assumed that viable alternative technologies could provide a mass and energy balance table for processing MSW based on the existing operating plants and the relative cost advantages of such alternatives.

Specific technologies that were reviewed included those that were in the GBB Report and grouped as follows:

- Organic Waste Management
- Mixed Waste Processing
- Waste to Biofuel and Biochemicals
- Chemical Recycling

Each of these categories included companies and/or jurisdictions that are currently operating facilities to reduce the amount of waste disposed at landfills.

The JRMA scope excluded reviewing any organics management options as these have been addressed in a recently completed “Diversion Master Plan” Report prepared by JRMA.

Further details on the technologies, operations, and companies evaluated can be found in **Appendix A**.

Specific findings detailed in **Appendix A** by technology groupings were as follows:

- ***Summary Mixed Waste Processing Technologies***
  The facilities represented all have similar features and use proven technologies to process waste and recover marketable materials. Such facilities are very capital intensive and most produce refuse-derived fuel (RDF) supplied to an existing industrial facility (e.g., cement kilns) near and capable of using the RDF.

  In each of the projects reviewed the cement plants are located within 50 miles of the processing facility. In Oregon, Ash Grove Cement Company operates the primary kilns located in Portland and near Baker City which are 175 and 200 miles away, respectively.

  There are other financial challenges with these types of operations including commodity price risk, and high costs of disruptions when the facility goes down as all feedstock would have to be landfilled,

- ***Summary Waste Conversion to Biofuels and Biochemical Fuels***
  There is a concerted effort to develop technologies that can convert the energy value of MSW into a valuable resource. These conversion technologies are continuing to make progress. However, at this time there are no technologies that are commercially operating and because they require a large capital investment may not be cost-effective for waste streams comparable to Deschutes County.

  Further, because these technologies are designed to recover and/or produce an alternative fuel using a select portion of the MSW stream, it remains a question whether they can result in reducing the amount to be landfilled by more than 80%.

- ***Summary Chemical Recycling***
  These types of facilities have a similar challenge as waste conversion to biofuels and biochemical fuels with a focus on a smaller portion of the waste stream. Some companies are pursuing facilities to process separated plastics and organics that are

sorted from the MSW stream. Oregon DEQ is currently in the process of completing a detailed waste composition study for the state of Oregon. Using past data DEQ reported that all plastics represent about 12% of the total MSW waste stream. As reported in the Deschutes County SWMP in 2019 total plastics are about 6% while organics make up 43% a larger portion of the waste stream.

Appendix A

Task 5: Assess Commercially Operating and Viable Conversion Technologies

4/2/24

Task 5: Assess Commercially Operating and Viable Conversion Technologies

Purpose

This technical memorandum represents a focused update of the Waste Conversion Technologies Report (December 14, 2021) prepared by GBB. It summarizes research and specific information related to technologies that can process municipal solid waste (MSW) and convert the material into a useful by-product. These processes must be proven technologies that are commercially operating and therefore, represent a feasible alternative to reliably transform solid waste into a marketable product to avoid landfill disposal.

Background

Deschutes County completed a comprehensive Solid Waste Management Plan (SWMP) in 2019. The SWMP examined future landfill life at the Knott Landfill and concluded the landfill had approximately ten years or less of capacity. It was recommended that a new landfill siting process be initiated which was started in 2021.

Table 1 shows the projections for the amount of waste to be disposed of by 2030 to be 185,143 TPY. This represents an expected reduction from the current amount due to new recovery programs and actions resulting from the implementation of Oregon's Recycling Modernization Act.

Table 1: Deschutes County Waste Disposal Projections[1]

Year	Population Projections	Per Capita Generated (lbs.)	Waste Generated (tons)	Waste Recycled (tons)	Recovery Rate	Waste Disposed (tons)
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[1] Population estimates are based on the 2022-2072 Deschutes County Coordinated Population Forecast, with 1.1% AAGR continuing over the fifty-years.

Waste disposal projections assume an incremental reduction to 2,800 lbs./capita by 2030.

Waste disposal projections assume a flat recovery rate through 2024 until the Recycling Modernization Act takes effect and new composting capacity comes online. Then an incremental increase of the recovery rate to 45% by 2030 is projected.

The SWMP also evaluated other long-term solutions for managing and disposing of solid waste when the Knott Landfill closes. This included examining the alternative technologies that were operating in the United States that could provide a reliable option for landfilling. Considering the projected waste to be disposed of any alternative technology should be capable of processing 200,000 TPY of MSW.

After completing a thorough review of facilities employing alternative technologies to convert or transform MSW into a useful by-product such as renewable energy, the County concluded that "markets for renewable energy or fuel by-products were not readily available at the time." The SWMP did acknowledge there were proven technologies that could process the organics portion of the solid waste stream i.e., yard debris, wood, and food waste. However, several mechanical and chemical processes aimed at converting MSW to renewable energy were still under development. As a result, the County adopted Recommendation 6.1 stating "*The County should continue to monitor and assess the status and feasibility of alternative Technologies as a part of the Solid Waste system in three to five years."*

The objective for the County would be to develop a technology that would process solid waste and result in mitigating the future need for a new landfill in the County. However, the SWMP recognized that several technologies were still in the development stages. Therefore, in the SWMP a policy was adopted stating "*The County should only consider those technologies/vendors that have a proven record of successfully operating a commercial scale facility."*

For this research, a Viable Conversion Technology is defined as follows:

1. Facilities that have successfully operated with MSW for a minimum of three (3) years. They must have accepted and processed a minimum of 500 TPD and 200,000 TPY.
2. Technologies must provide a feasible alternative compared to the cost of landfilling. Specifically, it shall not require a significant increase in the rates charged to residences and businesses excluding vendor's financial subsidies as these are not considered guaranteed.
3. The technology shall significantly reduce by 80% the amount of MSW to be disposed of in a landfill.

It is also assumed that viable alternative technologies can provide a mass and energy balance table for processing MSW based on the existing operating plants and the relative cost advantages of such alternatives.

In 2021 the County engaged GBB, a consulting company that specializes in solid waste management options, to conduct a review of the status of alternative technologies.

In this report, GBB selected facilities within the following technology groups for inclusion in the review.

- Organic Waste Management
- Mixed Waste Processing
- Waste to Biofuel and Biochemicals

- Chemical Recycling

Each of these categories included companies and/or jurisdictions that are currently operating facilities to reduce the amount of waste disposed at landfills. The results of the study determined that technologies were not viable for the County at the time, as markets for by-products were not readily available in the County.

Technologies to be Assessed

The scope of this "Landfill Alternative Analysis" study is to review the GBB report and other publicly available documents to examine the status of these technologies and determine if they are commercially operating and potentially viable for implementation in Deschutes County. Cost information is provided if available related to the cost of the technology and resulting tip fees or rates to the supporting jurisdiction. The scope excludes reviewing any organics management options as these have been addressed in a recently completed "Diversion Master Plan" Report prepared by JRMA.

The categories of technologies reviewed in the GBB report are as follows:

1. Mixed Waste Processing Technologies – These technologies are designed to process MSW to recover recyclable commodities and produce usable fuel by-products for customers.

   Specific facilities:

   a. Entsorga West Virginia
   b. RePower South
   c. Wasatch Integrated Waste Management District, Davis County, Utah
   d. Continuus Materials
   e. Georgia Pacific
   f. New facilities that are commercially operating are not included in the previous GBB report.
2. Waste Conversion to Biofuels and Biochemical Fuels – Similar to the previous category these technologies process and convert MSW into an alternative fuel to replace gasoline and/or diesel.

   Specific facilities:

   a. Fulcrum BioEnergy
   b. UBQ Materials
   c. Velocycs
   d. Red Rock Biofuels
   e. New facilities that are commercially operating
      Note: Any new technologies may include updates of Plasma Arc or other pyrolysis or gasification projects
3. Chemical Recycling /Transformation

   Specific facilities:

   a. Agilyx
   b. Brightmark

Facilities that meet the "proven technology" thresholds of at least three years of commercial operation and processing 500 TPD and 200,000 TPY will be further evaluated from a feasibility

perspective if financial information is readily available. The feasibility analysis will focus on financial viability and associated risk to ratepayers.

Alternative Technology Update

Mixed Waste Processing Technologies

Mixed waste processing embodies a variety of systems and/or facilities that accept MSW collected from both residences and businesses to recover materials and create a usable by-product. The MSW would typically be transported to a landfill for disposal.

MSW received is processed over an equipment line using proven technologies and may include proprietary technologies to sort out high-value recyclable commodities as well as undesirable items that impact the quality of residual materials to be marketed as solid fuel feedstock or perhaps usable building material.

Entsorga West Virgina

The Berkeley County Solid Waste Authority in Martinsburg, WV has committed to deliver MSW to the Entsorga processing facility. The facility commenced commercial operations in 2019 and reportedly can process up to 120,000 TPY to convert MSW into solid fuel suitable for industrial processes such as cement kilns, steam boilers, and electric power plants. The facility utilizes the technology provided by Entsorgafin SpA, an Italian manufacturer of waste processing equipment. It is designed to recover high-grade recyclables and convert up to 75% of the inbound material into solid fuel to be used as a substitute for coal and natural gas in a local cement kiln operated by Argos, USA, a leading manufacturer of cement. The Argos cement kilns are located less than 5 miles from the plant.

The County of Berkeley and neighboring jurisdictions represent the primary source of MSW processed at the plant. The Entsorga plant is built on land owned by the Berkeley Authority. As stated in the GBB Report the Apple Valley Waste Company that collects waste from residences and businesses in the region is charged a tip fee of $50 per ton based on the Waste Supply Agreement. In the initial Limited Offering Memorandum (LOM) a financial pro forma showed that tip fees were assumed to generate roughly 66% of the total $7.8M operating expenses.

The remaining operating expenses for the plant were projected to be offset by the sale of recyclable materials and the sale of fuel for cement kilns. Based on the financial information provided in the GBB report, revenues from the sale of fuel represent 17% of total revenues. Likewise, revenues from the sale of recyclables are expected to generate an additional 17% of total revenues based on commodity prices in 2018. Thus, the financial viability of the facility is highly dependent on revenues generated from the sale of by-products of the system.

The plant has encountered financial struggles in recent years partially due to an interruption in demand for fuel at the Argos Cement plant during the pandemic and periods of scheduled maintenance. A published article by Waste Dive on July 1, 2022, reported that Renovare Environmental, owner of the facility, was on the brink of failure with some possibility of being saved by an acquisition in 2022. However, the acquisition did not materialize, and as a result of the ownership default the Authority now owns the plant and has assumed the $25M debt. In speaking with the Authority, they have issued a request for proposals and are currently reviewing several companies interested in operating the plant. The Authority can still deliver alternative fuel for the kilns at the Argos cement plant. While the pant is not operating, waste is

disposed of at the Waste Management LCS Services Landfill located about 12 miles from the Martinsburg City Center.

RePower South

GBB reported that RePower South ("RePower") operates two facilities that convert MSW into alternative fuel. The first facility is located in Berkeley County, SC, and the second is in Montgomery, Alabama. Both facilities receive MSW from the local jurisdictions to be processed using state-of-the-art materials recovery equipment to recover marketable recyclable materials such as paper, OCC, plastics (PETE and HDPE) aluminum, and ferrous metals. The remaining materials are then made into a renewable fuel for kilns or boilers for industrial customers as an alternative to fossil fuels.

The Montgomery, Alabama plant has encountered financial challenges since it was originally constructed in 2014. However, RePower South, which started operating the plant in 2019, continues to process MSW from the City of Montogomery. When market prices for commodities crashed the City provided subsidies to Repower to continue operations. RePower has been working with the City, which stills hold the bonds on the plant, to implement a plan to continue the operation. Repower recovers materials for sale and transports the fuel by-product to an Argos Cement plant located about 50 miles from Montgomery. The City is motivated to reduce waste disposed at its landfill and extend the site life. Tip fees at the landfill are $42 per ton.

Both RePower facilities operate state-of-the-art MRFs that recover materials for sale to markets. The revenue from the sale of recyclables contributes to maintaining financial viability. The impact on tip fees and ratepayers relies on the operating contract between the vendor and jurisdiction delivering MSW to the plant. The sale of commodities and fuel offset operating expenses. Tip fees range from $42 to $57 per ton. The plants are dependent on the availability of markets for fuels that are in reasonable proximity to the jurisdictions generating MSW.

To learn more about RePower South please visit Home - RePower South Trash Isn't Garbage. Let's recycle more and landfill less.

Wasatch Integrated Waste Management District (WIWMD), Davis County, UT

In 2020 WIWMD constructed an MRF designed to process MSW to recover recycled commodities and produce a fuel by-product. The fuel is transported to the Hocim Devils Slide Cement Plant located 27 miles from the MRF in Layton, UT. The MRF is designed to process 400 TPD. The plant was working successfully but in 2022 WIWMD converted the MRF to process commingled single stream to increase recycling rates in response to change in collection services. The was also an increase in demand from neighboring jurisdictions to process commingled single-stream materials. Recycled materials are marketed in the greater Salt Lake City area.

A fuel product is still being produced from the MRF residue and transported as needed to the cement plant. But similar to other projects discussed in this category the Hocim Cement Company experiences shutdowns for maintenance that last four to six weeks. During this period residue is disposed in WIWMD's landfill. The tip fees at the landfill are $42 per ton.

For more information see Material Recovery and Transfer Facility - Wasatch Integrated Waste Management District.

Continuus Materials

Continuus Materials ("Continuus") has developed a technology to produce a construction roofing board from waste fiber and plastic extracted from MSW. These materials are generally considered non-recyclable via traditional MRFs and, if found in a single-stream recycling feedstock, are considered contaminants.

As reported in the GBB report, Continuus operates a pilot project in Des Moines, Iowa that makes "Everboard" a durable roof cover board made from plastic and fiber from MSW processing facilities. However, at this time there are no new plants in operation. The company website notes it's jointly owned by WM and Tailwater Capital.

In its commercial offerings to communities, Continuus couples a mixed waste processing system in front of its construction board manufacturing element to provide a complete municipal waste management system. The facilities offered by Continuus are based upon 400,000 TPY of inbound municipal solid waste.

To learn more about Continuus Materials please visit About – Continuus Materials.

Georgia Pacific

Georgia Pacific (GP) is one of the world's largest manufacturers of tissue, pulp, paper, packaging, and building products. Its recycling division, GP Recycling, is a leading trader of recycled fiber, managing over 100,000 tons per week.

GP is developing a proprietary waste processing and fiber recovery technology called Juno. The technology is a variant of mixed waste processing. The unique aspect of the Juno system is its focus on recovering low-value fibers via an autoclave technology as a recycled fiber pulp. A technology pilot facility is planned at GP's containerboard mill in Toledo, Oregon. As of June 2021, mechanical construction had been completed, and the facility was in the commission phase.

Once ready for commercial deployment, GP reportedly plans to offer communities a full-service mixed waste processing solution. Traditional recovered recyclables can be brokered through GP – Recycling while recovered fiber can be directed to GP mills or sold into the commercial pulp market.

GP Recycling Juno is actively pursuing new projects in the United States as captured in the Waste 360 article link below:

ACUA Announces Qualified Vendors for Solid Waste Conversion Facility Development (waste360.com)

To learn more about GP Recycling Juno please see their website at Home - Juno | Georgia-Pacific (gpjuno.com).

Summary Mixed Waste Processing Technologies

The facilities represented all have similar features and use proven technologies to process waste and recover marketable materials. To further advance the desire to reduce dependency on landfilling they produce a refused derived fuel (RDF) to replace or augment traditional fossil fuels at existing plants. Supplying alternative fuel to existing industrial facilities capable of using the RDF reduces the required capital investment to build the processing facility, whereas a typical Energy from Waste Facilities (EfWF) must build dedicated boilers to generate steam and

make electricity that is very capital cost intensive. An example of this is the Covanta EfWf in Salem, Oregon.

The majority of the projects listed supply RDF to burn in cement kilns. Certain industrial boilers may be capable of accepting RDF, but it does require the user to be located in proximity to the MSW processing facility. In each of the projects listed the cement plants are located within 50 miles of the processing facility. In Oregon, Ash Grove Cement Company operates the primary kilns located in Portland and near Baker City which are 175 and 200 miles away, respectively. Also, the RDF fuel price must be competitive with fossil fuels.

The ash from cement kilns is regulated on a state-by-state basis. In Oregon, the ash is special waste and can be reused or disposed of in a subtitled D landfill. How the state of Oregon would regulate ash if RDF is used as a supplemental fuel for cement kilns in Oregon is not known.

Financial viability represents the primary risk to a jurisdiction wishing to pursue this alternative. In the case of the Entsorga plant in Martinsburg, WV, and the RePower plant in Montgomery, AL, both have experienced disruptions impacting financial reliability. This includes contractual issues with the bondholders or unforeseen interruptions in the energy user. When the cement kilns are not operating the refuse fuel must be landfilled. In each of the projects listed the backup landfill is located within 30 miles of the host jurisdiction. Also, the disposal fee appears to be competitive with the processing plant provided revenues are adequate to offset operating expenses. When these revenue sources are disrupted, it may require increases in the rates.

The MSW processing plant also needs to be located in reasonable proximity to recycled material markets. The further these markets are from the processing plant the higher transportation cost. Another financial risk is the exposure to recyclable commodity prices. Each of the facilities relies on the sale of commodities to offset operating expenses. When market prices fall the facilities must raise revenue from ratepayers or obtain a subsidy from the local jurisdiction to pay expenses. Of course, the specific details of these market risks will vary based on contractual conditions, but local jurisdictions must plan for such events.

In the projects reviewed, it appears revenues from the sales of recovered materials and fuel represent a sizable portion of the plant's operating cost ranging from 34% for the Entsorga plant to 64% for the RePower facility in Berkeley County, SC. Thus, in the case of unforeseen interruptions for any length of time jurisdictions will need to increase either tip fees or perhaps provide some sort of subsidy.

Waste Conversion to Biofuels and Biochemical Fuels

Waste to Biofuels and Biochemical projects typically include a front-end mixed waste processing element to prepare the feedstock for its proprietary backend technology. This technology differs from the previous category as these plants are designed to produce byproducts that can be converted to biofuel. The biofuel conversion plant is a proprietary component of each system.

Fulcrum BioEnergy

Fulcrum BioEnergy (“Fulcrum”) has been developing its Sierra waste-to-biofuel project outside of Reno, Nevada for several years. The project is designed to process MSW to produce a feedstock for its biorefinery to make syncrude oil. The syncrude can then be upgraded into renewable transportation fuels such as diesel, jet fuel, and gasoline at existing refining plants. The MSW processing plant prepares the feedstock by removing high-valued commodities, ferrous metals, aluminum, and inerts. The feedstock is then sent to the biorefinery. Since July

2021 when the primary construction of the biorefinery was completed. Fulcrum has continued efforts to complete startup and commissioning activities. Based on the latest information the biorefinery plant is anticipated to be commercially operating by the 2nd quarter of 2024.

Fulcrum's Biorefinery is designed to convert 175,000 dry tons of processed MSW into 11 million gallons of zero-carbon syncrude. Assuming that MSW averages roughly 30% moisture, about 600,000 tons would need to be processed to achieve the number of dry tons required for the bioconversion plant after inerts, metals, and other undesirable materials are removed.

Fulcrum does have plans to develop more projects. These plants are expected to be located in larger populated areas to ensure a sufficient supply of waste to support the facilities. It is also desirable to be located in proximity to markets for fuel products such as large regional (hub) airports.

The Sierra Biorefinery project has received several hundred million dollars of funding from capital investors and grants. To date, there have been no published costs to build and operate the biorefinery plants. This is one of several projects designed to create an alternative low-carbon fuel for transportation, notably for renewable aviation fuel. On the Fulcrum website, they have announced plans to build refineries including Centerpoint in Gary, Indiana., Trinity Fuels on the Texas Gulf Coast and NorthPoint in Cheshire, England. Each of these plants is expected to process approximately 700,000 TPY of MSW and produce 31M gallons of synfuel. The estimated cost to build the plants is approximately $800M.

To learn more about Fulcrum please visit their website at Home | Fulcrum BioEnergy (fulcrum-bioenergy.com).

UBQ Materials

UBQ Materials ("UBQ") is an Israeli company that has developed an innovative technology for converting MSW into a thermoplastic resin suitable for use as an alternative to virgin plastic resins. The plastic resin can then be used to manufacture thermoset plastic products. Over the past few years, UBQ has continued to expand the sustainable products it can produce with manufactured resin. This includes building materials such as flooring, plastic pipes, and a variety of consumer-durable products. UBQ's only production facility is in Israel but seeks to develop facilities in the United States.

Velocycs

Velocys is a United Kingdom-based technology company focused on the waste-to-biofuels sector. It is developing a project in Immingham, UK, to convert municipal solid waste into renewable jet fuel in partnership with British Airways. The project will be designed to produce 20M gallons of sustainable aviation fuel (SAF) per year from MSW. The project is still in its preliminary stages of development, with a projected financial closing in 2022.

Velocycs also announced its plans to develop the Bayou Fuels Biorefinery in Natchez, MS. It plans to use a combination of biomass or woody waste and other forms of biogenic feedstock to produce SAF. GBB reported the project was expected to close on financing in 2022.

The company's website shows the intent to develop a third project in the UK using a different feedstock. As of this report, none of the plants are commercially operating.

Red Rock Biofuels

Red Rock Biofuels (“Red Rock”) is developing a 25 million gallon per year wood waste for a biofuels project near Lakeview, Oregon. The innovative technology plans to convert woody biomass materials from slash generated from logging and forest thinning projects into a jet-grade liquid fuel to replace fossil fuels used in aviation fleets. The Oregonian reported on January 7, 2023, that the Red Rock Biofuels project was headed for foreclosure after backers failed to make principal and interest payments on some $300M in debt. Project supporters are continuing to pursue investors to fund future capital for completing the project. However, the technology focuses on woody waste materials representing a small portion of the MSW waste stream.

Chemical Recycling

Chemical recycling is a term applied to a broad range of technologies that attempt to recycle plastic waste by converting it into a liquid form for use as a fuel or chemical feedstock. This is usually accomplished through a thermochemical process known as pyrolysis to produce a synthetic oil. Synthetic oil could be used for its energy value in industrial combustion applications such as boilers and kilns. By using proprietary upgrading technology, it can be converted into a higher-value chemical feedstock. The latter pathway potentially leads to infinite circular reuse of the chemical molecules.

Agilyx

Agilyx is arguably the most mature and advanced of the chemical recycling companies. Its first production facility, located in Tigard, Oregon began operations in 2008. In 2018 it was retrofitted with the company’s latest technology to convert polystyrene waste back into a mono-styrene molecule, a chemical building block used to produce styrene-based plastics. The facility is. capable of processing 10 TPD of plastic waste. In July 2021, Agilyx announced its retrofitted Tigard facility had accumulated over 16,000 hours of commercial operations.

Agilyx continues to expand its plastic recycling ventures. On their website, they announced the launch of a joint venture with ExxonMobil to form a consortium-based plastic feedstock management company.

Brightmark

Brightmark is a private equity-backed project development company focused on chemical recycling and anaerobic digestion. In the chemical recycling sector, Brightmark is developing a 100,000-ton-per-year facility in Ashley, Indiana to convert plastic waste into low-sulfur diesel fuel. The facility is under construction with a projected commissioning date of late 2021. An article from Inside Climate News, June 16, 2023, stated the plant is still in startup mode. It is also reported the facility is mired in controversy regarding environmental health and safety concerns by former employees after a release of flammable vapors resulting in a fire.

Brightmark planned on developing a second facility to be constructed in Macon, Georgia, with a projected capacity of 400,000 TPY of plastic waste. However, in April 2022 it was reported in Reuters the project was cancelled.

Brightmark continues to pursue projects to recycle plastic resin to produce low-sulfur fuel and opportunities to manage organics.

For more information on Brightmark please visit their website at Reimagine Waste | Brightmark | Brightmark.

Encina – Point Township, PA

In April 2022 Encina announced its plan to build a manufacturing plant in Northumberland County in central Pennsylvania. The company could invest up to $1.1 billion to convert post-consumer waste materials (plastics) into a feedstock that can be used to manufacture thousands of new products. The feedstock is expected to be recovered by processing 450,000 tons of MSW that would otherwise be landfilled or managed by incineration.

The manufacturing plant will use a catalytic conversion process to extract benzene, toluene, xylenes, and propylene from end-of-life plastics. Once these molecules are extracted the by-products can be used to produce a variety of products replacing natural resources. The plastics feedstock would be recovered from multiple materials recovery facility(s). The plant is located less than 150 miles from several large municipalities such as Philadelphia and New York City and would have an on-site PRF to prepare the material for the catalytic conversion process.

Reportedly this plant is still in its pilot plant status.

Summary Waste Conversion to Biofuels and Biochemical Fuels

There continues to be a concerted effort to develop technology to convert MSW into usable products. Most efforts have looked to find a way to convert the organics into usable fuel as opposed to burning directly in mass burns incinerators or RDF in dedicated boilers. Although these mass burn or RDF technologies are most proven with many plants operating throughout the world and the United States, these facilities are very capital intensive and typically are not environmentally acceptable. Thus, there is a concerted effort to develop technologies that can convert the energy value of MSW into a valuable resource. These conversion technologies are continuing to make progress. However, at this time there are no technologies that are commercially operating and because they require a large capital investment may not be cost-effective for waste streams comparable to Deschutes County.

Likewise, some companies are pursuing facilities to process separated plastics and organics that are sorted from the MSW stream. However, these technologies are designed to manage only a portion of the total waste stream. Oregon DEQ is currently in the process of completing a detailed waste composition study for the state of Oregon. Using past data DEQ reported that all plastics represent about 12% of the total MSW waste stream. As reported in the Deschutes County SWMP in 2019 total plastics are about 6% while organics make up 43% a larger portion of the waste stream. For these reasons, the County is developing a comprehensive organics management plan using proven technologies and marketing materials locally.

Finally, because these technologies are designed to recover and/or produce an alternative fuel using a select portion of the MSW stream, it remains a question whether they can result in reducing the amount to be landfilled by more than 80%.