CITY OF TUCSON
ENVIRONMENTAL & GENERAL SERVICES

Zero Waste Roadmap

May 2023

TUCSON ZERO WASTE

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Acronyms and Abbreviations

ASP
aerated static pile

C&D
construction and demolition

City
City of Tucson

EGSD
Environmental and General Services Department

EPA
U.S. Environmental Protection Agency

HHW
household hazardous waste

LRSC
Los Reales Sustainability Campus

MRF
Materials Recovery Facility

MSW
municipal solid waste

MWP
mixed waste processing

PAYT
pay-as-you-throw

RFI
Request for Information

RFP
Request for Proposals

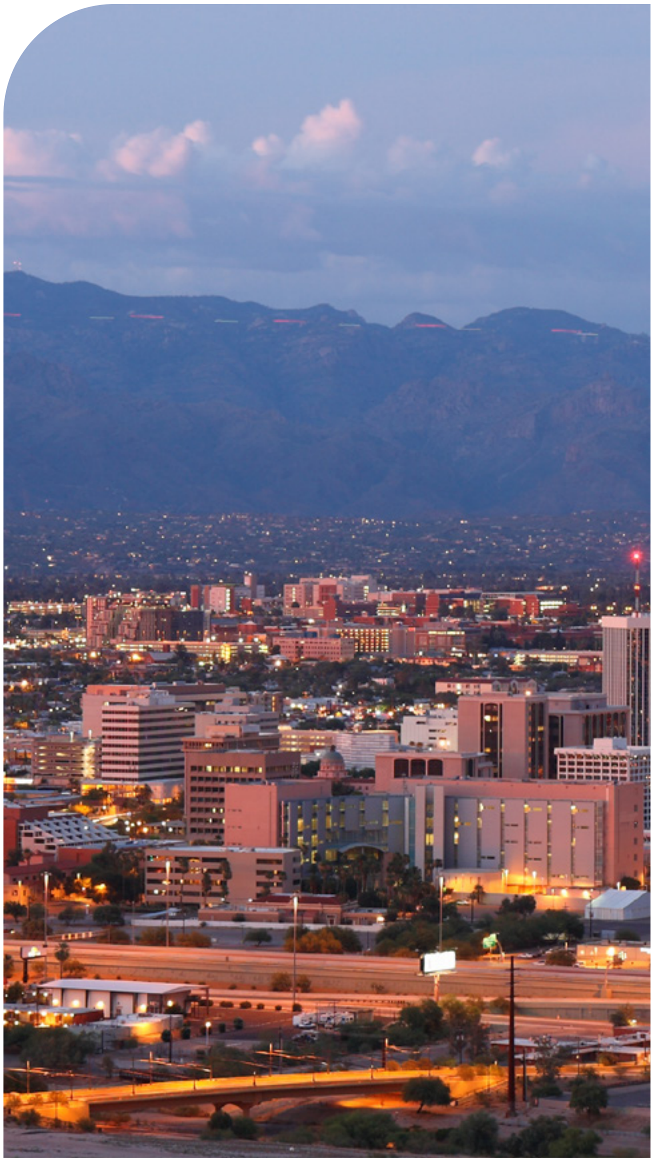
Roadmap
Zero Waste Roadmap

WTE
waste-to-energy

EXECUTIVE SUMMARY

Zero Waste Roadmap for City of Tucson

The Tucson Mayor and Council declared a Climate Emergency in September 2020. The Climate Emergency set clear goals to address the emergency and the concerns specifically in the City of Tucson (City).



Two of those goals are related to waste diversion:

Attain 50 percent waste diversion by 2030, and

Achieve zero waste by 2050.

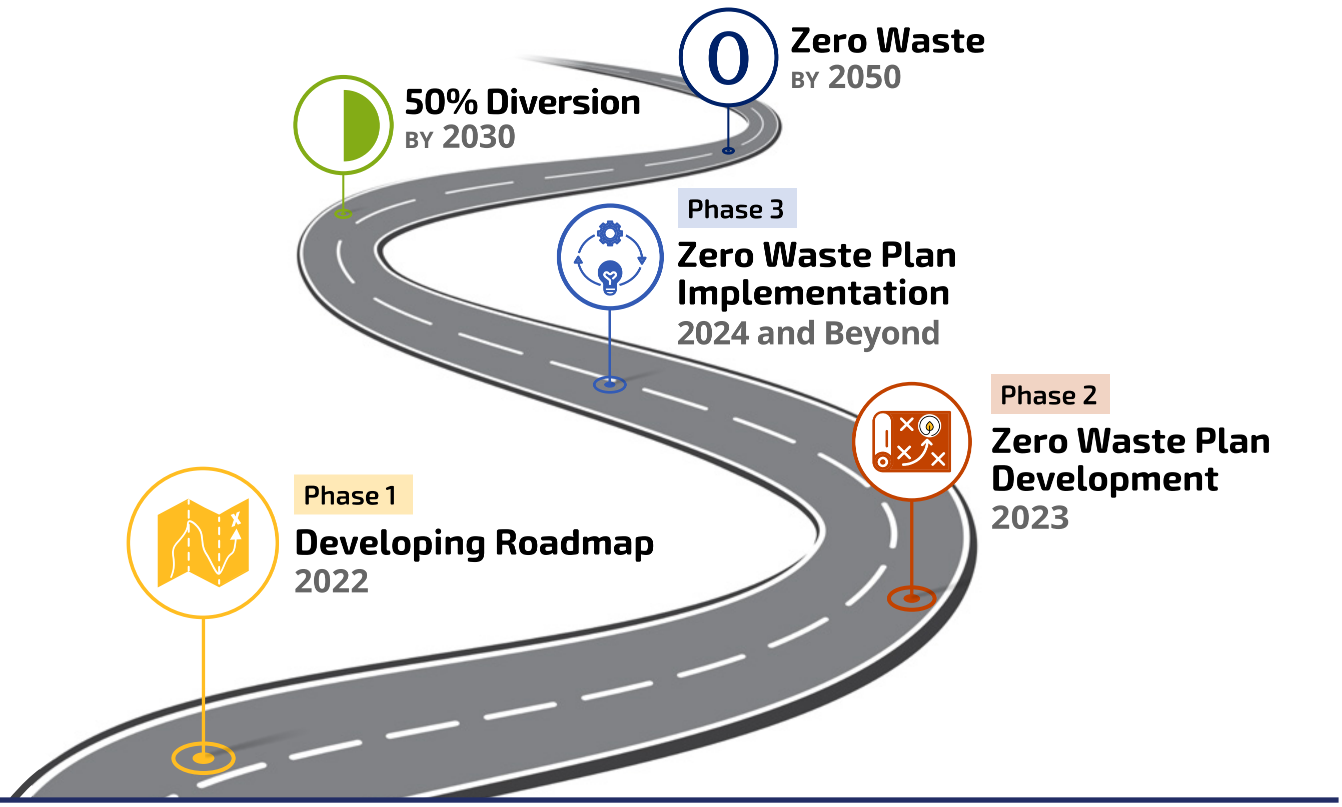
To meet these goals, the City's Environmental and General Services Department (EGSD) is implementing many tasks to move Tucson closer to zero waste and to create a framework and plan for the next steps to achieve zero waste. This Zero Waste Roadmap (Roadmap) is a high-level planning document that outlines critical tasks and identifies a path toward zero waste for Tucson, with a specific focus on the services provided by EGSD.

The Roadmap to zero waste:

- Describes the current landscape of solid waste management systems in the City and its facilities,
- Gathers information on what zero waste would look like in Tucson, and
- Identifies clear potential strategies to support that vision, including:
  - Opportunities for immediate actions that ESGD can take to reduce waste, such as improving the brush and bulky service, increasing recycling education, and expanding organic waste collection and processing, and
  - Potential routes for EGSD to incorporate additional aspects of waste diversion, waste reduction, new and innovative technology, near-term solutions, development options, and public engagement going forward.

The Roadmap is intended to be the first step (see Figure ES-1) toward a Zero Waste Plan, establishing the specific means by which the City will reach its 2030 and 2050 goals. The Zero Waste Plan will include key milestones, important partnerships, community inputs, and long-term planning for the City.

Figure ES-1. Road to Zero Waste by 2050

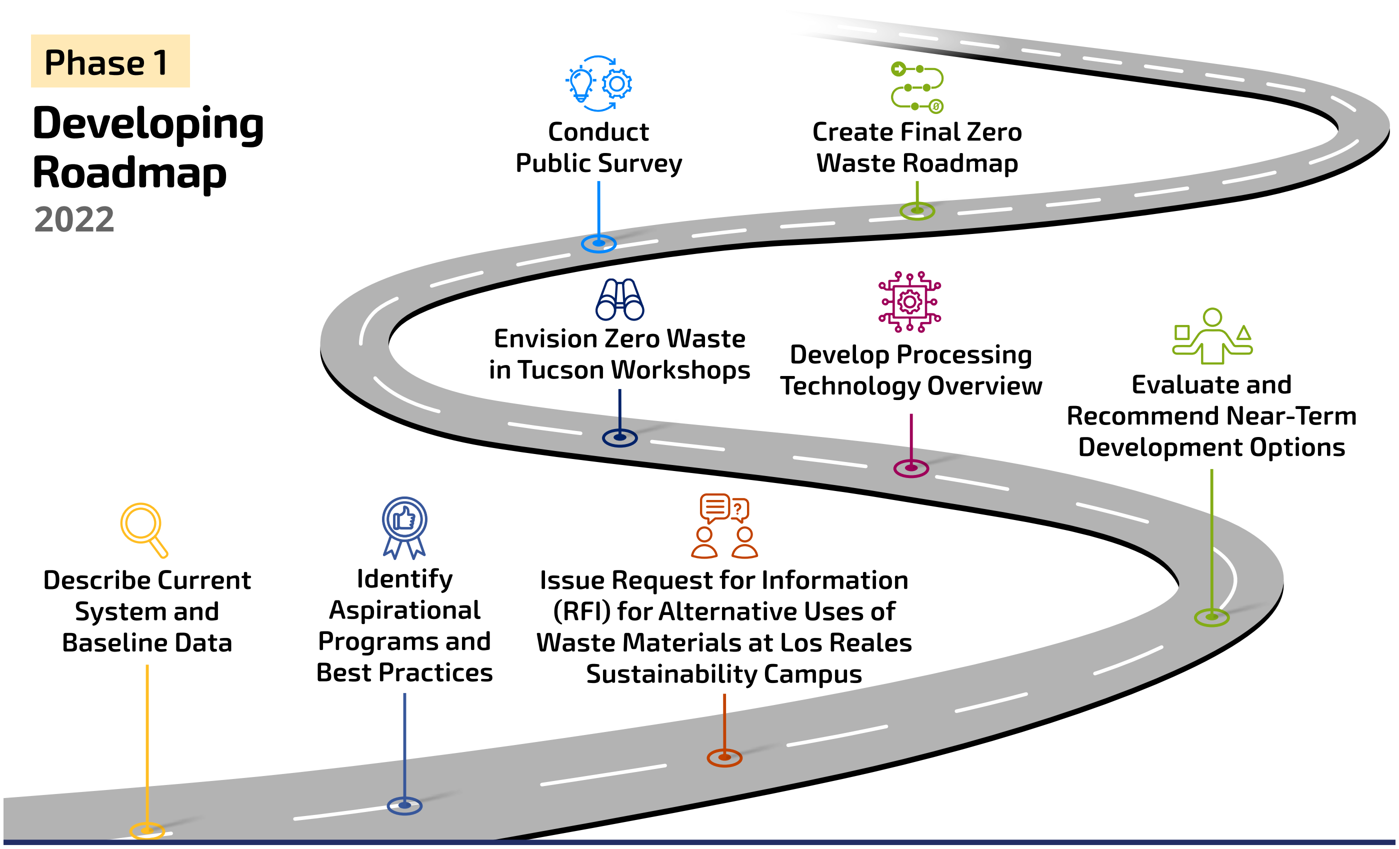


1

Summary of Work Completed

As mentioned previously, the Roadmap is just one step toward the Zero Waste Plan and the 2030 and 2050 goals; however, this step included seven supporting tasks along the way to lay the foundation for the eighth task, the final Roadmap (see Figure 1-1). These tasks are highlighted below and described in more detail throughout. References to the full reports and other summary documents are provided in the footnotes for further information.

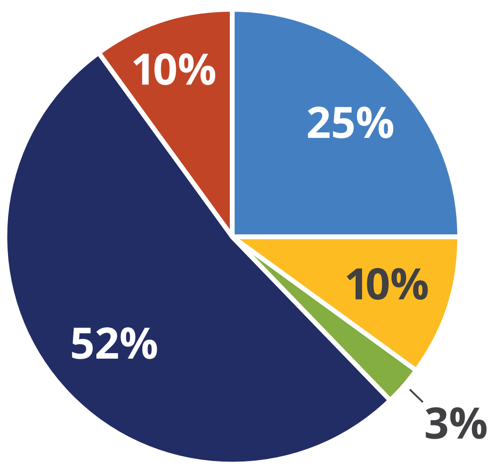
Figure 1-1. Zero Waste Roadmap development process



1.1

Background and Current Conditions

The landfill at the Los Reales Sustainability Campus (LRSC) managed 764,000 tons of waste in 2021. Of this, 38 percent was collected by the City's collection services. **The materials were estimated to be from the following sources:**



- Collected by the City's residential collection service (25%)
- Collected by the City's commercial collection service (10%)
- Collected by City departments (3%)
- Hauled to the landfill by commercial haulers (52%)
- Hauled to the landfill by landscapers, small haulers, and public self-haul/daily users (10%)

Currently, the waste streams that are either collected by the City or received at a City facility and are diverted from the landfill include recyclables sent to the Republic Services Materials Recovery Facility (MRF), scrap metal, household hazardous waste (HHW), City glass recycling, and compostable materials from the FoodCycle program. Other haulers also provide commercial collection services within and outside of the City limits and residential collection services outside of City limits. All commercial haulers, defined as anyone who operates four or more front load, rear load, side load, or roll off collection vehicles within the City at any time, are required to have a permit from the City for each collection vehicle. Haulers operating outside of City limits and hauling waste to the landfill are not required to report any vehicle or collection data to the City.

The City's overall diversion rate (the amount of waste not sent to the landfill) in 2021 was approximately 4 percent, based on quantities collected by the City or received at LRSC. This includes residential and commercial waste and recycling, City department waste and recycling, scrap metal, HHW, glass, and FoodCycle compostable items. Focusing strictly on the City's collection services, the collections diversion rate for 2021 was approximately 9 percent. This includes trash and recycling collected by the City from residential, commercial, and City department accounts.

In 2021, the City recycled and diverted the following materials in addition to the curbside program:

1,700 tons of glass were recycled through the City's glass collection program.

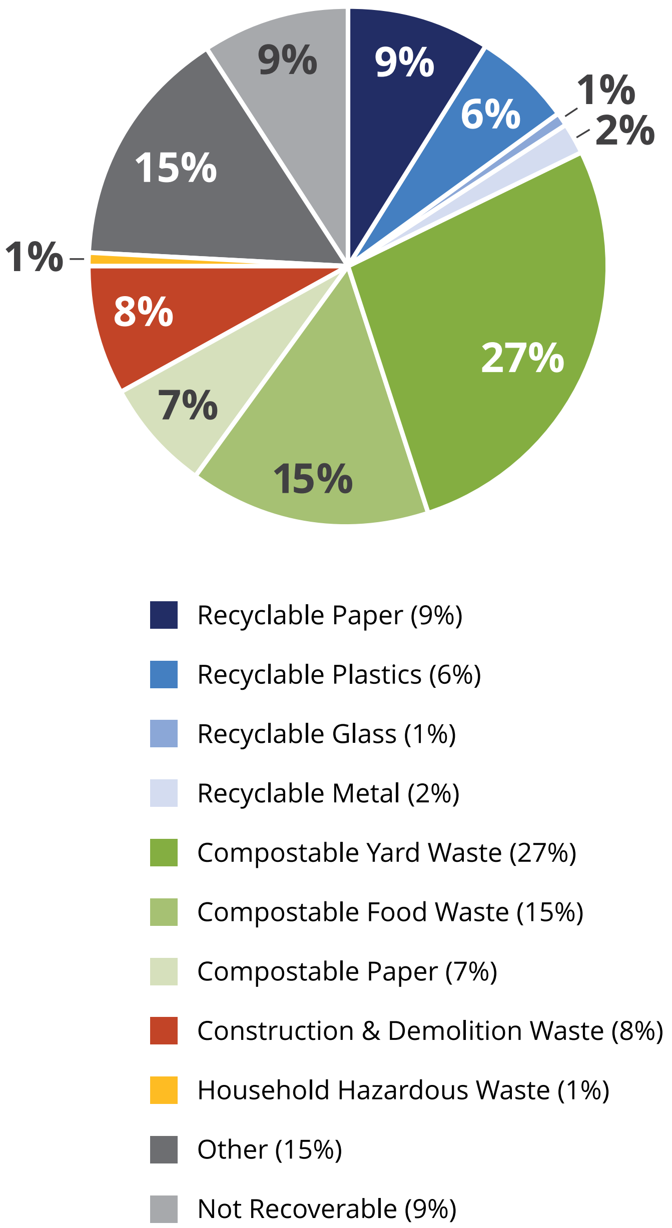
261 tons of material were composted through the FoodCycle pilot program.

518 tons of HHW were collected.

29,620 tons of City-collected materials were diverted to the MRF.

Audits performed at the MRF in 2021 indicated a contamination rate of 29 percent in the material received from City collection vehicles. The MRF charges the City an excess contamination charge (also known as a residue charge) of $1 per ton for each percent above 18.7 percent contamination. The excess contamination charge ultimately cost the City $314,085 in 2021.

Estimated Waste Composition



The City referenced several waste characterization studies to determine the likely composition of materials remaining in the waste that could be recycled or diverted.[1] Based on this information, **40 to 50 percent of waste could be composted and 10 to 20 percent of waste could be recycled**.

The City's 2021 Climate Action Community Survey indicated that **88.1 percent of respondents supported or strongly supported increasing recycling compliance and landfill waste diversion.** The City continues to value feedback and input from its residents in guiding zero waste planning.

[1] *City of Tucson Waste Diversion Plan and Roadmap (prepared by Cascadia Consulting Group, January 2014), City of Phoenix Waste Characterization Study (prepared by Cascadia Consulting Group, September 2015), and City of Phoenix Residential Waste Characterization Study: 2017–2018 Final Report (prepared by Cascadia Consulting Group, May 2018).*

Understanding and quantifying the current conditions in the City's waste management systems was a critical first step and provided the building blocks for additional study reports, research, and community engagement. This information allows the City to understand the existing system better and identify what is next in its Roadmap to zero waste. It also highlights the need for the Zero Waste Plan to comprehensively consider all waste generation and diversion activities in the City, including private-sector activities. More detailed information about the City's solid waste management system can be found in the Current Conditions Assessment in *Appendix A*.

The definition of "zero waste" has many variations across communities, agencies, and industry. Definitions may include quantitative goals for the percentage of waste diverted from disposal, or they may include waste management hierarchies and guiding principles. For Tucson, the definition should be developed in accordance with the goals of the City's climate action and adaption plan, taking into account the local environment, conditions, and materials, in order to set a goal that is sustainable and beneficial for the local community. As part of the public outreach conducted during the development of a Zero Waste Plan, the City will seek input from the local community and stakeholders before adopting a formal definition of what "zero waste" means to Tucson.

1.2

Best Practices of Aspirational Zero Waste Programs

Many communities in North America have innovative features as part of their waste management programs and services. The City selected five communities for review in the western United States with some similarities to Tucson that have implemented best practices for zero waste that may be of interest to the City: Austin, Texas; Denver, Colorado; Phoenix, Arizona; Portland, Oregon; and Seattle, Washington.

Some of the reviewed programs and legislation have been successful in helping the communities reduce waste, and the recommendations below were based on the potential to achieve similar success in Tucson. Because no program can be 100 percent replicated, Tucson can learn from the successes and challenges in these communities. While all of these communities have different strengths, it will ultimately be up to stakeholders to make the best decisions for Tucson.

Included here are the top three types of programs that were successfully implemented by all five cities reviewed. The full Aspirational Programs and Best Practices report can be found in *Appendix B*.

Expand organics composting efforts

Expanding organics composting efforts has the potential for substantial waste diversion. The City of Portland implemented a successful organics collection program, and composting accounted for 74 percent of the community’s diverted waste. Organics composting presents an opportunity for significant waste reduction in Tucson, and many existing programs can serve as examples for guidance and future implementation.

Decrease recycling contamination

The City could prioritize decreasing recycling contamination, which has been a costly issue in recent years. Public education campaigns have successfully reduced contamination, including Tucson's "Feet on the Street" pilot program. The City of Phoenix created a similar but permanent cart inspection program called "Oops/Shine-On" to reduce contaminants in the recycling stream, using staff to examine recycling bins and leave educational materials as appropriate. Investing more resources in "Feet on the Street," other education campaigns, and cart inspections may reduce contamination, increase recycling, and further zero waste goals.

Expand local partnerships in reuse and recycling

The City of Tucson has an established partnership with the Environmental Education Exchange to provide school education programs focused on recycling, with curricula developed for K-5 and middle school students. The City of Denver implemented a successful educational program in schools that could serve as a model for expanding the education outreach programs in Tucson to include other aspects of zero waste, such as composting. The school curriculum could incorporate information about new waste diversion programs in the City and additional details on how students and families could participate. In addition to the current practice of tracking the number of schools and students participating, the program could also measure success by tracking the reduction in waste disposal at participating schools.

1.3

Near-Term Development Option Considerations

The City identified near-term development options[2] to potentially reduce waste and increase recycling and reuse in Tucson. These options were evaluated with the intent to provide insight to the City on potential pathways toward zero waste that use current operations and resources within the City's existing framework and programs.

The options considered were evaluated based on the positive impacts on waste diversion, environmental aspects, and the community and based on negative impacts related to cost and implementation timeframes. The full evaluation can be found in the Near-Term Development Options report in *Appendix C*.

Each of these options are shown below in order of potential positive impact, from high to low:

1. Brush and Bulky Collection
2. Pay-As-You-Throw (PAYT)
3. Recycling Program Changes: Recycling Education and Enforcement
4. Residential and Commercial Organics Recycling
5. Reuse Store
6. Recycling Program Changes: Multi-Stream Recycling

[2] *Near-term solutions are defined as operational or service level programmatic changes that could be achieved within the next 5 years, including program planning through full implementation.*

Brush and Bulky Collection

The current Brush and Bulky Collection program collects items curbside from residents twice per year and **generates 19,000 tons of material annually.** All collected materials are disposed of at Los Reales Landfill. By separating the collection of brush and bulky items, the City has the potential to divert waste by recycling brush and yard waste. This program change could be implemented fairly easily and quickly, given the existing collection program. The City would need to secure an end market or outlet for yard waste management for recycling.

Impact:

The potential diversion impact, as well as community and environmental impacts for this option, are considered to be medium. The cost to the City is relatively low, and the implementation timeframe is relatively short.

Pay-As-You-Throw

The City's current fee structure for trash service varies only slightly between cart sizes. Implementing a robust PAYT model has the potential to incentivize customer behavior change to reduce waste. PAYT fee structures have proven to be successful if the price differential between cart sizes is $5.00 or more. A well-designed PAYT program can potentially **reduce landfill waste by as much as 15 to 20 percent, or approximately 30,000 to 40,000 tons per year, in Tucson.** Increased contamination in recycling bins, accumulation of waste on private properties, and illegal disposal of waste (i.e., illegal dumping) are potential concerns with such a program and should be considered.

Impact:

The cost impacts to the City for this option are relatively low, and the implementation timeline can be short to medium-term. The potential for positive diversion and community and environmental impacts is high.

Recycling Program Changes: Recycling Education and Enforcement

The study team considered the implementation of a robust education program for curbside recycling collection. Robust education would aim to reduce contamination and increase recycling and waste diversion.

Impact:

The cost impact of recycling education can vary greatly, depending on the level of engagement, but the implementation timeframe is generally short. The potential positive impact of additional diversion can range from low to high depending on the specific education and enforcement programs implemented, and the potential positive impact for the community and environment is medium.

Residential and Commercial Organics Recycling

Residential and commercial organics recycling programs are rapidly expanding across the county, and the City implemented a pilot program in the last few years. A robust curbside food waste program could result in a **5 to 8 percent increase in overall diversion or up to 14 to 20 percent overall in collections system diversion.** A drop-off organics recycling program could also be implemented at a much lower cost and in a quicker timeframe, with lower diversion rates.

Impact:

The implementation timeframe for a curbside residential and commercial organics collection program is long, and the cost impacts are high. Still, the diversion, community, and environmental impacts have the potential to be highly positive.

Reuse Store

Waste reduction goals could be advanced by creating a reuse store in partnership with the LRSC. A reuse store would accept items with a useful life remaining for reuse or resale, including furniture, doors, construction materials, appliances, and paint. Similar programs have relied on commitments from local partner organizations, and some may include ongoing financial support from the City depending on the structure of operations. The design and construction of a new facility comes with a longer implementation timeframe and higher costs compared to other near-term options. This may be mitigated by opportunities to partner with local non-profits that have infrastructure already in place.

Impact:

Overall, the waste diversion impact and environmental impact could be relatively low. However, the reuse store could provide added value to the community through partnerships with local nonprofits and community organizations that help support those in need or underserved communities. This ultimately would result in a medium positive community impact.

Recycling Program Changes: Multi-Stream Recycling

Multi-stream recycling was another recycling program change considered that could address the high levels of contamination in recyclables and additional associated costs to the City. Changing the curbside collection program from single-stream to multi-stream would require residents to further separate recyclable materials for collection. This option could produce cleaner waste streams but comes with added costs for collection, necessary changes at the MRF, and significant education and outreach needs.

Impact:

The cost impact of changing to multi-stream recycling is high, and the implementation timeframe is medium to long. There is only a low potential for positive diversion impacts and a medium potential for positive community or environmental impacts.

1.4

Infrastructure Improvements at LRSC

In 2021, the City designated the 1,100-acre site that hosts its landfill and ancillary facilities as LRSC. The City set the goals below in order to guide the development of LRSC in bringing long-term environmental, economic, and social benefits to the metro Tucson region.

LRSC Goals

- To be the physical catalyst in driving, supporting, and implementing the various programs and initiatives of the Declaration of Climate Emergency for the City
- To provide the physical infrastructure to foster and entice just and equitable regional collaboration in the areas of climate, environment, and sustainability
- To provide integrated and cutting-edge solid waste and resource management for generations to come to achieve the City's Zero Waste goal by 2050
- To ensure that the LRSC is seen as a community open space asset, today and in the future
- To transition how we view and treat waste from a liability to a resource
- To maximize the use of current assets

The City is considering implementing waste processing technologies at LRSC. First, the City explored industry interest in Public-Private Partnerships. Next, planning-level estimates for the capture and diversion of waste streams for each processing facility type were developed. High-level cost estimates were developed to determine ranges of costs per ton of material processed and ranges of costs per ton of material diverted, assuming City-owned and operated facilities. See *Appendix D* for the full Processing Technology Overview.

Public-Private Partnerships

To explore alternative technologies, programs, and partnerships for diversion and recycling, a Request for Information (RFI) was issued on behalf of the City to seek information and qualifications from experienced companies, organizations, and/or individuals who represent innovative waste processing, conversion, or beneficial technologies and are interested in developing a project at the City's LRSC. Twenty-seven companies responded to the RFI, covering a variety of technologies and programs, and respondents ranged from small local organizations to large international companies. The RFI identified partners locally with existing and/or potential relationships with the City. The results of the RFI also identified technologies that the City could ultimately own, operate, or contract with for alternative uses of materials. This information will be used for additional guidance for the LRSC Master Plan and Zero Waste Plan.

Expanding Organics Processing

A pilot-scale composting operation is already in place at LRSC— this operation could be expanded based on increasing the collection of organic waste. The City evaluated organics recycling and management options, assuming a voluntary or subscription-based curbside collection or drop-off program. The assumption is that such a program could **capture 127,300 tons of yard waste and 23,300 tons of food waste** in the initial year, which equates to approximately **60 percent of yard waste and 20 percent of food waste currently landfilled**. The City may elect to use mulching, composting, anaerobic digestion, or some combination of the three. These technologies could result in **approximately 7 percent diversion from the landfill for anaerobic digestion or up to approximately 18 percent diversion for composting.**

An expanded composting operation similar to the pilot project already in place would be limited in the amount of food waste it could accept. An aerated static pile (ASP) composting system could accept higher levels of food waste, while an anaerobic digestion system would be able to accept the highest proportions of food waste but limited yard waste, depending on the anaerobic digestion technology chosen. *Appendix D* provides a more in-depth discussion on the differences in these technology options.

Alternative Technologies for Processing Mixed Waste Streams

Other opportunities could further reduce waste and increase diversion through alternative technology that uses residential and commercial waste, currently bound for disposal in the landfill, as a resource. The alternative technology options presented below are likely longer-term options. See *Appendix D* for more details.

Construction and Demolition

Construction and demolition (C&D) waste includes materials generated from the construction, renovation, and demolition of buildings, roads, bridges, and other structures.[3] For C&D materials to be reused, they must be separated from other waste through a recycling facility, a C&D-specific MRF, a mixed waste processing facility specialized in C&D, or by source separation at job sites. **It is estimated that 8.4 percent of the City's waste is C&D materials, and a C&D facility could capture up to 70 percent of C&D waste in the City's jurisdiction.** Construction of a C&D processing facility could **divert 4 to 6 percent of waste that is currently landfilled.** Reusing and recycling C&D materials has the potential to create employment and economic opportunities.

[3] *Construction and Demolition Debris Management in the United States, U.S. Environmental Protection Agency (EPA) Office of Resource Conservation and Recovery, 2020.*

Mixed Waste Processing

Another option to increase recycling is mixed waste processing (MWP), which sorts mixed municipal solid waste (MSW) and removes recyclables and reusable materials that would otherwise be sent to the landfill. If the City implemented this program, a facility would potentially **divert up to 20 percent of waste currently landfilled,** depending on the technology chosen.

Durham York Energy Centre

Waste-to-Energy

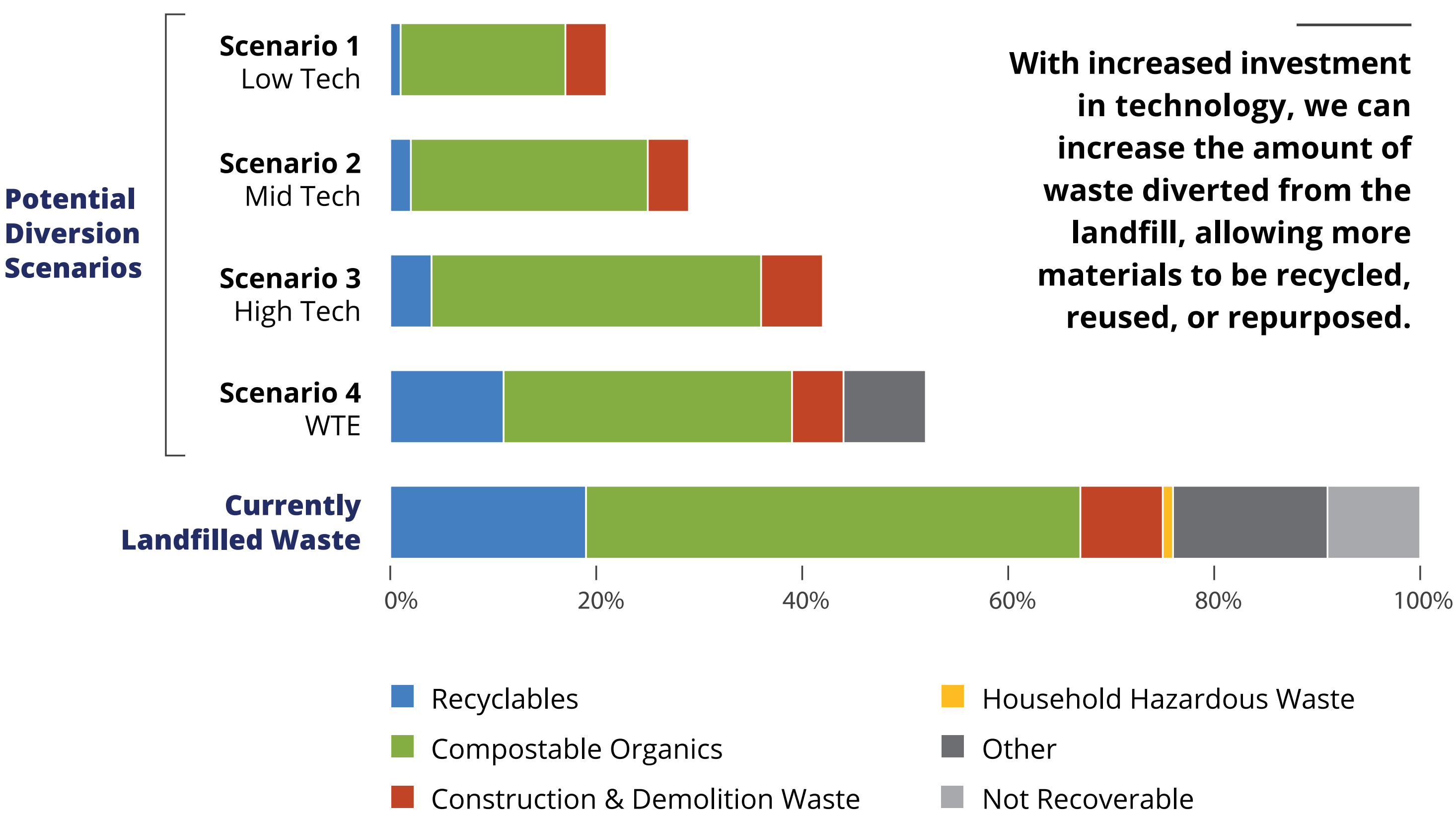
An additional alternative technology for consideration is waste-to-energy (WTE), which produces electrical power or steam by combusting waste. WTE can greatly reduce the waste volume sent to a landfill. If approximately 80 percent of the waste currently sent to the landfill were to be processed through the WTE facility, it could result in a **57 percent reduction by weight of waste sent to the landfill** after accounting for the disposal of the ash produced.

Potential Diversion Scenarios

No single technology would be able to meet the City's zero waste goal. However, these technologies can be used in various combinations to increase total diversion, and these combinations can change over time as facilities are upgraded, or new collection programs are implemented. At this early stage of planning, diversion assumptions are based on voluntary organic waste collection programs and processing waste already coming to the landfill. The figure below shows some possible combinations of technologies.

The "Low Tech" scenario combines windrow composting, a C&D waste sorting pad and bunkers, and the low-level technology option for MWP. The "Mid Tech" scenario combines ASP composting, a C&D sorting system, and the mid-level technology option for MWP. The "High Tech" scenario combines anaerobic digestion for organics, windrow composting of yard waste, a C&D mixed waste processing system, and the high-level technology option for MWP. The "WTE" scenario would implement the WTE technology on its own.

Potential Diversion from Landfill by Processing Technologies



With increased investment in technology, we can increase the amount of waste diverted from the landfill, allowing more materials to be recycled, reused, or repurposed.

Potential Cost Comparison

The cost and impact of each type of facility depends on the level of technology used (see Table 1-1). For organics processing, the difference is primarily the amount of food waste accepted. For C&D processing, low- and mid-level technologies focus on processing loads containing high amounts of C&D waste that can be easily separated and diverted. For MWP, the higher levels of technology can process waste from more varied sources (e.g., residential, commercial, self-haul). The cost per ton processed is based on the amount of material moving through each facility. The cost per ton diverted is based on the number of tons actually diverted by that facility, accounting for contamination and residues.

Table 1-1. Opinion of probable costs for processing technologies at LRSC

Technology	Cost per Ton Processed (Range Low to High)	Cost per Ton Diverted (Range Low to High)
Organics Processing Options		
Windrow Composting	$21 – $30	$23 – $31
ASP Composting	$32 – $45	$34 – $47
Dry Anaerobic Digestion	$110 – $153	$135 – $187
Construction and Demolition Waste Processing Options		
C&D Pad and Bunkers	$27 – $37	$31 – $43
C&D Sorting System	$39 – $55	$52 – $72
C&D Mixed Waste Processing	$76 – $106	$107 – $148
Mixed Waste Processing Options		
Low-Tech MWP Facility	$27 – $38	$269 – $373
Mid-Tech MWP Facility	$32 – $45	$114 – $158
High-Tech MWP Facility	$32 – $45	$97 – $135
Waste-to-Energy		
WTE Facility	$135 – $187	$189 – $263

Source: Processing Technology Overview, HDR, 2023 (included as Appendix D*).*

1.5

Community and Stakeholder Engagement

Community Survey

To engage the public in the Roadmap development, a zero waste survey was distributed in English and Spanish to the community in September 2022. The survey focused on the community's zero waste priorities and values. In total, 434 survey responses were received. A summary of the survey results is available in *Appendix E*. Below are the key results from the survey.

Defining Zero Waste

The community was asked if they had heard the term "zero waste" and to select the definition of zero waste that closely aligns with their definition.

In total, **91 percent of respondents** said they had at least heard the term zero waste.

Sixty-two percent of respondents would define zero waste as "Conserving all resources through responsible production, consumption, reuse, and recovery of products and materials."

Interest in Zero Waste

The community was asked about their interest in different zero waste opportunities, and of the ten options provided, the following were the top three responses:

- Creating a curbside food and yard waste residential recycling program
- Banning the use of items that are hard to recycle (Styrofoam®, plastic bags, etc.)
- Developing programs for manufacturers to take back nonrecyclable products

Importance of Zero Waste

The community was asked two questions related to the importance of zero waste. First, they were asked what zero waste topics were most important to them.

Twenty-four percent of the community stated food and yard waste recycling for households was most important.

Twenty-three percent stated increased recycling options for curbside or drop-off programs was most important.

The community was then asked why zero waste was important to them, in order to ultimately help develop zero waste values and guide the Zero Waste Plan. Of the options provided, the top three choices were:

- Climate change impacts related to drought and heat waves
- Greenhouse gas emissions
- Reducing pollution

Stakeholder Workshops

In addition to the community survey, EGSD hosted two interactive workshops to help guide the development of the Roadmap. Multiple stakeholder groups, organizations, and City staff were invited to participate in these workshops, including the City's Water Conservation Staff; the City's Economic Initiatives Staff; the Mayor's Office; all City Council Ward Offices; the City's Environmental Services Advisory Committee; the University of Arizona; the City's Commission on Climate, Energy, and Sustainability; the Mayor's Climate Action Committee; Pima County; local businesses; and local environmental groups. The attendees were asked to identify their top three values related to zero waste in Tucson (see Table 1-2).

Table 1-2. Top three zero waste values among workshop participants

Workshop 1[a]	Workshop 2
1. Impacts on tree health, green spaces	1. Greenhouse gas emissions
2. Economic benefits, including job creation and local economic effects	2. Economic benefits, including job creation and local economic effects
3. Reduce material going to Los Reales Landfill	3. Reduce material going to Los Reales Landfill
4. Climate change impacts related to drought and heat waves	

[a] *Three values tied at second place; therefore, four top values were identified in the first workshop.*

Key results from both workshops as they relate to each near-term development option can be found in Table 1-3. Additional information from the workshops can be found in *Appendix F*.

Table 1-3. Results of discussion of near-term development options

Discussion topic	Brush and Bulky Program Modifications	Residential and Commercial Organics Collection	Recycling Collection Changes	Pay-As-You Throw	Reuse Store
Would this help Tucson achieve its goal of zero waste?	Strongly agree	Strongly agree	Agree, but it would take system enhancements	Maybe	Maybe
Key result(s)	Support for program enhancement	Support for the program and use of compost	Concerns about current recycling processes	May not create real incentives for residents	Help reduce waste in the landfill and create jobs
Key concern(s)	Increased scavenging at the curb	Odor, costs	Lack of technology and education	Equity	Funding and participation

All of the information collected from the community survey and the stakeholder workshops provided valuable insight that helped guide the Roadmap development and potential zero waste developments that will be further evaluated during the creation of the Zero Waste Plan.

1.6
Environmental Justice Commitment and Goal

"Working towards an equitable, green future for all Tucsonans"

— Mayor Regina Romero

An Environmental Justice Snapshot was completed to ensure an equitable process for the Roadmap (see *Appendix D*). The snapshot identified that the community around Los Reales Landfill may be an environmental justice community of concern.[4] As part of the Zero Waste Plan, a full environmental justice analysis should be completed to understand impacts and mitigate risks as the City looks to expand the diversity of services offered at the landfill.

[4] *Arizona Department of Environmental Quality, data accessed on October 27, 2022, https://www.azdeq.gov/.*

2

Timeline

Creating a robust and comprehensive Zero Waste Plan that will help the City reach its goals for 2030 and beyond will require additional time to determine what goals and action items should be included and how priorities will be identified. **The City should spend 12 to 18 months working to further define a pathway to zero waste, seeking additional stakeholder input, identifying key partnerships, and considering specific action items for the plan.** Planning should also include developing an LRSC Master Plan to integrate the facility with zero waste plans.

Further investigation of priorities, technologies, policies, and programs could occur under this timeframe to determine what the City will include in its Zero Waste Plan. The items listed in this Roadmap are possible components of a plan and are meant to provide guidance and references. Refining and defining goals will require additional research and evaluation specific to the City.

The City should include expanding existing and creating new community partnerships as a part of the Zero Waste Plan. Additional community outreach and input gathering can be a part of these planned activities, including public meetings, forums, and other meaningful interactions. Identifying and connecting with local partners will continue to be beneficial, especially as the City explores potential infrastructure improvements or programs that rely on community partnerships. These include City programs such as Tucson Million Trees, and community partners such as food rescue organizations, community gardens, Tucson Repair Cafe, and others processing hard to recycle materials.

Gathering feedback and insight from other City staff members and elected officials will also be useful in planning. These groups should be included in the planning stages to create support for the long-term success of the Zero Waste Plan.

3

Next Steps

With the Roadmap, the City is well-positioned to take the next steps to draft a Zero Waste Plan for Tucson. This plan will help the City determine and clearly articulate the desired outcomes for the community and what priorities should be included to achieve those goals. **A perfect plan for zero waste does not exist; rather, the City should focus on taking steps toward zero waste and making incremental improvements and forward progress where possible.** No one program or technology will be able to increase diversion enough for the City to meet its goals. It will take a combination of changes to existing policies, operations, and services and new processing infrastructure and new partnerships.

3.1

Zero Waste Plan

The Zero Waste Plan will be a living document used to identify specific actions, monitor progress, and report on efforts. It will include the following key components:

City Policy Development

The Zero Waste Plan will develop a Zero Waste Policy for the City and consider policy and legislative activities to support programs. Policy development will take time to build and refine goals, determine the overall project timeline and scope, and build consensus and understanding.

Goal setting will be critical to refining the Zero Waste Plan details and creating a broad framework for determining action items. Balancing the City's needs for fiscal responsibility while benefiting the environment will need to be considered and discussed, particularly with elected officials.

It is extremely important to engage the City Council, City leaders, stakeholders, private sector companies operating in collections and diversion, and the community throughout the plan's development and have touchpoints for critical input that align with major technical decisions and milestones. Key messaging during the Zero Waste Plan development should focus on education regarding the proposed solutions and technologies, at-home or at-business impacts/considerations, personal/community-level benefits, costs, and timing.

Public-Private Partnership

The Zero Waste plan will evaluate and look for public-private partnerships to support and expand waste diversion, reuse, and recycling programs.

Infrastructure

This Roadmap identified many potential options to advance zero waste efforts, including improving existing infrastructure or building new infrastructure to manage waste more efficiently and effectively. The Zero Waste Plan will identify specific infrastructure needs with associated costs and a timeline for development to meet the City's zero waste goals.

LRSC Master Plan

The Roadmap identifies both private and nonprofit interest in transitioning the Los Reales Landfill into a sustainability campus. The LRSC Master Plan would include evaluating site layout and needs, issuing a Request for Proposals (RFP) to find partners to advance or support zero waste efforts, developing campus goals and operations, and developing a timeline for development.

Public Outreach and Engagement Plan

Implementing a zero waste program in Tucson requires community-wide systemic and personal change. Therefore, public education, engagement, and input are critical to success in developing and implementing the Plan. The City should implement a full city-wide education and engagement campaign while developing the Zero Waste Plan. It should first focus its efforts on developing a comprehensive Public Outreach and Engagement Plan that outlines the following:

- Communications goals for the plan development
- Key stakeholder groups and audiences
- Key messaging topics
- Key considerations for equitable outreach as related to underserved or linguistically isolated communities
- Outreach tools that will be used at each phase

This plan will be a living document, allowing the City to adjust and adapt outreach and engagement efforts throughout the development of the Zero Waste Plan based on the community's needs.

Operations

Waste collection changes and new programs can potentially require operational changes internal to the City or with City partners. The Zero Waste Plan will evaluate current City curbside collection programs and identify whether and how to expand curbside programs for brush and bulky and/or organics processing.

Accountability and Metrics

To achieve the goals of 50 percent waste diversion by 2030 and zero waste by 2050, the City must be able to measure waste diversion and track progress toward those goals. Measuring and quantifying waste reduction efforts through tracking metrics will identify successes and areas for improvement. Creating Tucson-specific metrics will be critical to ensure the zero waste priorities and initiatives are monitored appropriately.

Education

As we heard during the community and stakeholder engagement efforts for the Roadmap, education is a critical component of the outreach effort. Although the community understands what zero waste is, the definition differs. It will be critical to define zero waste as a community and develop an educational campaign that highlights key components of zero waste in Tucson. The educational portion of the outreach efforts should be implemented consistently throughout the Zero Waste Plan development to help build community understanding, awareness, and a zero waste culture. Ultimately, the education campaign launched throughout the Zero Waste Plan's development will be the foundation for future education and a community shift toward a zero waste culture.

City Practices

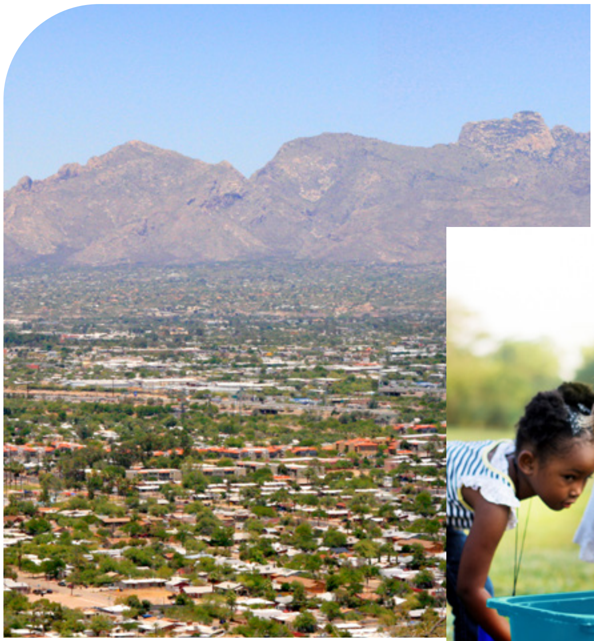
The City should review existing internal policies to ensure they allow for zero waste goals and any needed flexibility for implementation. The City should use the TRUE[5] program to evaluate its internal waste practices and strive to become a TRUE-certified operation.

[5] *"TRUE: Less waste, higher efficiency, greater savings," accessed November 29, 2022, https://true.gbci.org/.*

3.2 Summary

This Roadmap provides options and guidance to reach zero waste in Tucson. It identifies community support for zero waste programming, partnership opportunities for developing a sustainability campus, and opportunities for increased waste diversion.

The next steps for the City include developing its Zero Waste Plan, which will be a critical resource for achieving zero waste in Tucson and for guiding the implementation of policies and projects to achieve that ambitious goal.



APPENDIX A

Current Conditions Assessment

Current Conditions Assessment

Zero Waste Roadmap Development

Prepared for: City of Tucson Environmental and General Services Department

Tucson, Arizona

June 30, 2022

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Contents

Tables

Figures

Acronyms and Abbreviations

ADEQ	Arizona Department of Environmental Quality
Assessment	Current Conditions Assessment
City	City of Tucson
CNG	compressed natural gas
CY	calendar year
EGSD	Environmental and General Services Department
FY	fiscal year
HDPE	high-density polyethylene
HHW	household hazardous waste
LFG	landfill gas
LRSC	Los Reales Sustainability Campus
MRF	Materials Recovery Facility
MSW	municipal solid waste
NRC	Neighborhood Recycling Center
OCC	old corrugated cardboard
ONP	old newsprint
PET	polyethylene terephthalate
RNG	renewable natural gas
Roadmap	Zero Waste Roadmap
SBWAP	Small Business Waste Assistance Program
UArizona	University of Arizona
WTE	waste-to-energy

1 Executive Summary

HDR has been retained by the City of Tucson (City) to assist the City during the first phase of its move toward zero waste, with implementation of the Zero Waste Roadmap (Roadmap). The Roadmap is meant to gather information on what “zero waste” means to Tucson and to identify strategies that would best support that vision. To build a Roadmap that is tailored to Tucson and the surrounding communities that use City facilities, it is important to first define the starting point.

This Current Conditions Assessment (Assessment) is one of a series of tasks developed to support the Roadmap. Its intent is to provide a clear understanding of the baseline system that can be used to identify opportunities and priorities for future waste diversion planning. To develop this comprehensive overview of the City’s waste management systems, HDR reviewed previous reports and historical records, as well as publicly available information.

The key findings of this report include the following:

- This baseline data evaluation focuses on material that is processed through the City’s Los Reales Sustainability Campus (LRSC). Most of the material received at the LRSC is disposed of in the landfill, with 764,000 tons of waste disposed in the Los Reales Landfill in 2021. Approximately 25 percent of that material is collected by the City’s residential collection service, 3 percent is collected by City departments, 62 percent consists of commercial and industrial waste from local businesses, and 10 percent is hauled to the landfill by landscapers, small haulers, and public self-haul/daily users (see Section 4.2). This combination of materials collected by the City and received at LRSC represents the baseline system condition for the Roadmap.
- The City’s diversion rate in 2021 was approximately 4 percent, based on quantities collected by the City or received at LRSC. This includes residential and commercial waste and recycling, City department waste and recycling, scrap metal, household hazardous waste (HHW), glass, and FoodCycle compostables.
- 29,620 tons of City-collected material were diverted to the ReCommunity Materials Recovery Facility (MRF) in 2021. Of that, the MRF reported that 8,679 tons were determined to be contamination, which represents a recycling contamination rate of 29 percent. The MRF charges the City an excess contamination charge (also known as a residue charge) of $1 per ton for each percentage point above 18.7 percent contamination. The excess contamination charge cost the City $314,085 in 2021 and has cost the City approximately $1.2 million since 2018.
- In 2021, the City implemented a program called “Feet on the Street” to provide direct feedback to curbside recyclers on their recycling behaviors. After the study, the percentage of recycling carts observed to contain contaminants fell from 44 percent at the beginning of the program to 18 percent at its conclusion. Furthermore, the percentage of contamination within the curbside recyclables sampled from the study areas fell from 24.5 percent to 19.1 percent (by weight). These results indicate that outreach and educational programs may be effective in reducing contamination rates at the MRF.

- The City recycled approximately 1,700 tons of glass in 2021 through the City's glass collection program.
- 518 tons of HHW were collected and diverted by the City in 2021. The City reports that typically 98 percent of its HHW is diverted.
- The FoodCycle pilot program composted 261 tons of compostable materials in 2021.
- The City's 2021 Climate Action Community Survey indicated that 88.1 percent of respondents supported or strongly supported increasing recycling compliance and landfill waste diversion.
- The City plans to invest in expansion of services and associated infrastructure at the LRSC. A summary of planned sustainability projects is included in Section 7.

2 Previous Reports

The City has commissioned reports and studies in the past to characterize waste streams and disposal options. The following reports were prepared on behalf of the City and were used to prepare this Assessment:

- *City of Tucson Waste Diversion Plan and Roadmap* (prepared by Cascadia Consulting Group, January 2014)
- *Refuse & Recycling Study, City of Tucson, Arizona* (prepared by MSW Consultants, February 2020)
- *Recyclables Processing Contract Benchmarking Assistance* (prepared by MSW Consultants, May 2020)
- *Glass Reuse Plan* (prepared by City of Tucson, November 2020)
- *Los Reales Landfill Composting Facility Operations Plan* (prepared by City of Tucson, November 2020)
- *City of Tucson "Feet on the Street" Recycling Cart Monitoring & Recyclables Composition Study* (prepared by MSW Consultants, The Recycling Partnership, January 2022)
- *Los Reales Sustainability Campus Landfill Gas Recovery and Reutilization Feasibility Assessment* (prepared by GHD, December 2021)

An updated waste characterization specific to Tucson will not be prepared while developing the Roadmap. The City directed HDR to use waste characterization studies prepared for the City of Phoenix, with the assumption that the composition of Phoenix and Tucson waste streams was likely similar. The following waste characterization studies have been prepared for the City of Phoenix and were used to prepare this Assessment:

- *City of Phoenix Waste Characterization Study* (prepared by Cascadia Consulting Group, September 2015)
- *City of Phoenix Residential Waste Characterization Study: 2017–2018 Final Report* (prepared by Cascadia Consulting Group, May 2018)

3 City Waste Management Services and Facilities

The City's Environmental and General Services Department (EGSD) provides trash and recycling collection services to all single-family households and some multifamily households and commercial businesses within the city limits. The City is responsible for managing and completing long-range planning for waste collection, recycling, and disposal operations within the city limits. These operations apply to a City-owned and operated municipal solid waste (MSW) landfill, seven Neighborhood Recycling Centers (NRCs), 22 glass recycling drop-off locations, and equipment and facilities for waste collection, disposal, and recycling operations. The City also contracts with an MRF, the ReCommunity MRF owned by Republic Services, for residential and commercial recycling services.

The flow diagram in Figure 3-1 illustrates the City's waste stream and associated infrastructure. The diagram shows where waste is collected and diverted or disposed.

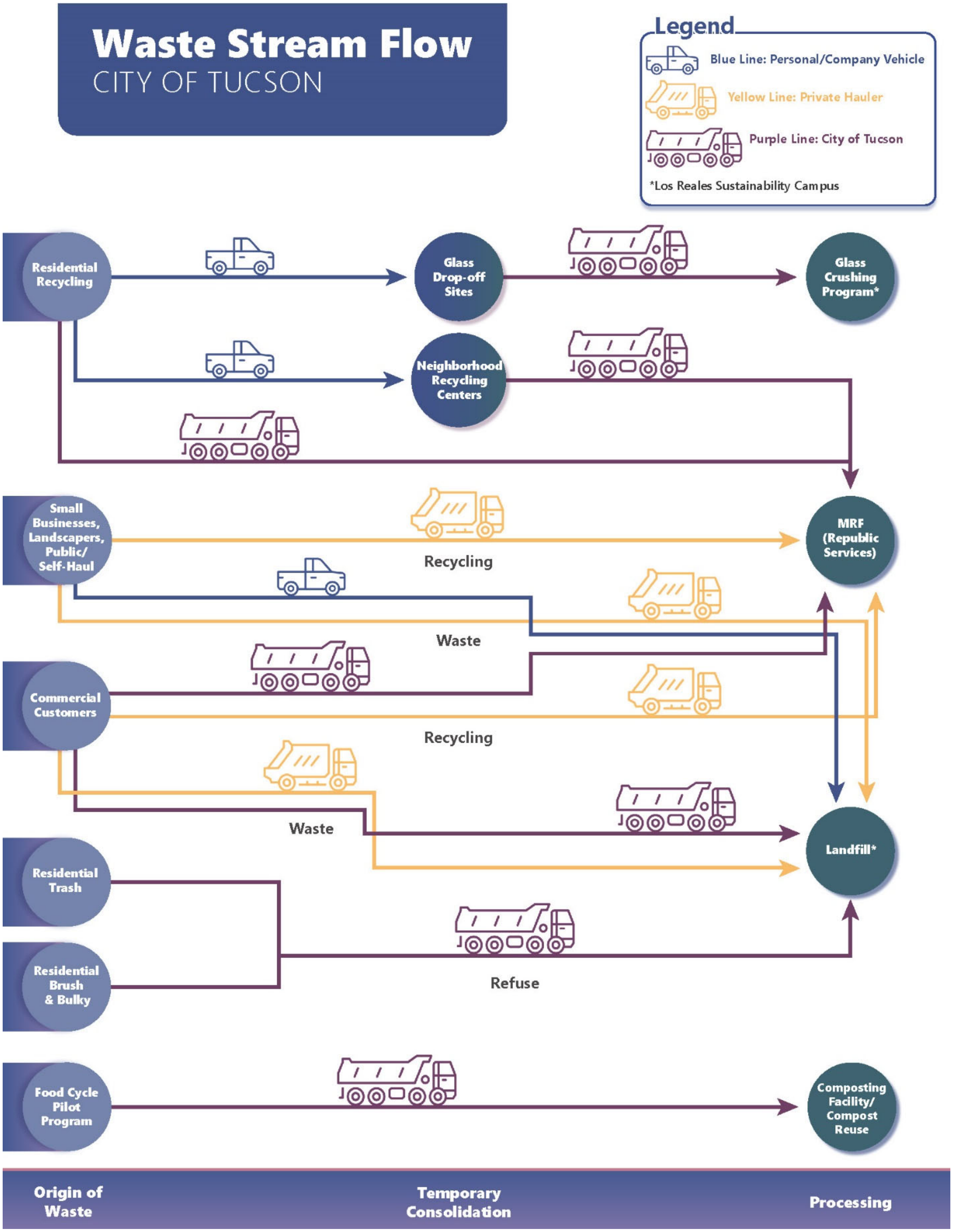
3.1 Collections

The City currently has 119 collections employees, which includes 72 residential collections staff, 24 commercial collections staff, and 23 brush and bulky collections staff. The City also maintains equipment fueled by compressed natural gas (CNG) and diesel (as of February 2022), as listed in Table 3-1.

Table 3-1. City of Tucson collections equipment quantities

Fuel type	Side loaders	Front loaders	Roll offs	Rear loaders	Skid steers
CNG	59	12	4	11	0
Diesel	1	5	3	2	10
Total	**60**	**17**	**7**	**13**	**10**

Figure 3-1. City of Tucson waste flow



3.2 Los Reales Sustainability Campus

The City's Los Reales Landfill is an approximately 283-acre MSW landfill located at 5300 East Los Reales Road,[1] and is now known as the LRSC. The landfill began accepting waste in 1967 and serves the residents and businesses of Tucson and Pima County. Approximately 2,300 tons of solid waste per day (790,000 tons per year) are brought to the landfill for disposal. Based on the current rate of disposal, the landfill is anticipated to have approximately 60 remaining years of life, with an anticipated closure date of 2085 to 2087. Los Reales is open to private haulers, commercial haulers, and residential self-haulers.

The landfill has drop-off sites for recycling, including scrap metal, which are open to residents and commercial customers. It also accepts HHW and some waste that requires special handling for additional fees.

The City plans to invest in expanding services and associated infrastructure at the LRSC. A summary of planned sustainability projects is included in Section 7.

3.2.1 Residential Collection and Hauling

Approximately 25 percent of the material delivered to the Los Reales Landfill (200,000 tons per year) is collected from City residents. The City provides collection services to approximately 142,000 households (74,000 single-family and 68,000 multifamily).[2] Residential customers are charged a monthly fee for weekly trash and every-other-week recycling services.[3]

In addition to regular collections, the City offers brush and bulky services to residents twice per year, which accounts for approximately 20,000 of the residential tons collected annually. The City also provides special trash collection services, including additional brush and bulky collection and HHW removal, upon request for an additional fee.[3] Residents can also self-haul to the landfill, which accounted for 10 percent of waste received by the Los Reales Landfill.

3.2.2 Commercial and Industrial Collection and Hauling

Approximately 62 percent of the material delivered to the Los Reales Landfill (475,000 tons per year) is collected from commercial and industrial clients. The City provides trash and recycling collection services for 2,900 refuse commercial customers, of which 650 also have recycle services provided by the City. Other haulers also provide commercial collection services within the City limits to approximately 18,000 commercial clients.[4] Commercial refuse haulers who operate front load, rear load, side load, or roll-off collection vehicles are required to have a permit with the City for each vehicle.

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[1] Arizona Department of Environmental Quality. "Los Reales Site Overview." https://azdeq.gov/los-reales-landfill. Accessed April 2022.

[2] MSW Consultants. *Refuse & Recycling Study*. February 2020.

[3] City of Tucson. "City of Tucson Residential Rate Schedule." https://www.tucsonaz.gov/files/es/ResidentialRateSchedule2013.pdf. Accessed April 2022.

[4] Comments from Carlos De La Torre, Director of City of Tucson EGSD, dated April 1, 2022.

Proceeds from the permits are used to administer and implement litter collection activities in the City.[5]

Various private haulers within the city also provide waste collection services for commercial and industrial clients within the city limits and provide residential trash and collection services to customers outside city limits. Most haul the waste to Los Reales Landfill. Waste Management also collects waste from commercial and industrial clients but does not haul to the Los Reales Landfill. Instead, it hauls the waste to its transfer station, and from there it is hauled to another landfill.

3.3 Recycling Services

For recycling services, the City contracts with the Republic Services MRF, known as ReCommunity Recycling Tucson, located at 3780 East Ajo Way. This contract expires on June 30, 2027, with one optional renewal period of 5 years or a portion thereof. The MRF accepts old corrugated cardboard (OCC), old newsprint (ONP), other paper, aluminum, tin, other metals, polyethylene terephthalate (PET) bottles, high-density polyethylene (HDPE) natural bottles, HDPE pigmented bottles, #5 plastics, and rigid plastics.[6] The MRF also accepts glass, but glass is no longer accepted in the City's curbside recycling collection program (see Section 3.5). The MRF charges the City an excess contamination charge (also known as a residue charge) of $1 per ton for each percentage point above 18.7 percent contamination. The contamination rate from the City of Tucson in fiscal year (FY) 2021 was approximately 29 percent.

3.4 Neighborhood Recycling Centers

The City of Tucson has seven NRCs—one located in each of the six City wards and one at the LRSC. A photo of a City NRC is shown in Figure 3-2. The materials accepted at the NRCs are the same as those accepted in the residential Blue Barrel program and include the following:

- OCC and other paper
- ONP and other paper
- aluminum
- tin
- other metal
- PET bottles
- HDPE natural bottles
- HDPE pigmented bottles
- #5 plastics
- rigid plastics

[5] City of Tucson. "Environmental and General Services." https://www.tucsonaz.gov/environmental-services. Accessed April 2022.

[6] Republic Services. "Frequently Asked Questions." https://www.republicservices.com/customer-support/faq. Accessed April 2022.

Figure 3-2. City of Tucson NRC at Eastside City Hall

Recycling from the NRCs is taken by EGSD to the Republic Services MRF. Figure 3-3 shows the locations of the Tucson NRCs.

Figure 3-3. Neighborhood recycling center locations

3.5 Glass Recycling

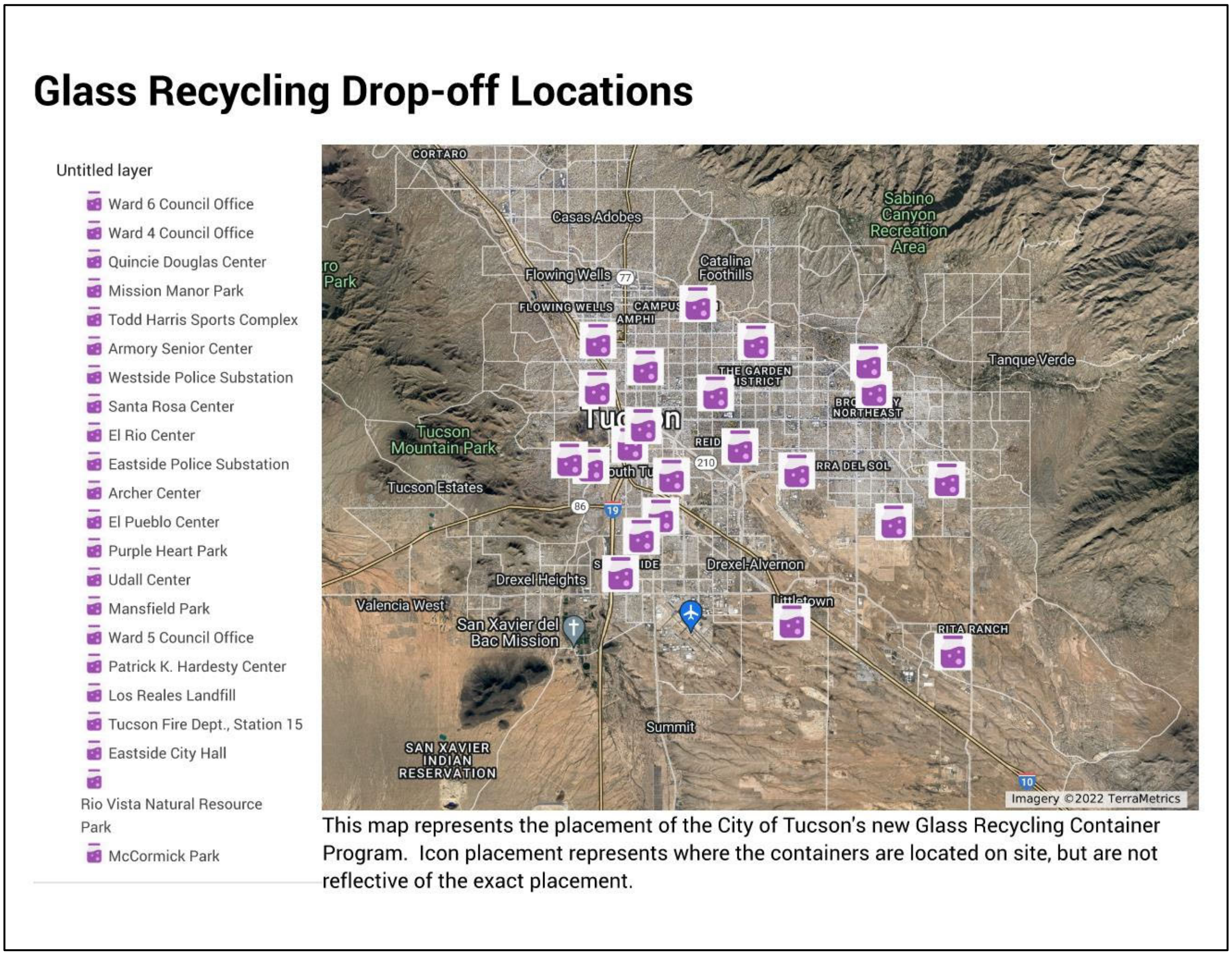
The City has 22 glass recycling drop-off locations throughout Tucson, as shown in Figure 3-4. The City has a *Glass Reuse Plan*,[7] which is intended to reuse glass in the community rather than recycling it. In previous years, glass was collected from residential customers at the curb and processed at the Republic Services MRF. From there, it was sent to Strategic Materials in Phoenix, Arizona, and then to Mexicali, Mexico, for use by beverage bottlers (a total transport distance of approximately 350 miles). This process resulted in high greenhouse gas emissions associated with transportation costs, and high processing costs to the City at the Republic Services MRF. After the glass recycling program was implemented in February 2021, glass was removed from curbside collection.

Glass that is collected from the recycling drop-off locations was transported to the LRSC to be crushed with a small glass crusher. EGSD had planned to provide the crushed glass to the City's Department of Transportation and Mobility and other City departments for use in sandbags and as aggregate for construction projects. Approximately 1,700 tons of glass was collected at the NRCs in calendar year (CY) 2021, and an additional 2,500 tons was processed by the MRF in CY 2021 as residents continued to place glass in the blue recycling bins.

EGSD has not begun crushing because of staffing shortages. The Glass Packaging Institute and Strategic Materials, Inc. (Strategic Materials), has expressed interest in glass collected from the drop-off program given the low contamination. The City recently entered into a temporary agreement with Strategic Materials. Strategic Materials will return 10 percent of the tonnage collected from the City in the form of unsorted crushed glass to meet the City's glass reuse program requirements.

[7] City of Tucson Environmental Services. *Glass Reuse Plan*. November 13, 2020.

Figure 3-4. Glass recycling locations



4 Waste Streams and Diversion Data

The following sections provide waste generation data for waste disposal at the LRSC, Republic Services MRF, NRCs, and glass disposal locations.

4.1 Waste Characterization Studies

The City used several studies to categorize the material that is going to the landfill. They relied on the following studies prepared for the City of Tucson and the City of Phoenix:

- *City of Tucson Waste Diversion Plan and Roadmap* (prepared by Cascadia Consulting Group, January 2014)
- *City of Phoenix Waste Characterization Study* (prepared by Cascadia Consulting Group, September 2015)
- *City of Phoenix Residential Waste Characterization Study: 2017–2018 Final Report* (prepared by Cascadia Consulting Group, May 2018)

Waste from a subset of residential customers was sorted by hand and classified into categories. The general categories examined in the waste characterization studies included paper, plastic, glass, metal, organic material, construction and demolition waste, HHW, and other materials. The studies from Phoenix further subdivided the categories. They also estimated the amount of material that could be diverted through recycling and composting programs. Table 4-1 summarizes the results of the 2014, 2015, and 2018 waste characterization studies. Estimated percentages for the City of Tucson were prepared based on the average percentage of material in each category in the three waste characterization studies.

All three studies indicated that at least 40 percent of waste could be diverted through a composting program, and 10 to 20 percent of material disposed of in the trash could be recycled.

Table 4-1. Summary of waste characterization studies

Material	2014 Tucson[a]		2015 Phoenix[b]		2018 Phoenix[c]		Tucson[d]
	%	Est. tons	%	Est. tons	%	Est. tons	Est. %
Paper	**25.1%**	**107,190**	**12.6%**	**49,132**	**16.0%**	**68,440**	**17.90%**
Newspaper	—	—	0.95%	3,699	0.77%	3,316	—
Unwaxed OCC/Kraft paper	—	—	1.38%	5,380	2.38%	10,209	—
Other recyclable paper	—	—	4.36%	17,037	5.35%	22,931	—
Compostable paper	—	—	5.43%	21,200	6.07%	26,013	—
Other paper	—	—	0.47%	1,816	1.39%	5,971	—
Plastic	**9.10%**	**38,939**	**9.80%**	**38,127**	**11.40%**	**48,900**	**10.10%**
PET (#1) plastic	—	—	1.09%	4,245	1.21%	5,188	—
HDPE (#2) plastic	—	—	0.53%	2,069	0.86%	3,697	—
Other recyclable plastic	—	—	2.46%	9,599	3.63%	15,532	—
Compostable plastic	—	—	0.02%	66	0.01%	45	—
Clean plastic film (grocery sacks)	—	—	1.40%	5,469	0.79%	3,374	—
Other plastic film	—	—	2.61%	10,181	3.47%	14,854	—
Expanded polystyrene	—	—	0.72%	2,814	0.64%	2,735	—
Other plastic	—	—	0.94%	3,685	0.81%	3,476	—
Glass	**2.30%**	**9,771**	**1.90%**	**7,250**	**1.80%**	**7,773**	**2.00%**
Recyclable glass	—	—	1.18%	4,591	1.60%	6,843	—
Other glass	—	—	0.68%	2,659	0.22%	930	—

Material	2014 Tucson[a]		2015 Phoenix[b]		2018 Phoenix[c]		Tucson[d]
	%	Est. tons	%	Est. tons	%	Est. tons	Est. %
Metal	**5.00%**	**21,400**	**2.70%**	**10,352**	**3.80%**	**16,134**	**3.83%**
Aluminum cans	—	—	0.26%	1,027	0.24%	1,009	—
Tin/steel food cans	—	—	0.60%	2,329	0.54%	2,297	—
Other recyclable metals	—	—	0.88%	3,444	1.50%	6,440	—
Other metals	—	—	0.91%	3,552	1.49%	6,389	—
Organic	**40.80%**	**174,510**	**48.10%**	**187,991**	**38.70%**	**165,683**	**42.53%**
Compostable yard waste	—	—	29.91%	116,821	22.03%	94,362	—
Food waste	—	—	14.68%	57,351	13.89%	59,517	—
Noncompostable organic	—	—	3.54%	13,820	2.76%	11,804	—
Construction and demolition waste	**12.50%**	**53,526**	**5.90%**	**23,227**	**6.80%**	**28,982**	**8.40%**
HHW	**0.60%**	**2,569**	**0.70%**	**2,566**	**0.60%**	**2,628**	**0.63%**
Other materials	**4.60%**	**19,858**	**18.40%**	**71,903**	**21.00%**	**89,842**	**14.67%**
Subtotal: recyclable material	**11.02%**	**47,138**	**13.70%**	**53,419**	**18.10%**	**77,461**	**14.27%**
Subtotal: compostable material	**40.80%**	**174,510**	**50.00%**	**195,438**	**42.00%**	**179,937**	**44.27%**

[a] *City of Tucson Waste Diversion Plan and Roadmap* (prepared by Cascadia Consulting Group, January 2014)
[b] *City of Phoenix Waste Characterization Study* (prepared by Cascadia Consulting Group, September 2015)
[c] *City of Phoenix Residential Waste Characterization Study: 2017–2018 Final Report* (prepared by Cascadia Consulting Group, May 2018)
[d] Prepared and verified by HDR (2022).

4.2 Waste Disposal at Los Reales Landfill

Figure 4-1 shows the percentage of material (by source) delivered to Los Reales Landfill in 2021. In 2021, approximately 25 percent of waste received by the landfill was residential waste delivered by the City, 10 percent was commercial waste delivered by the City, 3 percent was waste from City departments, 47 percent was delivered by commercial clients with accounts at Los Reales Landfill, 5 percent was commercial clients without accounts (pay-as-you-go), and 10 percent was delivered by residents who self-hauled to the landfill.[8]

[8] Provided by City of Tucson EGSD staff in an email from Lisa Rotello, Principal Planner, dated March 16, 2022.

Figure 4-1. 2021 tons delivered to landfill, by source[8]

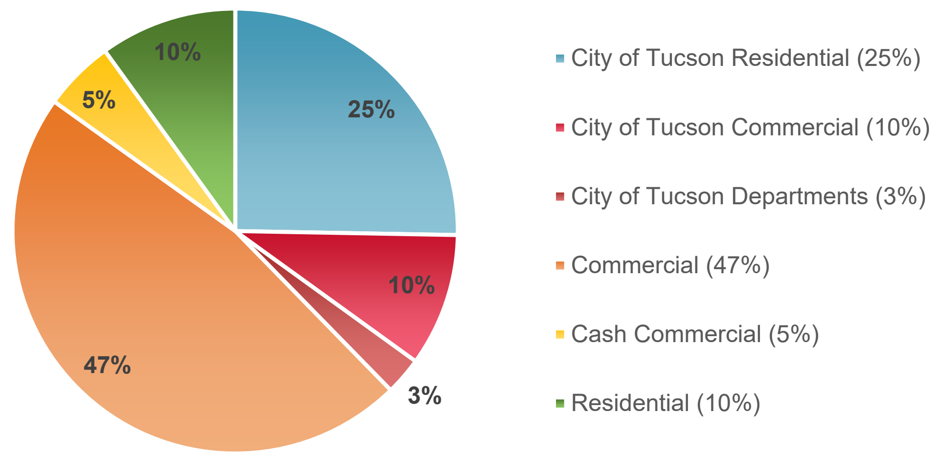


Table 4-2 provides the annual tonnages of material disposed of in Los Reales Landfill between 2019 and 2021. Currently, a more detailed breakdown of waste sources disposed of in the landfill (for example, by private hauler) or reused or recycled elsewhere is not available. The City's zero waste efforts should prioritize developing consistent data tracking to monitor progress.

Table 4-2. Estimated Los Reales disposal (net tons per year)[8]

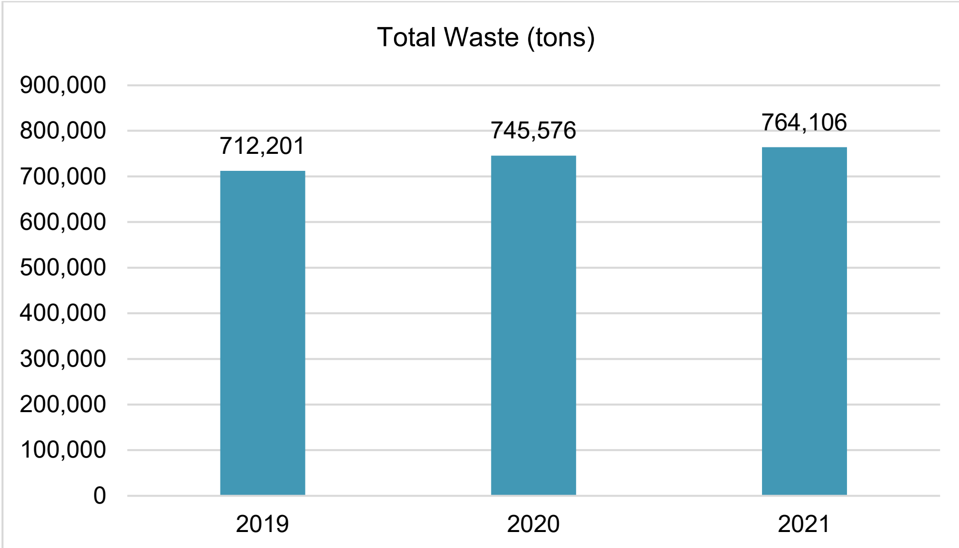
Material	2019	2020	2021
City of Tucson residential	163,276	183,452	193,273
City of Tucson commercial	65,500	59,320	73,910
City of Tucson departments	47,718	21,933	20,847
Commercial	354,725	348,346	360,626
Cash commercial	32,978	41,390	39,358
Residential	48,004	91,135	76,092
Total	**712,201**	**745,576**	**764,106**

Notes: Prepared and verified by HDR (2022).

The cash commercial category is for pay-as-you-go commercial customers hauling to Los Reales Landfill. The commercial category includes haulers who set up an account with the City. Residential includes self-haul to Los Reales Landfill (not collected by City collections employees).

Figure 4-2 shows the total waste disposed at Los Reales Landfill from 2019 to 2021. Total disposal has increased slightly over the past 3 years.

Figure 4-2. Refuse and materials collected at Los Reales Landfill[8]



4.3 Household Hazardous Waste

Los Reales Landfill accepts HHW from both residential and commercial customers. HHW can be dropped off at Los Reales Landfill. Drop off is free for City residents. Residents from Marana, Oro Valley, Sahuarita, and unincorporated Pima County are charged a $10 fee for the service. The City also holds HHW collection events on the second Saturday of every month for residents.

The City of Tucson runs a Small Business Waste Assistance Program (SBWAP), which is operated by the City's HHW Program. Businesses that operate as conditionally exempt small generators are eligible for the program and must register with the City. The program is intended to prevent illegal disposal of hazardous waste and ensures that businesses meet legal and financial responsibilities for proper waste handling. The SBWAP tracks waste for each business in the program and guarantees that it will be properly disposed of or recycled. The program also helps businesses to identify hazardous wastes that they generate on site to ensure proper disposal.

Figure 4-3 shows the breakdown of HHW collected by the City by customer type. Most of the HHW is generated by residents dropping off material at the landfill. The City website reports that approximately 98 percent of materials collected through the HHW program are recycled or reused.[5]

Figure 4-3. 2021 HHW disposal, by source

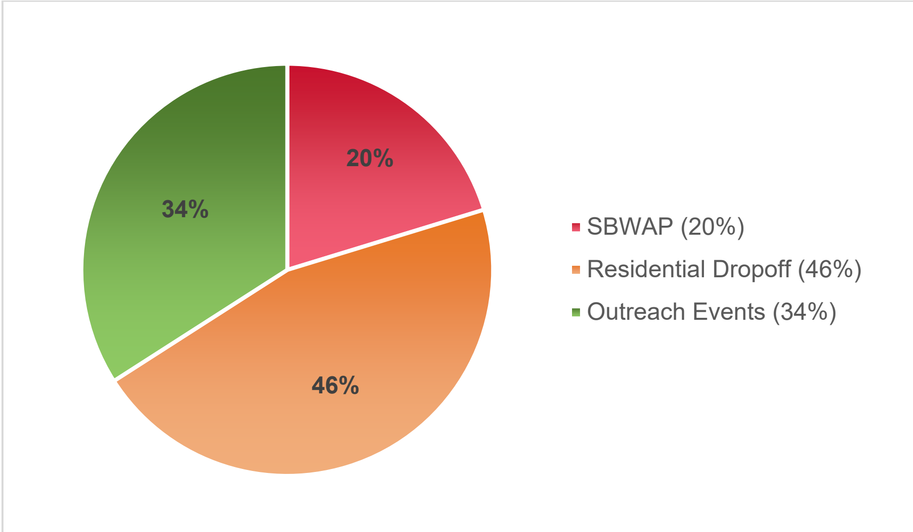
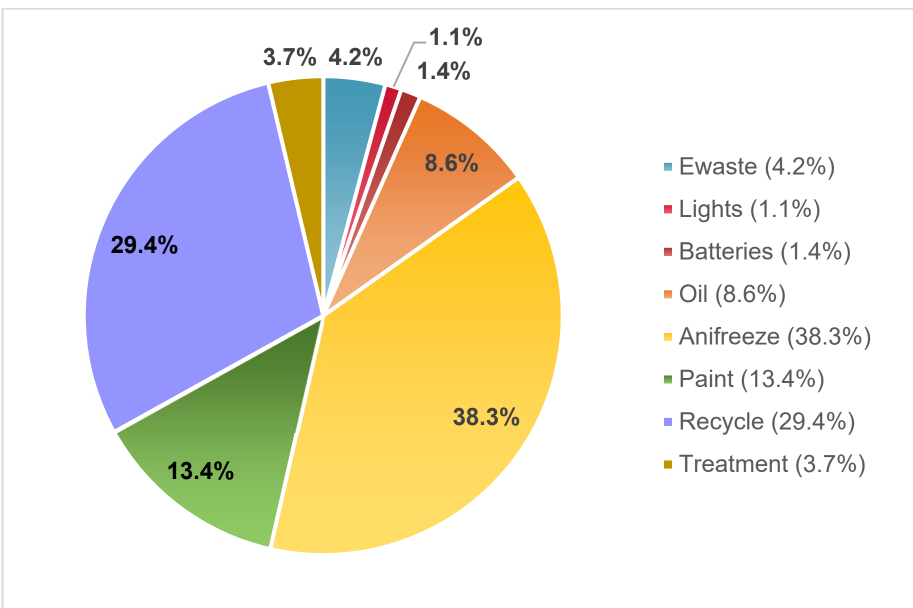


Figure 4-4 shows the composition of HHW that was collected by the City in 2021. The HHW diverted from Los Reales Landfill includes electronic waste, lights, batteries, oil, antifreeze, paint, recycled material (which includes paint sludge, aerosols, etc.), and treated material (acids and bases, oxidizers, etc.). The largest components of HHW that are generated and collected by the City include antifreeze and recycled material.

Figure 4-4. 2021 HHW composition



The City is making improvements to the HHW facility at the LRSC. In previous years, HHW from the City was sent to the Sweetwater HHW facility, which was closed in the summer of 2020. In response, the City implemented improvements at the LRSC, including two new hazardous waste storage bunkers with additional space for processing and storage. The project is scheduled for completion by October 2022.

4.4 Composting Pilot Program

In 2013, the EGSD partnered with the University of Arizona (UArizona) Compost Cats to divert compostable materials from Los Reales Landfill. The program was operated by the Compost Cats at the San Xavier Co-op Farm. The students collected food scraps from restaurants near the university. They requested that EGSD assist by transporting food waste, green waste, and animal waste from the zoo and other commercial customers to the Co-op Farm.

Eventually the program grew into the FoodCycle program, a commercial food waste collection service for local businesses within the City. In 2019, the San Xavier Co-op Farm closed. EGSD obtained a permit from the Arizona Department of Environmental Quality (ADEQ), which allowed composting of food scraps and green waste at the landfill to continue to provide services to its existing customers.

The City plans to expand the program by diverting green waste from internal City departments, including EGSD, Tucson Clean and Beautiful, Reid Park Zoo, and Transportation and Mobility. EGSD estimates that the composting facility will process and divert approximately 35,000 tons per year, which represents an annual 4 to 6 percent diversion rate. EGSD anticipates that composting food scraps and green waste will result in operational cost savings of approximately $175,000.

The City plans to collect data on composting operations and management, the quality of compost that can be produced, and operational cost, and will use that information to eventually expand to a curbside composting service. The finished compost will be used to support the Tucson Million Trees Campaign,[9] Green Stormwater Infrastructure program, roadside erosion stabilization, and daily cover and erosion and slope stabilization at the LRSC. The final compost will be available to City departments, Tucson Clean and Beautiful, and UArizona for sustainability programs and projects within the community.

The City also collects Christmas trees and mulches them. The mulch is then available to the public for free.

4.5 Annual Tonnages at Republic Services Materials Recovery Facility

Table 4-3 and Figure 4-5 show the composition of material processed by the Republic Services MRF between FY 2018 and FY 2021. FY 2018 is used as the starting point for this review given changes in how materials received were recorded between FY 2017 and FY 2018. The material list with quantities was provided by Republic Services. The facility processes large quantities of OCC, ONP, other paper, and glass. Materials processed in FY 2021 are shown in Figure 4-5.

[9] City of Tucson. "City of Tucson Climate Action Hub." https://climateaction.tucsonaz.gov/pages/milliontrees. Accessed April 2022.

Typically, trash (contamination) is the largest component of material processed by the MRF. The MRF charges the City an excess contamination charge (also known as a residue charge) of $1 per ton for each percentage point above 18.7 percent.[10] In FY 2021, the excess contamination charge cost the City $314,085, and excess contamination has cost the City approximately $1.2 million since FY 2018.[11]

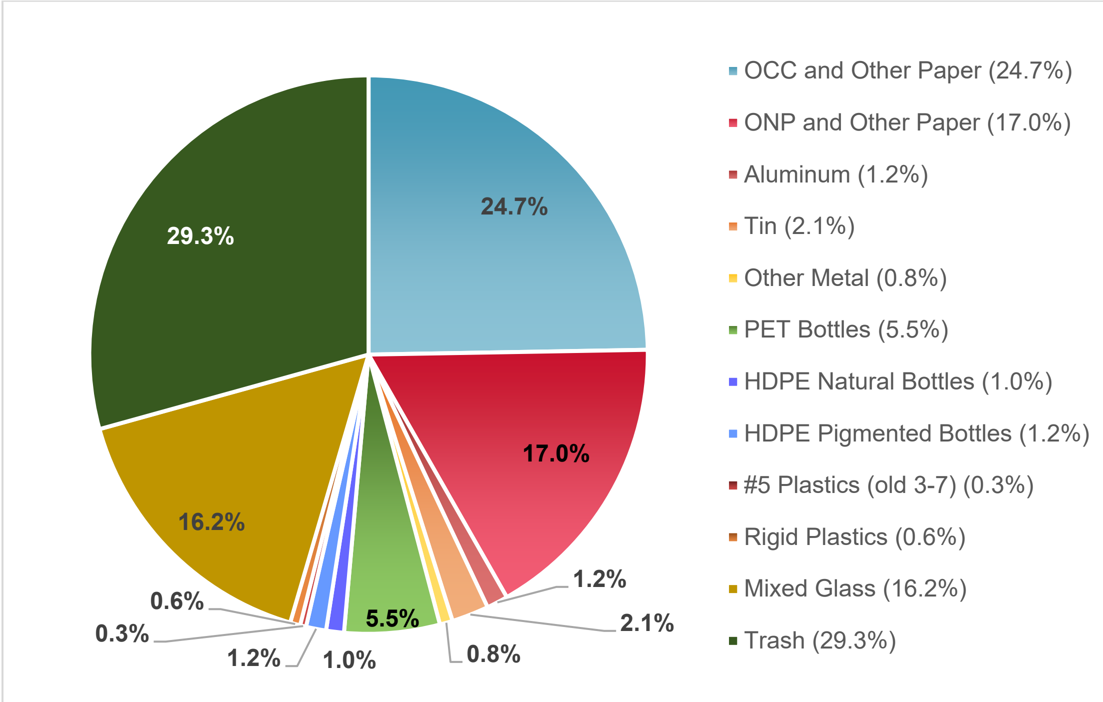
Table 4-3. MRF waste processing, in tons[11]

Material	2018	2019	2020	2021
OCC and other paper	6,617	8,069	7,025	7,322
ONP and other paper	11,312	6,882	5,977	5,045
Aluminum	376	389	395	366
Tin	792	800	756	636
Other metal	367	375	210	223
PET bottles	1,629	1,578	1,593	1,633
HDPE natural bottles	403	372	314	305
HDPE pigmented bottles	419	393	436	344
#5 plastics (old 3–7)	155	99	76	103
Rigid plastics	434	282	107	175
Mixed glass	6,818	6,950	6,295	4,788
Trash	8,276	10,988	9,844	8,679
Total	**37,598**	**37,175**	**33,027**	**29,615**

[10] MSW Consultants. *City of Tucson "Feet on the Street" Recycling Cart Monitoring and Recyclables Composition Study*. January 2022.

[11] Based on the "Tons and Revenue MRF Report thru FY2021," provided by Republic Services to the City.

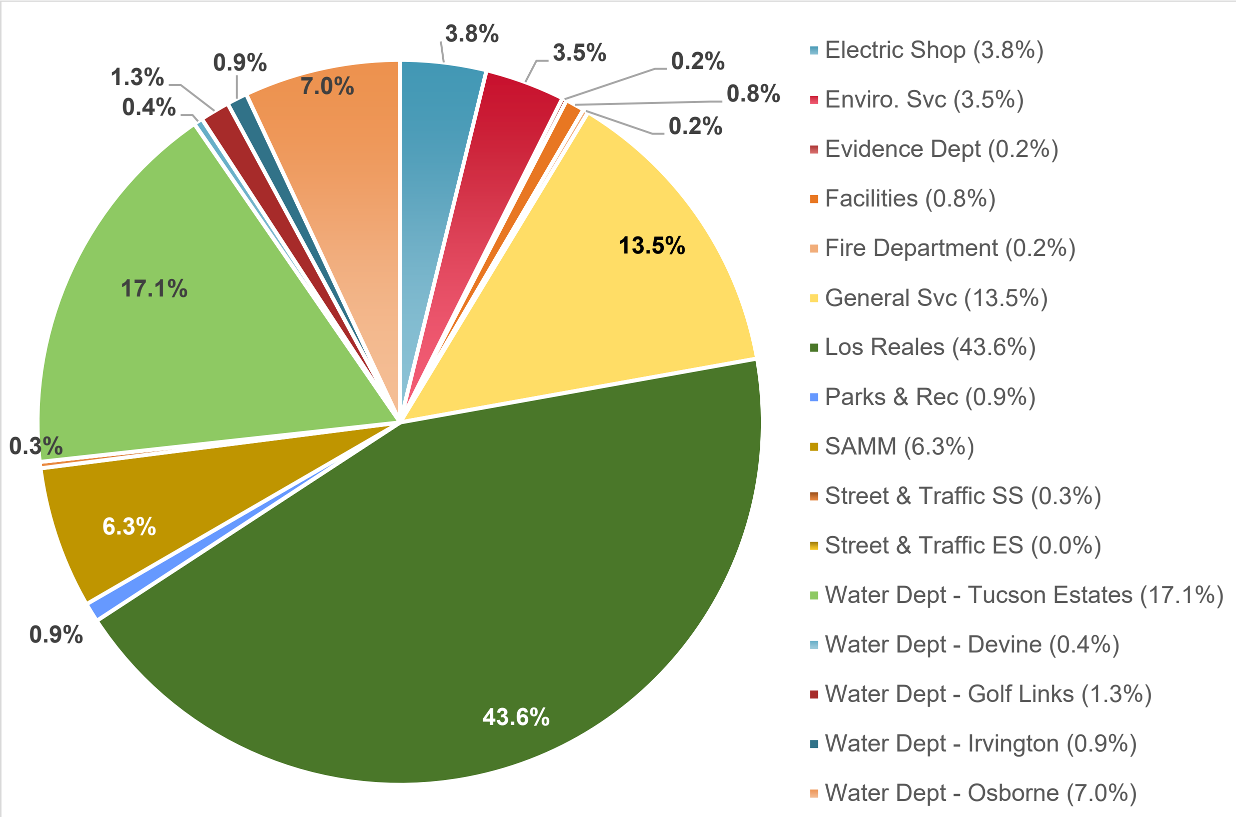
Figure 4-5. FY 2021 tons delivered to MRF (by commodity)



4.5.1 Scrap Metal

The City collects scrap metals, which are collected by HVF West, LLC, for recycling. A breakdown of metals collected by department in 2021 is included in Figure 4-6. Los Reales Landfill, the Fire Department, and the General Services Department contribute a majority of City-generated metal material that is sent to HVF West, LLC.

Figure 4-6. 2021 metals recycled, by City department

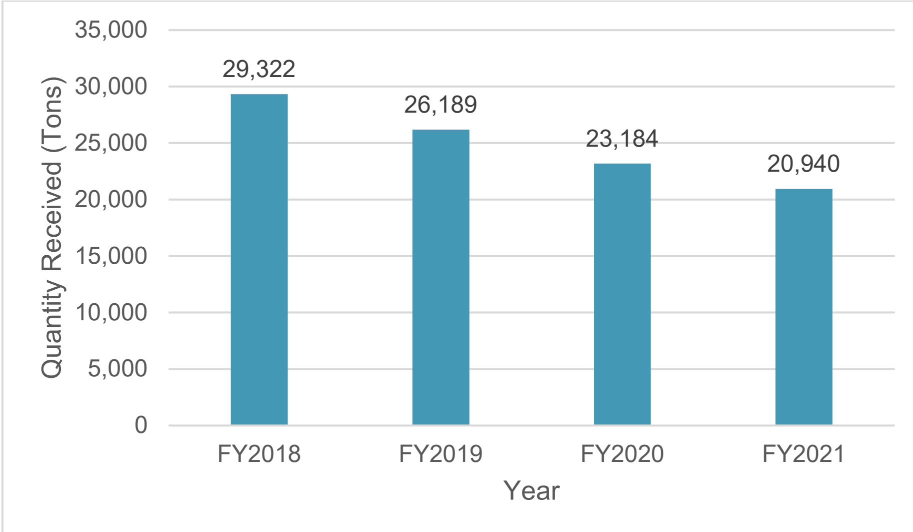


4.5.2 Recycling Contamination

Table 4-3 demonstrates that, on average, the MRF receives approximately 30,000 to 40,000 tons per year of material collected by the City, including both residential and commercial recycling. However, approximately 30 percent of the material received by the MRF each year is contamination, leaving approximately 20,000 to 30,000 tons per year of materials that are recycled. The quantity of material recycled (minus trash contamination, which is disposed in the Butterfield Station Landfill) appears to be declining steadily since 2018 (see Figure 4-7). The City of Phoenix *Waste Characterization Study* conducted in 2015 found that approximately two-thirds of residential garbage consisted of material that could be diverted through standard recycling and composting programs.[12] Compostable yard waste and food waste were the most prevalent waste types that were disposed of in residential garbage. The City of Tucson assumes that the composition of Phoenix and Tucson waste streams is likely similar. The study's results, along with high contamination rates at the Tucson MRF, indicate that a large portion of waste being disposed of at Los Reales Landfill could be diverted with more effective recycling practices by residents and expanded options for composting provided by the City.

[12] Cascadia Consulting Group. *City of Phoenix Waste Characterization Study*. September 2015.

Figure 4-7. Recycling delivered to MRF (with contamination removed)



In 2021, the City implemented a program called "Feet on the Street" to provide direct feedback to curbside recyclers on their recycling behaviors. The purpose of the program was to improve the quality of curbside recyclables and decrease contamination at the MRF. The City dispatched teams of monitors on recycling collection days to inspect the recyclables set out on the curb and identify whether residents were placing contaminants or non-recyclable materials in their bins. Recycling carts that contained contamination received an informational tag that identified the observed materials and asked residents to keep them out of their recycling carts in the future. The study targeted approximately 24,000 households across the City, or about 17 percent of all households receiving curbside recycling service.

The program was successful: the percentage of recycling carts observed to contain contaminants fell from 44 percent at the beginning of the program to 18 percent at its conclusion. Furthermore, the percentage of contamination within the curbside recyclables sampled from the study areas fell from 24.5 to 19.1 percent (by weight). These results indicate that outreach and educational programs may be effective in reducing contamination rates at the MRF.

4.6 Diversion Performance

Currently, the waste streams that are either collected by the City or received at a City facility and are diverted from the landfill include recyclables sent to the MRF, scrap metal, household hazardous waste (HHW), City glass recycling, and compostable materials. Waste streams that are disposed of in Los Reales Landfill include residential and commercial waste collections from the City of Tucson, waste from City departments, commercial collection and disposal, and residential self-haul.

In 2021, approximately 797,000 tons of waste were collected or received via the waste streams listed above. Of that, 29,620 tons (3.72 percent) were diverted to the MRF, 894 tons (0.11 percent) were sent to scrap metal recycling, 518 tons (0.06 percent) were diverted as HHW, 1,713 tons (0.21 percent) were recycled through the City glass recycling program, and 261 tons (0.03 percent) were processed to create compost. This resulted in a diversion rate of 4.14 percent for the material that the City either collected or received in 2021.

Focusing strictly on the City's collection services, the diversion rate for 2021 was 9.3 percent. The City collected 288,030 tons (90.7 percent) of trash and 29,620 tons (9.3 percent) of recycling from residential, commercial, and City department accounts.

Table 4-4 shows the waste streams that were considered in this evaluation, averaged over the past 3 years. The average diversion rate over this time period for waste streams either collected by the City or received at a City facility is 4.8 percent. The average diversion rate over this time period for waste streams collected by the City's collection services is 10.8 percent.

Table 4-4. Waste diversion evaluation

Waste stream	2019 (tons)	2020 (tons)	2021 (tons)	Percentage of waste stream (3-year average)
City of Tucson residential	163,276	183,452	193,273	23%
City of Tucson commercial	65,500	59,320	73,910	9%
City of Tucson departments	47,718	21,933	20,847	4%
Commercial	354,725	348,346	360,626	46%
Cash commercial	32,978	41,390	39,358	5%
Residential (self haul)	48,004	91,135	76,092	9%
MRF recycling	37,176	33,027	29,620	4.29%
Scrap metal	1,133	2,518	894	0.20%
HHW[a]	257	197	518	0.04%
City glass recycling[b]	—	—	1,713	0.21%
Compostable materials[b]	—	—	261	0.03%
Total	**750,766**	**781,319**	**797,112**	**—**

[a] HHW includes material from the Drop N Swap, SBWAP, home pickup, and outreach events.
[b] Tracking information from the City's glass recycling and compost pilot program is available only beginning in 2021.

The LRSC is a regional waste disposal site and, therefore, a regional diversion rate methodology would ideally consider all material processed by the regional MRF, not only the recycling processed for the City, to be an equivalent comparison. However, information on all recycling processed by the MRF is not currently available and, therefore, only the material diverted to the MRF through City collections is included in the MRF recycling category in Table 4-4.

It is likely that the City's overall diversion rate is higher than indicated. There is potentially other recycling and reuse of material in the City outside of the data provided that is not accounted for by the City's tracking systems. Scrap metal recycling from construction and demolition jobs or remodels, food waste that is either land spread or fed to animals, bales of cardboard that are sold direct to OCC markets, and other diversion types may be occurring in the City but are not currently tracked. HHW that is received outside of the Los Reales system was also not included in this evaluation. Tracking those recycling streams could potentially increase the City's diversion rate above 4 to 5 percent with additional data collected.

5 Population Growth Considerations

Planning for future program and facility requirements, including those that would reduce waste generation and increase waste diversion, requires consideration of how the population in Tucson and surrounding communities will grow and change over time. This was addressed in the recent *Landfill Gas Recovery and Reutilization Feasibility Assessment* prepared for the LRSC by GHD. To provide continuity across planning programs, the Roadmap will also use the same range of population growth as the landfill gas planning, which is 0.5 to 1.5 percent annually. Although the landfill gas study evaluated three scenarios that assumed varying rates of success in increasing diversion, the Roadmap is focused on the generation of waste and will assume that waste generation will increase proportionally to population.

6 Previous Zero Waste Outreach

The City conducts regular outreach and education for customers, both online and in person, and through printed media. Online activities include maintaining and expanding its social media presence, providing the Recycle Coach website and app, and maintaining an informative website. The City also conduct in-person outreach through neighborhood associations, schools, landfill tours, and partnerships with local organizations such as Tucson Clean and Beautiful. Printed media includes brochures and printable guides to services provided by the City.

Gathering public feedback specifically on zero waste was included in the City's Climate Action Community Survey, which was rolled out in February 2021. The City received 1,772 registered responses to the survey. These results showed support among respondents for implementing waste reduction and diversion programs. The survey asked respondents which waste strategies they would support to reduce greenhouse gas emissions. 88.1 percent of respondents supported or strongly supported increasing recycling compliance and landfill waste diversion. 72.5 percent of respondents supported or strongly supported pilot programs for curbside collection of compostable materials. 83.8 percent of respondents supported or strongly supported promoting the transition from "demolition" to "deconstruction" to maximize the reuse, resale, and/or recycling of building structures and features.

The survey also indicated that residents are interested in implementing measures into the climate action plan in an effort toward reaching equity. 90.9 percent of respondents support or strongly support reducing waste to landfill by diverting excess food (for example, from restaurants) to those in need. 27.9 percent of respondents indicated that they are interested in recycling, reducing food waste, and composting, and 56.7 percent of respondents responded that they are already practicing those measures.

7 Proposed Sustainability Initiatives

On March 9, 2022, the Assistant City Manager issued a memorandum on project updates and proposed projects at the LRSC to the Mayor of Tucson and City Council. Several sustainability projects have been identified by the Mayor and City Council as part of *Phase I – LRSC Proposed Long-Term Programmatic and Sustainability Improvements.* The following sustainability improvements are being considered:

1. Landfill Gas Recovery and Reutilization – GHD prepared an assessment of options for methane gas generated by the landfill. GHD recommended upgrading the current landfill gas (LFG) system to a renewable natural gas (RNG) processing facility, where it could be transferred to a nearby natural gas pipeline. The RNG produced could be used to fuel the City's fleet, and the excess RNG could be marketed and sold. This project is intended to reduce fugitive methane emissions, improve air quality, fuel the City's fleet, and potentially provide a revenue stream to the City.
2. City Tree Nursery – The City plans to create a space to grow low-cost, drought-tolerant trees to achieve the Tucson Million Trees Initiative.[9] Trees from the nursery will also be used to provide a landscaping buffer around LRSC to minimize impacts to surrounding neighborhoods.
3. Perimeter Landscaping Buffer and Multi-Use Trail System – The City plans to construct a 2-mile multi-use pathway populated with trees and vegetation. The project will include stormwater capture.
4. Passive and Active Recreational Areas – Portions of the 1,100-acre LRSC have been set aside for future active and passive recreational areas. These areas will function as additional perimeter buffer zones and as an opportunity to plant additional drought-tolerant trees.
5. Shovel-ready Pad, New/Proposed Mixed Waste Processing Facility – A mixed waste processing facility would increase the City's waste diversion rate by extracting traditional recyclables that have been disposed of in the trash. There has been substantial interest from private investors to build a multi-stream waste processing facility and/or waste-to-energy (WTE) facility at the LRSC. This project will create a shovel-ready site for future construction of a mixed waste processing facility.
6. Shovel-ready Commercial and Industrial Pads – This project will create shovel-ready buildable pads to provide space for local companies, entrepreneurs, research institutions, and nonprofit organizations to implement alternative disposal, reuse, and recycle technologies. To support this project, HDR has prepared a Request for Information from respondents who present innovative waste processing, conversion, or beneficial technologies and are interested in developing a project within the LRSC.
7. Improvements to On-site Non-potable Reuse Water System – The City operates a groundwater pump and treat system with re-injection and reuse of treated water as a non-potable water source for daily operations. Improvements to this system are required to meet future demand for water in daily operations.

8. Build Back Better Grant Proposal – The City of Tucson was awarded a Phase I Build Back Better Regional Challenge Grant on behalf of the Southern Arizona Coalition for Climate Adaptation and Resilience. The Phase I award provides funding for the City and its partners to build out the conceptual framework and define specific projects and programs for which the City will seek implementation funding.

8 Summary

The City is currently diverting several waste streams from the landfill, including blue bin recycling, scrap metal, glass, limited food waste collection for composting, and HHW. This evaluation indicated that the City's current diversion rate is approximately 4 percent. Based on waste characterization studies prepared on behalf of the Cities of Tucson and Phoenix, at least 40 percent of waste disposed of in the landfill could be diverted through a composting program and 10 to 20 percent of waste could be recycled.

This evaluation demonstrates that the City could improve the efficiency of existing programs and develop new waste diversion strategies for recyclable, reusable, and/or compostable materials from the MSW stream collected by the City.

The next step is to identify potential diversion options or programs that could improve the City's diversion rates to make progress toward a goal of zero waste. Next steps will also include developing plans to expand or improve existing diversion programs. Several of the proposed sustainability initiatives listed in Section 7 address the potential issues identified in this report. A mixed waste processing facility could increase diversion of traditional recyclables from the landfill, even if residential recycling behaviors remain unchanged. Furthermore, the Feet on the Street recycling initiative indicated that recycling behaviors can be measurably improved with targeted public education.

The City is also working to treat waste as an asset, rather than a liability, by soliciting local companies, entrepreneurs, research institutions, and nonprofit organizations who may be able to incorporate reused materials into their products or deploy alternative reuse and recycle technologies.

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APPENDIX B

Aspirational Programs and Best Practices

Aspirational Programs and Best Practices

Zero Waste Roadmap Development

Prepared for: City of Tucson Environmental and General Services Department

Tucson, Arizona

June 30, 2022

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Contents

Appendices

Tables

Acronyms and Abbreviations

C&D	construction and demolition
City	City of Tucson
EJ	environmental justice
HHW	household hazardous waste
LRSC	Los Reales Sustainability Campus
Metro	Oregon Metro
MRF	materials recovery facility
MSW	municipal solid waste
NRC	neighborhood recycling center
Roadmap	City of Tucson's Zero Waste Roadmap
SPU	Seattle Public Utilities

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1 Introduction

HDR has been retained by the City of Tucson (City) to assist the City during the first phase of its move toward "zero waste" with the implementation of the Zero Waste Roadmap (Roadmap). The Roadmap is meant to gather information on what "zero waste" means to Tucson and to identify strategies that would best support that vision.

The City previously identified and commissioned a report on five cities with zero waste or solid waste management plans that it considers to be aspirational; these plans contain best practices that may be applicable to Tucson. As part of the Roadmap development efforts, HDR reviewed this previous research and the latest versions of the plans and progress reports for these previously identified cities. In addition, new areas of focus were added, such as environmental justice (EJ), and interviews were conducted with representatives from several jurisdictions to provide further insight that could be valuable to the City as it embarks on its own path toward zero waste. Interview notes are provided in Appendix A.

1.1 Selection of Communities

Many jurisdictions in North America have innovative features as part of their waste management programs and services. This benchmarking memo discusses five communities that have some similarities to Tucson and have implemented best practices that may be of interest to the City.

Five jurisdictions/communities in the western United States were previously reviewed for Tucson, and the relevant information was updated to support this project. The communities selected include Austin, Texas; Denver, Colorado; Phoenix, Arizona; Portland, Oregon; and Seattle, Washington. Their solid waste plans are listed in Section 11, *References*.

While many aspects of these programs could be assessed, the following metrics were chosen in consultation with the City for benchmarking:

- population and demographics
- waste reduction and diversion goals
- definition of zero waste
- waste composition, if available
- diversion rates
- partnerships/collaborations
- economics and end markets
- EJ indicators
- current engagement and education efforts
- policy, legislative, and/or regulatory requirements (for example, extended producer responsibility programs)

2 Zero Waste Goals

Zero waste goals have been adopted by many communities to improve their solid waste management programs. The chosen communities in this report have each created their own zero waste plans and have defined the term *zero waste* to meet their community's goals or visions. Zero waste goals are established in zero waste plans or as targets in a master plan.

2.1 Tucson

The City of Tucson is in the process of defining *zero waste* and identifying waste reduction goals. The City declared a Climate Emergency in a resolution approved in September 2020. The Resolution states that the City will develop a Zero Waste Plan with a 50 percent waste diversion goal by 2030 and a goal of zero waste by 2050.

The City gathered public feedback on zero waste in the Climate Action Community Survey, which was rolled out in February 2021. The results indicated that respondents support waste reduction and diversion programs, particularly by increasing recycling compliance and landfill waste diversion. Most respondents also supported pilot programs for curbside collection of compostable materials. For more information on the survey and the City's existing waste infrastructure, see the *Current Conditions Assessment* memo, dated June 2022.

2.2 Austin

The City of Austin defines *zero waste* as designing and managing products and processes to systematically avoid and eliminate the volume and toxicity of waste and materials, conserve and recover all resources, and not burn or bury them.[1] Austin developed the *Austin Resource Recovery Master Plan* in 2011, which set goals to divert 85 percent of its waste from landfills by 2025 and 95 percent or more by 2040, and to achieve a restorative economy by 2050. Austin adopted the concept of the restorative economy from Paul Hawken, a prominent environmental activist, as follows:

> In a restorative, "least cost economy," we move to that system of agriculture, forestry, transportation, construction, and communication that has the least cost to the environment… In a least-cost system, those resources, our "natural capital," are valued at their true replacement cost. Instead of competing to produce the cheapest goods in terms of price, we compete to produce the goods and services we need, according to which have the lowest impact on those resources and thus the lowest cost to current and future generations.[2]

In the Plan, the City set forth the following goals:

- Expand and improve local and regional reuse, recycling, and composting programs;
- Adopt new rules and incentives to reward those who embrace the goal of zero waste;

[1] *Austin Resource Recovery Master Plan*, https://www.austintexas.gov/sites/default/files/files/Trash_and_Recycling/MasterPlan_Final_12.30.pdf, 2011
[2] Ibid.

- Develop green campuses and resource recovery parks for zero waste infrastructure;
- Advocate for producer and retailer responsibility for product and packaging wastes, and bans on problem materials;
- Educate and advocate for a zero waste agenda as part of climate change and sustainability policies and programs; and
- Involve the community through collaboration and partnerships to achieve zero waste.

2.3 Denver

Denver produced a *Master Plan for Managing Solid Waste in the Mile High City* in 2010, which defined a zero waste economy as one in which less is consumed, all products are built to last and are easy to reuse and repair, and all materials are reused, recycled, and composted in a continuous cycle.[3] Denver stated that it wanted to have a 34 percent reduction in the total landfilled waste by 2020. For City facilities, the goal diversion rate was higher, at 40 percent.

The State of Colorado performs an annual waste composition study to track diversion rates between recycling, compost, and what ends up at landfills.

2.4 Phoenix

Phoenix developed its *Solid Waste Strategic Plan* (Fiscal Years 2016–2021) in 2015 to achieve 40 percent diversion by 2020 and to become a zero waste city by 2040.[4] In a recent interview with the City of Phoenix, City representatives said they are currently producing an updated solid waste plan to achieve zero waste by 2050. The term *zero waste* has not been defined by the City because it is flexible and evolving. Phoenix works through a circular economy model to increase waste diversion.

In the 2015 *Solid Waste Strategic Plan*, Phoenix outlines five major strategic focus areas with targets and metrics.[5] Those focus areas were defined as:

- Sustainable Infrastructure – Supporting environmentally sound design, construction, and maintenance;
- Net-Positive Operations – Maximize efficiency, reduce impact, increase handprint;
- Community & Economic Development – Promote quality local jobs and business attraction, create a circular economy;
- Education and Community – Transform behavior, empowerment through communication; and
- Healthy and Safe Environment – Protect the environment, residents, and employees.

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[3] CoPIRG, https://copirg.org/feature/cop/Zero-waste#:~:text=A%20Zero%2Dwaste%20economy%20is,composted%20in%20a%20continuous%20cycle, March 2022

[4] Solid Waste Strategic Plan, https://www.phoenix.gov/publicworkssite/Documents/Final%202016.2021.Strategic%20Plan.pdf, May 2015

[5] Ibid.

Within each major goal, Phoenix defined several steps for the City to improve its waste diversion, measure success, and identify programs to achieve goals.

2.5 Portland

In researching zero waste goals and other metrics for the City of Portland, HDR also included Oregon Metro (Metro) and its relationship to the City of Portland. Metro is a public agency that serves 24 cities (including Portland) and 3 counties in the Portland region. It is the only regional government agency in the country that consists of elected officials. One of Metro's responsibilities is to plan and oversee the solid waste system for the region. State law made Metro responsible for creating an overarching waste management plan for the region. The plan is not necessarily meant to focus on diversion goals but to instead focus on the quality of and access to basic solid waste management services.[6] Metro also supports cities with creating their own annual implementation plans in accordance with regional guidance and requirements.

In 2019, the Metro Council approved the 2030 *Regional Waste Plan*.[7] The Plan is both a vision for the Portland region's garbage and recycling system and a blueprint for achieving that vision, focusing on the following three points:

- Listening and learning shaped the plan. Metro gathered input from more than 4,000 local residents to design program changes.
- Solutions by the community, for the community. The plan's goals and actions were generated in partnership with people most affected by historical injustices and inequities: people of color, immigrants and refugees, people with low incomes, residents of multifamily housing communities, and English language learners.
- Benefits will be shared by all residents. The plan moves the community toward a system where barriers and disparities are eliminated and includes actions designed to correct previous wrongs and honor the differences among people, no matter their race, immigration status, or income level.

The plan outlines:

- The values, principles, and vision to guide how improvements will be made and managed;
- 19 goals and 105 related actions to help the region achieve its vision by 2030; and
- An approach to carrying out the plan and measuring progress over time.

Cities within Metro may choose to go above and beyond the requirements of the *Regional Waste Plan* and may develop their own specific diversion goals. In 2008, the City of Portland set a goal to achieve a 75 percent diversion rate by 2015,[8] and current recovery rates are around 54 percent. In 2015, a new goal was adopted to reduce per capita solid waste by 33 percent and to recover 90 percent of municipal solid waste

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[6] Phone interview with Luis Sandoval, Senior Solid Waste Planner at Metro, March 29, 2022
[7] Regional Waste Plan, https://www.oregonmetro.gov/regional-waste-plan, 2019
[8] Portland Recycles, https://www.portlandoregon.gov/bps/article/230043, 2008

(MSW) that is generated. There is an intentional focus on food scraps, with a reduction goal of 90 percent.[9]

2.6 Seattle

Seattle defines *zero waste* as designing and managing products and processes to systematically avoid and eliminate the volume and toxicity of waste and materials, conserve and recover all resources, and not burn or bury them.[10]

Seattle sets goals and reports its updates in various reports rather than one master plan. The City produces an annual waste prevention and recycling report to show progress towards key goals, a solid waste quarterly report that reports all the tonnage data, and construction, demolition, and land waste, transfer station, and recycling market reports more specific to their scope of work. Future specific goals will be included in Seattle's 2022 *Solid Waste Plan Update* to work toward a preventative strategic plan with multiyear planning initiatives on waste prevention efforts.[11]

2.7 Comparison of Goals

Table 2-1 shows a timeline for each jurisdiction's waste reduction and diversion goals.

Table 2-1. Comparison of goals

City	2020	2030	2040	2050
Tucson	—	50% diversion	—	Zero waste
Austin	75% diversion	90% diversion	95% diversion	Restorative economy
Denver	34% citywide recycling goal	—	—	—
Phoenix	40% diversion	—	Zero waste	—
Portland	75% recycling rate	Recover 90% of generated MSW	—	—
Seattle	To be redefined in the 2022 *Solid Waste Plan Update*	—	—	—

[9] Refuse & Recycling Study, MSW Consultants, 2020
[10] Seattle Public Utilities, http://www.seattle.gov/utilities/about/plans/solid-waste/Zero-waste, 2004
[11] 2020 *Waste Prevention & Recycling Report*, http://www.seattle.gov/documents/Departments/SPU/Documents/Recycling_Rate_Report_2020.pdf, 2020

3 Population and Demographics

The following sections provide an overview of the population and demographics of each community, according to the U.S. Census Bureau.[12]

3.1 Tucson

Tucson is the second-largest city in Arizona, with a population of 557,718, according to the 2020 census. The geographic area of Tucson is 238 square miles, and the City has a population density of 2,343 persons per square mile (the lowest of any city included in this evaluation). The City's estimated population growth is 0.5 to 1.5 percent per year.

3.2 Austin

Austin ranks as the 10th-largest city in America and the fastest-growing city in Texas.[13] According to the U.S. Census Bureau, in 2020, the population was estimated at 1,028,255, and Austin has experienced 30 percent growth since 2010. The city spans over 327 square miles, resulting in a population density of 3,214 persons per square mile.

3.3 Denver

Denver is the largest city in Colorado, with a population of 715,522 according to the 2020 census. The city spans approximately 153.4 square miles, resulting in a population density of 4,742 persons per square mile. Since 2010, the City has had a 26.6 percent growth rate, consistently increasing by 1.7 percent each year.

3.4 Phoenix

Phoenix is the capital of Arizona, with a population of over 1.7 million. The city is the fifth-largest city in America and, in 2013, Phoenix ranked the eighth fastest-growing city, behind Las Vegas. The city's annual growth rate is approximately 1.5 percent; since the last census in 2010, the population has increased by 21.74 percent. Phoenix spans approximately 517 square miles, with a population density of 3,400 people per square mile.

3.5 Portland

Portland is the capital of Oregon and the state's most populated city, with a population of 652,503, according to the 2020 census. The city has grown at a constant rate of around 1 percent each year since 2010, with an overall growth of 14 percent. Portland covers approximately 133.4 square miles, with a population density of 4,995 people per square mile. Oregon governs with Oregon Metro as the overarching democratic council that sets the baseline for 24 cities and 3 counties in the Portland area, with a total population of

[12] U.S. Census Bureau, https://www.census.gov/, 2020
[13] Austin World Population Review, https://worldpopulationreview.com/us-cities/austin-tx-population, 2022

more than 1.5 million people.[14] The local government of Portland is required to follow the set standards and is also allowed to make stricter rules for city residents.

3.6 Seattle

Seattle, Washington state's capital, is one of 14 cities in America that grew by more than 100,000 people in the last decade.[15] There was 29.5 percent population growth between 2010 and 2020, bringing the population to 787,995. Seattle is 83.9 square miles, and the population density is over 9,396 people per square mile.

3.7 Comparison of Population and Demographics

This section compares population and population density because they may affect the costs of implementing additional collection services related to the distance between stops, time to service, and available markets. The median income is provided because it may indicate what residents are willing and/or able to pay for zero waste and waste reduction services. Demographics may have an impact on how outreach is conducted, including translation into additional languages.

Table 3-1 summarizes the information for the communities listed above in relation to Tucson. Compared to other communities, Tucson has the current lowest population and the lowest population density. Population, demographics, and EJ indicators are important factors when creating an equitable and inclusive zero waste plan. Key factors such as population density and food deserts contribute to material movement and distances. Distance affects tipping fees and shipping costs because the farther materials need to be shipped, the more expensive. The median income is also listed as a comparison reference point.

Table 3-1. Comparison of population and demographics

	Tucson[a]	Austin[b]	Denver[c]	Phoenix[d]	Portland[e]	Seattle[f]
Population	557,718	1,020,000	715,522	1,700,000	652,503	787,995
White (%)	43.9%	48.3%	54.2%	42.5%	70.6%	63.8%
Black/African American (%)	5.2%	7.8%	9.2%	7.1%	5.8%	7.3%
Hispanic/Latino (%)	43.6%	33.9%	29.9%	42.6%	9.7%	6.7%
Asian (%)	3.2%	7.6%	3.7%	3.8%	8.2%	15.4%
Foreign born (%)	15.3%	18.8%	15.0%	19.4%	13.5%	18.8%
Geographic area (square miles)	238.0	319.9	153.3	517.7	133.4	83.9

[14] Oregon Metro, https://www.oregonmetro.gov/regional-leadership/what-metro, 2022

[15] Seattle U.S. Census 2020 Data, https://www.seattle.gov/opcd/population-and-demographics/about-seattle, 2020

	Tucson[a]	Austin[b]	Denver[c]	Phoenix[d]	Portland[e]	Seattle[f]
Population density (people per square mile)	2,343	3,214	4,958	3,400	4,995	9,396
Median household income (2019 $)	$43,425	$71,576	$68,592	$57,459	$71,005	$92,263
Poverty rate	22.45%	13.23%	12.86%	17.97%	13.72%	10.96%

[a] U.S. Census Bureau, https://www.census.gov/quickfacts/fact/table/tucsoncityarizona,US/POP010210, 2022
[b] U.S. Census Bureau, https://www.census.gov/quickfacts/fact/table/austincitytexas/POP010210, 2022
[c] U.S. Census Bureau, https://www.census.gov/quickfacts/fact/table/denvercitycolorado/POP010210, 2022
[d] U.S. Census Bureau, https://www.census.gov/quickfacts/fact/table/phoenixcityarizona/POP010210, 2022
[e] U.S. Census Bureau, https://www.census.gov/quickfacts/fact/table/portlandcityoregon/POP010210, 2022
[f] U.S. Census Bureau, https://www.census.gov/quickfacts/fact/table/seattlecitywashington/POP010210, 2022

4 Waste Composition

The following section breaks down the city-wide waste composition for each community based on recent waste characterization studies. When the distinction of materials was completed, the applicable breakdown is provided in Table 4-1.

4.1 Tucson

The City of Tucson used three waste characterization studies to estimate the composition of material being disposed of at LRSC: the City of Tucson Waste Diversion Plan and Roadmap (2014), City of Phoenix Waste Characterization Study (2015), and City of Phoenix Residential Waste Characterization Study (2017–2018), which were averaged to estimate current waste composition in Tucson. The waste breakdown for the City of Tucson is provided in Table 4-1.

4.2 Austin

Austin conducted a community diversion study in 2015 to represent the current recycling and waste characterization.[16] The waste composition study involved making 1,500 observations at commercial facilities and creating zones to group approximately 80 to 150 businesses into categories. The commercial waste breakdown for the City of Austin is provided in Table 4-1.

[16] Austin's 2015 *Community Diversion Study*, https://www.austintexas.gov/sites/default/files/files/Resource_Recovery/Austin_s_2015_Community_Diversion_Study-Final-04.29.16.pdf, April 2016

Table 4-1. Waste characterization study results per community as percentage of total materials

Material	Tucson[a]		Austin[b]		Denver[c]	Phoenix[d]		Portland[d]		Seattle[f]
	Recycling (%)	Trash (%)	Recycling (%)	Trash (%)	Recycling (%)	Recycling (%)	Trash (%)	All (%)	Recycling (%)	Trash (%)
Cardboard	24.7	—	68.5	51.7	29.8	—	—	9.0	16.4	—
Mixed paper	17.0	17.9	51.4	22.4	8.6	44.7	8.5	6.9	39.5	20.3
Hard plastics	8.6	10.1	38.9	18.1	3.2	11.0	5.7	6.2	5.0	11.5
Metals	4.1	3.8	36.7	5.9	1.6	4.2	2.3	5.1	2.5	3.1
Glass	16.2	2.0	9.8	2.1	4.1	9.6	1.6	0.8	26.1	2.3
Unknown	—	—	9.5	61.9	—	—	—	—	—	—
Trash	29.3	—	3.0	26.7	—	18.0	27.0	—	10.5	—
Plastic films	—	—	9.8	7.3	—	0.6	0.8	5.4	—	—
Organics	—	42.5	1.8	12.9	29.1	—	35.9	49.0	—	53.8
Textiles	—	—	1.0	3.3	1.5	—	—	6.2	—	—
Other	—	14.7	7.0	17.3	0.3	14.8	21.0	15.8	—	2.8
Commingled	—	—	—	—	0.2	—	—	—	—	—
Electronics	—	—	—	—	1.3	—	—	—	—	0.9
Tires	—	—	—	—	3.5	—	—	0.2	—	—
White goods	—	—	—	—	6.1	—	—	—	—	—
Yard trimmings	—	—	—	—	10.7	—	—	—	—	—

Material	Tucson[a]		Austin[b]		Denver[c]	Phoenix[d]		Portland[d]		Seattle[f]
	Recycling (%)	Trash (%)	Recycling (%)	Trash (%)	Recycling (%)	Recycling (%)	Trash (%)	All (%)	Recycling (%)	Trash (%)
Construction and demolition	—	8.4	—	—	—	1.7	6.8	—	4.6	—
Household hazardous waste	—	0.6	—	—	—	—	0.6	0.3	0.5	—

[a] More detail on the City of Tucson's waste characterization is included in the Current Conditions Assessment Memo (April 2022). The waste characterization of the trash was estimated using three waste characterization studies from the City of Tucson and the City of Phoenix: City of Tucson Waste Diversion Plan and Roadmap (2014), City of Phoenix Waste Characterization Study (2015), and City of Phoenix Residential Waste Characterization Study (2017-2018). The recycling summary was collected from the MRF, and does not include materials recycled at the LRSC, including household hazardous waste (HHW), scrap metal, or compostable materials diverted through the City's FoodCycle program.

[b] Austin's 2015 *Community Diversion Study*, https://www.austintexas.gov/sites/default/files/files/Resource_Recovery/Austin_s_2015_Community_Diversion_Study-Final-04.29.16.pdf, 2016

[c] 2020 Colorado Recycling Totals, https://cdphe.colorado.gov/colorado-recycling-totals, March 2022

[d] *Residential Waste Characterization Study*, https://www.phoenix.gov/publicworkssite/Documents/Final_web_Phoenix_2017-18%20WCS.pdf , May 2018

[e] *Waste Composition Study*, https://www.oregon.gov/deq/mm/pages/waste-composition-study.aspx, July 2018

[f] Solid Waste Composition Studies, https://www.seattle.gov/utilities/about/reports/solid-waste-reports/composition-studies, 2014 and 2015

4.3 Denver

The State of Colorado conducts an annual waste composition study to track its progress toward its goal diversion rate.[17] In 2020, the composition was divided between industrial materials and MSW materials from residential and commercial sources. Colorado's Solid Waste and Materials Management Program is responsible for monitoring and inspecting various facilities, ranging from landfills, recycling facilities, waste tire sites, to many others. The Program conducts annual waste composition studies of the waste disposed of at landfills, or diverted to recycling/composting facilities, or used for beneficial reuse and industrial recycling.[18] While not specific to Denver, this is the best available data over time for the city.

4.4 Phoenix

In 2018, Phoenix conducted a waste characterization study to identify areas where diversion rates could use improvement. There were 260 hand-sorted garbage samples and 200 hand-sorted recycling samples to represent the residential waste in Phoenix.[19] Notable findings from the study included that approximately 60 percent (77,400 tons) of the residential waste could potentially be diverted through recycling and compost programs.[20] In the recycling findings, it was noted that approximately 30.5 percent of the recycling stream contained contaminants. The waste breakdown provided in Table 4-1 includes both waste and recycling data.

4.5 Portland

The State of Oregon conducted a waste characterization study in 2016, collecting 974 samples weighing more than 200 pounds each.[21] The data reflect samples collected from all waste streams, garbage, recycling, and composting levels. Samples were collected at landfills, transfer stations, and mixed solid waste processing facilities throughout the year to gauge an average waste stream to represent residential, commercial, and self-haul composition. Results for Portland are provided in Table 4-1.

4.6 Seattle

Seattle Public Utilities (SPU) conducted a residential waste composition study in 2014 and a residential recycling stream composition study in 2015.[22] The residential waste and recycling streams consist of single-family and multifamily residences, where samples

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[17] 2020 Colorado Recycling Totals, https://cdphe.colorado.gov/colorado-recycling-totals, March 2022

[18] Ibid.

[19] *Residential Waste Characterization Study*, https://www.phoenix.gov/publicworkssite/Documents/Final_web_Phoenix_2017-18%20WCS.pdf, May 2018

[20] Ibid.

[21] Oregon *Solid Waste Characterization and Composition Study*, https://www.oregon.gov/deq/mm/pages/waste-composition-study.aspx, July 2018

[22] Solid Waste Composition Studies, https://www.seattle.gov/utilities/about/reports/solid-waste-reports/composition-studies, 2014 & 2015

were collected in eight sampling zones. In the waste stream study, 362 samples were sorted into 115 categories. For the recycling composition study, 270 samples were obtained from 177 single-family and 93 multifamily residences throughout 2015.

5 Recycling and Diversion Rates

The following sections provide an overview of each community's recycling and diversion rates.

5.1 Tucson

Currently, the waste streams that are either collected by the City or received at a City facility and are diverted from the landfill include recyclables sent to the MRF, scrap metal, household hazardous waste (HHW), City glass recycling, and compostable materials. Waste streams that are disposed of in Los Reales Landfill include residential and commercial waste collections from the City of Tucson, waste from City departments, commercial collection and disposal, and residential self-haul.

In 2021, approximately 797,000 tons of waste were collected or received via the waste streams listed above. Of that, 29,620 tons (3.72 percent) were diverted to the MRF, 894 tons (0.11 percent) were sent to scrap metal recycling, 518 tons (0.06 percent) were diverted as HHW, 1,713 tons (0.21 percent) were recycled through the City glass recycling program, and 261 tons (0.03 percent) were processed to create compost. This resulted in a diversion rate of 4.14 percent for the material that the City either collected or received in 2021. This diversion rate does not take into account other waste streams that are collected and transported elsewhere by others (e.g., material taken to the MRF by private haulers, commercial and multi-family accounts using private haulers that do not take material to the LRSC, and material taken to privately owned recycling and disposal sites). Data on this material may be tracked in the future in order to provide a more comprehensive picture of diversion within the City.

Focusing strictly on the City’s collection services, the diversion rate for 2021 was 9.3 percent. The City collected 288,030 tons (90.7 percent) of trash and 29,620 tons (9.3 percent) of recycling from residential, commercial, and City department accounts.

5.2 Austin

In fiscal year (FY) 2021, the City of Austin reported a diversion rate of 41.96 percent, which is almost halfway to its goal of 95 percent by 2040. Austin Resource Recovery collected approximately 63,030 tons of recycling, 53,455 tons of compost, and 138,955 tons of trash from residential homes in FY 2021. A severe winter storm created a surplus of debris, which drastically increased the material collected through the compost curbside collection program compared to previous years.[23]

[23]Austin Resource Recovery Annual Report, https://www.austintexas.gov/news/austin-resource-recovery-releases-2021-annual-report February 2022

Austin used data from both the residential and commercial sectors to calculate the citywide diversion rate. Approximately 2,400 properties (including multifamily properties) and 37,555 businesses participated in the waste study. Randomly selected participating businesses provided data by estimating recycling and reuse quantities and quantities of waste reduced or not generated. Reuse organizations and large waste generators provided Austin Resource Recovery waste data, including residential trash collection, litter control, street cleaning, bulk material trash and recycling and reuse, household hazardous waste disposed and recycled and reused, Resource Recovery Center recycling, tires, and residential organics including yard trimmings, brush, and the residential organics pilot. Materials recovery facility (MRF) contamination rates were observed by sorting through commercial samples of recyclable materials.

The diversion rate equation from the waste characterization study is provided below:[24]

$$Diversion\ Rate = \frac{Tons\ Recycled + Tons\ Composted + Tons\ Reused + Tons\ Reduced}{Tons\ Diverted + Tons\ Disposed}$$

5.3 Denver

The Colorado Department of Public Health and Environment reports a state diversion rate every year. In 2020, the state's MSW diversion rate was approximately 15.3 percent, including materials recycled from residential and commercial sources of waste. The total diversion rate was reported at 35.8 percent, including residential, commercial, and industrial MSW, construction and demolition (C&D) debris, and other non-hazardous waste. The program in Colorado separates the total diversion rate from residential MSW to better inform the public.

The City of Denver does not report individually the total as residential or commercial components. Denver reported 761,941 tons of recycling and 273,316 tons of compost while landfilling 5,342,465 tons of MSW in 2020, resulting in an approximate diversion rate of 19.4 percent.[25] Denver calculates its diversion rate by totaling its recycling and compost tonnage and dividing it by the total MSW generated (landfilled, recycled, composted).

5.4 Phoenix

Reimagine Phoenix is the initiative to help Phoenix reach a citywide diversion rate of 40 percent by 2020. The latest reported data were from June 2019, when the diversion rate was 36 percent. In the *Residential Waste Characterization Study 2017–2018 Final Report,*[26] city-wide residential garbage and city-wide residential recycling were evaluated for single-family homes in the city. Phoenix groups waste into four categories to quantify diversion opportunities and their quantities as a percentage toward its goal. Curbside

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[24] Austin's 2015 *Community Diversion Study*, https://www.austintexas.gov/sites/default/files/files/Resource_Recovery/Austin_s_2015_Community_Diversion_Study-Final-04.29.16.pdf, April 2016

[25] 2020 Colorado Recycling Totals, https://cdphe.colorado.gov/colorado-recycling-totals, March 2022

[26] *Residential Waste Characterization Study*, https://www.phoenix.gov/publicworkssite/Documents/Final_web_Phoenix_2017-18%20WCS.pdf, May 2018

recycling includes materials accepted by recycling technologies, programs, and readily available markets. Compostable material includes organics, such as food waste and yard waste, even if a program in Phoenix does not yet accept them. Other recoverable material includes items that have markets available for recycling; however, the markets are not yet well-developed or are not a part of the curbside collection program. Lastly, non-recoverable waste includes trash and garbage that is not readily recyclable and cannot be diverted.

5.5 Portland

Portland is currently on track to reach its 2030 goal of diverting 90 percent of its waste. Portland distinguishes its waste as six main waste streams: household waste, commercial waste, yard debris, food waste, demolition material, and hazardous material. The FY 2018 to 2019 reported City recovery rate was 81 percent.[27] Composting accounts for 74 percent of the diverted waste. The lunch food scrap composting stations at public schools have helped reduce over 300,000 pounds of garbage annually by diverting food waste away from landfills and into proper composting facilities. Portland is continuously working to create unique ways for additional recycling methods to achieve its goal by 2030.

5.6 Seattle

Because of the pandemic, the residential generation in Seattle surpassed the commercial generation for the first time in 21 years.[28] The major shift came from the state being in lockdown and reducing commercial waste generated, which affected the overall waste generation by 6 percent. Recycling efforts in both residential and commercial sectors have continuously grown since 2003, when the Zero Waste Program began.

Recycling and composting rates remained high at 54 percent in 2020, despite the pandemic.[29] Residential waste, including single-family and multifamily units, accounts for approximately 45 percent of the MSW generated in Seattle, commercial generated 40 percent, and self-haul reported the remaining 15 percent of waste generated. In 2020, it was calculated that approximately 2.27 pounds per person of waste per day was generated, including 0.86 pounds per day per person disposed of and 1.14 pounds per person recycled and composted. Waste disposed of decreased by almost 40 percent from 2000, and recycling and composting reached an all-time high in 2010 but remains 8 percent higher than in 2000.

[27] Waste Recovery Dashboard, https://www.portland.gov/bps/scg/scg-dashboard/waste-recovery, March 2022
[28] Waste Prevention and Recycling Report, http://www.seattle.gov/documents/Departments/SPU/Documents/Recycling_Rate_Report_2020.pdf, September 2021
[29] Ibid.

6 Current Engagement

Waste reduction and diversion programs are important steps on the road to zero waste. Each of the five communities have taken different approaches to engagement—from municipal engagement to community organizations. The effectiveness of each program has varied by community and by program. The selected communities documented in this report have included programs in their zero waste plans to be considered and implemented (Table 6-1).

6.1 Tucson

The City of Tucson partners with the University of Arizona on the FoodCycle program, a commercial food waste collection service for local businesses within the City. The City plans to expand the program by diverting green waste from internal City departments, including the City's Environmental and General Services Department, Tucson Clean and Beautiful, Reid Park Zoo, and Transportation and Mobility. The City plans to collect data on composting operations and management, the quality of compost that can be produced, and operational cost, and will use that information to eventually expand to a curbside composting service. The finished compost will be used to support the Tucson Million Trees Campaign, Green Stormwater Infrastructure program, roadside erosion stabilization, and daily cover and erosion and slope stabilization at the LRSC.

In 2021, the City implemented a program called "Feet on the Street" to provide direct feedback to curbside recyclers on their recycling behaviors. The study targeted approximately 24,000 households across the City (17 percent of all households receiving curbside recycling services). After the study, the percentage of recycling carts observed to contain contaminants fell from 44 percent at the beginning of the program to 18 percent at its conclusion. Furthermore, the percentage of contamination within the curbside recyclables sampled from the study areas fell from 24.5 percent to 19.1 percent (by weight). These results indicate that outreach and educational programs may be effective in reducing contamination rates at the MRF.

The City also offers recycling education to consumers. The City offers a free waste audit to local businesses who are considering adding recycling services. Recycle Coach, which is available both on the City's website and as an app, provides information about waste and recycling pick-up schedules, guidance on recycling, and pick-up reminders. The City offers educational programming that teachers can use in their classrooms.

Table 6-1. Current engagement[a]

	Tucson	Austin	Denver	Phoenix	Portland	Seattle
Programs and partnerships	▪ FoodCycle Compost Program (University of Arizona) ▪ HHW collection program ▪ Tucson Clean & Beautiful	▪ Austin Green Business Leaders Program ▪ Keep Austin Beautiful ▪ Circular Economy Program ▪ Generation Zero	▪ Eco-Cycle ▪ CHaRM ▪ Denver Public School System ▪ Green Star School	▪ HHW Collection Program ▪ Green Business Leader Program ▪ Keep Phoenix Beautiful ▪ Recycle+	▪ Resourceful PDX ▪ City of Portland Bureau of Planning and Sustainability	▪ Seattle Good Business Network ▪ PreCycle Innovation ▪ Clean City Program
Current engagement	▪ Climate Action Community Survey gathered public feedback on the City's waste goals. ▪ "Feet on the Street" initiative provided direct feedback to curbside recyclers on their recycling behaviors.	▪ The Office of Sustainability-led Green Business Leader Program aids local businesses in waste reduction efforts. ▪ Expansion and relocation of RRF to better meet the community's needs.	▪ Eco-Cycle is one of the oldest and largest nonprofit recycling organizations in the U.S. ▪ CHaRM supports recycling and composting at local businesses and schools. ▪ Collection of recyclables at 82 of 207 Denver Public Schools.	▪ Public Works collects HHW to reduce contamination in the waste stream. ▪ Businesses meet a certain "green" criteria to be recognized and rewarded in the Green Business Leader program. ▪ Currently, 109 local businesses are eligible for the Green Business Leader program.	▪ "Pick it up, Portland" is coordinated by the City to engage the community in a 2-day litter pickup. ▪ Resourceful PDX hosts events that educate individuals on reducing waste and reusing materials.	▪ Seattle Good Business Network helps businesses and the community gain access to free tools, technical assistance, and other resources. ▪ The PreCycle Innovation is a competition for students and individuals to pitch their best idea on how to use recyclables/waste.
Education efforts	▪ Free waste audit to business considering adding recycling services. ▪ Recycle Coach website and app provide waste and recycling pick-up schedule and recycling guidance. ▪ Classroom presentations available.	▪ Generation Zero organizes classroom presentations specific to grade level about recycling, trash processing, and the evolution of trash.	▪ Programs for preschool to grade 12 teach about traditional recycling, composting, and sustainability through the Green Star School Program. ▪ Monthly feedback to individual schools on program.	▪ Games and activities per grade level geared toward recycling and sustainability through Recycle+. ▪ "Oops/Shine On" educates residents on if they contaminated their recycling bin with informational door tags.	▪ Portland Public Schools[b] have implemented the elimination of Styrofoam trays and trash separation and composting in the school cafeteria to give students hands-on experience.	▪ The innovation contest provides mentorship with a local college to provide workshops on sustainability and waste solutions.

[a] See program descriptions in sections below.
[b] Cafeteria Recycling/Composting, https://www.portlandschools.org/departments/operations/food_service/cafeteria_recycling__composting, March 2022

6.2 Austin

Keep Austin Beautiful is Austin's overarching program to increase waste diversion and reach its zero waste goal.[30] The Austin Green Business Leaders Program, led by the Office of Sustainability, has partnered with Austin to help local businesses focus on sustainability performance measures. Additionally, Austin works with local recycling facilities (see Section 7.2 for additional information on these facilities) to allow the addition of recyclable materials into the product market for the community by expanding and relocating the Resource Recovery Facilities to meet people's needs. FY 2019 expenses were broken down in the Keep Austin Beautiful 2019 Annual Report[31] into three categories: Program Services, General & Administrative, and Fundraising. Respectively, each expense was approximately $813,460, $143,997, and $80,648, totaling $1,038,105. The program had $1,034,468 in total revenue from corporations, charities, the government, and other individuals.

The Circular Economy Program is a partnership between Austin Resource Recovery and the Economic Development Department to enhance the circular economy in Austin to make it the "most vibrant" in the United States.[32] Through this program, businesses and residents can obtain resources to reuse, repair, and share materials and maximize materials recyclability to its fullest extent. Events such as "Fix-it" clinics are held for residents to bring in broken household items and learn how to repair them.

Generation Zero in schools provides three presentations over the school year for each grade level, geared toward the current education level.[33] Starting from kindergarten, students learn about the nature of recycling and the science of composting. In high school, students learn more about the in-depth processes of trash, waste production, and disposal methods.

6.3 Denver

Denver currently partners with the public school system to promote education and additional recycling methods. The solid waste department provides single-stream recycling collections to 170 schools and compost collections in 40 selected schools.

Eco-Cycle[34] participates in educational programs in the classroom and throughout the community in Boulder and in Denver. The Green Star School program educates over 55,000 children from K-12 on sustainability, composting, and traditional recycling. Eco-Cycle is a nonprofit social enterprise, according to the 2020 Annual Report for CHaRM,[35] which means the organization conducts mission-based business activities and uses

[30] Keep Austin Beautiful, https://keepaustinbeautiful.org/, March 2022

[31] Keep Austin Beautiful Annual Report 2019, https://keepaustinbeautiful.org/wp-content/uploads/2020/01/Keep-Austin-Beautiful-2019-Annual-Report-FINAL.pdf, June 2022

[32] Circular Economy Program, https://www.austintexas.gov/circulareconomy, March 2022

[33] Generation Zero: K-12 Youth Education, https://www.austintexas.gov/genZero, March 2022

[34] Eco-Cycle, https://www.ecocycle.org/schools/overview, March 2022

[35] CHaRM 2020 Annual Report, https://ecocycle.org/files/pdfs/Annual_Reports/Eco-Cycle_Annual_Report_2019-2020.pdf, June 2022

surplus revenue to fund education, outreach, and advocacy. The top five categories for expenses and revenues in FY 2019–2020 are provided in Table 6-2.

Table 6-2. Eco-Cycle financial report

Activity	Expenses	Revenues
Boulder County Recycling Center Operations	4,363,580	4,619,114
Hauling of Commercial, Single-Stream, & Hard-to-Recycle Materials	1,986,742	1,949,811
Center for Hard-to-Recycle Materials	880,617	935,319
Programs	1,280,057	551,964
Fundraising	81,089	150,390
Total	**$8,592,085**	**$8,206,598**

CHaRM[36] is Denver's Center for Hard-to-Recycle Materials, Colorado's first community center for recycling electronics and other non-typical recyclables. CHaRM is a part of Eco-Cycle, one of the oldest and largest nonprofit recyclers in the United States. This program helps supports recycling at businesses and schools and advocates for schools to become "Green Star Schools."

6.4 Phoenix

The City of Phoenix collaborates with the Public Works Department on a household hazardous waste collection program to reduce hazardous items placed in the trash and recycling.[37]

The Green Business Leader Program recognizes businesses that operate in a more environmentally responsible manner through sustainable actions.[38] Depending on the quantity of sustainable actions the business takes, a business can achieve three different levels of certification, which return more benefits as the business progresses. This program requires businesses to meet a certain "green" criterion to be eligible for the benefits of being part of the program. To be eligible for the Green Business program, the business must:[39]

- be located within Phoenix city limits
- achieve a minimum of 10 action items on the Green Business checklist
- provide quarterly metrics on the percentage of waste the business is diverting from the landfill (if applicable)

Currently, 108 businesses in Phoenix are part of the Green Business Leader Program.

[36] Eco-Cycle, https://www.ecocycle.org/aboutus, March 2022
[37] Household Hazardous Waste Collection, https://www.phoenix.gov/publicworks/hhw, March 2022
[38] Green Business Leader, https://www.phoenix.gov/greenbusiness, March 2022
[39] Ibid.

Reimagine Phoenix is the City's initiative to increase the City's waste diversion rate and better manage its solid waste resources.[40] Through Reimagine Phoenix, programs such as Recycle+ and inspection programs have helped educate the public on what more they can do to help.

The Zero Waste Team in Phoenix created the Recycle+ Education program, which educates children throughout their school years on sustainability.[41] For younger age groups, games are brought into the classroom to educate children on what materials can and cannot be recycled; the older students learn more about the science behind sustainability.

The City of Phoenix implemented a cart inspection program called "Oops/Shine-On," which created teams of volunteers to examine recycling bins to reduce contaminants in the recycling stream. Team members sort the recycling, and if it contains too many contaminants, it does not pass the inspection, and a tag is left out to educate the residents on the materials in their bins.

6.5 Portland

As discussed in Section 2.5, Metro sets the baseline regulatory plan that the cities and counties under its authority need to follow and use in their own annual implementation plans. Metro works with the counties and cities on specific mandates to see what would be most beneficial, given the diversity in the region's population. The 2030 *Regional Waste Plan* was developed by Metro after extensive community outreach, beginning with forming partnerships with eight community organizations that were able to assist Metro with recruiting and leading discussions with participants to obtain input on what should be included in the 2030 *Regional Waste Plan.* These community organizations were chosen specifically for their work serving groups that typically don't participate in public engagement or whose voices are not typically heard at the regional planning level.[42]

Portland develops its own climate change plan, sustainability plan, and additional waste diversion requirements, further explained in the FY 2021 *Annual Waste Reduction Plan* for the City of Portland.

Resourceful PDX is Portland's primary partnership to engage the community and businesses to become more sustainable.[43] Resourceful PDX encourages residents to connect on a business and personal level to collaborate and be successful in their waste reduction practices. Events such as "pick it up, Portland" are coordinated by the City of Portland Bureau of Planning and Sustainability to engage the community in neighborhood/park clean-up days.[44]

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[40] Reimagine Phoenix, https://www.phoenix.gov/publicworks/reimagine, March 2022

[41] Recycle+, https://www.phoenix.gov/publicworks/recycleplus#:~:text=Public%20Works%20Recycle%2B&text=The%20Zero%20Waste%20team%20has,education%20directly%20to%20your%20homes!&text=We%20hope%20Recycle%2B%20motivates%20you,recycle%20right%20and%20recycle%20more, March 2022

[42] Phone interview with Luis Sandoval, Senior Solid Waste Planner at Metro, March 29, 2022

[43] Resourceful PDX, https://www.resourcefulpdx.com/#home, March 2022

[44] Pick it up, Portland, https://www.solveoregon.org/pick-it-up-portland, March 2022

Sustainability events, fix-it fairs, Resourceful PDX, and other programs in Portland are budgeted in the Sustainability Engagement Section of the Bureau of Planning and Sustainability's Requested Budget.[45] For these programs, there were 11.4 full-time employees. External Materials and Services expenses in 2018–2019 came to $19,083. Internal Materials and Services came to $5,000. There were no contingencies added to the funds.

6.6 Seattle

The Seattle Good Business Network[46] partnered with the City of Seattle to assist businesses and local communities in gaining access to free tools, technical assistance, and resources to help drive Seattle's recycling and diversion goals. The program partners with a local college by providing mentorships and workshops about sustainability and waste solutions in Washington State. The PreCycle Innovation challenge hosted by the network allows students, entrepreneurs, and individuals to pitch their ideas on using recycled materials/waste.

The City of Seattle has developed the Clean City Initiative to reduce littering, which can properly sort and divert more waste through the waste stream. Subgroups of the program include an Anti-Graffiti program, illegal dumping prevention program, and litter prevention program. The City of Seattle invests $3 million into the ongoing work of the Clean City Initiative to continuously clean up litter and garbage from the streets.[47]

7 Economics and End Markets

7.1 Tucson

The City provides trash and recycling collection services to all single-family households and some multifamily households and commercial businesses within the city limits. The City is responsible for managing and completing long-range planning for waste collection, recycling, and disposal operations within the city limits. These operations apply to a City-owned and operated MSW landfill, seven Neighborhood Recycling Centers (NRCs), 22 glass recycling drop-off locations, and equipment and facilities for waste collection, disposal, and recycling operations. The City also contracts with an MRF, the ReCommunity MRF owned by Republic Services, for residential and commercial recycling services.

The City of Tucson is in the process of identifying potential end markets for waste diverted from the landfill as part of the Zero Waste Roadmap Development Process.

[45] Bureau of Planning and Sustainability's Requested Budget, https://www.portlandoregon.gov/cbo/article/752708, January 2020

[46] Seattle Business, https://seattlegood.org/sustainable-business/, March 2022

[47] Clean City Initiative, https://www.seattle.gov/parks/about-us/special-initiatives-and-programs/clean-city-initiative, June 2022

7.2 Austin

In Austin, the City Department collects approximately 25 percent of MSW generated; approximately 68 percent is owned and operated by a private-sector service. The remaining waste is calculated at self-haul facilities. The Department relies on public-private partnerships because most reuse, recycling, composting, and landfill facilities are privately owned. The City's landfill is closed and currently under 30-year post-closure care. Development of the following infrastructure is to be expected from the partnerships with the private sector to aid in reaching Austin's goal of zero waste:[48]

- Austin Reuse Centers – Drop-off facilities located around the City to collect reusable items, recyclables, and hard-to-recycle materials.
- MRFs for Recyclables – MRFs are constructed and operated by two private-sector companies under contract with the Department to support the single stream recycling program and the zero waste initiatives of the master plan.
- Resource Recovery Centers – For collecting hard-to-recycle materials such as appliances, tires, furniture, carpet, and paint.
- Composting Facilities for Organics – Expanded organics processing capacity at the Hornsby Bend Biosolids Management Plant. The City may contract for additional composting services, if deemed appropriate.
- C&D Debris Processing Facilities – For the recovery and recycling of debris from construction sites, in response to a future C&D debris ordinance.
- Eco-Industrial Park – An industrial system of production facilities that conserves natural and economic resources, reduces energy and water use, and provides opportunities for reuse or recycling of wasted materials.

The City Department provides biweekly single-stream recycling collection for materials including paper, boxboard, cardboard, aluminum and metal cans, glass, and rigid plastic containers. These items are collected in a 96-gallon container that is required and provided by the Department; smaller carts are available in addition to the 96-gallon cart with additional costs. The 96-gallon cart has a monthly rate of $49.50, which covers curbside collection of garbage, recycling, large brush, and bulky item collection.[49] This does not include the monthly clean community fee of $4.70, which aids the zero waste program, reuse centers, and other programs Austin supports in diversion efforts. In the future, Austin aims to increase the accepted recyclable materials to include aseptic and gable-top containers, durable plastics (household items and engineering grade plastics), plastic wrap film, aluminum foil, and small scrap metal items.

[48] Master Plan, https://www.austintexas.gov/sites/default/files/files/Trash_and_Recycling/MasterPlan_Final_12.30.pdf, 2011

[49] Residential Service Rates and Fees, https://www.austintexas.gov/arrfees#:~:text=All%20residents%20in%20Austin%2C%20including,neighborhoods%20and%20the%20downtown%20area. June 2022

7.3 Denver

Denver Public Works is responsible for trash collection for all the households in the City and County of Denver, the City's recycling program, and the City's composting program. According to the 2010 *Master Plan*, the trash collection service collects waste from approximately 170,000 households every week.[50] Denver Recycles is a voluntary program with more than 100,000 participants. Denver Composts is a pilot program where residents have to pay to participate, and it had more than 2,200 residents involved in 2010. The City offers three sizes of trash bins with varying costs, where the largest is a 95-gallon bin that has a monthly cost of $21 per month.[51] This monthly fee covers trash pickup, weekly recycling, composting, equipment operators, and other costs. The City and County own the landfill and own and operate the transfer stations. The landfill is contracted out and accepts all City-managed trash and C&D waste. The transfer station manages reuse and recycling programs such as Denver Recycles, seasonal recycling, large-item pickup, and household hazardous waste.

7.4 Phoenix

In Phoenix, the Public Works Department separates its solid waste department into three divisions: field services, diversion and disposal, and customer engagement. Field services is responsible for collecting residential garbage, recyclables, bulk trash, and green waste from over 390,000 households.[52] As of January 2021, the monthly collection rate was raised to $33.80, which includes weekly trash collection, weekly recycling collection, and quarterly bulk trash service.[53] Diversion and disposal operates the transfer stations and landfill operations and is responsible for reducing waste that enters landfills through recycling and monitoring at the transfer station. For ease of location, the City owns two transfer stations, one in the north and one south of the city, and waste is then transferred to State Route 85 Landfill.[54] The landfill is not open to the general public. Recyclables that are sent to either transfer station are sorted at the adjoining MRFs that are also owned by the City. In 2017, a new compost facility opened to help boast Phoenix's Green Organics program for business composting and household composting.[55]

7.5 Portland

Metro is responsible for the garbage and recycling system in Portland. In the 2030 *Regional Waste Plan*, Metro stated that private haulers handle all waste. These are typically contracted by the cities or counties through franchise agreements or licensing.

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[50] 2010 Master Plan, https://www.denvergov.org/content/dam/denvergov/Portals/709/documents/master-plan/master_plan_exec_summary.pdf

[51] Denverite, https://denverite.com/2022/01/19/paying-for-trash-collection-in-denver-the-city-has-started-getting-serious-about-the-idea/, January 2022

[52] 2021 Solid Waste Strategic Plan, https://www.phoenix.gov/publicworkssite/Documents/Final%202016.2021.Strategic%20Plan.pdf

[53] Phoenix Community Feedback, https://www.phoenix.gov/newsroom/public-works/931, February 2020

[54] Transfer Stations, https://www.phoenix.gov/publicworks/garbage/disposable, March 2022

[55] Composting in Phoenix, https://www.phoenix.gov/publicworks/composting, March 2022

Within the Metro region, more than 40 private hauler companies collect residential, business, school, and other institutional waste, recyclables, and food scraps. Monthly residential rates are based on the size of the garbage container, despite the varying companies, and trash is collected every other week. The largest container option is 90 gallons, at a monthly rate of $45.70 beginning in July 2022.[56] This rate includes garbage, recycling, and compost services. Additional services such as extra yard waste or holiday trees are collected at an additional cost. Mixed recycling and glass are sent to separate sorting facilities to be recycled either locally or shipped to other parts of the country to be reused. There are seven transfer facilities, five private and two owned by Metro, where the garbage, yard debris, and food scraps go. Yard waste and food scraps are consolidated and sent to more than 40 composting or biogas facilities. Garbage from Portland is transferred to one of Oregon's seven landfills.

7.6 Seattle

SPU consists of public and private services to collect, transfer, process, and landfill the City's waste.[57] Two private contractors collect residential and commercial garbage, recyclables, and organics. Residents also can drop off their waste directly at a transfer station. Garbage and organics are picked up weekly, while recycling is collected every week. There are two different service levels that vary the cost of collection: curbside or backyard. Backyard collection includes an additional fee where families can have garbage picked up from their yard. The largest cart available, with the highest monthly cost, is a 96-gallon cart. Effective April 2022, the curbside monthly cost for the 96-gallon cart is $126.40 per month, and the backyard collection is $177 per month.[58] The contractors take the garbage and organics to one of two City-owned transfer stations. A local private transfer station is used when a City station is closed because of maintenance or unexpected equipment failures. Recyclable material is brought to a sorting plant. SPU has two contracts for processing recyclable and organic material, which receive about 60 percent of the organics and recyclables; the remaining materials are directed to other private processors from commercial businesses. Garbage is handled by Waste Management to rail haul and dispose of nonrecyclable waste at a Waste Management landfill in Gilliam County, Oregon.

8 Environmental Justice Considerations

8.1 Tucson

The City of Tucson has not conducted a specific EJ analysis at this point. The Climate Action Survey indicated that residents are interested in implementing measures in the climate action plan in an effort toward reaching equity.

[56] Residential Garbage Rates, https://www.portland.gov/bps/garbage-recycling/home-recycling/residential-garbage-rates, June 2022

[57] Picking up the Pace Towards Zero Waste, Chapter 4, https://www.phoenix.gov/publicworks/composting, 2011

[58] Garbage Rates, https://www.seattle.gov/utilities/your-services/accounts-and-payments/rates/collection-and-disposal/garbage-rates, June 2022

8.2 Austin

During the 15-month development period of the Austin *Solid Waste Master Plan*, residents and stakeholders were invited to workshops to provide input to help develop concepts and programs. No specific EJ analysis was completed.

8.3 Denver

In the 2020 *Annual Report to the Colorado General Assembly*, the program reports that EJ is addressed through the administration of the program and the decisions made.

8.4 Phoenix

The Public Works Department is focused on the triple-bottom-line (people, planet, and profit). While developing the current and past strategic plans, EJ indicators have always been considered, although they may not be specifically highlighted. In the next version of the *Strategic Plan*, the City wants to make sure that there is better documentation of how EJ indicators were used and how they were integrated with City's climate action plan.[59]

8.5 Portland

The 2030 *Regional Waste Plan* took approximately a year and a half to complete. Engagement with eight community organizations was incorporated into the population and cultural diversity sections of the Plan. Metro used a power mapping analysis to identify groups that typically do not participate in environmental conversations. A facilitator was hired to coordinate the outreach and communication to the community organizations to build trust within the new relationship. Grants and stipends were provided to groups and individuals for participating and providing feedback with each outreach session.

8.6 Seattle

SPU consists of seven branches, one of which is the human resources and service equity branch, which is in charge of the Environmental Justice and Service Equity division.[60] The division reviews projects, programs, and services to ensure that human health and minority economies are not affected.

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[59] Phone interview with Felipe Moreno, Assistant Public Works Director, Solid Waste Division, City of Phoenix, and Amanda Jordan, Circular Economy Project Manager, City of Phoenix, on March 18, 2022.

[60] Picking up the Pace Towards Zero Waste 2011, Chapter 6, https://www.phoenix.gov/publicworks/composting, 2011

9 Policy, Legislation, and/or Regulatory Requirements

9.1 Tucson

Currently, the City of Tucson does not have enforceable regulations to support its proposed zero waste initiative. However, in 2020, the City Council declared a Climate Emergency that set Tucson on a path for carbon neutrality by 2030. The City documents its progress in the Climate Action Hub. The City plans to take steps to slow down the impact of climate change while promoting equity, and is partnering with the private sector, academia, and community leaders to reach climate goals.

9.2 Austin

Austin has passed four main executive regulations that help enforce actions to meet its zero waste goals. A Universal Recycling Ordinance was passed to ensure that all commercial tenants, multifamily housing residents, and employees have access to recycling. This ordinance also covers food-permitted businesses, ensuring that employees have easy access to organic waste diversion for unused food, food scraps, and food-soiled paper.[61]

To support the City's Green Building efforts, the Construction and Demolition Recycling Ordinance took place to divert C&D waste away from landfills.[62] General contractors are to not dispose of more than 2.5 pounds of material per square foot of floor area to the landfill, or divert at least 50 percent of the debris away from the landfill by reuse and recycling. If unable to, contractors may request a waiver or be subjected to a fine.

The remaining two ordinances include the Hauler Licensing Ordinance and the Special Events Ordinance.[63] The Hauler Licensing Ordinance requires all private haulers to obtain a private license at any stage in the waste cycle. The Special Events Ordinance requires all events in Austin to submit a waste management plan documenting how they plan to divert and reduce waste during the event.

9.3 Denver

Currently, Denver is working to pass a "Waste No More" ordinance, which would require all businesses, including residential complexes, to provide compost and recycling pickup services.[64]

Recently, an ordinance that charges a fee for single-use bags was passed and put into effect in July 2021, along with an ordinance that will ban plastic bags beginning in 2023.

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[61] Universal Recycling Ordinance, https://www.austintexas.gov/uro, April 2022

[62] Construction and Demolition Ordinance, https://www.austintexas.gov/cd, April 2022

[63] Zero Waste Ordinances, https://www.austintexas.gov/circularresources, April 2022

[64] Waste No More, https://www.wastenomoredenver.org/?fbclid=IwAR3bd_KHO07MKRupNfMbTEM0vLC2qYxb1Ffb3_nRniJLnj0-6CCH0oR0NEg, 2021

Restaurants must follow the recently passed ordinance, Single-Use Accessory Restriction, that took effect in January 2022.[65] The ordinance takes away the automatic single-use plastic utensil given with take-away meals; customers must request them upon ordering. This has helped businesses reduce their impact on the waste stream and save them money by no longer needing to purchase the items.

9.4 Phoenix

In 2015, the State of Arizona passed a law that bans the regulation of single-use plastic bags/utensils and bans other environmental regulations. In a recent interview with the City, it was noted that the City plans all its programs assuming no regulations supporting the reduction of waste will be passed, and that incentives and voluntary efforts will drive waste reduction.

All participation in zero waste efforts has been completely voluntary by residents. Phoenix plans to expand with more incentive programs similar to the pay-as-you-throw program and to reduce the size of residents' garbage cans to increase engagement.

9.5 Portland

Similar to the other cities, Portland participates in banning single-use plastic bags at checkout locations in stores and requires customers to pay a 5-cent fee if the customer requests a paper bag. Paper checkout bags must also be made from at least 40 percent post-consumer recycled fiber.[66]

9.6 Seattle

In 2014, Seattle enforced a municipal code that requires businesses to not put compostable material, including food, yard waste, and other recyclables, in their garbage, or they may receive a fine.[67] City inspectors inspect dumpsters to confirm businesses and buildings are properly sorting their waste and not allowing more than 10 percent of their waste to be recyclable.

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[65] Single-Use Ban, https://denvergov.org/Government/Agencies-Departments-Offices/Agencies-Departments-Offices-Directory/Climate-Action-Sustainability-Resiliency/Zero-Waste/Skip-The-Stuff

[66] Plastic Bag Ban and Paper Fees, https://www.portland.gov/bps/garbage-recycling/business-garbage-policies/bag-ban-and-fees

[67] Ban of Recyclables in Garbage, https://www.seattle.gov/utilities/your-services/collection-and-disposal/ban-of-recyclables-in-garbage#:~:text=Seattle%20Municipal%20Code%20(SMC)%20sections,and%20recyclables%20in%20their%20garbage

10 Next Steps

Some of the discussed programs and legislation have been successful in helping the communities reduce waste consumption. Because no program can be 100 percent replicated, Tucson can learn from successes and challenges in these communities. While all these communities have different strengths, ultimately it will be up to stakeholders to make the decisions that are best for Tucson. As the Zero Waste Roadmap develops, this document can be a resource during the development of future programs.

Based on HDR's review of the five aspirational cities, HDR recommends that the City of Tucson consider the following measures:

1. Publish the Zero Waste Plan and initiate waste tracking.

Resolution No. 23222, which declared a climate emergency, set a waste diversion goal of 50 percent by 2030 and zero waste by 2050. The City of Tucson is currently diverting approximately 4.14 percent of its waste.[68] This diversion rate does not take into account other waste streams that are collected and transported elsewhere by others (e.g., material taken to the MRF by private haulers, commercial and multi-family accounts using private haulers that do not take material to the LRSC, and material taken to privately owned recycling and disposal sites). The City may consider collecting these data in the future to provide a more comprehensive picture of diversion within the City.

2. Expand organics composting efforts.

Based on a review of three waste characterization studies conducted in Tucson and Phoenix in 2014, 2015, and 2018, the organics fraction represents approximately 42.5 percent of Tucson's waste stream. This presents an opportunity to substantially increase diversion efforts.

In FY 2018 to 2019, the City of Portland reported that the City recovery rate was 81 percent, which is on track with the City's goal of 90 percent waste reduction by 2030. Composting accounts for 74 percent of Portland's diverted waste. The City of Portland also has lunch food scrap composting stations in schools, which have diverted 30,000 pounds of garbage per year.

The City of Tucson could initiate an organics composting program for residents and partner with businesses and schools to increase diversion. Successful collections programs would create demand for more organics processing capacity in the region, either at LRSC, private facilities, or a combination of both.

3. Decrease recycling contamination.

Recycling contamination represents approximately 30 percent of the material received by the City of Tucson's MRF. The high levels of contamination have cost the City approximately $1.2 million since FY 2018. In 2021, the City of Tucson saw some success in reducing contamination when it implemented the "Feet on the Street" pilot program to provide direct feedback to curbside recyclers on their recycling behaviors. The City of

[68] Current Conditions Assessment, HDR Engineering, 2022

Phoenix has implemented a similar cart inspection program called “Oops/Shine-On,” which is staffed by teams of volunteers who examine recycling bins to reduce contaminants in the recycling stream. If bins have contamination, they leave a tag to educate residents on the materials in their bins. This is similar to Feet on the Street but is an ongoing program and is staffed by volunteers rather than paid consultants.

The City could set up a program like Oops/Shine-On. A reduction in recycling contamination could save the City money, which could then be funneled into other waste reduction programs.

4. Coordinate with local businesses.

The City of Phoenix has a Green Business Leader Program that recognizes businesses that operate in a more environmentally responsible manner through sustainable actions. Depending on the quantity of sustainable actions the business takes, a business can achieve three different levels of certification, which return more benefits as the business progresses. The City of Tucson already partners with businesses who are considering adding commercial recycling to their waste disposal services by providing a free waste audit. The City charges less for pickup services to businesses that elect to use both waste and recycling services. The City could expand their coordination with local businesses by creating a program similar to the Green Business Leader program, with benefits to businesses who participate.

5. Incorporate waste education into school curriculums.

The City of Tucson has teaching materials available on its website. However, City schools do not necessarily have a set curriculum that includes education on waste reduction. Denver and Phoenix both have educational programs in schools. The Green Star School program in Denver educates over 55,000 children from K-12 on sustainability, composting, and traditional recycling. The City of Phoenix has a Recycle+ Education program, which educates children throughout their school years on sustainability. For younger age groups, games are brought into the classroom to educate children on what materials can and cannot be recycled; the older students learn more about the science behind sustainability. The City of Tucson could implement a school curriculum that incorporates waste to make students and their family aware of existing waste diversion programs and how to participate in them.

6. Increase engagement with citizens.

The City of Tucson can benefit from understanding and learning from other communities with developed waste diversion plans. It is recommended that there be an overarching program such as “Keep Austin Beautiful” or “Resourceful PDX” to organize social media, event information, and diversion information for residents.

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Generation Zero: https://www.austintexas.gov/genZero

Cost Reporting: https://data.austintexas.gov/stories/s/sabp-xcz6

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Reimagine Phoenix: https://www.phoenix.gov/publicworks/reimagine

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%2B&text=The%20Zero%20Waste%20team%20has,education%20directly%20to%20your%20homes!&text=We%20hope%20Recycle%2B%20motivates%20you,recycle%20right%20and%20recycle%20more.

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Portland

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Portland Recycles: https://www.portlandoregon.gov/bps/article/230043

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Appendix A. Interview Notes

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Meeting Minutes

Project:	Tucson Zero Waste Roadmap
Subject:	Task 3: Aspirational Program Interviews – City of Phoenix
Date:	Friday, March 18, 2022
Location:	Conference Call
Attendees:	City of Phoenix Felipe Moreno, Asst PW Director, Solid Waste Division <felipe.moreno@phoenix.gov> Amanda Jordan, Circular Economy Project Manager <amanda.jordan@phoenix.gov> HDR Kate Bartelt Abigail Fleming Andrea Ramirez

1) Has your community reached its 2020 Zero Waste Goal of 40% Diversion? What were the major takeaways you have learned as you aim for Zero Waste by 2040?
   a) Although the "40 by 20" goal was not met in 2020, Phoenix achieved a higher recycling rate than the national average.
   b) Phoenix is updating its Zero Waste Plan to achieve zero waste by 2050. The new plan will incorporate learnings from the first plan and is designed to fit the unique community's practices. Amanda is expecting to have the draft done in April.
   c) After several years and practice, the council realized that 40 by 20 was not a realistic goal, but it was ambitious. The City wants to have achievable goals and plans for the next plan.
   d) For the next plan, they are looking at what has already been successful, what else they can add in, and then building the program around that
   e) 40 by 20 was very focused on waste diversion (achieving a specific percentage) rather than the big picture of waste diversion, management, and reduction. In the next plan, the council plans to broaden the vision on what they want to accomplish– marrying a circular economy and zero waste.

2) Has Phoenix defined the term "Zero Waste," and how is waste measured?
   a) The term "Zero Waste" has not been defined; it is very flexible. The City wished to work through a circular economy lens to define Zero Waste in the next plan.
   b) In the 20 by 40 Plan, waste is being measured by what is going across the scale, including single-family residential waste and what the City directly handles.
   c) The City has a different make-up now than the 20 by 40 Plan development. The new City Council is looking to change how waste is measured for a more accurate diversion rate in the new plan.
   d) Measurement of Progress
      i) There is nothing standardized yet. They are exploring programs/software
      ii) They use economic development metrics for circular economy progress

3) What programs have you found to be most successful in reducing waste generated?
   a) Reimagine Phoenix has been very successful in the community, emphasizing reducing, reusing, recycle. An incentive called “SAY R&R” (Save As You Reduce and Recycle) was implemented; if a resident chooses to downsize their garbage container for a larger recycling bin, the resident saves money.

   b) Phoenix is planning to add an expanded curbside green organics program that includes a separate yard waste cart. They are currently still in the program's pilot phase and will need more trucks and drivers to expand.
   c) The North Gateway MRF has been upgraded to receive more recyclables and improve recycling. The 27th Avenue MRF is in the process of being renovated.
   d) On the circular economy side, the City of Phoenix works with ASU and other internal staff to help plan and build out the Resource Innovation Campus (RIC).

4) How long did it take to develop the Zero Waste Plan?
   a) The 40 by 20 goal and plan took about a year to develop with the help of ASU. There were no pushbacks or large projects that were difficult to comprehend. The hardest part was internal management, which changed the internal management structure – now a circular organization style.
   b) This project moved the City's solid waste division from a behind-the-scenes solid waste collections and processing provider to a front-facing community leader, driving policy changes and working on resource management.

5) What policies/legislative actions have you used to reach your Zero Waste goals? How has the state law that bans the regulation of single-use plastic affected your zero-waste plan?
   a) There have been no legislative actions. The state has a "no bans" ordinance which makes all activities through the community voluntary.
   b) Incentives such as reducing the size of personal garbage cans through SAY R&R have increased voluntary recycling actions. More incentives are being explored in the updated Zero Waste Plan development.
   c) They do have code enforcement and education/outreach.
   d) They also look for partnerships to help them accomplish goals.

6) Did you consider environmental justice in developing your Zero Waste Plan, and how/did it impact your programs?
   a) Yes, public works are triple bottom lined focused; however, EJ is not highlighted as well as they want them to be in the next version. The City is looking for the next version of the plan to be the next steps in making progress and integrating with the City's climate action plan

7) How is your zero-waste program funded? How are those markets working?
   a) An enterprise fund –residential fees for service, tipping fees and revenues from recycling
   b) Grant funding
   c) Ppartnerships with other entities that receive funding

8) Do you perform an annual zero-waste report to present how well the program went over the past year?
   a) Phoenix has not in several years but will be to create the 2050 road map. The plan will release a public-facing 5-year reporting vision and annual accomplishment reports.
   b) The council plans to implement data recoding metrics to trend revenues, money raised, and patents filed. They are currently looking for data management solutions.

9) Final thoughts
   a) Advice
      i) Know your identity – communities are unique, but there is no need to reinvent the wheel
      ii) Make sure the policymakers are in lockstep with staff on vision, goals, reporting

iii) Make sure the community and stakeholders are engaged early and often
iv) Stay realistic (40 by 20 Plan was ambitious)
v) Internal procurement – make sure expectations of a partner are realistic. There have been long term, high feedstock requirements requested by some entities considered for the Resource Innovation Campus.
vi) Find opportunities to cross collaborate between city departments (Remove silos) and to be aware of what other departments are doing. Amanda works between Community and Economic Development and Public Works.

Meeting Minutes

Project:	Tucson Zero Waste Roadmap
Subject:	Task 3: Aspirational Program Interviews – Oregon Metro
Date:	Tuesday, March 29, 2022
Location:	Conference Call
Attendees:	Oregon Metro Luis Sandoval, Senior Solid Waste Planner < Luis.Sandoval@oregonmetro.gov> HDR Abigail Fleming Andrea Ramirez

1) How much does Metro collaborate with the cities and counties in the region when regional and city-level plans are developed? How does this affect diversion goals?
   a) The state of Oregon assigned Metro the responsibility to have an over-arching plan for the three counties.
   b) Metro sets the baseline for regulatory plans that the cities and counties under their authority need to follow and use as the base for their own plans. Metro works with the counties and cities on specific mandates to see what would be most beneficial given the diversity of the region. The Regional Waste Plan 2030 was developed by Metro through large community outreach programs to learn the best methods of practice.
   c) Cities and Counties develop their own sustainability and climate change plans which can sometimes have higher standards than those set by Metro. Most Cities and Counties have an internal waste plan and/or developan annual waste plan with the help of Metro.
   d) Metro is the only regional government agency in the country that is comprised of elected officials.
   e) The Climate Action Plan and Waste Equity Work Plan are developed by cities and counties that are separate from the Regional Plan. Metro owns and operates transfer stations and regulates private transfer station. It does not do collection; only cities and counties collect through franchise agreements with or licenses to private collection companies. Metro can mandate what minimum service standards are required to be provided in its region, such as mandatory business recycling.
   f) Metro works with local governments to create annual plans, but those are not made available to the public (they are public documents, but not posted on websites or promoted). Metro uses IGAs between Metro and local jurisdictions in order to distribute funding to the local jurisdictions. Funding uses include outreach to single family/commercial/multifamily customers on waste prevention, composting, etc.
      i) Funding is how metro incentivizes participating in the regional waste plan outside of the boundary where it has jurisdiction
      ii) Luis to send Portland waste reduction plan
   g) Metro waste goals are minimum; cities can go above and beyond; Portland definitely is more involved.

2) Did you consider using the term zero waste?
   a) Zero Waste was considered in the early stages of pre-planning, however, staff did not like the implication of the possibility of completely eliminating waste (true zero waste is an

unattainable goal). It was also found that using terms such as “waste” in general was not approachable to the average person, who understood the term “garbage” better.

3) How long did it take to develop the 2030 Regional Waste Plan?
   a) The pre-planning process took about a year to prep for the actual development of the plan.
      i) They used a power mapping analysis to identify groups to reach out to that typically don’t participate and whose voices aren’t heard often. They were not able to successfully recruit all groups identified due to time constraints.
   b) The development of the plan took 2 years (March 2017 to March 2019). This time was spent setting goals and communicating with the organizations on what would work best.
      i) During phase 1, Metro was making connections and relationships with community organizations which they would benefit from during the development and roll out of the Regional Waste Plan. They developed the engagement terms for using the community organizations.
      ii) Metro worked with 8 community organizations to incorporate the diversity and the different needs throughout the region. They recruited people from within the communities they serve. Metro set up contracts with community organizations to recruit participants and lead discussions with them to provide feedback for the regional plan.
      iii) Stipends (gift cards) were given by the community organizations Metro contracted with to the community members to compensate their participation in the Regional Waste Plan. Metro contracted directly with the community organizations and paid for their facilitation and consulting services, as well as the stipends to be given to community members who participated in the process.
      iv) Stipends were given to individuals participating in the outreach/feedback sessions organized in conjunction with the community organizations and Metro. About 100 people total participated.
   c) They hired a facilitator to coordinate outreach and the community organizations and work to overcome distrust from those groups.
   d) There was a lot of learning, which took time
   e) They had to introduce community members to the waste management system and goals. They would have liked to have been able to start that earlier in the Regional Waste Plan development process.

4) Have you had any challenges developing the annual progress report?
   a) The main issue was the capacity and staffing for the development of the plan due to the pandemic. Although Metro has been responsible for waste diversion since the 70’s, producing the annual report was the first time under the new framework.
   b) The first progress report took approximately a year to develop. Throughout the year, stakeholders were still narrowing down certain indicators they wanted to report and needed to collect the data to support. Another challenge Metro had to overcome with the first progress report was developing new data sources for some indicators. For other indicators, Metro used existing data already regularly collected by state agencies, cities, counties and Metro.
   c) Over the year they had approximately four staff members working on the report, not full time, so it would be approximately the equivalence to two full time employees.
   d) Waste characterization is not planned to be a part of the annual progress report as the study is conducted statewide every 6 years for garbage. Metro pays for an additional recycling

characterization study that they can report, which is facility-based for residential and commercial, and generator-based for multifamily. Their goal is to provide data every 3-5 years because it is an indicator in the Regional Waste Plan.

e) A large focus of the Regional Waste Plan is on the multifamily sector when it comes to access to services because historically, they have been neglected.
   i) The focus is not so much on diversion, but on basic quality and access to services, including garbage, mixed recycling and glass recycling (glass is collected separately). Since at least 2017, Metro has found that many multifamily sites in the region lack adequate recycling service, as in, not enough bins for people to place their recyclables, which leads to overflowing bins and lower material quality.

f) Metro gets reports from the MRFs serving the region. Anyone collecting recycling also has to send reports to ODEQ.

5) Were there any challenges with incorporating input from stakeholders, such as disagreements on goals or definitions, during development of the Plan?
   a) Agreeing on definitions was a challenge. One challenge between stakeholders was the clarification between a goal and an indicator; what were measurable goals/targets they could track and report. This lack of consensus led to an absence of set targets in the final plan.
   b) Another challenge with the roll out was that in trying to keep everything high level, they did not incorporate anything specific about what facilities existed, needed to be built, or needed to be updated to facilitate the new goals. To remedy this, they are currently working on a separate Systems Facilities Plan, which will be considered a companion document of the Regional Waste Plan at first, and maybe incorporated into the next update of the Regional Waste Plan later (not sure at this point).
   c) There were debates about how much programs were going to cost
   d) The previous 64% recovery goal used to be a mandatory goal which then turned into a voluntary target with passage of a bill in 2015 by the Oregon legislature, which became effective Jan. 1, 2018.
   e) They have regional indicators, but not specific for jurisdictions. There are no current targets that people are aiming for (except for the regional 64% recovery rate, which includes recycling, composting and energy recovery); some individual cities do have targets for waste reduction.

6) What policies/legislative actions have you used to reach your Zero Waste goals?
   a) Opportunity to Recycle Act - main driver for programs, metro is required to have a waste reduction plan.
   b) Business Recycling and Food Waste Collection Requirements
      i) The more recent of these is mandatorycommercial food waste collection, which is likely to have a positive impact on recovery (program implementation was delayed. It was supposed to begin in 2020, but because of COVID, it started to be implemented in March 2022).
   c) Clean Fuel Program
      i) Hasn't seen evidence this has had a noticebale impact on solid waste fleets.
      ii) The effect of this program would be mainly on garbage trucks and long-haul transport.
      iii) There have been other policies and requirements implemented by individual jurisdiction's, such as Portland's requirements on collection vehicles and Metro-owned transfer stations switching to renewable diesel for the long-haul transport of waste to the Arlington landfill (~130 miles away).

d) Oregon's Plastic Pollution and Recycling Modernization Act – passed by legislation but rules are being developed, so not a factor yet.

7) Can you share any lessons learned from incorporating equity and environmental justice into your planning process?
   a) Engagement summary outlines more in detail about what they did for outreach.
   b) The Equity Work Group members focused mainly on racial equity and environmental justice, they did not necessarily have any background in waste. They worked with the planning team to come up with the principles in the Regional Waste Plan.
   c) The Equity Work Group helped the Metro project team take into consideration and include things in the final Regional Waste Plan that would not have included without the EWGs close collaboration.

8) How are programs funded?
   a) System Fees/Excise Tax on garbage and other waste but not on recycling, applied at transfer stations or landfill (both public and private facilities).
      i) Metro has tax authority over solid waste, including garbage and recycling, but exempts recycling from taxes and fees as a way to incentivize recovery.
   b) System Fees/Excise Taxes are lower on food waste and wood/compostables than on garbage.
   c) Cities have their own franchise fees.
   d) Systems fee is what funds a lot of the waste reduction programs:
      i) Funds household hazardous waste program, school outreach

9) Other insights or advice for the City of Tucson?
   a) Cannot rush the engagement step.

APPENDIX C

Near-Term Development Options

Near-Term Development Options

Zero Waste Roadmap Development

Prepared for: City of Tucson Environmental and General Services Department

Tucson, Arizona

October 24, 2022

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Contents

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Figures

Acronyms and Abbreviations

City	City of Tucson
EGSD	Environmental and General Services Department
EPA	Environmental Protection Agency
FTE	full-time equivalent
GHG	greenhouse gas
HDPE	high-density polyethylene
HHW	household hazardous waste
LRSC	Los Reales Sustainability Campus
MRF	Materials Recovery Facility
OCC	old corrugated cardboard
ONP	old newsprint
PAYT	pay-as-you-throw
Roadmap	Zero Waste Roadmap
UArizona	University of Arizona

Near-Term Development Options Graphics

	Brush and Bulky Waste
	Residential and Commercial Organics Collection
	Reuse Store
	Recycling Program Changes
	Pay-As-You-Throw

1 Executive Summary

HDR has been retained by the City of Tucson (City) to assist the City as it moves toward zero waste with the implementation of the Zero Waste Roadmap (Roadmap). The Roadmap is meant to gather information on what “zero waste” means to Tucson and to identify strategies to best support that vision. Multiple steps have been developed to guide the Roadmap, including this report, which discusses five near-term development options identified by the City as potential opportunities to advance zero waste. These opportunities represent activities that will start new waste reduction or diversion programs.

Based on data from the Current Conditions Assessment completed in June 2022, the City has significant potential to increase waste diversion, reduce recycling contamination rates, and implement programs to divert waste from disposal at the Los Reales Sustainability Campus (LRSC). The Los Reales Landfill received 764,000 tons of waste in 2021. The City’s diversion rate for all materials either collected or received by the City was approximately 4 percent in 2021. The diversion rate for all materials collected by the City was approximately 9 percent. The reported recycling contamination rate at the Republic Services’ ReCommunity Materials Recovery Facility (MRF) was 29 percent. Both figures represent significant opportunities for increasing recycling and the potential to reduce the financial burden on the City.

This report presents five near-term development options. Each option has undergone a high level evaluation and analysis to compare the benefits and impacts of program implementation. The evaluation matrix summarizes the potential benefits, impacts, costs, and implementation timeframes for each option. This matrix is meant to guide the City in decision-making and communicate the values and challenges of each option based on the three pillars of sustainability: environmental, economic, and social. Local impacts were also considered for each option, including convenience and accessibility to residents, local economic impacts, and impacts on the Los Reales Landfill and LRSC.

The five options are as follows:

- Brush and Bulky Collection
- Residential and Commercial Organics Recycling
- Reuse Store
- Recycling Program Changes
- Pay-As-You-Throw (PAYT)

A summary of the findings is included in this report.

Brush and Bulky Collection

The City's current Brush and Bulky Collection program offers a convenient service for residents to dispose of brush and bulky household items curbside twice per year at no additional cost as part of the residential collection service. Acceptable items include brush (defined as yard waste up to 5 feet long and 24 inches in diameter), cacti, lumber, appliances, tires (up to five), scrap metal, furniture, and carpet. This program is available to 140,000 households and generates 19,000 tons of material, which is currently disposed of at Los Reales Landfill. This represents approximately 271 pounds of materials collected per household. The program is well-established and highly utilized by Tucson residents. Additional pickups are available to customers upon request for an additional fee.

Currently, none of the items collected are recycled or diverted from Los Reales Landfill. Implementing waste diversion for some or all of these materials collected has the potential to further zero waste goals for the City. Changing the frequency and way in which materials are collected would provide alternative options for increased processing efficiency.

The City has not tracked separately the amounts of brush collected versus bulky waste, but some hypothetical scenarios provide insight into potential for diversion. Assuming 75 percent of the 19,000 tons collected is brush and yard waste material, the City has the potential to divert and recycle about 14,000 tons per year by offering brush collection twice per year, separate from the bulky collection. With separate bulky waste collection once per year, and assuming 25 percent of the bulky waste collected could be diverted, an additional 1,200 tons per year would be diverted from the landfill. This results in approximately 80 percent of brush and bulky materials diverted from the landfill. A more conservative estimate would assume that 50 percent of brush and bulky materials could be diverted. These scenarios illustrate a possible increase of 1 to 2 percent in the City's overall diversion rate, and 3 to 5 percent in the collections diversion rate.

By collecting the brush or yard waste separate from bulky materials, these organic wastes could be recycled and processed. Some additional costs to the City such as fuel would result from separate collection events. More households are expected to be served annually with expanded routes for the separate collections. The City would need to procure an end market for yard waste materials or continue to invest in the necessary machinery and space to compost or mulch yard waste materials at the LRSC.

Brush and bulky waste collection changes have the potential to be implemented easily and quickly, given the existing collection program, including necessary staff, trucks, and operational requirements. Securing end markets or outlets for yard waste necessitates the most time and potential capital costs. The City could also consider separating and recycling bulky waste items collected for further waste reduction in conjunction with existing or planned facilities, including the new reuse store and the new Mixed Waste MRF that are currently being considered and evaluated as part of the Roadmap efforts.

The potential diversion, community and environmental impacts for this option are considered to be medium. The cost to the City is relatively low and the implementation timeframe is relatively short.

Residential and Commercial Organics Recycling

Food waste diversion has been slowly introduced in small pilot programs throughout Tucson for the last 10 years. The City's current program is called FoodCycle. The FoodCycle program collects 260 tons of material annually from local businesses for composting at the Los Reales Landfill. Expanding this program to allow residential and other commercial customers to recycle food waste has the potential to significantly increase waste diversion. Assuming capture rates of 20 to 30 percent for residential food waste and 50 to 75 percent for residential yard waste, this program could divert 44,000 to 62,000 tons of compostable organic waste per year. This would result in an increase of 5 to 8 percent in overall diversion, and 14 to 20 percent in collections system diversion. This diversion could be increased by targeted collection of commercial food waste and additional diversion of yard waste at the LRSC gate.

Curbside food waste programs are rapidly expanding across the country. In a previous study, the City reviewed collection program information from similar and aspirational cities to determine what food waste programs are currently implemented across the country. Five of the cities reviewed used separate curbside carts for food waste collection, and all included yard waste material in their collection program as well.[1] Such programs involve costs for collection, processing, and recycling of material; staff time; and education and outreach; and a minimal cost reduction in landfill operations. Program implementation would take 2 to 3 years to fully execute, and participation is anticipated to continue to increase thereafter.

Another option would be for the City to start a food waste collection program via drop-off sites as an alternative or complement to a curbside program. Drop-off collection is a much less expensive option that has barriers to usage but could be an effective way to gauge the interest of residents in a food waste recycling program.

Both the curbside and drop-off programs could be initiated as pilot programs to minimize costs and risk, gauge interest, and identify potential challenges for full systems. Regardless of how food and yard waste are collected, the material will require an end market for composting or other type of organics processing. The City will need to procure an appropriate end market capable of accepting the type and quantity of materials collected or invest in the necessary equipment and space for processing food waste materials at the LRSC.

The implementation timeframe for this option is long, and the cost impacts are high, but the diversion, community, and environmental benefits also have the potential to be high.

Reuse Store

Creating a space on the LRSC to conveniently divert material from landfill disposal for reuse has been identified by the City as a potential development option. The City is considering developing a reuse store to create a place to further sustainability and waste diversion in partnership with the LRSC. A reuse store would accept items with a useful life remaining but no longer needed by the owner for reuse or resale. This could include items such as furniture, doors, construction materials, appliances, and paint.

[1] *City of Tucson Refuse & Recycling Study*, MSW Consultants, 2020

Not only would a reuse store divert waste from the landfill, it has the potential to generate community involvement and local economic benefit. The facility could be owned and operated by the City, use partnerships for operation with local organizations and nonprofits, or be owned by another entity. The LRSC has space available for such a facility.

Similar programs have used space to remove items from disposal areas and collect items directly from residents for reuse or resale, and such models have proven to be successful in local communities. They require commitment from partner organizations and potential ongoing financial support from the City, depending on the structure of operations. Defining how materials will be separated is critical and could include direct donations, volunteer collection, and/or mechanical sorting of materials after disposal.

Construction and development of a new facility could take approximately 2 to 3 years, and a 10,000-square-foot facility is estimated to cost $3 million to $5 million. Ongoing operation and maintenance costs should be considered, along with staff time from the City or partner organizations. Similar programs have been able to generate minimal revenue from the resale of items as well.

Overall, the waste diversion impact and environmental impact can be relatively low for a reuse store as compared to other near-term development options discussed, especially with consideration given to the medium to high cost impacts and medium implementation timeline associated with it. However, the reuse store could provide added value to the community and a strong focus on reuse, resulting in a medium community impact.

Recycling Program Changes

The City currently provides single-stream recycling collection for approximately 142,000 households (74,000 single-family and 68,000 multifamily) and 650 commercial customers. All collected materials are taken to the Republic Services MRF (known as ReCommunity Recycling Tucson) for processing and recycling. This MRF accepts old corrugated cardboard, old newsprint, other paper, aluminum, tin, other metal, polyethylene terephthalate bottles, high-density polyethylene natural bottles and pigmented bottles, #5 plastics, and rigid plastics. The MRF serves other communities and haulers in the region as well. Although accepted and processed at the MRF, glass is not accepted in the City's curbside collection program but rather collected at glass recycling drop-off centers and recycled or reused through a separate program.

Republic Services charges the City an excess contamination charge (residue charge) of $1 per ton for each percentage point above 18.7 percent contamination. In 2021, the contamination rate was approximately 29 percent, resulting in an additional cost to the City of $314,085.[2] Additionally, regional waste sort data show that approximately 10 to 20 percent of material being disposed of at the landfill is recyclable and could be diverted.[3] Contamination and confusion about what is recyclable are significant and costly issues for the City and a common challenge for many recycling programs. Research has documented that contamination rates across the country range from 10 to

[2] *Current Conditions Assessment*, HDR, 2022

[3] Ibid.

40 percent and create challenges for many MRFs.[4] Reducing recycling contamination is an opportunity for increased waste diversion and advancement of the City's zero waste goals.

Multi-stream recycling requires customers to separate their recyclables into multiple carts (a common form of which is dual-stream recycling) rather than recycling all items together (called single-stream recycling). Multi-stream recycling requires additional recycling carts, trucks, and staff time for collection. Typically, multi-stream collection produces cleaner materials because of greater separation of materials at the source rather than separation at the MRF. Multi-stream recycling historically was a more common form of collection. However, single-stream recycling is now more prevalent. Single-stream recycling uses a cart with greater capacity for service rather than a bin, allowing additional recyclables to be captured. Single-stream recycling is also typically more efficient for collection because the driver can collect using an automated or semi-automated collection vehicle without getting out of the truck. Research has shown that, generally, the single-stream collection is more cost-effective in dense, urban areas where route density and the volume of recyclable materials are higher. Implementing multi-stream recycling may have associated additional costs but would also depend on the capability to maintain separation of materials at the MRF. Tipping fees at the MRF are typically lower for multi-stream recycling.

Changing the current curbside collection would require significant education and outreach to customers, particularly given the current high contamination rate for curbside recycling. Changing the program to a multi-stream system requires more effort by residents and may be difficult to implement. Additionally, multi-stream recycling is unlikely to result in decreased tipping fees at the Republic Services MRF because this facility has technology designed to separate single-stream materials. The City would need to procure an agreement with a facility or multiple facilities that can accommodate the multi-stream collection, which would not be an available option until the current contract with Republic Services ends in 5 years. The timeframe for implementing a collection program change would depend on the available end markets and proper outreach to customers—a minimum of 1 to 1.5 years.

The cost impacts for multi-stream recycling are based on evaluation and necessary changes to the existing recycling collection program. The implementation timeline would require changes to key recycling processing infrastructure and collection updates. This option could provide a community or environmental impact by producing cleaner recyclables but the waste division impact may not be significant. Tucson's high contamination rates in current curbside recycling indicate residents may not possess a strong understanding of what is and is not recyclable. Programmatic changes would require significant and ongoing education and public outreach.

The cost impact for multi-stream recycling is high and the implementation timeframe is medium to long. There is only low potential for additional diversion impact and medium potential for community or environmental impacts.

The City could also consider implementing a robust recycling education program for curbside recycling collection. Given the current high level of contamination, there is an opportunity for the City to save money by implementing a program to further encourage

[4] *City of Tucson Refuse & Recycling Study,* MSW Consultants, 2020

proper recycling and reduce contamination fees at the MRF. A successful program should include funding over many years to reach residents numerous times and provide repeated education regarding recycling best practices. The cost savings from reducing contamination at the MRF and additional revenue from increased quantity and quality of recyclables could be a direct benefit of an effective program and offers the possibility of offsetting the new costs for educational programs. Implementing such a program will depend on available program funding, staff time, and outreach channels for education.

The cost impact for recycling education can vary greatly depending on the level of engagement chosen, but the implementation timeframe is generally short. The potential impact on additional diversion can range from low to high (depending on level of investment) and there is medium potential for community and environmental impact.

Pay-As-You-Throw

The City's current fee structure for trash service varies slightly based on the size of the trash carts. The City currently offers 48-, 65-, and 96-gallon trash carts. The current monthly cost for each trash cart is $15.00, $16.00, and $16.75, respectively. All of these rates include trash collection once every week, recycling collection once every other week, and brush and bulky collection twice a year. However, a more robust PAYT program has the potential to shift customer behaviors with added financial incentive. PAYT fee structures incentivize residents to right-size their carts and reduce their trash as a result. The Environmental Protection Agency (EPA) considers a strong PAYT program to be one with a $5.00 or more price differential between cart sizes.[5] Such programs have documented increased recycling tonnage and decreased waste generated. Such a program has the potential to increase waste diversion and implement effective zero waste policies in the City.

PAYT programs incorporate the three pillars of sustainability: environmental, economic, and social impacts. Data have shown that effective programs result in less waste produced, thus conserving natural resources, and reducing GHG emissions. PAYT has the potential to be economically sustainable for local communities managing solid waste as well. PAYT also allows individuals to benefit economically from their personal behavior changes in reducing waste by also reducing their fees. PAYT programs are viewed as equitable on account of the inherent fairness of the fee structure, similar to utility rates. Residents who recycle more and reduce their waste are rewarded and do not take on the financial burden of those producing more waste. The City's current rate system has less variability between cart sizes, spreading out the overall cost of waste management to all households within the program rather than more accurately charging for the individual services utilized.

Implementation and fee structures for a robust and effective PAYT system could be developed in a short to medium period of time and could easily be implemented but would require an in-depth analysis of the cost of service and cost recovery models to ensure that the necessary revenue is generated to offset all operating and capital costs. This would need to include a plan for implementation in neighborhoods with shared containers in the alleys that are used by more than one residence. This option may

[5] Skumatz "Pay-As-You-Throw variable Rates for Trash Collection, 2015, Pay-As-You Throw / Variable Rates for Trash Collection (epa.gov)

require the purchase of new carts in smaller sizes, but does not require additional trucks or staff time and does not require new infrastructure or other production inputs. Yet the impact on residents has the potential to be significant, as does the waste diversion opportunity. Education and outreach regarding program changes would be critical, particularly to share the benefits and equality of the new program to gather community support.

A robust and well-designed PAYT program has the potential to reduce waste to the landfill by as much as 15 to 20 percent, or approximately 30,000 to 40,000 tons per year in Tucson. This would increase the City's overall diversion rate by 3 to 5 percent and would increase the collection system's diversion rate by 9 to 13 percent but, again, it would require a robust financial analysis that could result in a significant change to the current rate structures.

PAYT programs do come with challenges related to contamination. Other municipalities have documented trash being placed in recycling carts because of limited space as a result of such programs. There are some concerns that it could also lead to more illegal dumping of waste. PAYT implementation could occur over multiple years to slowly increase the differential and address contamination and education concerns. Alternatively, a PAYT system could be implemented over a few years, with more significant rate changes for residents.

Regardless of the timeframe for changing fees, strong education and outreach campaigns to reduce contamination in recycling carts will be critical. This is the main timeline consideration for this program implementation in addition to considering the speed at which rates change for customers. Education about proper recycling and the negative impacts of improper recycling practices should be clearly communicated and regularly shared with residents. Ongoing education and outreach will be highly valuable for the success of a PAYT program. The City may also want to consider enforcement or penalties—including fines—for contamination and other issues related to inadequate trash cart capacity.

The cost impacts to the City for this option are low and the implementation timeline can be short- to medium-term. The potential for diversion, community, and environmental impacts is high.

Recommendations

The near-term development options identified all provide viable options to assist the City in meeting its waste diversion goals on the path toward zero waste. Each option has its own benefits, challenges, and various levels of involvement for the community and the City. The comparison matrix found in Table 1-1 identifies the impact for each option with regard to diversion impact, community or environmental impact, implementation timeframe, and cost impacts.

Table 1-1. Comparison matrix of near-term development options

Program	Diversion Impact	Community or Environmental Impact	Implementation Timeframe	Cost Impacts
Brush and Bulky Collection	Medium	Medium	Short	Low
Residential and Commercial Organics Collection	Medium–High	High	Long	High
Reuse Store	Low	Low–Medium	Medium	Medium–High
Recycling Program Changes: Multi-Stream Recycling	Low	Medium	Medium–Long	High
Recycling Program Changes: Recycling Education	Low–High	Medium	Short	Low–High
Pay-As-You-Throw	High	High	Short–Medium	Low

Comparing these options, the overall impact potential based on the criteria above is as follows, from highest to lowest positive impact:

1. Brush and Bulky Collection
2. Pay-As-You-Throw
3. Recycling Program Changes: Recycling Education
4. Residential and Commercial Organics Collection
5. Reuse Store
6. Recycling Program Changes: Multi-stream Recycling

This evaluation considers the level of impact of each near-term option as compared to the other options identified. Additional work is necessary to further evaluate the actual costs for each option and better define the diversion potential. This report also includes a recommendation for a review of local ordinances that pertain to each option, a visual waste characterization study where it makes sense to better define waste diversion potential, and public engagement and education for program changes. The detailed analysis that follows and the final comparison matrix provide guidance regarding such decisions to the City in its zero waste efforts.

2 Purpose and Methodology

In this report, "near-term" solutions are defined as operational or service level programmatic changes that could be achieved within the next 5 years. This timeframe includes program planning through full implementation.

The intent of this report is to provide insight to the City on potential pathways toward zero waste that use current operations and resources. Many of the options detailed exemplify opportunities that fit within the City's existing framework and programs, making them practical options for immediate consideration. Waste diversion is the basis for each option, with guidance on moving the current services toward more aggressive zero waste goals.

The evaluations considered the ease of implementation, schedule, program costs, waste diversion, and other benefits or impacts of the program.

3 Brush and Bulky Collection

3.1 Existing Program

The City currently offers brush and bulky services to residents twice per year, accounting for approximately 19,000 tons of residential waste collected annually, which is 10 percent of the total annual residential waste disposed of at Los Reales Landfill. All 140,000 customers are eligible to participate in this program. This service is used by many residents and provides an opportunity to dispose of bulky items and brush conveniently through curbside collection. All 26 of the City's residential trash service areas are served during these events. The City currently has 23 full-time equivalent (FTE) employees who provide brush and bulky collections.

Residents are encouraged to clean out their homes, garages, and sheds to remove unwanted items for the collection events. Each household is allowed to dispose of up to 10 cubic yards of material during each collection event. Acceptable items include appliances, auto tires, brush, cacti, furniture, carpet, lumber, and scrap metal and pipes. The collection will not accept compressed gas/air cylinders, concrete, construction materials, dirt, stones, rocks, gravel, glass, mirrors, household hazardous waste, televisions, or computer monitors. Currently, all the brush and bulky items are collected together and disposed of at Los Reales Landfill.[6] The City has not separately tracked the amounts of brush collected versus bulky waste.

In addition to the regular waste collection services—which include the twice-annual brush and bulky collection—the City provides special trash collection services upon request for an additional fee for extra brush and bulky collections and for household hazardous waste removal. Residents call the City to schedule this special trash collection at any time during the year. The fee for this special collection is $55 for up to 10 cubic yards and an additional $25 for each additional 15 minutes of collection time and $5 for each additional cubic yard of material.

[6] *Current Conditions Assessment*, HDR, 2022

In 2019, the City added additional services as a part of the brush and bulky collection program. In collaboration with the City's Transportation Services, Police Department, and Fire Department, the program now provides additional cleanups in public spaces throughout the community. The City also coordinates with neighborhood associations ahead of the events to identify priorities for each neighborhood, identify properties in violation of the Neighborhood Preservation Ordinance, and encourage compliance through the brush and bulky collection events for those properties.

Normal collection events occur twice per year for residential customers and provide a convenient and simple way for residents to dispose of hard-to-manage items. It requires substantial work on behalf of City crews, and there are no separate costs to residents because the cost is embedded in the monthly residential fees. The City estimates the cost for these collection events at $5 million annually. The program aims to provide waste disposal options while making Tucson a cleaner and more visually appealing city. The cleanup work in public spaces has addressed illegally dumped items and public areas that need attention.

3.2 Alternative Program

The City is considering alternative service programs to manage brush and bulky waste in a manner that provides increased waste diversion while still providing a valuable service to customers. Considerations include separating services by material type and offering bulky pickup once per year and brush collection twice per year. The City may also explore options to provide one or both services on a subscription or case-by-case basis. Separating the brush and bulky waste collection into two distinct programs would result in cleaner waste streams with the potential for diversion. Comingling these materials prevents the brush or yard waste from being processed and recycled. Brush and bulky items are currently disposed of at the landfill, adding to the volume of materials that could be managed in a more efficient and environmentally preferrable manner. Modifying the program to collect different materials by way of different events creates greater potential to recycle or process most items and significantly reduce the amount of waste going to Los Reales Landfill.

Providing a specific collection of brush and yard waste curbside to residents could significantly increase waste diversion if such materials were processed and recycled. Materials such as grass, leaves, tree trimmings, brush, and other yard waste are relatively easy to process and break down in the proper facility. The environmental benefit and reduced volume of material to the landfill would advance the City's zero waste efforts.

The City completed the *Los Reales Landfill Composting Facility Operations Plan* in November 2020. The composting facility site consists of 7.7 acres and can currently accommodate 2,800 cubic yards for composting. This site is likely not large enough to accommodate the amount of material collected through curbside services unless the active composting phase is accelerated and/or the permitted maximum of yards allowed on site is increased.

Yard waste disposed of in landfills contributes to GHG emissions. Seventeen states in the United States have banned the disposal of yard waste in landfills and require the material to be processed and recycled.[7] Other successful yard waste reduction strategies that have been implemented across the country include source separation of yard waste for processing. The EPA estimated that 63 percent of yard waste generated in 2018 was composted.[8] Yard waste can be processed at facilities and turned into finished compost quite simply as compared to other organic materials such as food waste, which require additional management considerations. The City has an opportunity to collect yard waste separately from other waste streams and create a valuable product while also preventing yard waste from entering the landfill.

The curbside collection program could be modified to still include bulky waste pickups but be reduced to annually rather than twice annually to reduce cost and staff impacts on account of the separate collections. An annual bulky waste collection would still provide residents with a valuable and convenient service while encouraging proper disposal of materials to reduce illegal dumping of unwanted items. A once-per-year bulky collection could use the existing City infrastructure. Bulky volumes may be reduced because of the less frequent collection. However, residents could still request a special collection service at any time for a fee.

Changing this program to only a case-by-case basis or subscription-based service would allow for more efficient pickup events and likely larger quantities collected on a per-stop or per-household basis. The overall collection of the material may decrease but there is a potential for more efficiency with staff time and trucking operations. Subscription services shift the effort to customers to determine pickup events and pay for the services they need rather than providing a service they may not fully utilize. However, this model could also lead to equity concerns, code violations from waste accumulating on private property, and an increase in illegal dumping if residents are required to pay for special collections or cannot afford the service. This would require additional staff time to address illegally dumped items.

Providing a subscription option to multifamily and commercial customers could likewise prove to be an efficient way to collect materials and produce larger quantities per event. Collecting brush or bulky waste items from larger customers such as commercial and multifamily locations could produce large amounts of material at a single stop, collected from many households. Allowing those customers to subscribe, rather than providing the service without a subscription, is a more efficient and cost-effective method of collection. Multifamily and commercial subscriptions present an opportunity for further efficiencies, increased quantities of materials collected in a single event, and greater diversion of reusable bulky items to thrift and reuse stores. Yard waste should be collected separately and processed for further waste reduction.

3.3 Benefits/Impacts

A significant benefit of changing the brush and bulky collection program is the potential to recycle the yard waste material collected and potentially recycle some of the bulky items as well. By separating the waste streams, the materials can be managed more efficiently

[7] "Organics Bans & Mandates," U.S. Composting Council, June 2021, https://www.compostingcouncil.org/page/organicsbans

[8] "Advancing Sustainable Materials Management: 2018 Fact Sheet," EPA, December 2020, https://www.epa.gov/sites/default/files/2021-01/documents/2018_ff_fact_sheet_dec_2020_fnl_508.pdf

and have a higher likelihood of being recycled, advancing zero waste efforts and waste reduction goals. The waste composition of the brush and bulky collection has not been evaluated in recent years, but some assumptions can illustrative the diversion potential. For example, consider a scenario where the 19,000 annual tons collected through brush and bulky services consist of 75 percent brush and 25 percent bulky materials. Separating these two waste streams could make it possible to divert nearly the full estimated amount of yard waste (less contamination), which would be approximately 14,000 tons per year. If the bulky waste were processed at a mixed-waste processing facility or other facility with some level of sorting materials for recovery, about 25 percent of the bulky waste collected, or about 1,200 tons per year, could be diverted. Combined, this diversion of approximately 80 percent of brush and bulky material (15,200 tons per year) would increase the City's overall (collections plus LRSC) diversion rate by 2 percent, and increase the City's collection system diversion rate by 5 percent. Even a more conservative scenario estimating approximately 50 percent diversion of brush and bulky waste would result in an increase of 1 percent in overall diversion and 3 percent in collections system diversion.

While this could be beneficial for diversion rates, it would be critical to ensure there is infrastructure for the collection, transportation, and storage of materials as well as viable end markets for proper recycling and management of materials collected.

Yard waste has a negative environmental impact when disposed of in a landfill. Yard waste materials that decompose in landfills release methane gas and leachate, both needing management to protect the environment and the surrounding community. Nutrients that could be used in soil amendments are inaccessible when yard waste is enclosed in a landfill. Yard waste is also generally unsuitable for combustion because of its high moisture content.[9] It is worthwhile to note that organic material, including compostable yard waste and food waste, is estimated to account for approximately 43 percent of the waste entering Los Reales Landfill, based on the *Current Conditions Assessment* completed for the City.[10] By separating yard waste materials for processing through composting, a higher-value product (compost) is produced, and it would significantly reduce waste entering Los Reales Landfill. Once processed into mulch or compost, the material can be used to benefit soil health as a soil additive and help the soil retain moisture and nutrients.[11] Many municipalities use compost for landscaping, recreational areas, and public property.

Best practices for such events should include events on different weeks or even different months to ensure participant understanding of what items are collected during each separate event. Collection routes will likely be capable of serving more stops per route when collecting fewer items. Determining the costs to the City and to residents for any program change will be critical. The current service is at no additional charge—being embedded in the monthly fees—and that will likely be the expectation of residents. Changing service schedule and frequency and charging fees for a second bulky waste collection, which is currently included with the existing service, may have negative impacts, including illegal dumping of materials or improper disposal in curbside trash or

[9] "Environmental Fact Sheet: Yard Waste Composting," EPA, May 1991, https://nepis.epa.gov/
[10] *Current Conditions Assessment*, HDR, 2022
[11] "Environmental Fact Sheet: Yard Waste Composting," EPA, May 1991, https://nepis.epa.gov/

recycling carts. It will be critical to consider these negative impacts when determining costs for various levels of service.

3.4 Implementation Timeframe

Planning is critical to implementing a new or modified brush and bulky collection program and includes establishing necessary and possibly new end markets for materials. If the program is expanded to offer recycling of collected materials, the City will need to procure proper outlets or establish its own processing site for the material. Depending on how the brush and yard waste material will be managed, the timeframe and cost will differ drastically.

Implementation of the collection changes to the brush and bulky collection program could be completed quickly and easily because this is an existing and well-established program that does not require significant operational changes. However, it will be critical to inform residents of any program changes well in advance, especially because the program is long-running and many residents expect the service twice annually. It may be necessary to announce the program changes up to a year in advance and invest in public outreach and education about the planned changes. Routes may also need to be modified to maximize the number of households served in a route depending on participation. It will be important to inform residents of the difference in the program, what materials are collected at what time, and by what method, while highlighting the added benefits of this operational change.

There would be minimal operational changes necessary to reduce or reconfigure collection for the brush and bulky materials. Scheduling and providing on-call or subscription-based pickups may require additional staff and equipment depending on demand and program structure. Participation in multi-unit and commercial properties is difficult to gauge but could also result in an increase in demand for these services. There may be different needs for these types of properties, too, depending on the number of materials generated for collection. It will be important to consider transportation, storage, and end-market facilities for such items before launching any program changes.

3.5 Cost Considerations

The current twice-yearly pickup program is provided to residents at no separate cost, and residents are charged for additional pickups only as requested. Modifying the program frequency may lead to expanded subscription or on-call services for pickups. This could be a way to illustrate the value of this service to residents, but the additional costs may result in equity concerns. The City will need to determine what is an appropriate cost to residents. For regular subscription and on-call services, the City should consider the cost of staff time for scheduling and collection, equipment, and management or disposal of items collected. The City estimates the current cost for the existing program to be $5 million. Based on 19,000 tons of waste, the average cost of material collected is $263 per ton. Modifying the program to include twice-yearly brush collection and once-yearly bulky item collection may require additional staff time and truck operations for the additional collection event. At the very least, fuel costs and truck maintenance would increase for covering the same routes under a third event. Although the collections and disposal would be more efficient in regard to waste diversion, the operational costs would increase, including possible extra staff time, fuel, and truck operation and maintenance. The City would likely need to hire one or two FTE employees for the additional work.

Multi-unit and commercial property fees would also need to be determined and could potentially be a revenue source for the City, if desired. Private waste companies that currently provide this service would be in direct competition with City services. The City will need to determine whether all associated fees need to be accounted for in the fees to customers or whether this service should be subsidized.

There will be an added cost to manage and recycle yard waste that is currently going into the landfill, but there are also financial savings from the reduction of tons needing to be disposed of in the landfill and long-term landfill costs. This economic cost should be considered and weighed against the environmental benefits of proper management of yard waste, including reduced methane and leachate, beneficial end product, and extension of the landfill's life. The City will need to invest in the necessary machinery and space for processing yard waste at the LRSC or procure outside services to manage and process the collected material elsewhere. If additional transportation and trucking are required to move the collected yard waste to a different facility, those impacts should also be considered.

3.6 Next Steps

Modifying the existing brush and bulky collection program has the potential to divert significant waste from the landfill and create a more efficient program. The City will need to evaluate how to best manage yard waste separated from other materials, either by procuring an outlet to process this material or by expanding and further establishing its own yard waste processing facility at LRSC.

City leadership should consider how best to manage the cost to residents and commercial customers for any program changes. These fee structures will need to be determined before the program change is communicated. Public engagement, education, and outreach will be critical to the success of a program change and to ensure residents are properly separating materials for collection events. Public engagement should be done well in advance of any programmatic changes.

Additionally, early activities can help define and plan any program changes, including the following initial steps:

- Review codes and ordinances on yard waste and bulky item collections from residential, commercial, and institutional sources.
- Complete a visual observation study of waste coming to the landfill from the brush and bulky collection program, as well as self-haul sources, to determine approximate percentages of yard waste and bulky waste items.
- Review existing and projected program costs.
- Conduct public engagement and education with residents regarding program changes.

4 Residential and Commercial Organics Collection

4.1 Existing Program

Various food and yard waste recycling programs have been implemented in the City for nearly a decade in an effort to expand diversion of organic materials. In 2013, the City's Environmental and General Services Department (EGSD) partnered with the University of Arizona (UArizona) Compost Cats to divert compostable materials through a student collection program. The Compost Cats operated at the San Xavier Co-op Farm. Students collected food scrap waste from restaurants near the university and EGSD assisted by transporting that food waste, green waste, and animal waste from the local zoo to the Co-op Farm. This program grew over time and eventually became the FoodCycle program, providing food waste collection services for local businesses. In 2019, the San Xavier Co-op Farm closed and EGSD obtained a permit from the Arizona Department of Environmental Quality, allowing it to compost food waste and yard waste at the landfill. This program provides services to existing customers. In 2021, the FoodCycle program composted 261 tons of compostable material. In October 2022, EGSD obtained approval to process white paper and animal waste at the City's composting facility located at the LRSC. The City also collects Christmas trees and mulches them. The mulch is then available to the public for free.

Based on aggregate data from Food Rescue US, ReFED, EPA, and the US Composting Council, Arizona wasted the most food in the country, based on 2021 data. This ranking is defined by metrics regarding Arizona having the highest share of food wasted and lowest share of food recycled. Arizona was also the third lowest for food donated to people.[12] Local steps taken by Tucson and other municipalities can address these matters.

EPA identified a food recovery hierarchy to prioritize actions to prevent and divert food waste, prioritized based on benefits for the environment, society, and the economy. The top level and most preferred method is to prevent surplus food generation, then to donate extra food to people, and then donate food to animals. The next preferred method is industrial use for food waste to recover energy, then composting for soil amendment. The least preferred management method is sending food waste to landfills or incineration.[13]

4.2 Alternative Program

The City plans to expand the FoodCycle program by including the collection and recycling of green waste and food waste from internal City departments including EGSD, Tucson Clean and Beautiful, Reid Park Zoo, and Transportation and Mobility. EGSD estimates that the composting facility will receive approximately 35,000 tons per year for

[12] "2022's States That Waste the Most Food," Lawnstarter, 2021, https://www.lawnstarter.com/blog/studies/states-that-waste-most-food/

[13] "Food Recovery Hierarchy," EPA, 2022, https://www.epa.gov/sustainable-management-food/food-recovery-hierarchy

processing, which represents an increase of approximately 4 percent in the City's overall diversion rate (and an 11 percent increase in the collection system's diversion rate). EGSD anticipates that composting food waste and yard waste will result in landfill operational cost savings of approximately $175,000.[14] The City plans to collect data on operations, management, finished product, and operational costs, which will be used to guide the eventual facility expansion.[15] The finished compost will be used to support other Tucson Climate Action initiatives including the Tucson Million Trees Campaign, Green Stormwater Infrastructure program, roadside erosion stabilization, and daily cover and erosion and slope stabilization at Los Reales Landfill. The finished compost would be made available to City departments, Tucson Clean and Beautiful, and UArizona for sustainability programs and projects in the community.

The City is considering adding a curbside food waste recycling program for both residential and commercial customers for the collection of food waste and other compostable items. Food waste and other organic materials are approximately 30 percent of the residential waste stream.[16] Collecting and diverting that material from the landfill has the potential to significantly reduce waste and reduce GHG emissions that result from organic materials breaking down in the landfill. The EPA-developed waste management hierarchy provides guidance regarding waste management, ranking the various management strategies from most to least environmentally preferred. After source reduction and reuse, the next recommended waste management strategy is recycling and composting.[17]

Composting food waste and yard waste would reduce GHG emissions that contribute to climate change and would create a valuable end product. EPA estimates the average amount of food waste generated per household weekly is 6.5 pounds,[18] with various collection programs ranging up to 8 pounds per participating household. If 40 percent of households in Tucson participate in this program, the City should plan to manage approximately 9,000 to 12,000 tons of food waste annually. Assuming that approximately 15 percent of residential waste is food waste, based on regional waste characterizations, this is roughly equivalent to a 20 to 30 percent capture rate of the food waste currently being sent to disposal by residents. Additional food waste could be captured by targeting commercial customers with high rates of food waste for participation in the new program. Additional research and data collection would be needed to gauge the potential level of diversion from commercial organics collection.

The City would want to capture at least 35,000 to 50,000 tons per year of yard waste to blend with the residential food waste at a compost facility, assuming 20 percent of the mix is food waste. Assuming that approximately 25 percent of residential waste is compostable yard waste, based on regional waste characterizations, this is roughly equivalent to a 50 to 75 percent capture rate. This amount of yard waste should be

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[14] *Current Conditions Assessment*, HDR, 2022

[15] Ibid.

[16] "Composting At Home," EPA, 2022, https://www.epa.gov/recycle/composting-home

[17] "Sustainable Materials Management: Non-Hazardous Materials and Waste Management Hierarchy," EPA, 2022, https://www.epa.gov/smm/sustainable-materials-management-non-hazardous-materials-and-waste-management-hierarchy

[18] "2018 Wasted Food Report," EPA, 2020, https://www.epa.gov/sites/default/files/2020-11/documents/2018_wasted_food_report-11-9-20_final_.pdf

achievable through an effective curbside yard waste collection program and could be supplemented by capturing yard waste loads arriving at the landfill.

Combined, these estimates account for 44,000 to 62,000 tons of potential diversion each year. This would result in an increase of 5 to 8 percent in overall diversion, and 14 to 20 percent in collections system diversion.

Most successful collection programs use a third collection cart specifically for food waste from homes and often include yard waste as acceptable materials in addition to food waste. Through a previous study, the City investigated other food waste collection programs around the country that also collected yard waste items such as grass, leaves, and brush as well as food waste. Seven of the cities, including five cities that the City considers to have aspirational waste diversion programs, provided some level of curbside food waste collection. All cities use cart service for collection with varying fee structures for collection. Three cities consider food waste collection mandatory (part of base services) and four cities have voluntary or subscription options for participation.[19]

BioCycle completed a nationwide survey regarding residential food waste collection programs in 2021 and identified 510 municipally supported programs, including curbside and/or drop-off programs. BioCycle has been performing this survey since 2005 when only 24 communities had curbside collection available. Program specifics and collection frequency and type vary greatly across the country, with many communities modifying programs to meet their specific community needs and waste diversion goals. Most programs gauge their success based on participation and waste diversion goals. Participation, contamination, and processing facility capacity were identified as program challenges for most communities.[20] In 2011, BioCycle research found that the average level of participation for residential curbside food waste programs was 35 to 45 percent of eligible households.[21]

The necessary supplementary cart or dumpster service for food waste and yard waste collection would require additional collection routes including trucks and drivers, which would likely add emissions from truck operations and increased staff. Food waste is putrescible and needs to be collected on a weekly basis to minimize odors and vectors. Cost impacts for adding this service are similar to adding an additional route for trash or recycling services; however, with more participation in the program, costs per stop could be less.

The City should also consider adding a food waste collection drop-off program by way of dumpsters at existing City facilities such as the glass recycling drop-off locations. Although participation and volume of food waste collected would likely be significantly less than a curbside program, drop-offs are an alternative with significantly less cost and do not require curbside collection or hauling. In 2021, 101 drop-off only organics collection programs were available across the country. Survey data from these programs indicated 65 percent of sites helped their communities meet diversion goals and

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[19] *City of Tucson Refuse & Recycling Study*, MSW Consultants, 2020

[20] "Residential Food Scraps Collection Access in the U.S. – The Programs, BioCycle, 2021, https://www.biocycle.net/residential-food-scraps-collection-access-in-the-u-s-the-programs/

[21] "Food Scraps Programs in the United States," BioCycle, 2011, https://www.biocycle.net/food-scraps-programs-in-the-united-states/

accessibility and convenience were key for selecting drop-off locations.[22] Drop-offs are oftentimes a transition program that occurs prior to curbside food waste collection.

Collected material will also require processing and recycling at an appropriate facility that can manage the collected materials. The City would need to determine what local options are available or consider expanding its composting facility at the LRSC to process the food and yard waste collected.

4.3 Benefits/Impacts

Curbside food waste collection has the potential to significantly increase waste diversion in Tucson and reduce waste sent to landfill, further extending the life of Los Reales Landfill. Food waste recycling would also decrease the amount of organic material decomposing in the landfill and decrease GHG emissions that result from this breakdown process. Given these benefits, food waste recycling programs have become more popular around the country and with that comes best practices from programs implemented by other communities.

The impacts of such a program depend on how the food waste collection program is executed. Providing residents or commercial customers with an additional cart for collection would increase trucks on the local roads, increasing emissions, fuel costs, staff requirements, and wear and tear on roadways. Although this is simple for participants and an efficient way to collect materials, it does come with challenges that should be considered.

Quality of materials collected and the potential for high rates of contamination are the primary concerns with food waste collections. Over half of the programs surveyed by BioCycle indicated contamination rates less than 5 percent, but that same amount also enforced zero tolerance policies regarding contaminated materials being collected.[23] Tucson has a 29 percent contamination rate in curbside recycling collection as of 2021. Adding a new collection program curbside will be challenging and ensuring collected food waste materials are free of contamination will be key to long-term success of the program. Communicating to residents about what items can and cannot be included with food waste collection is often more challenging than recycling education because such programs are less familiar to participants. High levels of contamination in curbside food waste collection would be

Case Study: City of Minneapolis – Curbside Organics[1]

The City of Minneapolis launched its drop-off organics recycling program in 2014 to collect food scraps and other items, including certified compostable items. In 2015, it rolled out its curbside organics program, which was fully implemented by the end of 2016. Minneapolis' participation rate for the voluntary opt-in, no cost to residents program was at 32 percent in 2015, 44 percent by 2017, and is currently just under 50 percent. The estimated cost per household is between $105 and $125 each for cart purchase, collections, and processing. The 2022 monthly service fee charged by the City of Minneapolis ranges from $28.46 to $31.46 per unit, depending on solid waste cart size, and includes solid waste, recycling, and organics recycling. The City works hard to promote the program, target areas with low participation rates, and educate residents about unacceptable items. The contamination rate is 1 percent.

[1] *Carted Organics Collection Costs,* Foth Infrastructure & Environment, LLC, 2019

[22] "Residential Food Scraps Collection Access in the U.S. – The Programs, BioCycle, 2021, https://www.biocycle.net/residential-food-scraps-collection-access-in-the-u-s-the-programs/

[23] Ibid.

problematic for a compost facility or other end market that is processing and recycling the materials. Food waste recycling drop-off programs typically have less contamination because of the higher barrier to entry and additional effort on the part of the participant. Only 19 percent of survey respondents indicated contamination was a concern for drop-off only programs.[24] Individuals who choose to separate food waste items in their home and then bring that material to a drop-off site are much more likely to do so correctly because of the level of effort required.

Allowing both residential and commercial customers to participate in a curbside food waste recycling program would make this program accessible for all household types in the city. Such a program could include collection of food waste generated from commercial customers such as restaurants, hotels, and schools. A larger program of this nature does come with additional challenges including coordination with private waste haulers and increased quantity of materials to haul and process. City ordinances should be reviewed to consider implementing requirements for private waste haulers to offer subscription collections of yard waste and food waste.

4.4 Implementation Timeframe

Implementing and launching a food waste collection program can take a significant amount of time. Effort levels can vary depending on the type of program selected and available end markets for processing the collected materials. Confirming there is available processing capacity for the collected food waste (and possible co-collected yard waste) will be a critical first step in planning. A successful program will need political desire to implement such a program, which has been a well-documented barrier in other communities. Broad program support from City leadership and key stakeholders will be needed. Education about the benefits of food waste and yard waste recycling has proven to be successful in saving landfill space and avoiding disposal costs.[25]

Creating and launching a curbside food waste or comingled food and yard waste recycling program will take between 1.5 to 2 years for program planning, community engagement, and initial phase launching. The program model could be subscription opt-in participation or mandatory service regardless of participation. Subscription-based participation programs can reasonably be used by 20 percent of the households and reach up to 50 percent with an active public education campaign. Fees charged for the subscription service will also affect participation. Implementation of curbside organics collection with basic services provided to all City customers would increase participation. Similar curbside organics programs have taken up to 2 years to fully implement. Although long-term waste diversion could be significant, those diversion metrics may not be fully realized in either program until many months or years into implementation.

A robust drop-off food and/or yard waste recycling program would be simpler and quicker to implement if there is a processor for the collected material. Collection carts or dumpsters could easily be added at the glass drop-off locations or other City-owned facilities. Using sites with existing infrastructure to accommodate adding another material

[24] "Residential Food Scraps Collection Access in the U.S. – The Programs, BioCycle, 2021, https://www.biocycle.net/residential-food-scraps-collection-access-in-the-u-s-the-programs/

[25] "Accelerating Implementation of Food Scraps Programs," BioCycle, 2011, https://www.biocycle.net/accelerating-implementation-of-food-scraps-programs/

for collection would provide a simple and cost-effective option. Such programs can be beneficial for gauging the interest of residents to evaluate how successful a curbside program may be.

The glass drop-off locations are distributed throughout the City and are well-utilized by residents. Adding food and/or yard waste recycling drop-off collection at these facilities could be a near-term solution to gauge the interest of residents before implementing a curbside collection program. It would allow the City to evaluate participation, tonnage of materials collected, and address any contamination concerns as well. Additionally, this could be done concurrently as the City plans for and launches a curbside program.

4.5 Cost Considerations

The overall costs will vary greatly depending on the type of program, method of collection, and available processing facilities for collected materials. The cost considerations for a drop-off program at existing locations such as the glass drop-off locations would be significantly less than a curbside collection program, although oversight would be needed to maintain quality. The additional costs associated with collection dumpsters, marketing and educating, and waste hauling would need to be considered. This overall cost could be reasonably low compared to curbside collection programs. Promotional and educational materials could be paired with existing materials generated for the glass recycling programs or other City public education programs.

Implementing a curbside program for food waste collection would have significantly higher costs. Cost considerations include purchasing collection carts, additional waste hauling and associated costs, tip fees for food waste/yard waste materials, and public education and outreach efforts. Some costs will be offset by the reduced amount of waste going to the landfill and associated saved capacity at the landfill. Similar to changes in recycling collection discussed further in Section 6, additional collection routes add increased trucks, labor, workers' compensation, and fuel costs.

The City would need to invest in the necessary machinery and space for processing higher quantities of food and yard waste at the LRSC or procure outside services to manage and process the collected materials. Permitting requirements for a facility or collection sites will need to be further investigated as well. If additional transportation and trucking is required to move the collected materials to a different facility, those impacts should also be considered.

Full-scale residential curbside organics program with weekly collection of commingled food waste and yard waste will have initial capital costs and ongoing operating costs. Capital costs for carts to residents will be more than $10 million, assuming carts are provided to all single-family residences and to about half of multifamily residences (this assumes cart sharing). Operational costs are estimated to range from $200,000 to $250,000 per year for a dedicated daily route with 50 percent participation, including automated collection truck amortization, driver, fuel, and maintenance. Costs for public education campaign and processing facility tip fees will also occur.

4.6 Next Steps

Implementing a curbside food waste and yard waste recycling program will require advance planning. Establishing sufficient end markets for collected materials will be critical before implementing a collection program. There would be benefit in determining the interest level of residents and commercial customers to better understand what participation in a food/yard waste recycling program in Tucson may be. This could be done by way of public survey, implementation of a drop-off program, and/or implementing a pilot food waste collection to provide guidance on how to implement a more robust curbside program in the future. Some of the first steps need to be collection of additional data to help define the program. Initial steps include:

- Review codes and ordinances on food and yard waste collections from residential, commercial, and institutional sources. Ordinances requiring haulers to provide subscription services to collect food waste and/or yard waste from certain commercial entities could be explored for Tucson.
- Conduct public engagement through a public survey and meet with stakeholders including residents, haulers, cash customers, and self-haulers to gauge interest in curbside food waste collection.

5 Reuse Store

5.1 New Program

The LRSC provides waste disposal services to residents and businesses in Tucson and Pima County. Approximately 2,300 tons of material are disposed of daily at Los Reales Landfill. Long-term plans for the LRSC aim to implement waste diversion activities on site, creating a campus working toward zero waste. Establishing a reuse store at the landfill would create an on-site option for waste diversion of targeted materials and directly include local businesses, organizations, and residents. The store could recover waste items disposed of at the landfill, collect items from direct drop-off for reuse, or use businesses to implement reuse options for waste items.

The reuse store could be staffed by local nonprofits such as the Salvation Army, Habitat for Humanity, veterans' organizations, or others, perhaps done through a rotating schedule. Such a partnership has the potential to be mutually beneficial for the City and partner organizations. Partner organizations can use this type of facility to provide job skills, education, and paid employment to struggling veterans, at-risk young adults, and others needing assistance and training. Examples include the Sacramento Regional Conservation Corps Re-Use Store and Last Chance Mercantile in Monterey, California. The Sacramento Re-Use Store sells donated deconstruction and used building materials, while staffing the store with at-risk young adults. Last Chance Mercantile, which historically was operated by the Monterey Regional Waste Management District from 1991 to 2020, recently transferred operations to the Veterans Transition Center nonprofit assisting veterans. The 8,000-square-foot warehouse retail store diverts approximately 700 tons per year from the landfill and is now staffed by 12 paid FTE employees along with active-duty military and veteran volunteers.[26]

The City could also consider including a maker space for local artists and makers, allowing them to use the space for a fee or create a membership program. A membership program could include storage space for reclaimed items, access to tools or other materials, and possibly a retail location for the sale of made items. There is an opportunity for collaboration by sharing the space with the household hazardous waste (HHW) facility and incorporating new reuse or swap opportunities of HHW at the LRSC. HHW swap shops like the one in Mesa, Arizona, can divert up to 60 percent of materials received, especially paint.

Additionally, the City could consider the prospect of engaging with the Tucson Repair Café. This group of volunteers organizes a space for residents to get free assistance to fix their broken items, with the intent of reducing waste, decreasing consumption, and teaching community members valuable skills in reuse. This could be a great opportunity for collaboration at the LRSC with an existing and established organization with similar goals of promoting reuse and reducing waste.

5.2 Benefits/Impacts

The potential impacts of creating a reuse center could be wide ranging but are challenging to quantify. Waste diversion potential will depend on the types of materials collected and reused, driving the amount of waste diverted from the landfill.[27] These metrics will depend on the operation of the reuse center and how materials are reused, repurposed, or sold. A reuse store co-located at the LRSC would allow more opportunity to recover items from the landfill and encourage customers to reuse or donate items instead of throwing them away. The City can also target diversion of hard-to-handle materials like mattresses that can cause problems in the landfill. In Omaha, Nebraska, the Partnership 4 Hope organization operates a Youth Mart providing furniture, small kitchen appliances, home goods, baby items, cleaning supplies, and clothes free of charge to young adults aging out of the foster care system. The Youth Mart also accepts mattresses in usable condition. They sanitize the mattresses, box springs, couches, and pillows in a special chamber using high heat. The sanitization chamber cost $5,000 to $6,000 to construct and install in 2018, but has proven to be highly successful and now the Youth Mart is constantly requesting donations of additional mattresses.

A community-focused reuse store has the potential to benefit local residents, engage them in waste reduction, and provide economic benefit to those using the reuse space and store. Although these benefits may be harder to quantify, they should not be undervalued. Engaging residents and businesses in reuse has the potential to make personal and lasting changes in behavior. A reuse store and, specifically, a drop-off facility would provide residents the opportunity to more closely examine their waste and consider reuse options for items they normally throw away. Becker County, Minnesota, opened a reuse store in 2020 that worked specifically to recover items going to the landfill and to divert materials for reuse and resale by the County. Thanks to a

[26] "Last Chance Mercantile," 2022, https://www.lastchancemercantile.org/

[27] *Montgomery County, Evaluation of Options,* HDR, 2019

partnership with a local nonprofit, items collected are considered donations and residents are not charged for drop-off. Staff works to fairly price the reusable items and profits are used to offset the cost of the program. The reuse facility averages approximately 95 customers per month and 2.3 tons of waste are diverted from the landfill each month. The facility also has a free product exchange program in coordination with the HHW recycling program.

The reuse store can also complement the City's bulky waste collection events and any neighborhood cleanup events to divert even more materials from the landfill. For example, the director of the Omaha Youth Mart worked with a neighborhood association in 2021 to attend a cleanup event. They collected furniture, mattresses, and other items in good condition, and the items were separated for reuse.

Depending on the structure and operation of the reuse store, there is added potential for job skills training and expanded community partnerships with other local businesses. These benefits could be realized in the longer term as the store becomes more established, expands operations, and thus further positively impacts the community.

Significant impacts for this development option are the capital costs associated with construction of a new building along with long-term operating and maintenance costs for the building. Although using volunteer or nonprofit organizations would be preferred, the City should consider the potential need for some City staffing at the reuse store.

5.3 Implementation Timeframe

Establishing a physical space suitable for the reuse store will provide the longest time constraint in launching a program of this nature. Development and construction of a facility for this specific purpose could take approximately 2 to 3 years. Permitting, construction, inspections, and operations of the building will take time to finalize before waste diversion and reuse activities can begin. The LRSC may offer a suitable location for such a facility, in which case a more expedited timeframe may be feasible and reduce difficulties if the City is overseeing the project.

The City will need to determine how materials are separated or sorted for a reuse store as well. This could be completed by machinery like a skid loader for picking, or by partnering with community organizations to sort select loads and encourage direct donation. Another model could encourage community members to sort acceptable materials for drop-off. Other reuse stores, such as the Habitat for Humanity Tucson HabiStore, use customer drop-off to separate materials for reuse. This is a simple and safe mechanism to collect materials and ideally keeps desired materials clean, in sellable condition, and well-suited for reuse. This model of operations would require staffing and space for drop-off, sorting, and eventual resale. There is the potential to track waste diversion by quantifying or weighing materials that are dropped off.

Stakeholder engagement should be completed early in program implementation, specifically for any community organizations or nonprofits that the City may consider for managing the facility. Finding one or more partner organizations is critical for success unless the City plans to staff the facility independently. Defining a business model that results in a mutually beneficial partnership between the City and organizations will ensure long-term success and commitment from any external partners. The City could consider partnering with multiple organizations in the community as well, which would necessitate clearly defined roles and responsibilities for all involved. If the City chooses to partner with multiple organizations, it should consider the additional staff time necessary for coordination.

5.4 Cost Considerations

This program presents a significant upfront cost for the construction of a building for a reuse store, including space for sorting and storage. Such a building will need to be a warehouse retail type store, capable of receiving direct donations and salvaged items, with space for temporary storage, preparing items, and displaying the goods for sale. The City should also consider space for holding repair workshops and providing equipment where customers and volunteers can repair furniture, appliances, and more. A 10,000-square-foot facility is estimated to cost $3 million to $5 million. The City should plan for ongoing maintenance and operational costs for the building, similar to other City-owned facilities. Additional staff time would be required to manage and operate the reuse store during days and hours of operations unless labor and maintenance could be included as part of an agreement with partner community organizations and volunteers managing the store. During its last year of operating the Last Chance Mercantile in 2020, the Monterey Regional Waste Management District spent approximately $1.5 million to operate and staff the facility; revenues during the same period were approximately $800,000.[28] The current veterans organization responsible for operations relies on more volunteers and money donations from other sources to help cover paid employee salaries.

Depending on how materials for reuse are sorted, the City may need to consider the costs of machinery or equipment to help sort recoverable materials received at the landfill, along with safety measures to facilitate removal from the landfill or roll-offs. Equipment could include skid loaders and grapple attachments. Until the reuse store program is well-established, most of the initial goods for sale are anticipated to be salvaged daily from waste delivered to the landfill.

If local artists or makers are encouraged to work at the store to attract customers and donations, there may be some added costs for supplies, payment for their time, or other materials necessary to ensure the success of such partnerships.

The reuse store can provide a location to host fix-it events. These events help residents repair items they normally would have thrown away. Portland, Oregon, has held Fix-It Fair events around the City three times a year, attracting approximately 1,725 participants annually. Each event costs about $15,000, excluding staff time.[29]

5.5 Next Steps

Owning and operating a reuse store would require long-term commitment and oversight by the City. This should be thoroughly considered and evaluated to ensure there is

[28] "Waste Management District Considers New Management at Last Chance Mercantile in Marina," *Monterey County Now*, 2021, https://www.montereycountyweekly.com/news/local_news/waste-management-district-considers-new-management-at-last-chance-mercantile-in-marina/article_1a024f34-8cd7-11eb-ae5e-8f73c9eabb6e.html

[29] "Fix-It Fairs," Portland.gov, 2022, https://www.portland.gov/bps/fix-it-fairs

support and the necessary infrastructure for such a program. There are also legal concerns to consider, and the City should ensure there is no liability regarding items recovered from the landfill that are reused or given to individuals for further personal use. The City's legal department and legal counsel for other parties to be involved with reuse store development should review any agreements or operational plans for potential liability concerns and address them early in the process. Agreements with other organizations working or volunteering at the site may be necessary. Establishing relationships with local nonprofits or organizations to manage the facility should be addressed early in planning as well to gather community support and long-term partnerships to manage a successful reuse store.

Additionally, early activities to help plan and develop a reuse store should include:

- Review codes and ordinances for limitations or issues that could affect the City's ability to develop and operate a reuse store or to partner with nonprofits and organizations.
- Complete a visual observation study, where appropriate, to determine percentages of potentially reusable materials including construction and demolition materials, furniture, appliances, durable goods, electronics, mattresses, etc.
- Conduct public engagement with stakeholders including haulers, cash customers, self-haul, organizations, and nonprofits to obtain input and gauge interest in a reuse store concept at the landfill.

6 Recycling Program Changes

6.1 Existing Program

The City currently offers single-stream recycling to all households for curbside pickup. The current collection serves approximately 142,000 households (74,000 single-family and 68,000 multifamily). Residents receive trash collection once per week and recycling services once every other week. The City has had single-stream collection since curbside recycling was first implemented. The City initially used 18-gallon recycling bins, and increased to larger, standard carts in 2002. Additionally, the City provides recycling collection services for 650 commercial customers. The City contracts with the Republic Services MRF, known as ReCommunity Recycling Tucson, for processing of the recyclables. The City is currently in negotiations for the last 5 years of the original 15-year contract with Republic Services. This MRF accepts old corrugated cardboard (OCC), old newsprint (ONP), other paper, aluminum, tin, other metals, polyethylene terephthalate bottles, high-density polyethylene (HDPE) natural bottles, HDPE pigmented bottles, #5 plastics, and rigid plastics. Glass is accepted at the MRF but not accepted in the City's curbside collection program. The MRF charges the City an excess contamination charge (residue charge) of $1 per ton for each percentage point above 18.7 percent contamination. In fiscal year 2021, Republic Services determined the contamination rate to be approximately 29 percent and the City paid an additional $314,085 contamination fee. Contamination of curbside recycling is a significant and costly issue for the City and a common challenge throughout the United States. The *Current Conditions Assessment* report stated that approximately 10 to 20 percent of waste disposed of at the landfill is recyclable materials that could be diverted to the MRF. These recyclables currently going in the trash offer opportunities for significantly more waste diversion through increased recycling practices.

Until the summer of 2022, the City operated seven neighborhood recycling centers to provide residents additional opportunities for recycling. Recently, two neighborhood recycling centers have closed permanently, leaving five remaining centers. Materials accepted at these facilities include OCC, ONP, aluminum, tin, other metals, PET bottles, HDPE natural bottles, HDPE pigmented bottles, #5 plastics, and rigid plastics. Figure 6-1 shows the locations of the Tucson neighborhood recycling centers.

Figure 6-1. Neighborhood recycling centers

Because the City's recycling program does not accept glass, the City also operates 22 glass recycling drop-off locations. Glass was intended to be taken to the LRSC to be crushed and then be suitable for use. In 2021, approximately 1,700 tons of glass were collected at the drop-off sites. EGSD has not begun crushing glass because of staffing shortages but has a temporary agreement with Strategic Materials, which will use most of the material and return 10 percent back to the City in the form of unsorted crushed glass to meet the City's glass reuse program requirements. Figure 6-2 shows the locations of the glass recycling drop-off locations.

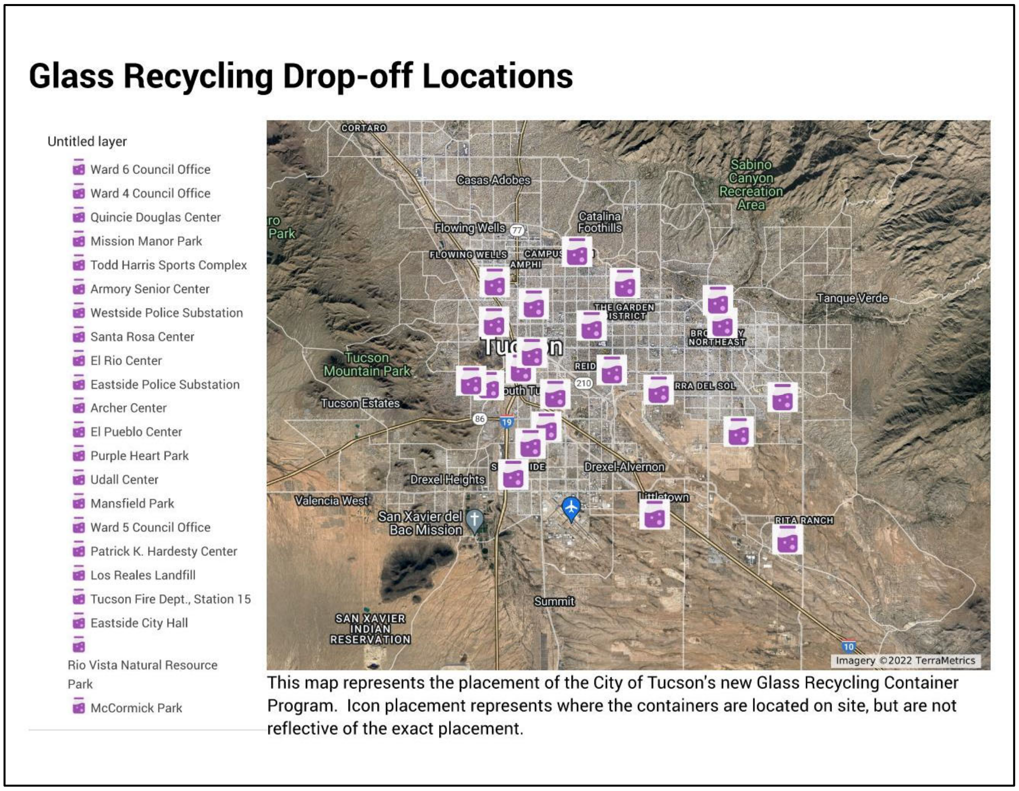

Figure 6-2. Glass recycling drop-off locations

6.2 Alternative Program: Multi-Stream Recycling

Residential curbside recycling collection has evolved over time to collect more materials, increase efficiency, and recycle additional items. In the late 1990s, single-stream recycling became common in most of the country, replacing multi-stream recycling, which was commonly seen in the form of dual-stream recycling (typically separating containers from fiber products). This system was meant to be convenient for residents to participate in and to allow more capacity for materials collected at the curb. Single-stream resulted in more efficient collections because only one truck, more similar to a trash truck, was necessary for pickups. This type of collection resulted in the need for MRFs to sort the single-stream materials.[30] Single-stream recycling has proven to result in more materials collected; however, contamination has increased and resulted in additional processing or separation steps and collected commodities being worth less than multi-stream collected material. Conversely, multi-stream recycling does produce cleaner commodities that can be more valuable to end markets because they do not require cleaning incoming streams. Many processors and end markets prefer materials that are source-separated, such as through multi-stream recycling collection programs. They can pay higher revenues for cleaner products that require less processing for the end market users.[31]

[30] "Single Stream Recycling," Container Recycling Institute, 2022, https://www.container-recycling.org/index.php/issues/single-stream-recycling

[31] *Wyoming Solid Waste Diversion Study,* LBA Associates, 2013

Daniel Lantz of Metro Waste Paper Recovery, based in Ontario, Canada, analyzed recovery rates and residential collection in existing systems. The study evaluated existing single- and multi-stream systems and did not account for changing collection methods. The study found that lower collection costs result in a proportionate rise in processing costs. Mr. Lantz concluded that the benefits of single-stream do not outweigh its costs compared to dual-stream because of collections savings not fully offsetting the processing costs and lost revenues.[32]

Although the materials collected via multi-stream separation may have a higher value, the City would need to ensure there is a mechanism to transport the separated materials to the appropriate locations and end markets. The City's current agreement with Republic Services MRF is for processing of single-stream material. Republic's facility is not intended for multi-stream recycling and may not have the tip floor or storage capacity to accommodate such materials. The MRF, with some modifications, may be able to handle multi-stream recycling. It may require new infrastructure from Republic Services or a different MRF to accommodate materials that are collected by multi-stream collection.

Implementing a multi-stream program would require additional trucks for collections with associated emissions and wear and tear on local roads. There would be increased labor, potentially increased workers' compensation costs, and fuel costs. Multi-stream collection can require an additional collection cart for residents as well if the existing cart is not used for both containers and fibers collection on a rotating schedule.

Modifying the existing single-stream recycling program would require significant behavior change for residents and educational outreach by the City. Single-stream recycling has been successful in part due to the convenience to participants. Single-stream recycling has also been proven to capture more recyclable materials and, as a result, has been widely implemented across the country. In urban and suburban areas, where collection routes can be done efficiently, single-stream recycling is commonplace. Historically there has been an increase in participation by residents when recycling is easy and convenient. Residents can easily recycle more items using their single, larger cart and simplified system.

6.2.1 Benefits/Impacts: Multi-Stream Recycling

Clean and separated recyclable materials are the significant benefit of multi-stream recycling options. Multi-stream collection produces materials that are of higher value and typically less contaminated than single-stream recycling. There is potential for savings in processing costs and costs associated with contamination, especially when accounting for the current contamination fees paid to Republic Services at the MRF. Research has found the overall net cost of dual-stream is less than single-stream when accounting for collection costs, processing, and disposal of contaminated materials.[33] Conversely there are drawbacks to multi-stream recycling, including lower capture rates.

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[32] "Understanding Economic and Environmental Impacts of Single Stream Collection Systems," Container Recycling Institute, December 2009, https://www.container-recycling.org/assets/pdfs/reports/2009-SingleStream.pdf

[33] "Single Stream Recycling," Container Recycling Institute, 2022, https://www.container-recycling.org/index.php/issues/single-stream-recycling

Although the direct net costs for recycling may be lower with multi-stream collection in some scenarios, it is important to accurately account for the economic costs of added labor, trucks, and equipment, along with the social and environmental impacts of associated emissions for additional collection trucks. Multi-stream recycling also typically captures lower volumes of recyclables, indicating that less recyclables are collected and more materials are, therefore, going to the landfill. The lower capture rate of recyclables has been attributed to the added challenge and higher level of effort required by residents to separate their recyclables.

The current Republic Services MRF is set up to sort and separate single-stream recycling and is not designed to accommodate multi-stream recycling. Other waste haulers in the greater Tucson area provide single-stream recycling collection services and also use the Republic Services MRF, which has significant infrastructure with highly sophisticated technology to sort the specified materials that are currently collected as single-stream. Modifying the MRF to process recyclables differently would likely require additional tipping floor space for the separated materials, a new infeed conveyor system, transfer conveyors, and possibly a new process equipment line. Space in MRFs is expensive to change and an existing facility like the Republic Services MRF may not have the space or capabilities to accommodate and fully utilize the benefit of multi-stream collected materials. The City would need to thoroughly vet this option with Republic Services or consider finding other outlets for collected recyclables. An evaluation of associated MRF processing costs should be included in overall considerations.

6.2.2 Implementation Timeframe: Multi-Stream Recycling

Changing a well-established curbside single-stream recycling program to a multi-stream recycling program would require significant time and effort. Residents would need to be educated on the change, the City would need to purchase additional or different collection trucks, carts, and/or other containers and additional drivers would need to be hired and trained. Behavior change of this scale would not be easily achieved and would require numerous educational outreach touch points. A program change of this nature should be done over 1 to 1.5 years and possibly be phased into the existing program by routes.

Implementing a program such as multi-stream recycling would require significant staff time to educate residents and ensure the program is implemented correctly. This is especially critical because this type of program change would require residents to increase their level of effort regarding curbside recycling. Not only would multi-stream recycling require proper separation, but it may also require an additional collection cart or dumpster and more trucks. The volume of recyclable materials collected may stay the same or could decrease because of a program change of this nature.

Confirming the necessary MRF space or alternative end markets for multi-stream recycling will also require time, effort, and due diligence to ensure the program change is successful and recoups the investment. Infrastructure changes, if necessary, would take significant time and capital investment as well and would require cooperation from Republic Services or another MRF, which would either need to be newly developed or could require further hauling distances. Implementing major modifications to an existing MRF can take 1 to 1.5 years; recent supply chain delays have pushed equipment deliveries out, further delaying these construction schedules. If building expansion is required, MRF upgrades could require 2 to 3 years to complete.

6.2.3 Cost Considerations: Multi-Stream Recycling

A significant cost consideration to the City for a curbside recycling program change will be additional trucks and equipment, labor, workers' compensation costs, and fuel costs necessary for additional collections. This cost is estimated to be 1.5 to 2 times the current cost to the City for the curbside recycling collection, assuming this program has two collection carts—one for containers and one for papers and fiber—picked up on the same every-other-week schedule. Collections may not be entirely duplicated since each truck would collect less recyclables per household (that is, commingled containers in one cart or mixed papers in a different cart) and should be able to extend daily routes before unloading at the MRF. Alternatively, households could use the same cart for collecting papers/fibers one week and containers the next. This has the potential for greater contamination because residents may confuse which materials are being collected during each week. Adding further source-separating of recyclables into more than two streams would increase cost impacts.

The City must determine where the multi-stream material would be sent for processing, whether the Republic Services MRF or a different facility, and the associated tipping fees. Changes at the Republic Services MRF if the multi-stream recycling could be accommodated would likely result in a cost increase per ton for processing of the materials related to recovering costs from necessary facility improvements, although this may be offset by decreased contamination fees and possible increased recyclables revenues sharing. If another facility can accept the multi-stream material, associated tip fees would need to be determined.

Research conducted in Ontario, Canada, found that single-stream recycling in dense, urban areas is more appropriate and lowers the processing costs per ton for curbside recycling based on programs from 223 municipalities. Efficient collection via dense routes brings more material to MRFs for processing and recovery of recyclables. As more recycling tons go to a facility, the processing costs lower overall.[34] The City's current challenge is increasing recyclables collected while decreasing contamination.

MRF modifications to accommodate recycling program changes can vary depending on the space available and configuration. Based on some MRFs' construction and modification over the past few years, costs can be $5 million or more for process line modifications and up to $30 million for significant building expansion and addition of a high-tech system capable of processing 55 tons per hour.

Additionally, the City will need to consider any fee changes to customers for curbside recycling. The City's current fee structure does not charge residential or commercial customers directly for curbside recycling. With the added program costs for implementing multi-stream recycling, the existing fee structures would need to be modified.

[34] "A Comparison of Single and Multi-Stream Recycling Systems," Lakha, Clavin, *Resources*, March 2015

6.3 Alternative Program: Recycling Education

Implementing a robust recycling education program could provide cost savings and waste reduction benefits to the City. Approximately 30 percent of the material received by the MRF each year is contaminated; contamination is not recycled and is instead sent to the Butterfield Station Landfill. The excess contamination charge cost the City $314,085 in 2021 and has cost the City approximately $1.2 million since 2018, which equates to an annual cost of over $2 per household or commercial account.

In 2021, with financial and technical support from The Recycling Partnership, the City implemented the “Feet on the Street” program to provide direct feedback to curbside recyclers on recycling behaviors. The purpose of the program was to improve the quality of curbside recyclables and decrease contamination at the MRF.[35] The City dispatched teams of monitors on recycling collection days to inspect the recyclables set out on the curb and identify whether residents were placing contaminants or nonrecyclable materials in their carts. Recycling carts that contained contamination received an informational tag that identified the observed materials and asked residents to keep them out of their recycling carts in the future. The study targeted approximately 24,000 households across the city, or about 17 percent of all households receiving curbside recycling service. The program was successful. The percentage of recycling carts observed to contain contaminants fell from 44 percent at the beginning of the program to 18 percent at its conclusion. Additionally, the percentage of contamination within the curbside recyclables sampled from the study areas fell from 24.5 to 19.1 percent by weight. An increase in the market value of the City’s recyclables was also observed during implementation of the Feet on the Street program.

The City of Phoenix has implemented a similar cart inspection program called “Oops/Shine-On,” which is staffed by teams of volunteers who examine recycling carts to reduce contaminants in the recycling stream. If carts have contamination, they leave a tag to educate residents on the materials in their carts. This is similar to Feet on the Street but is an ongoing program and is staffed by volunteers rather than paid consultants.

Roanoke, Virginia, is piloting a “Recycle Right” program modeled after the Recycling Partnership’s “Feet on the Street Program,” which will combine recycling education and recycling inspection at the curb. Roanoke Solid Waste Division staff will check the recycling carts in the pilot area over 3 months and tag contaminated carts with an “Oops Tag.” The Recycling Partnership has noted cart tagging and rejection, combined with education, have been twice as effective as education alone in reducing contamination.[36]

These results indicate that targeted outreach and educational programs may be effective in reducing contamination rates in collected recyclables delivered to the MRF. Implementing a long-term program modeled after Feet on the Street or Oops/Shine-On could potentially decrease recycling contamination.

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[35] *City of Tucson “Feet on the Street” Recycling Cart Monitoring and Recyclables Composition Study,* MSW Consultants, 2022.

[36] “Roanoke, VA Launches ‘Recycle Right’ Pilot Program,” Frolo, Caitly, from *WasteAdvantage Magazine*, 2022, https://wasteadvantagemag.com/roanoke-va-launches-recycle-right-pilot-program-aims-to-stop-recycling-contamination/

6.3.1 Benefits/Impacts: Recycling Education

The significant impact of increased recycling education with cart tagging is the reduced contamination of recyclables at the MRF and reduced costs to the City. In 2021, the MRF received 29,620 tons of material, while 764,000 tons was disposed in the Los Reales Landfill. Of the material received by the MRF, 29.3 percent, or 8,670 tons, was contamination that was sorted out and shipped to the Butterfield Station Landfill. The Feet on the Street program reduced recycling contamination by 5.4 percent. If that drop in recycling was consistent across all households, a citywide recycling education program could potentially reduce contamination to approximately 23.9 percent in the first year. From there, with continued robust recycling education, HDR estimates that the contamination rates could drop at a rate of approximately 0.5 percent per year. If the program was initiated in 2025, by 2040, the City may be able to drop its recycling contamination below the excess contamination charge of 18.7 percent.

Education regarding recycling also has the potential to increase curbside recycling rates and increase waste diversion. Based on waste characterization studies prepared on behalf of the Cities of Tucson and Phoenix, 10 to 20 percent of waste disposed in the trash could potentially be recycled. If 10 percent of waste disposed in the Los Reales Landfill was diverted to recycling, 76,400 tons of recyclable materials would have been diverted in 2021, compared to the 29,620 tons that were actually processed by the MRF. These amounts depend on the effectiveness of the recycling education campaigns.

6.3.2 Implementation Timeframe: Recycling Education

The Recycling Partnership provides guidance and best practices for recycling education and outreach. Their research indicates that building consistently good recycling behavior requires education at least seven times per year. Consistent and ongoing education could produce favorable outcomes and increased recycling with proper recycling habits. Implementation could happen relatively quickly if funding was available. Staff and/or volunteers may be necessary depending on the specifics of an education and outreach plan.

6.3.3 Cost Considerations: Recycling Education

The Recycling Partnership, which researches and invests in recycling infrastructure and education, estimates that an investment of $3 to $5 per household per year can substantially reduce contamination. Furthermore, they anticipate that $10 per household per year would fully enhance recycling in the United States and push the national recycling rate 20 percent higher than would be accomplished with infrastructure investments alone. These figures are also based on the principle that people need to be educated at least seven times per year to build consistently good recycling behavior.[37]

The costs for recycling education would be based on the number of households served by the City and the level of investment chosen per household. If the recycling education investment per household for the first 5 years of the educational program were $5 per household, the program would initially cost approximately $725,000 annually. This amount of funding could reduce contamination and increase proper recycling habits.

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[37] *The Cost of Transformation*, Scott Mouw and Cody Marshall, Resource Recycling, July 2021

After the first 5 years, efforts could be reduced to approximately $3 per household. These costs could be offset by the reduction and eventual elimination of the approximately $315,000 annual cost for contamination fees at the MRF, as well as additional revenue (through the current revenue sharing agreement with Republic Services) from the increased market value of recyclables.

6.4 Next Steps

The City should evaluate its priorities for the curbside recycling program and what type of collection is best suited for the community as it strives for zero waste. Multi-stream recycling has a low diversion impact as compared to other options evaluated and a medium community or environmental impact. If the City values clean recycling streams, multi-stream recycling may be beneficial and provide cleaner materials for processing and potential revenue sharing. However, if the City values tonnage of recyclable materials diverted from the landfill, single-stream recycling has proven to be the better option as long as contamination levels are managed. End market facilities should also be thoroughly considered to ensure that any programmatic changes can be accommodated by MRFs, local end markets, or other processing facilities. Discussing these options with Republic Services may be a necessary first step.

Other potential opportunities may exist outside of the traditional curbside collection program. Similar to the glass recycling program, drop-off locations could provide opportunities for the collection of other specific materials with identified end markets outside of the MRF. One example of this is the current pilot program at the City's Ward 6 office, which is currently collecting specific types of non-recyclable plastic waste for conversion into repurposed building material.[38] The impacts of programs like this would need to be evaluated on a case-by-case basis, along with any opportunities for partnerships. Contamination and other challenges that have been faced by the neighborhood recycling centers would likely also need to be considered.

A strategy that could reduce contamination and increase the amount of recyclables collected through any type of curbside or drop-off recycling program is implementing a strong recycling education program. Investing in recycling education efforts has the potential to have low waste diversion impacts and medium community and environmental impacts. The cost impacts are low to medium as compared to other options and implementation could be completed in a short timeframe. Prior to implementing any changes in the curbside recycling program, the City should:

- Use data and insight from Republic Services, the Feet on the Street program, and any other available sources to further identify components of contamination in curbside recycling.
- Review City codes and ordinances for potential conflicts with desired program changes.
- Consider the level of initial and ongoing education and outreach to customers that would be required to ensure a thorough understanding of curbside recycling collection changes.

[38] "Time to Stop Talking: Take the Tucson Pledge to End Plastic Waste," ByFusion, 2022, https://www.byfusion.com/pilot-program

7 Pay-As-You-Throw

7.1 Existing Program

The City's current fee structure for trash service has minor price differences between the service levels offered: 48-, 65- and 96-gallon trash carts. Customers are not charged directly for recycling service but rather those fees are included in overall service rates. There are fees for additional trash carts but there is no fee for an additional recycling cart. This policy was encouraged because of concern from customers when recycling service changed from weekly to every other week. The fees to City customers were last adjusted in 2010. The City has completed a rate study to update its fee structure to maintain the current level of service; the fee adjustment is being considered by the Mayor and City Council.

PAYT programs incentivize customers to generate less trash and recycle more to reduce their waste disposal fees. The program is also called unit pricing or variable-rate pricing. PAYT is structured similarly to other utility fees where customers are charged based on the amount of service they use.[39] These programs are considered more equitable and fairer, allowing residents to make personal changes to reduce their monthly waste bills.

The City has the "Right Size Your Can" program to encourage households to reduce their cart size and save money on their monthly bills based on the current fee structure. The current price structure for the City's residential curbside collection offers a very small price savings for households opting for a smaller trash cart. Of the three size options available, there is only a $1 to $1.75 difference in total monthly fees, detailed below (Table 7-1 and Figure 7-1).

Table 7-1. City of Tucson residential rates

Trash cart size	Monthly fee
48-gallon	$15/month
65-gallon	$16/month
96-gallon	$16.75/month

[39] "Pay-As-You-Throw Programs," EPA, 2016, https://archive.epa.gov/wastes/conserve/tools/payt/web/html/index.html#:~:text=Pay%2DAs%2DYou%2Dthrow%20(PAYT)%20breaks%20with,can%20of%20waste%20they%20generate.

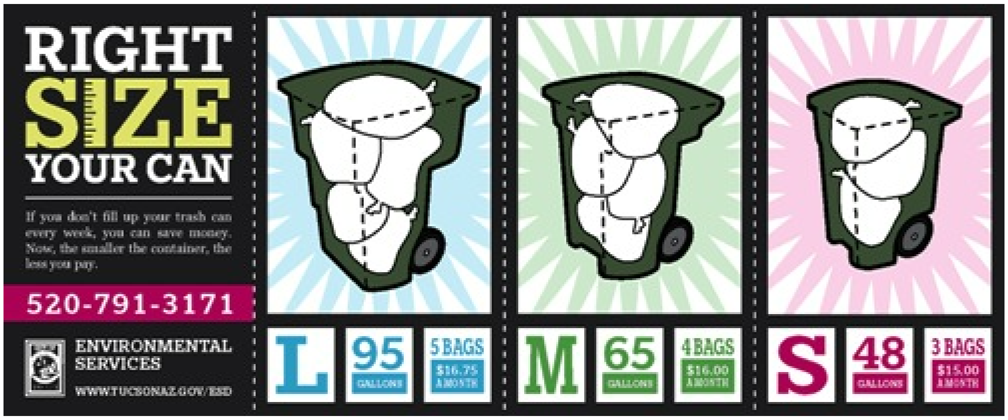

Figure 7-1. Right Size Your Can[40]

Although this rate structure does have higher costs for larger carts, the savings is not significant between the three sizes and likely not enough of an incentive for noticeable waste reduction by households in Tucson.

7.2 Alternative Program

The City should evaluate changing the fee structure for residential trash service to more closely reflect industry recommendations for PAYT systems to further incentivize waste reduction and cost savings for residents. PAYT remains a successful strategy for reducing waste and incentivizing individual actions related to waste reduction by way of monetary incentives for smaller trash carts. Research supports that communities that implement effective PAYT programs report significant increases in recycling tonnage and reduction in waste generated.[41] The key to creating a strong program is ensuring the variable pricing is enough of an incentive for individual behavior change. EPA considers a strong PAYT program to implement more than a $5 price differential between trash cart service levels. Programs with only a $1 to $2 monthly price differential are considered less effective programs that are less likely to experience waste reduction or increased waste diversion.[42] Best practices for successful programs also include higher fees for additional carts over the largest size (95 gallons in Tucson). These larger monetary changes between cart sizes have proven to represent enough cost savings to motivate participants to change their behaviors or simply right size their carts to more appropriately align with their waste generation. Residents would still be able to use the City's bulky waste program to account for larger items that do not fit in their smaller curbside trash carts.

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[40] "Right Size Your Can," City of Tucson, 2022, https://www.tucsonaz.gov/es/container-request

[41] "Sustainable Materials Management (SMM) Web Academy Webinar: Pay-As-You Throw: Growth & Opportunity for Sustainable Materials Management," EPA, 2015, https://www.epa.gov/smm/sustainable-materials-management-smm-web-academy-webinar-pay-you-throw-growth-opportunity

[42] "Pay-As-You-Throw Variable Rates for Trash Collection," 2015, Econservation Institute, https://www.epa.gov/sites/default/files/2015-09/documents/skumatz.pdf

HDR has evaluated similar programs regarding PAYT systems in Florida, California, and Texas. Gainesville, Florida, was the first city in the state to implement a PAYT program.[43] The program was not without challenges and pushback from residents on account of the increased and modified fees but has proven highly successful over the last several years. The fee structure for trash service increased the monthly fee approximately $5 for each cart size increase. Gainesville charges residents a $12 delivery fee to switch to a larger cart but does not charge for switching to a smaller cart, further incentivizing smaller trash carts. In the first 2 years of its PAYT program, trash tonnage decreased by 14 percent and recyclables tonnage increased by 25 percent. Gainesville's current recycling and diversion rate is 32 percent, including recycling and yard waste.

There are numerous models across the United States with slight variations for PAYT pricing models. Several utilize a $4 price differential between cart service levels, while others vary the differential with a larger price jump between the medium-size cart and largest-size cart. For the City, the disposal cost savings from a 65-gallon cart as compared to a 96-gallon cart is only $0.65. The remainder of the fee is associated with collection and administrative costs and does not vary substantially between the different size carts. However, PAYT models do not necessarily assign the actual cost of collection and disposal for each individually sized cart, but rather an overall price structure that accounts for all expenditures. Implementing a greater variation of fees to residents based on size has the potential to generate more funds for the City to support the operational, diversion, and disposal costs of the collection program overall. Placing the higher cost burden on those generating the most waste and using the largest cart option is intended to incentivize behavior toward decreasing cart size and reducing trash generation.

As residents right-size or decrease the size of their trash cart, there may be additional one-time operational and cart costs for the switches. Some programs charge for cart delivery or cart size changes to account for staff time and efforts. Others charge delivery fees to change to a larger cart size but do not charge when changing to a smaller cart. Current policies such as the charge for extra bags above the trash cart limit could be retained but may need to be modified. For example, some programs allow extra trash bags outside of the cart to be picked up with pre-paid stickers at an added, reduced cost to account for occasional extra waste. Other programs allow requests for an additional cart for an additional monthly fee for those households with home-based businesses. A Tucson PAYT model would also need to include a plan for shared containers in residential alleys, which are used by more than one residence.

7.3 Benefits/Impacts

The benefits of robust PAYT programs have been well-documented and affirmed over many years. EPA supports this approach to solid waste management specifically because it incorporates all three pillars of sustainability: environmental, economic, and social impact. Data has proven that PAYT programs result in less trash tonnage and increased recycling tonnage as a result of the economic incentives to manage waste appropriately and equitably. Reducing waste and increasing recycling results in less natural resources depletion, less waste to landfills, and fewer GHG emissions from production of new materials and waste decomposition at landfills. For Tucson, a strong

[43] *PAYT Benchmarking Matrix,* HDR, 2012

PAYT program similar to that of Gainesville, Florida, and other programs could reduce City-collected residential waste to the landfill by 15 to 20 percent, or approximately 30,000 tons to 40,000 tons per year, and further increase recyclables quantities. This would increase the City's overall diversion rate by 3 to 5 percent and increase the collection system's diversion rate by 9 to 13 percent.

PAYT programs have also proven to be economically sustainable for local communities managing solid waste. The PAYT model also allows individuals in the community to directly benefit from their own waste reduction. Flat rates or less variable fees spread out the overall cost of waste management to all households within the program. The PAYT system more closely reflects usage fees common among water and electric utilities, which are charged based on consumption.[44] Other secondary impacts may include increased reuse or donation of materials to reduce items being disposed of curbside.

Finally, the PAYT model is seen as the most equitable way to charge residents for waste management services by way of the inherent fairness of the fee structure. Residents who recycle and/or reduce their waste are rewarded for their behavior and do not take on the financial burden of others producing more waste. EPA believes successful programs bring together these three components of revenue generation, individual benefit from waste reduction, and an equitable program for all residents.[45] A potential downside of PAYT programs occurs when residents select a smaller trash cart and regularly place excess trash in the recycling cart. There is also the potential for an increase in illegal dumping. A robust public education program and monitoring will be needed to prevent these behaviors, along with the ability to assess fines on repeat offenders.

7.4 Implementation Timeframe

Implementing an updated PAYT program could be completed relatively easily, but may take longer if fee changes are made slowly over multiple years. There is no requirement for additional trucks, infrastructure updates, or other physical assets to complete this development option. Additional quantities of carts may be necessary depending on the cart size residents select. The timeframe for implementation should consider the most appropriate time to change the billing rate structure for residents and whether such an update should be done over multiple years. Often other similar utility rate increases are done on an annual basis, making it likely the best option for a trash/recycling services rate changes as well. The City will need to determine whether an updated internal policy or ordinance is necessary for changes to the PAYT system.

The significant obstacle to consider in this program change is related to how PAYT pricing applies to households using dumpster service.[46] Currently in Tucson, some households use shared front load trash and recycling services and are charged a flat rate per dwelling unit of $16. Often in these cases, multiple households use the shared centralized dumpster for trash collection. The fees to these households will need to be further evaluated to determine how a modified PAYT system may affect them and, if

[44] "Pay-As-You-Throw Programs," EPA, 2016, https://archive.epa.gov/wastes/conserve/tools/payt/web/html/index.html#:~:text=Pay%2DAs%2DYou%2Dthrow%20(PAYT)%20breaks%20with,can%20of%20waste%20they%20generate.

[45] Ibid.

[46] *Wyoming Solid Waste Diversion Study,* LBA Associates, 2013

possible, identify a system that also provides beneficial incentives for waste reduction to these households. The City could also explore options to reduce or remove shared dumpster service and provide only cart service for residential properties.

Implementing a more robust PAYT system could require more effort from residents because they would need to more accurately monitor the amount of trash their households generate and potentially make changes to their service level. Households wanting to right-size or decrease the size of their cart may want to do this before the rate change is implemented. There may be a bigger learning curve as residents are asked to choose their service level and consider the associated costs with increasing or decreasing their cart size. The City should consider implementing a strong public engagement and educational campaign first to alert residents of the upcoming change. This would allow individuals time to assess their current level of service and make changes proactively. This may also benefit the City by expanding the timeframe in which cart exchange requests are received by households seeking service changes. There could be substantial cart request changes, specifically households choosing smaller cart sizes to save money. Currently, approximately 85 percent of single-family households with carts have the largest 96-gallon cart. Approximately 6 percent have the 48-gallon cart and 9 percent have the 65-gallon cart. More public education will also be needed to reinforce correct recycling habits and monitor contamination levels in recycling carts. In some instances, households may select trash carts that are too small and place trash in the recycling cart. A new ordinance may be needed, or an existing ordinance modified, to allow the City to monitor and issue fines.

7.5 Cost Considerations

Significant research has been completed regarding PAYT systems and most data indicate that such programs do not result in added costs to the communities providing the collection and disposal service. Potential added costs include offering an additional smaller-sized trash cart to further incentivize waste reduction and associated costs with a new or updated billing system.[47] The cost of purchasing more sizes of carts should be considered as well. Staff time may also be added to deliver carts based on size change requests. Currently, the City charges residents $20 per delivery event and $40 for cart removal and delivery. A similar model could be considered for the PAYT system. The City could also consider a different or higher flat rate for cart size change requests going from a smaller cart to a larger cart or allow for a set number of changes within a given timeframe, or provide this at no cost to residents.

Individual households and potentially businesses would take on the added cost by way of the updated rate structure for collection. Program costs would need to be evaluated to ensure that new rates are enough to continue to cover costs of the base services provided by the City. A detailed rate analysis would be critical for determining this information. The City should evaluate the social and political implications of such a program and consider how to address those public concerns. Considerations for low-income households should also be assessed in the PAYT program. The City currently offers a $12 low-income assistance credit for all sizes of trash carts. This could be

[47] "Recycling Incentives: Part 1," Skumatz et al., 2011, https://resource-recycling.com/images/Skumatz0211rr.pdf

updated to accommodate the updated PAYT rate structure. The proposed monthly fee structure is presented in Table 7-2.

Table 7-2. Proposed rate structure for PAYT

Trash cart size	Proposed monthly fee
48-gallon	Base fee developed from rate study
65-gallon	Base fee + $4 to $5
96-gallon	Base fee + $10 to $12

Public education costs are recommended to be at least $5 per household per year in the initial years of program changes to encourage long-term behavioral changes and reduce contamination. This estimation is based on the Recycling Partnership's extensive research and data-backed best practice approaches to residential recycling education and engagement.[48]

7.6 Next Steps

The City will need to consider and evaluate what fee structure will best meet its goals for waste diversion while accounting for social and political constraints and support. This evaluation should build on the results of the rate study and determine what PAYT fees are acceptable to the City from a policy perspective to achieve the desired waste diversion goals on its path to zero waste. The research and results from other programs detailed provide a framework for a successful PAYT program. Prior to implementing updates and rate changes to the City's PAYT program, the City should:

- Review City codes and ordinances for areas needing revisions to better support the PAYT program and provide enforcement.
- Determine policy level support for implementation and consider necessary policy changes.
- Conduct public engagement and education to strategically communicate the program changes and accountability measures to customers.

8 Summary and Recommendations

The five near-term development options discussed in this report all provide viable options to increase waste diversion from Los Reales Landfill and advance the City's zero waste efforts. These options provide unique opportunities and challenges for waste diversion that should be carefully considered. Table 8-1 is a comparison matrix identifying the impact potential for each option in four categories.

[48] *The Cost of Transformation*, Scott Mouw and Cody Marshall, Resource Recycling, 2021

Table 8-1. Comparison matrix of near-term development options

Program	Diversion Impact	Community or Environmental Impact	Implementation Timeframe	Cost Impacts
Brush and Bulky Collection	Medium	Medium	Short	Low
Residential and Commercial Organics Collection	Medium–High	High	Long	High
Reuse Store	Low	Low–Medium	Medium	Medium–High
Recycling Program Changes: Multi-Stream Recycling	Low	Medium	Medium–Long	High
Recycling Program Changes: Recycling Education	Low–High	Medium	Short	Low–High
Pay-As-You-Throw	High	High	Short–Medium	Low

Table 8-1 illustrates the various impacts for each near-term option. The impact definitions are detailed below:

- The diversion impact is the potential to divert waste from the landfill and the level of impact is relative to the existing diversion levels and the diversion potential of the other options identified.
- The community or environmental impact represents the potential to positively affect the local community or environment. This could include GHG emissions reduction, air or water quality improvement, local job creation, community involvement related to waste reduction, fostering change in individual habits, and other benefits to the community.
- Implementation timeframe represents the amount of time necessary to begin a new program or modify an existing program. All the programs discussed in this report are considered near-term (within the next 5 years), but some can be more quickly implemented than others. Modifying existing programs has a short implementation timeframe, while implementing new and complex programs has a longer implementation timeframe. Implementation timeframe also considers disruptions to an existing program, modifications, possible ordinance language revisions, and necessary infrastructure such as new equipment, labor, and facilities.
- Cost impacts consider the upfront costs, infrastructure and capital inputs, and ongoing operations and maintenance costs to the City.

Based on the evaluation detailed above, the near-term development options with the most effective combination of impact potential are the brush and bulky collection modifications and PAYT fee structure updates. Both options provide medium or high diversion and community and environmental impacts while requiring only short or medium implementation timeframes and low cost impacts. Residential and commercial organics collection has medium to high diversion depending on whether the program targets only food waste or also includes yard waste. It has a high community and environmental impact potential but a longer implementation timeframe and higher cost as compared to the other options. A reuse store offers low diversion impact as compared to the other options, along with initial medium to high costs and a medium implementation timeline, but could provide medium levels of community impact through community engagement and effecting positive change on individual behaviors related to waste reduction. Multi-stream recycling is a complex option and involves many unknowns related to diversion potential and community and environmental impacts compared to the existing single-stream program. It has a longer implementation timeframe and possibly high-cost impacts to change the collection and processing program. The greatest benefit of multi-stream recycling collection would be higher-quality recyclables recovered at a MRF, although the overall quantity of recyclables diverted is not expected to increase significantly. Recycling education has a short implementation timeframe. The cost impacts and diversion impacts are variable; higher investment would likely lead to higher diversion impact. A robust and effective program has the potential to offset costs by reducing contamination fees at the MRF and increasing quantities and values of recyclable commodities. The community and environmental impacts are medium.

This report provides a broad level of understanding about the potential impacts of each near-term development option as compared to the current systems and other options identified. Information and details provided will help the City evaluate and implement changes to existing programs and/or create new programs that best utilize the City's resources and further zero waste goals. Efficient use of City resources—including available funds, staff time, facilities, and equipment—should be considered in the decision making. While some options discussed may not be the most effective near-term development option, such as residential and commercial organics collection, such programs could be beneficial for long-term waste reduction goals especially as new technology is further evaluated and public awareness of zero waste grows.

Evaluation of these five near-term development options offers guidance for the City to further plan for zero waste in Tucson and better inform the Roadmap. Additional research and data collection are necessary to further define the waste diversion potential and evaluate the costs of each option. As discussed in the next steps for each of the options, it is also recommended that the City review relevant ordinances and implement robust public education and engagement campaigns for any selected development options. All the development options discussed will require policy updates and political support for implementation. The City will need to continue engaging with policy makers, stakeholders, and the community to determine what options may be supported and which best meet their goals for a Tucson-centric Zero Waste Plan.

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APPENDIX D

Processing Technology Overview

Processing Technology Overview

Zero Waste Roadmap Development

Prepared for: City of Tucson Environmental and General Services Department

Tucson, Arizona

March 9, 2023

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Acronyms and Abbreviations

AD	anaerobic digestion
AI	artificial intelligence
ASP	aerated static pile
C&D	construction and demolition
City	City of Tucson
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
cy	cubic yard
DOT	Department of Transportation
ECS	eddy current separator
EPA	U.S. Environmental Protection Agency
H_2S	hydrogen sulfide
HCl	hydrogen chloride
HDPE-C	high-density polyethylene colored (pigmented) bottles
HDPE-N	high-density polyethylene natural bottles
LRSC	Los Reales Sustainability Campus
MBT	mechanical biological treatment
MP	other paper
MRF	Materials Recovery Facility
MSW	municipal solid waste
MWP	mixed waste processing
MWPF	Mixed Waste Processing Facility
NO_X	nitrogen oxides
O&M	operations and maintenance
O_2	oxygen
OCC	old corrugated cardboard
OMRI	Organic Materials Review Institute
ONP	old newsprint
Partnership	The Recycling Partnership
PCC	Portland cement concrete
PET	polyethylene terephthalate bottles

PM	particulate matter
PM2.5	particulate matter 2.5 micrometers and smaller
PP	polypropylene (#5) plastics
RFI	Request for Information
RNG	renewable natural gas
Roadmap	Zero Waste Roadmap
SO_X	sulfur oxides
TPD	tons per day
UBC	used beverage containers (aluminum)
WTE	waste-to-energy
WWTP	wastewater treatment plant

1 Executive Summary

The City of Tucson (City) is researching waste processing options as part of the Zero Waste Roadmap (Roadmap) process. The Roadmap is meant to gather information on what “zero waste” means to Tucson and identify strategies that best support that vision.

As part of the information gathering for the Roadmap, the City will review processing technologies, including Conversion Technologies, that use waste as a resource. In May 2022, HDR issued a Request for Information (RFI) on behalf of the City to seek information and qualifications from experienced companies, organizations, and/or individuals who represent innovative waste processing, conversion, or beneficial technologies and are interested in developing a project within the City’s Los Reales Sustainability Campus (LRSC). The responses received covered a variety of technologies and programs, and respondents ranged from small local organizations to large international companies. The RFI responses provide insight into potential partnerships and will serve as a starting point for future conversations.

The purpose of this report is to evaluate waste processing technologies with the potential to be fully owned and operated by the City at LRSC. The processing technologies identified for this report are at the commercial stage, meaning that at least one fully integrated facility has been built and has been in continuous operation for long enough to prove that it can achieve the anticipated performance level. This allows time for planned and unplanned outages, waste materials to pass through short-term and seasonal changes, and an understanding of the operational and maintenance costs and limitations to develop. While development risk is never fully eliminated, the risk of technology failure drops substantially once commercial operation is reached. The alternative technologies considered need to be economically viable and technically viable for commercial operation in the City’s waste jurisdiction.

1.1 Technologies Considered

The technologies considered for this processing evaluation are listed below and can be used individually or in various combinations to reduce landfilled waste across material types.

- Organics processing
  - Mulching
  - Composting
    - Turned windrows
    - Aerated static pile (ASP)
  - Anaerobic digestion (AD)
    - Wet Systems
      - Low solids
      - High solids

    - Dry systems

- Construction and demolition (C&D) waste separation
  - C&D pad and bunkers
  - C&D recycling system
  - Automated C&D materials recovery facility (MRF)
- Mixed waste processing (MWP)
- Waste-to-energy (WTE)

Single-stream recyclables processing technologies are not fully evaluated in this report, as the City is currently contracted to use the Republic ReCommunity MRF through 2027. However, this report does discuss general considerations for the role that an existing MRF can play maintaining and improving diversion rates.

There are waste conversion technologies that are a combination of two or more technology classes. For example, mechanical biological treatment (MBT) technologies combine mechanical separation and treatment with biological processing. In contrast, waste-to-fuel technologies combine mechanical pre-processing with thermal and chemical conversion processes, sometimes including a biological component like anaerobic digestion. Each vendor's product will have unique features that may differ slightly from the descriptions provided. For the purposes of this evaluation, each technology was considered individually.

HDR assessed key factors in the implementation of each technology. These factors include the following:

- **Functional/Logistical**: Area requirements, requirements for pre-processing and/or post-processing, likely residuals, and requirements for disposal.
- **Environmental Impacts**: Water usage, energy consumption, air quality, and climate impacts.
- **Beneficial Uses**: Productive byproducts, such as energy or soil amendments.
- **Typical Range of Project Expenses**: Capital costs, operating expenses, potential revenues, and potential risks.

HDR also conducted an Environmental Justice Snapshot to evaluate the potential impacts of the proposed location site for these facilities (LRSC, 7161 South Craycroft Road, Tucson, AZ 85756) on marginalized communities.

1.2 Summary of Findings

The technologies listed in Table 1-1 can be used separately or in various combinations to increase diversion at LRSC and move the City towards its zero waste goals. Each row in the table represents a stand-alone facility. Facility types with a range of technology levels (low to high) can be implemented in phases in order to reduce costs and startup times while still allowing for expansion and upgrades as new or improved feedstock collection programs are established.

For each facility option, Table 1-1 lists the annual processing capacity, which is based on an assumed capture rate of the desired feedstock. This varies by facility type and is described in more detail in subsequent sections. The potential for diversion is presented both at a facility level and at a system level. The percent diversion at each facility represents the portion of feedstock processed by each facility that is diverted from the disposal in the landfill. These estimates were developed based on anticipated feedstock contamination rates and processing technology efficiency. The percent diversion of total waste to the landfill translates the tons of material diverted by each facility to a percentage of the total tons that are projected to be sent to disposal at LRSC under the current waste management system.

Table 1-1 also shows cost ranges for the capital cost and total annual cost (which includes annualized capital cost, operations and maintenance, hauling costs, and cash reserves for equipment replacement and major building repairs or modifications). Annualized capital costs were estimated by amortizing the capital costs over 20 years at an assumed 4 percent interest rate. Estimated ranges of costs per ton of waste processed were developed based on processing capacity. Estimated ranges of costs per ton of waste diverted represent the cost of using each facility type to remove one ton of waste from a waste stream that is currently sent to disposal at the landfill. Costs do not include collection costs, only costs incurred to operate the facility itself. More details for the opinions of probable costs for each technology can be found in their respective report sections and in Appendix A.

Overall, waste-to-energy results in the greatest reduction of waste going to the landfill (primarily due to the volume reduction of the combustion process). However, waste-to-energy also has the highest initial capital costs, total annual operating costs, and cost per ton processed. It also has one of the highest costs per ton diverted.

Select C&D separation (low-level technology option) and turned windrow composting have lower capital and annual costs with the potential to be implemented quickly compared to the other technologies, which require more design, permitting, and building construction. These two scenarios will be able to divert approximately 4 percent and 16 percent, respectively, from landfilling while providing a base for developing more technologically advanced facilities capable of greater capacity and diversion.

The recommended next step is to determine which individual or combinations of processing technologies should be further evaluated for implementation at the LRSC. Further evaluations may be part of the development of the Zero Waste Plan and should include more refined planning and design based on additional information sources such as additional waste composition data, potential changes to collection services or other programs affecting feedstock quantity and quality, specific site locations, and utility availability. These may lead to or be performed in conjunction with Requests for Proposals from vendors offering specific types of processing technologies and/or operating agreements.

Table 1-1. Technology summary (Opinion of Costs presented in million dollars)

Technology	Processing Capacity (TPY)	Diversion Potential		Total Capital Costs ($ Million)		Total Annual Costs ($ Million)[3]		Cost per Ton Processed ($/Ton)[3]		Cost per Ton Diverted ($/Ton)[3]	
		Percent Diversion of Feedstock at Each Facility[1]	Percent Diversion of Total Waste Streams to Landfill[2]	Low	High	Low	High	Low	High	Low	High
Organics Processing Options											
Windrow Composting	132,000	95%	16%	$12.9	$17.9	$2.8	$3.9	$21	$30	$23	$31
ASP Composting	150,600	95%	18%	$30.0	$41.6	$4.9	$6.8	$32	$45	$34	$47
Dry Anaerobic Digestion	70,700	82%	7%	$50.1	$69.6	$7.8	$10.8	$110	$153	$135	$187
C&D Waste Processing Options											
C&D Pad & Bunkers	33,600	86%	4%	$1.3	$1.9	$0.9	$1.2	$27	$37	$31	$43
C&D Sorting System	47,000	76%	4%	$4.8	$6.7	$1.8	$2.6	$39	$55	$52	$72
C&D Mixed Waste Processing	67,100	71%	6%	$27.4	$38.1	$5.1	$7.1	$76	$106	$107	$148
Mixed Waste Processing Options											
Low Tech MWPF	120,700	10%	2%	$10.8	$14.9	$3.3	$4.6	$27	$38	$269	$373
Mid Tech MWPF	201,400	27%	7%	$26.2	$36.4	$6.5	$9.0	$32	$45	$114	$158
High Tech MWPF	491,500	32%	20%	$76.5	$106.3	$15.9	$22.1	$32	$45	$97	$135
Waste-To-Energy											
Waste-To-Energy Facility	639,300	71%	57%	$789.1	$1,096.0	$86.1	$119.6	$135	$187	$189	$263

Note: Table prepared by ARR/LJC and checked by EAA (11/14/2022).

[1] This represents the percentage of each facility's feedstock that is expected to be diverted from disposal by being processed through the facility.

[2] This represents the percentage of total waste currently being sent to disposal at Los Reales Landfill that would be diverted by the operation of the facility.

[3] Annual costs and costs per ton do not include the disposal costs for rejects and process residue, or potential revenues from tipping fees, recovered materials or energy. Potential revenues could lower the net cost per ton. Costs to haul the rejects and process residue are included. Additional disposal costs would increase the net cost per ton.

2 Purpose and Methodology

HDR has been retained by the City to assist during the first phase of its move toward zero waste, the development of the Roadmap. An important component of the Roadmap is exploring the potential for LRSC to host facilities that could process and divert waste material that is currently going into the landfill.

This report provides a preliminary evaluation of waste processing technologies with the potential to be fully owned and operated by the City at LRSC, with consideration of how these technologies can contribute to significant increases in the City's diversion rate. The processing technologies evaluated in this report were selected through discussions with the City, and focus on commercially viable technologies appropriate for processing the mixed waste streams received at the landfill, as well as organic waste streams that can be captured through voluntary collection programs.

HDR has prepared this report based on recent experience with these technologies and other Conversion Technologies. This includes site tours and inspections where these technologies are used around North America and the world, specifically Europe, Asia (Japan), the Middle East, and Australia. Conversion Technologies are a rapidly developing and evolving industry. HDR provides an overview of these technologies and current applications at the time of this report; however, this report does not represent or cover all the technologies that may be in development now or in the near future.

2.1 Methods

This report provides high-level estimates of potential diversion impacts, land requirements, and probable costs for each of the processing technology options discussed. Although data and estimates unique to Tucson were included where possible, many assumptions were made during the process of preparing these estimates. It is recommended that, in conjunction with other components of the Zero Waste Roadmap, the information in this report be used to determine which of these processing technologies would be most suited for further consideration and more in-depth feasibility studies.

2.1.1 Diversion Potential

In 2021, 764,000 tons of municipal solid waste (MSW) were disposed of in the Los Reales Landfill. Approximately 25 percent of that material is collected by the City's residential collection service, 3 percent is collected by City departments, 62 percent consists of commercial and industrial waste from local businesses, and 10 percent is hauled to the landfill by landscapers, small haulers, and public self-haul/daily users.

The City has chosen to use three prior waste characterization studies to estimate the composition of the material being disposed of in the Los Reales Landfill:

- *City of Tucson Waste Diversion Plan and Roadmap* (prepared by Cascadia Consulting Group, January 2014)
- *City of Phoenix Waste Characterization Study* (prepared by Cascadia Consulting Group, September 2015)

- *City of Phoenix Residential Waste Characterization Study: 2017–2018 Final Report* (prepared by Cascadia Consulting Group, May 2018)

The *Current Conditions Assessment,* prepared in June 2022, estimated the composition of Tucson's waste stream based on those three studies.[1] The composition studies were used to estimate approximate quantities of each type of material in Tucson's waste stream.

In order to account for the time to design, permit and construct new facilities, it is assumed that all new facilities would begin operating in 2030. An annual growth rate of 0.5 percent was assumed, with the same approximate composition estimated for the current and future landfilled waste. This results in a total of 799,000 tons estimated to be sent to the landfill in 2030 if diversion rates are not increased. The quantity of material processed, minus any rejected material or residues for each process, was compared to volumes of waste processed at the Los Reales Landfill to identify the estimated percent diversion for each technology (see Table 1-1). It should be noted that this report focuses only on potential diversion of material that is currently being disposed of in the Los Reales Landfill. Additional system diversion from current programs, such as curbside recycling and glass drop-offs, is not included in these diversion calculations.

2.1.2 Opinions of Probable Cost

High-level opinions of probable costs were prepared for each technology. These are planning level estimates and intended to aid the City's evaluation of options moving forward. As alternatives are selected for further evaluation, refinement and development, the cost estimates and all relevant assumptions should be updated.

The cost opinions presented in this report incorporate current industry prices for existing facilities. When direct data comparisons were unavailable, engineer's estimates were used based on HDR's experience with similar technologies and sites.

The opinions of probable costs include 20 percent contingency for capital costs and 10 percent contingency for operations and maintenance (O&M) costs. Low and high cost ranges are provided to account for market variability. Nationally, HDR has seen peak cost impacts ranging up to 40 percent on public bid tabulations, though more recent projects have seen the costs of some materials leveling off or falling. Building materials, prefabricated items, and equipment costs have been more impacted than horizontal construction costs. The opinion is that over time the impact will lessen but not necessarily go back to pre-pandemic levels. Since all of the processing technologies discussed will take some time to design and implement, it is felt that the ranges shown in this report are justified.

The year 2030 was used for estimating costs per ton for each technology in order to provide a consistent basis for comparison. For most technologies, these costs per ton have the potential to decrease with economies of scale; however, some technologies are more suited to build out in phases.

In order to provide a more focused view of the probable costs for each processing technology, the opinions of probable costs do not include system costs not directly tied to

[1] *Current Conditions Assessment.* HDR, 2022.

specific processing technologies. System costs may include additional collection services, costs for landfilling residues/contamination, avoided landfilling costs for diverted material, revenues from the sale of commodities and other byproducts, and monetized renewable attributes (e.g., renewable energy credits). Potential revenue sources for each processing facility are discussed but are not incorporated into overall facility costs. The values of recycled commodities, other byproducts, and renewable attributes can be volatile and are difficult to accurately predict for long term planning, thus it is recommended that the City not rely on that revenue estimate when initially considering the feasibility of a technology. However, O&M costs for all of the facilities do include hauling costs for moving the residue/contamination approximately one mile to the landfill working face. This represents the cost of double-handling the material that would have otherwise gone straight to the landfill working face from the gate.

Assumptions used for individual technologies are listed in the “Opinion of Probable Cost” sections of this report.

3 Environmental Justice Snapshot

Environmental justice, as defined by the U.S. Environmental Protection Agency (EPA), is the fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.[2] The City of Tucson aims to be a responsible steward of its resources and consider its impacts and effects on the local community. The City has elected to include environmental justice considerations in its long-term planning and decision-making processes.

This Environmental Justice Snapshot provides an overview of the potential impacts of LRSC (7161 South Craycroft Road, Tucson, AZ 85756) to determine if additional work should be completed during the next phase of the Zero Waste work.

The findings from this snapshot demonstrate that there are environmental justice communities near LRSC. HDR would recommend the City complete a full Environmental Justice Analysis as part of its work to design a Zero Waste Plan.

3.1 Demographic Information Review

The HDR team, using the United States Census Bureau data from the July 2021 update, reviewed the overall demographics of the City of Tucson as compared to the State of Arizona to document who is currently living in the community and income information. Currently, 20.8 percent of residents live in poverty, significantly higher than the State at 12.8 percent. See Table 3-1 to see a comparison of the demographic data.

3.2 Environmental Justice Screening Review

To understand the potential environmental justice impacts, HDR evaluated the community within 10 miles of LRSC,[3] see Appendix B (EJScreening Report). The report compares the 10-mile zone around the Landfill to the national average.

The report shows one critical area where the Environmental Justice Indexes are higher in the 10-mile zone compared to the national average. That area is Particulate Matter 2.5 (PM2.5). Particulate Matter (PM) is a mixture of solid particles and liquid droplets in the air. PM2.5 are fine inhalable particles with a diameter that is generally 2.5 micrometers and smaller. The sources of PM can be from various sources, including dust and air pollutants. These particulates are monitored as they can be inhaled and cause lung damage.[4]

It is unknown whether these PMs result from landfill operations or another source. Additional research is needed to evaluate sources of particulates.

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[2] "Environmental Justice Definition." EPA. Accessed November 14, 2022. https://www.epa.gov/environmentaljustice#:~:text=Environmental%20justice%20is%20the%20fair,laws%2C%20regulations%2C%20and%20policies.

[3] "EJScreen Tool." EPA. Accessed October 27, 2022. https://ejscreen.epa.gov/mapper/.

[4] "Particulate Matter Pollution, Particulate Matter (PM) Basics." EPA. Accessed October 27, 2022. https://www.epa.gov/pm-pollution/particulate-matter-pm-basics.

3.3 Findings

The Environmental Justice Snapshot has identified that the community around LRSC may be an environmental justice community of concern.[5] HDR would recommend that as the City looks to expand the diversity of services offered at LRSC, an Environmental Justice Analysis is completed to understand impacts and mitigate risks.

An Environmental Justice Community of Concern is defined as a neighborhood or community composed predominantly of persons of color or a substantial proportion of persons below the poverty line that is subjected to a disproportionate burden of environmental hazards and/or experiences a significantly reduced quality of life relative to surrounding or comparative communities.

Table 3-1. Demographic Information for the City of Tucson, AZ (Population Estimates, July 1, 2021)[6]

People	Data for the City of Tucson, AZ	Data for the State of Arizona
Population Estimate	543,242	7,276,316
Age and Sex (percent)		
Persons under 5 years	5.7%	5.5%
Persons under 18 years	20.6%	22.2%
Persons 65 years and over	14.8%	18.3%
Female persons	50.5%	50.1%
Race and Hispanic Origin (percent)		
White alone	69.3%	82.0%
Black or African American alone	4.9%	5.4%
American Indian and American Native alone	3.3%	5.3%
Asian alone	3.2%	3.8%
Native Hawaiian or Other Pacific Islander alone	0.2%	0.3%
Two or more races	8.7%	3.1%
Hispanic or Latino	44.2%	44.2%
Income and Poverty		
Median household income (in 2020 dollars)	$45,227	$61,529
Per capita income in past 12 months (in 2020 dollars)	$24,468	$32,340
Persons in poverty, percent	20.8%	12.8%

Note: Table prepared by KTB and checked by JLK (11/14/2022)

[5] "Arizona Department of Environmental Quality." Accessed October 27, 2022. https://www.azdeq.gov/.

[6] "Demographic information from the United States Census Bureau, Quick Facts." Accessed on October 15, 2022. https://www.census.gov/quickfacts/fact/table/tucsoncityarizona/PST045221.

4 Organics Management

HDR estimates that nearly 40 percent of Tucson's waste stream is organic material that could potentially be diverted from being landfilled. The City has been taking steps to capture and process organic material through a partnership with the University of Arizona Compost Cats since 2013. The program created by the partnership has changed and evolved over the years and is currently known as FoodCycle. FoodCycle provides food waste and green waste collection services to enterprises (e.g., restaurants, schools, food stores, hotels, and resorts) that generate waste within City limits. In 2019, the City obtained a permit from the Arizona Department of Environmental Quality, allowing it to compost food waste and yard waste at the landfill. In September 2022, the City obtained approval to also process paper products and animal manure at the facility.[7]

The program processed approximately 261 tons of material in 2021, but the current composting facility has the capacity to process more. The Solid Waste Facility Composting Notification (revised May 2020) states that the maximum material that can be handled or stored at the composting operation on any given day is 5,300 cubic yards (cy), which includes 2,800 cy on the composting operations area, 1,000 cy in the curing and screening area, and 1,500 cy in the loadout area.[8] Assuming an average density of 800 pounds per cy, this equates to approximately 2,120 tons of organics on the site at any given time. The Solid Waste Facility Composting Notification estimates that material will spend 2 to 4 months in active composting, depending on operations practices, and an additional 4 to 6 weeks in curing. Assuming an additional six weeks for screening and storage, this site could have an annual processing capacity in the range of 6,000 to 7,000 tons per year within the current permit limits.

The amount of compostable material that could be reasonably captured from the waste stream, even using only voluntary programs (as opposed to mandatory organics collection or organics disposal bans) far exceeds the capacity of the current operation. The City may elect to expand its composting program, using either windrow or ASP composting, or may decide to process its organic waste using AD or mulching, or some combination of these organics management options. Options for organics management using composting, AD, and mulching are detailed below.

4.1 Diversion Potential

Several key assumptions were made in order to estimate the amount of organics that could be captured and processed through some type of organics management. It is assumed that the City could expand the FoodCycle program or implement another voluntary/subscription-based curbside collection program in order to capture more food and green waste. In this case, it is assumed that the program could capture 127,300 tons of yard waste and 23,300 tons of food waste in the initial year, which equates to capturing approximately 60 percent of yard waste and 20 percent of food waste that is

[7] Letter from Masoud Arjmandi, Arizona Department of Environmental Quality. Re: Approval of Type III Permit Modification and Issuance of Permit, MFPA No. 07019500.13; LTF No. 95193; Place ID 3024, City of Tucson Los Reales Sustainability Campus, 5300 E. Los Reales Road, Tucson, Arizona 85756. Dated September 23, 2022.

[8] City of Tucson Environmental & General Services Department. Solid Waste Facility Composting Notification, Los Reales Landfill, Tucson, Arizona, Master Facility Plan Approval 07019500.11. Revised May 4, 2020.

currently landfilled. Approximately 5 percent of captured material is expected to be rejected as contamination. All of this material could be processed through a composting facility with appropriate technology. However, an AD facility would not be appropriate to process the full amount of yard waste; it is assumed that the AD facility could accept approximately 20 percent of yard waste that is currently landfilled (containing 5 percent contamination) based on the amount of food waste that is assumed to be captured.

Construction of a composting facility accepting both food and yard waste could result in the diversion of approximately 16 to 18 percent of waste that is currently landfilled, depending on how much food waste the facility was equipped to process. An AD facility that accepts both food and yard waste could result in the diversion of approximately 7 percent of waste that is currently landfilled. However, if a larger portion of the organic fraction of the waste stream was captured, diversion rates would increase. This could be accomplished through various methods of encouraging participating in a voluntary program or by implementing mandatory collection or disposal bans. It should be noted that increased or mandatory participation generally comes with increased contamination in the organics waste streams.

4.2 Mulching

Mulching organic waste, particularly yard waste, can reduce material being sent to the landfill while also providing beneficial reuse for yard waste. Mulching is the process of chipping or grinding organic material, particularly yard waste, to produce mulch. Mulch can then be provided back to the community for free or for a fee. Mulch can be used to reduce weeds, protect against temperature changes, retain water, add nutrients, and prevent erosion.[9] However, mulch produced from yard waste may not be as uniform as mulch produced from woody material and purchased commercially and may degrade more quickly as it is untreated. Mulch may be used as a bulking agent or feedstock for commercial composting or AD.

The City currently collects Christmas trees annually and mulches them. The mulch is then available to the public for free. This accounts for a small amount of the City's diversion, and the quantity of trees collected has been decreasing in recent years, from approximately 152 tons from the 2019 Christmas season, to approximately 42 tons from the 2021 Christmas season.

It is estimated that 20 percent of the City's waste stream is compostable yard waste based on historical reports provided by the City. Diverting yard waste year-round and processing a portion of it as mulch could result in substantial diversion from landfilling, with much lower capital and operating costs than other organics processing options. This type of operation could be standalone or used in conjunction with other types of organic waste processing operations.

[9] "Magic Mulch." Specialized Environmental Technologies, Inc. Accessed November 15, 2022. https://www.setmn.com/magic-mulch/.

4.3 Aerobic Composting

4.3.1 Technology Description

Aerobic composting is used to process source-separated organic materials. Composting is the aerobic, or oxygen-requiring, decomposition of organic waste by microorganisms under controlled, high-temperature conditions. During composting, microorganisms consume oxygen (O_2) while feeding on organic matter. Active composting generates heat and releases gaseous carbon dioxide (CO_2) and water vapor into the air. Composting reduces both the volume and mass of the raw materials while transforming the materials into a stable soil amendment.

The general objectives of composting are to:

- Transform biodegradable organic materials into a biologically stable material in a reasonable time (and, in the process, reduce the volume of the original material).
- Destroy weed seeds, pathogens, insect eggs, and other unwanted organisms that may be present in the original feedstock.
- Manipulate useful crop nutrients (nitrogen, phosphorus, and potassium) into a more usable form.
- Produce a product that can be safely used as a soil amendment to support plants, increase porosity, and conserve moisture.
- Prevent growth or inhibit molds and fungi.
- Avoid serious odors and other potential nuisances.

Composting feedstocks are typically food waste, yard waste, and biosolids. Some commercial facilities are permitted and designed to accept compostable paper and plastic. The two most common composting processes are windrow composting and forced ASP composting. There are also commercial vendors who offer enclosed, small-scale food waste composting units that can be stored indoors.

Windrow Composting

The composting operation at LRSC currently utilizes windrow composting. Windrow composting is the production of compost by piling organic matter or biodegradable waste, such as green waste and wood waste, in long rows (windrows). This method is suited to producing large volumes of compost. The piles are generally turned after 30 days to improve porosity and oxygen content, to maintain optimal moisture, and redistribute cooler and warmer portions of the pile. Process control parameters include the initial ratios of carbon and nitrogen-rich materials, the amount of bulking agents added to assure air porosity, pile size, temperature, moisture content, and turning frequency. In some cases, windrows are covered to protect the surface from drying and to filter ammonia and other odors from the pile. More recent designs have used a fabric cover material similar to the micro-pore fabric (water-proof and breathable) used in outdoor clothing products. The covers block ultraviolet rays from the sun, protecting the microbial population while helping maintain temperature levels in cooler weather. See Figure 4-1 for an example of a windrow composting system.

Figure 4-1. Example of a windrow aerobic composting facility with compost turner

Photo by HDR of privately owned and operated compost facility in California

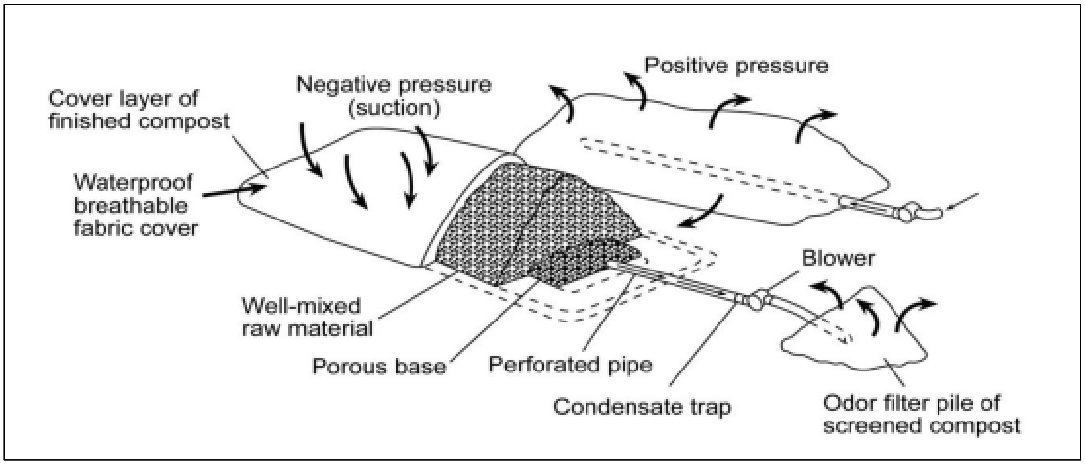
Aerated Static Pile Composting

Forced ASP composting is typically used for feedstocks that contain high quantities of putrescible material, such as food waste or biosolids, that decompose rapidly and potentially cause strong odors. Due to the potential for odors, ASP composting is often covered or indoors. However, some forced ASP composting is conducted outdoors and employs the use of biofiltration to minimize odor emissions.

ASP composting allows organic material to biodegrade without turning the pile by supplying oxygen to the feedstock. The blended mixture is usually placed on perforated piping or trenches, providing air circulation for controlled aeration. ASP systems can be either positively or negatively aerated. In a positively aerated system, air is injected into the windrows to maintain proper oxygen levels. In a negatively aerated system, a series of perforated pipes draws air through the compost to an air collection manifold that runs under the piles. The compost air is sometimes pushed through a biofilter to control odors.

The main advantages to ASP composting systems are 1) the process air can be collected for odor control and 2) the footprint of the composting area can be reduced. See Figure 4-2 for a diagram of an example ASP system.

Figure 4-2. Aerated static pile diagram, adapted from *On-Farm Composting Handbook*, NRAES-54



Source: Northeast Regional Agricultural Engineering Service Cooperative Extension. On-Farm Composting Handbook. June 1992.

ASP composting can produce large volumes of compost in relatively small areas because it does not require additional space for turning/relocating the compost pile. It can also produce finished compost more quickly than windrow composting if the process is managed properly. Temperature and moisture levels must be monitored for optimal operation.

The composting process may occur in windrows, bunkers, or mass beds and be open, covered, or in closed containers (in-vessel). ASP composting can also include a variety of cover systems, including specially designed tarps or fabric covers, organic covers such as finished compost, or a specially equipped bag system to contain the materials. See Figure 4-3 for an example of a fabric-covered ASP composting system.

Figure 4-3. Cedar Grove facility, showing the GORE-covered ASP system, in Issaquah, Washington

Photo by HDR

ASP composting can be particularly odorous if the composting pile has pockets of anaerobic activity. It is important to use best management practices to set up and maintain the composting system. The putrescible material and bulking material should be mixed in correct proportions to maintain adequate porosity, which allows oxygen to move through the material. Maintaining proper moisture control is also important; if an ASP system becomes too wet, water may fill the pore spaces and prevent aerobic digestion. Without sufficient oxygen in the system, the denser putrescible material would naturally default to an anaerobic condition and cause odors.

Small-Vessel Composting

Food waste aerobic composting can also take place in highly controlled, automated in-vessel equipment. Enclosed vessel composters use a combination of agitation and temperature/moisture control to convert food scraps into compost. Current models on the market have limited capacity; larger units can process up to 1.5 tons per day. This technology is most efficient for use with small food waste generators such as schools, hotels/conference centers, malls/food courts, cruise ships, hospitals, amusement parks, and sports stadiums.

4.3.2 Risk Considerations

Managing odors is a primary challenge for all types of composting. If the composting system becomes oxygen-deficient (due to low porosity, high moisture, insufficient turning, or malfunctioning forced-air systems), the compost may begin degrading anaerobically. This could cause odors, particularly when putrescible feedstocks, such as food waste or biosolids, are used. Odor can move offsite, particularly in windy areas, and cause conflicts with neighbors.

Maintaining sufficient quantities of feedstock is also a consideration. Active composting requires a balance between carbon and nitrogen, which is measured by the carbon-to-nitrogen (C:N) ratio. Raw materials should be blended into approximately a 30:1 carbon-to-nitrogen ratio by weight. Inadequate nitrogen results in limited microbial activities and slow decomposition, while excess nitrogen may cause odors. The City will have to develop a ‘recipe’ for their compost based on what materials are available as feedstock and their C:N ratio.

Compostable paper and compostable plastic materials in the compost can also cause issues. While many of these materials can eventually break down under ideal time and temperature conditions, the amount of time needed is typically longer than for other organic materials. Compostable paper and plastic residue can be left in the compost pile after the rest of the material has developed into a mature product. These materials may require additional screening to remove them from the final compost. At that point, the residue can either be returned to the compost system for additional biological degradation or disposed of as a residue. Management of compostable plastics can be challenging as it is difficult to differentiate between compostable and non-compostable plastics. This can result in non-compostable plastic residue left in the compost.

Facilities that have accepted post-consumer food waste with compostable serviceware have had to install robust screening/cleanup measures to remove glass, plastic, metal, and other foreign materials from compost products. These facilities often have operational issues, such as odor generation, and may have difficulty producing marketable products.

Composters attempt to produce the highest quality compost possible to secure the best price for the end product. Certified organic compost, which is compost reviewed and approved by Organic Materials Review Institute (OMRI) or organic certifying agencies for use on organic farms, tends to be sold for the highest price. However, the presence of foreign materials that derive from non-compostable feedstocks may prevent the compost from obtaining certified organic grades.

4.3.3 Opinion of Probable Cost

Preliminary sizing and planning level opinions of probable costs were developed for both an expanded windrow composting facility and for a new, larger-scale ASP composting facility at the LRSC. A windrow composting facility could be developed and operated at a lower level of cost compared to ASP composting but would be more limited in terms of the amount of food waste that could be accepted and would require a larger footprint on the site.

The ASP composting facility is assumed to process the full 127,300 tons of yard waste and 23,300 tons of food waste that it is expected the City could capture annually from voluntary programs. This equates to a combined feedstock that is approximately 15 percent food waste. As windrow facilities typically perform better with feedstock that has a lower percentage of putrescible feedstocks, the windrow composting facility is assumed to process a feedstock that is 4 percent food waste. This equates to 4,700 tons of food waste per year, blended with the 127,300 tons of yard waste assumed to be available.

The opinion of probable cost for the window composting facility assumes the composting period is 60 days, with a 36-day curing period. It was assumed that the compost would be stored onsite for 60 days after curing.

The opinion of probable cost for an ASP composting facility assumes that the composting period is 28 days, with a 36-day curing period. It was assumed that the compost would be stored onsite for 60 days after curing.

Both types of composting facilities would include an unloading and receiving area, mixing and grinding area, compost pad, compost curing pad, screening area, pre-screening and post-screening storage, traffic lanes for operations, and a retention pond. The ASP composting facility would also include a biofilter and a receiving/pre-processing building.

The initial capital costs include site preparation, site utilities, composting system (this includes aerated bed compost pad, aerated bed curing pad, biofilter, head walls, air manifold, and blowers in the case of the ASP facility), and construction of a compost leachate lagoon. Also included are contingency, engineering and design, construction quality assurance, and permitting costs. Capital costs also include equipment, including loaders, a pre-sort contamination removal system, mixer/shredder, aeration equipment, and support trucks. The costs are presented as a range to account for market variability factors .

Residue hauling costs for the site are relatively low based on the assumption that feedstock would contain 5 percent contamination, and that the facility would be located at the LRSC. The costs include fuel, tires, maintenance and repairs, truck and trailer amortization, and insurance and licenses for haul trucks. If the facility was located offsite, haul costs would be higher.

Operations and maintenance costs include labor (employee salaries), utilities, maintenance and repairs of equipment and roadways, supplies, fuel, ongoing consulting and engineering services, compost lab testing, and facility insurance. They also include cash reserves for equipment maintenance and replacement.

Revenues for the sites are not included in the total cost estimates. Revenue would be based on compost sales and tip fees from incoming material. If the City chooses to market the compost, a market study could provide additional insight into potential revenues.

Table 4-1 provides the preliminary sizing considerations for both windrow and ASP composting at LRSC. The opinions of probable costs for windrow and ASP composting are provided in Table 4-2 and Table 4-3, respectively. More detailed parameters and probable costs are provided in Appendix A.

Table 4-1. Preliminary sizing considerations for composting

	Turned Windrow	ASP
Total Received/Processed Waste, TPY	132,000	150,600
Total Received/Processed Waste, TPD	431	492
Percent Diversion of Feedstock Processed through Compost Facility	95%	95%
Reduction/Diversion from Total Waste Currently Landfilled	16%	18%
Required Land (acres)	19 to 28	15 to 23

Note: Table prepared by ARR/LJC and checked by EAA (11/14/2022).

Table 4-2. Windrow composting opinion of probable costs

	Low Range	High Range
Total Capital Costs	**$12,900,000**	**$17,900,000**
Annualized Capital Cost (4%, 20 years)	$900,000	$1,300,000
Annual O&M Costs	$1,900,000	$2,600,000
Total Annual Cost	**$2,800,000**	**$3,900,000**
Total Cost per Ton Processed ($/ton)	$21	$30
Total Cost per Ton Diverted ($/ton)	$23	$31

Note: Table prepared by ARR/LJC and checked by EAA (14/11/2022).

Table 4-3. ASP composting opinion of probable costs

	Low Range	High Range
Total Capital Costs	**$30,000,000**	**$41,600,000**
Annualized Capital Cost (4%, 20 years)	$2,200,000	$3,100,000
Annual O&M Costs	$2,700,000	$3,700,000
Total Annual Cost	**$4,900,000**	**$6,800,000**
Total Cost per Ton Processed ($/ton)	$32	$45
Total Cost per Ton Diverted ($/ton)	$34	$47

Note: Table prepared by ARR/LJC and checked by EAA (11/14/2022).

4.4 Anaerobic Digestion

AD is a process that converts organic material into energy (biogas) and a nutrient-rich digestate with beneficial uses. AD is a well-established technology in other countries but is less prevalent for food waste in the United States. AD facilities in the United States tend to be used most often by agricultural operations, specifically for manure processing or wastewater treatment plants (WWTPs). The manure and biosolids provide a uniform feedstock that can be used for consistent energy production.

However, the evolution of the technology in parts of Europe, particularly in Germany, Spain, France, Italy, and the United Kingdom, has renewed interest in expanding AD technology in North America. AD facilities using source-separated organics, and even in a few cases mixed MSW, are successfully operating in Europe due to landfill ban policies, high tipping fees, and high energy prices. In parts of Canada and the United States, AD processes for food and source-separated organic waste streams have been developed at the commercial scale.

4.4.1 Technology Description

AD is a waste management process commonly used to treat wastewater biosolids and manure. It has also been used to treat the organic fraction of the MSW waste stream. Feedstocks for AD vary but could include MSW-derived organics, manure, food waste, grass clippings, yard waste, brush, and WWTP biosolids. Biologically inert materials that might be contained in the digestion feedstock, such as metals, glass, and plastics, are undesirable and considered contamination and either must be removed prior to digestion (for wet type systems with low or high solids) or be screened out during or after digestion (for dry type systems).

The AD process occurs when organic matter is decomposed with bacteria in the absence of oxygen in a closed vessel. The process produces a methane-rich biogas that can be refined into a variety of beneficial fuels, including renewable natural gas (RNG) and compressed natural gas (CNG). It can also be used in low-grade conditions to fuel an engine generator. AD also produces a nutrient-rich digestate, which can be beneficially reused. AD is sometimes used in combination with aerobic composting to bio-stabilize the digestate.

There are several factors that influence AD system design and performance, such as the concentration and composition of nutrients in the feedstock, temperature of the digesting mass, retention time of the material in the reactor, pH, acidity, and oxygen level.

Three basic approaches are used for AD systems based largely on the nature of the feedstocks:

- Wet low solids for dilute feedstock materials with very little to no contamination
- Wet high solids for thick but pumpable materials that contain some contamination
- Dry or stacked for stackable feedstock blends with higher levels of contamination

Wet low solids AD systems are typically large, tank-based systems with mixing. This type of AD system is typically used for WWTPs and may be used in a co-digestion system that processes both biosolids and dilute putrescible material. They require careful pre-processing of feedstocks to remove grit and other contaminants.

Wet high solids AD systems use a vessel designed for higher viscosity (thicker) material. These systems use a plug flow or similar process, which does not include mixing. Instead, material advances through the digester whenever new feedstocks are added. High solids AD systems may be horizontal, as shown in Figure 4-4, or vertical tank arrangements, as shown in Figure 4-5. They can typically accept a more diverse feedstock, including some level of contamination. However, they often require some level of pre-processing and post-processing to remove contaminants.

Figure 4-4. High Solids Horizontal AD Plant in San Luis Obispo, California

Photo by Hitachi Zosen Inova

Figure 4-5. Vertical High Solids AD Plant in Perris, California

Photo by CRR

Dry or stackable AD systems are designed to treat material that remains stationary throughout the digestion process. These systems use enclosed tunnels or bunkers to stack and store drier feedstock for fermentation. Yard and green waste are often used for dry AD systems because the feedstock must be porous and have a high solids content. This allows the feedstock to be stacked and percolate to drain through the media. Biologically rich water is sprayed on the material and, after percolating through the material, is collected and recycled through the feedstock to control moisture levels. The resultant digestate requires post-processing to convert it from an anaerobic to an aerobic condition.

4.4.2 Risk Considerations

If not managed properly, the gases produced by an AD system are highly odorous and explosive. Since the AD process occurs inside a vessel, odors from these types of facilities are typically attributed to mismanagement of either the arriving feedstock or the residual digestate that has not been returned to an aerobic phase. Gas and digestate collection systems should be included in a properly designed and operating AD facility.

Some facilities that process food waste or mixed MSW have observed the formation of odorous trace gases, such as hydrogen sulfide (H_2S), due to the high protein content of the feedstock. These gases should be monitored and managed to prevent odors or air emissions from migrating offsite.

4.4.3 Opinion of Probable Cost

Dry AD was chosen as the AD technology used in the development of an opinion of probable cost due to its ability to maximize diversion potential and minimize risks. Dry AD is able to utilize both food and yard waste as feedstock, and is able to handle higher levels of contamination. In addition, it requires less process water than the wet types of AD, particularly as a stand-alone facility. This should not exclude the wet types of AD from future consideration if used in conjunction with other diversion facilities or if there is an interest from Pima County in partnering with the City to accept source-separated food waste at a local wastewater treatment facility.

The AD facility is assumed to process the full 23,300 tons of food waste that it is expected the City could capture annually from voluntary programs. For a dry digestion system, that food waste would be blended with 42,400 tons of the yard waste captured annually. It is also assumed that the City could obtain 5,000 tons of industrial food waste per year to augment the feedstock mix.

The opinion of probable cost for a dry AD facility assumes that the facility would include unloading bays, tipping floor, pre-processing system area, rejects and fines loadout area, and an office with a breakroom and restrooms. The facility would also include a shop room. The AD system would consist of digesters, a biogas to power system, and digestate/effluent management tanks.

The initial capital costs include site preparation, site utilities, building construction, pre-processing equipment, AD digesters, effluent management equipment, a building for biogas refinement to pipeline quality, and cost for installation and startup. Also included are contingencies, engineering, construction quality assurance, and permitting costs. Mobile equipment, including loaders, skid loaders, and roll-off trucks and containers, was also included in the initial capital cost. The costs are presented as a range to account for market variability factors.

Residue hauling costs for the site are relatively low based on the assumptions that the feedstock blend would contain about 18 percent contamination, and that the AD facility would be located at the LRSC. The contamination rate is expected to be higher for the organic waste going an AD facility than in the organics waste going to a compost facility due to the much higher level of food waste, which tends to have higher contamination than yard waste. Contamination levels can be reduced through robust education for program participants. The costs include fuel, tires, maintenance and repairs, truck and trailer amortization, and insurance and licenses for haul trucks. If the AD facility was located offsite, costs would be higher.

Operations and maintenance costs include labor (employee salaries), utilities, maintenance and repairs of equipment and roadways, supplies, fuel, ongoing consulting and engineering services, digestate lab testing, and facility insurance. They also include cash reserves for equipment maintenance and replacement.

Revenue for the site is not included in the total cost estimates. Revenue would be based primarily on energy revenues from biogas to electricity. It is possible that the facility would also be eligible for carbon credits, which can generate additional revenue. These monetary incentives from programs such as the EPA’s Renewable Fuel Standard Program (known for RINs, Renewable Identification Numbers) and California’s Low Carbon Fuel Standard Program are highly variable. The facility could see total revenues equivalent to as much as $20 or $30 per ton of feedstock processed, but this should not be considered as guaranteed, particularly in early planning stages.

Table 4-4 provides the preliminary sizing considerations for a dry AD facility at LRSC. The opinions of probable costs are provided in Table 4-5. More detailed parameters and probable costs are provided in Appendix A.

Table 4-4. Preliminary sizing considerations for anaerobic digestion

	Dry Anaerobic Digestion
Total Received/Processed Waste, TPY	70,700
Total Received/Processed Waste, TPD	231
Percent Diversion of Feedstock Processed through Anaerobic Digestion Facility	82%
Reduction/Diversion from Total Waste Currently Landfilled	7%
Required Land (acres)	2 to 4

Note: Table prepared by ARR/LJC and checked by EAA (11/14/2022).

Table 4-5. Anaerobic digestion opinion of probable costs

	Low Range	High Range
Total Capital Costs	**$50,100,000**	**$69,600,000**
Annualized Capital Cost (4%, 20 years)	$3,700,000	$5,100,000
Annual O&M Costs	$4,100,000	$5,700,000
Total Annual Cost	**$7,800,000**	**$10,800,000**
Total Cost per Ton Processed ($/ton)	$110	$153
Total Cost per Ton Diverted ($/ton)	$135	$187

Note: Table prepared by ARR/LJC and checked by EAA (11/14/2022).

5 Construction and Demolition Waste Processing

C&D waste includes a variety of materials that are generated from construction, renovation, and demolition of buildings, roads and bridges, and other structures.[10] Material types include steel, wood products, drywall and plaster, brick and clay tile, asphalt shingles, concrete, and asphalt concrete. EPA estimated that 600 million tons of C&D debris were generated in the United States in 2018, which was more than twice the amount of MSW generated during the same year.[11] Demolition accounts for more than 90 percent of total C&D debris generation, while construction represents less than 10 percent.[12]

C&D waste is generated by construction companies, homeowners, and contractors. Large quantities of C&D waste are likely to be collected separately from MSW, as C&D waste does not necessarily fit into residential bins. This provides an opportunity to recover and reuse portions of C&D waste that would otherwise be disposed.

5.1 Technology Description

C&D materials can be processed (ground, crushed, extracted, and melted) and incorporated into new materials. EPA notes that reuse for C&D wastes can include the following:

- C&D wood processed for use as feedstock in the manufacture of derivative products, such as engineered wood products;
- C&D shingles processed for use as feedstock in the production of asphalt mixtures;
- C&D drywall processed for use as feedstock in the manufacture of new drywall or Portland cement;
- C&D metals processed for use in the production of metal precursor products, such as billets and ingots;
- C&D concrete processed for use as aggregate in the manufacture of concrete and the production of asphalt mixtures;
- C&D asphalt processed for use in the production of asphalt mixtures.

However, materials must be separated before they can be reused. Municipalities can increase recycling by requiring debris to pass through a recycling facility, increasing the landfill tipping fee for C&D materials, or requiring contractors to pay a deposit that is returned after the debris is recycled.[13]

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[10] *Construction and Demolition Debris Management in the United States.* EPA Office of Resource Conservation and Recovery, 2020.

[11] "Construction and Demolition Debris: Material-Specific Data." EPA. Accessed November 15, 2022. https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/construction-and-demolition-debris-material.

[12] *Advancing Sustainable Materials Management: 2018 Fact Sheet*. EPA, 2020.

[13] *Benefits of Construction and Demolition Debris Recycling in the United States,* Construction & Demolition Recycling Association, 2017.

Materials can be source separated at the job site, particularly for large demolition projects with consistent debris types. The debris could also go to a C&D specific MRF or a mixed waste processing facility that specializes in C&D waste (see Section 6 for more information on mixed waste processing).

If the City were to develop a C&D processing facility at LRSC, there are varying levels of technology that could be utilized depending on the investment and diversion targets chosen. There is also the potential to develop the processing operation in phases as additional material sources, operational changes, and policies are established.

5.1.1 C&D Pad & Bunkers

Low-technology C&D processing includes an outdoor receiving pad with designated areas (i.e., bunkers) and roll-offs for select loads to sort wood, shingles, concrete, brick, scrap metal, drywall, cardboard, and other materials suitable for separation. Customers could be asked to sort their materials into the different bunkers or be directed to unload at the bunker associated with the majority of their load. Some manual sorting and picking with loaders is typically needed by staff to further sort materials. When possible, waste that is not recyclable should be identified immediately and reloaded on the customer's vehicle for disposal in the landfill.

Operations are outdoors, and measures should be implemented to control dust and provide relief from the heat during the summer season.

5.1.2 C&D Recycling System

The next level of C&D processing (medium technology) is to add a recycling system sort line to process additional loads containing mixed C&D wastes. Various manufacturers[14] provide mobile and stationary C&D recycling systems, including infeed hopper & conveyor, optional trommel, picking stations with cabin for sorter's comfort, magnet, blower, and other options. An example of a simple recycling system is at Portland Metro Central Transfer Station, where materials such as wood, concrete, metal, cardboard are pulled off a conveyor sort line. Portland is focusing on the materials that provide quick, high diversion by weight.

Sorting rich loads of C&D wastes is labor intensive and would need to address the heat during peak summer. An air-conditioned sorting cabin and/or canopy shade, along with air-conditioned equipment cabs, would help alleviate heat issues.

5.1.3 Automated C&D MRF

Advanced C&D processing (high-level technology) would include a building and complex recycling system with several screening equipment, shredders, magnets, and a non-ferrous eddy current separator (ECS). Manual sorting or optical sorters could be used to separate cardboard, treated wood, and untreated wood. Further processing of wood may involve shredders and additional magnets to recover nails and other metals from the wood. The fines, usually less than two inches and consisting of dirt, rocks, broken glass,

[14] Manufacturers of C&D recycling systems can include Complete Recycling Systems (CRS), General Kinematics, Krause Manufacturing/CP Group, Machinex, and other recycling equipment manufacturers.

ceramics, bottle caps, etc., may be further processed by magnets, ECS, and pneumatic sorting steps to recover metals, fiber, and a glass-rich stream.

5.2 Diversion Potential

Based on waste characterization studies prepared on behalf of the Cities of Tucson and Phoenix, approximately 8.4 percent of Tucson's residential waste is C&D waste. Commercial C&D waste received at LRSC is not tracked separately from other types of commercial loads, but for estimating purposes, it is assumed that C&D rich loads comprise a similar proportion of the overall waste received at LRSC.

Not all of the C&D waste arriving at LRSC would be routed to a C&D processing facility; however, as more mixed loads with C&D are received and processed, there will be greater diversion from landfilling. Contractors could go directly to the C&D facility to drop off materials, and scale house operators could visually assess incoming loads for C&D materials and redirect loads that are visually high in C&D materials. HDR estimates that 50 to 70 percent of the C&D waste would be routed to the low to medium technology facilities, respectively.

As recycling system technology increases, more mixed loads with C&D would be directed to the facility. The high-level technology facility is assumed to be able to capture and process the full 8.4 percent of landfilled waste at the LRSC that is assumed to be C&D materials, with approximately 5 percent of that material being non-recyclable material.

C&D recovery is estimated to range from 75 percent to 90 percent of the remaining waste based on more mixed loads to the high-level technology facility (i.e., lower percent recovery) and more select C&D rich loads to low-level technology facility (i.e., higher percent recovery). Construction of a C&D facility would result in diverting approximately 4 percent to 6 percent of the waste currently landfilled based on the assumptions listed above.

5.3 Risk Considerations

Reuse and recycling of C&D materials have significant benefits.[15] According to the EPA, increasing recycling of C&D waste can create employment and economic opportunities, particularly when deconstruction and selective demolition methods are used. Recovering materials through recycling requires more employees per ton processed compared to landfill disposal. The C&D processing facility will need equipment operators and sorters. C&D recovery at a building construction site can also reduce building project expenses through avoided purchase and disposal costs. If the recovered material is donated to qualified charities, companies can collect a tax credit.

There are also environmental benefits to reuse of C&D materials. Reusing materials reduces the environmental impact of using virgin resources and producing new materials. There are major energy savings from replacing virgin materials with recycled materials for manufacturing. Reusing C&D material also conserves landfill space since C&D waste is bulky and does not compact like MSW.

[15] *Demystifying Potential Midwestern Building Material Markets.* Delta Institute, April 2019.

However, there are risks associated with the reuse of materials.[16] Material that has been damaged by fire, flood, or insect infestation may not be able to be reused. Furthermore, materials from older houses may contain lead-based paint or asbestos, which could be a risk to people who process or use the material.

Markets are not fully developed for C&D materials. Scrap metal is a high-value commodity with established markets, so metals are often targeted for removal. Asphalt shingles are also regularly used for new asphalt pavement for roads. Conversely, crushed Portland cement concrete (PCC) could potentially be used as an aggregate in new PCC mixes, but there are few established Department of Transportation (DOT) specifications, which has limited the practice in the United States. Similarly, scrap drywall can be recycled into the production of new drywall and PCC, but manufacturing facilities typically need a large and constant supply of uniform material. The City could address this by identifying the C&D materials that are most frequently disposed of in the landfill, targeting these materials initially, and potentially stockpiling them for sale to end markets to ensure that sufficient volumes are collected prior to reuse.

5.4 Opinion of Probable Cost

The costs for the C&D processing facility depend upon the technology level implemented. The high-level technology facility includes a building with unloading bays, tipping floor, processing system area, recovered material storage, rejects and process residue waste storage, recovered C&D load-out area, and rejects and residue load-out area. It will also include space for an office, breakrooms, restrooms, and a shop room. Approximately 80 percent of the recovered C&D materials are assumed to be stored outside of the building. The medium technology facility has an outdoor receiving area leading to an infeed hopper and sort line with a canopy for shade, recovered material storage bunkers, and load-out areas. The low-level technology facility is an outdoor pad and bunkers for material receiving, storage, and load-out. No building is included with the low and medium technology facilities.

The initial capital costs include site preparation, site utilities (except for low-level technology), building construction (high-level technology), processing equipment (mid-level and high-level technology), contingency, engineering design, construction quality assurance, and permitting. Mobile equipment, including loaders, skid loaders, roll-off trucks, and containers, is also included in the probable capital cost. The costs are presented as a range to account for market variability factors.

Operations and maintenance costs include labor (employee salaries), utilities, maintenance and repairs of equipment, supplies, fuel, ongoing consulting and engineering services, and facility insurance. They also include cash reserves for equipment and building replacement. Operations for the low-level technology C&D facility are primarily loader operators and spotters, minimal utilities, and small maintenance and repairs. The medium technology facility is assumed to have six personnel manually sorting C&D materials in the sorting station for one shift 6-days per week, a process equipment operator for the recycling system, and a maintenance person in addition to loader operators and a spotter. Utilities are limited to the sorting cabin/canopy area, while maintenance and repairs are slightly higher with the process equipment. Operations

[16] Ibid.

costs for the high-level technology facility include more processing equipment operators and maintenance staff but less sorters.

Hauling costs to remove residuals from the facility are including in the O&M costs and are relatively low based on the assumptions that 14 to 29 percent of incoming material will need to be disposed of in the landfill, and the C&D facility would be located at the LRSC. The cost includes fuel, tires, maintenance and repairs, truck and trailer amortization, and insurance and licenses for haul trucks. If the C&D facility was located offsite, haul costs would be higher.

Revenue for the site is not included in the total cost estimates. Revenue would be primarily based on sale to C&D markets after material is diverted in the processing facility. An average revenue of up to $20 per ton of material diverted could be considered for planning purposes but is not considered in this analysis.

Table 5-1 provides the preliminary sizing considerations for the different types of C&D processing facilities at LRSC. The opinions of probable costs for each C&D processing facility option are provided in Table 5-2, Table 5-3, and Table 5-4. More detailed parameters and probable costs are provided in Appendix A.

Table 5-1. Preliminary sizing considerations for C&D processing

	C&D Pad & Bunkers (Low Tech)	C&D Sorting System (Mid Tech)	C&D Mixed Waste Processing (High Tech)
Total Received/Processed Waste, TPY	33,600	47,000	67,100
Total Received/Processed Waste, TPD	110	154	219
Processed Waste, TPH	-	-	26
Processed Waste/Line/Shift, TPH	-	-	26
Percent Diversion of Waste Loads Processed through C&D Facility	86%	76%	71%
Reduction/Diversion from Total Waste Currently Landfilled	4%	4%	6%
Required Land (acres)	4 to 6	5 to 7	5 to 8

Note: Table prepared by ARR/LJC and checked by EAA (11/14/2022).

Table 5-2. C&D Pad & Bunkers (Low-Level Technology) opinion of probable costs

	Low Range	High Range
Total Capital Costs	**$1,300,000**	**$1,900,000**
Annualized Capital Cost (4%, 20 years)	$100,000	$140,000
Annual O&M Costs	$800,000	$1,100,000
Total Annual Cost	**$900,000**	**$1,200,000**
Total Cost per Ton Processed ($/ton)	$27	$37
Total Cost per Ton Diverted ($/ton)	$31	$43

Note: Table prepared by ARR/LJC and checked by EAA (11/14/2022).

Table 5-3. C&D Sorting System (Mid-Level Technology) opinion of probable costs

	Low Range	High Range
Total Capital Costs	**$4,800,000**	**$6,700,000**
Annualized Capital Cost (4%, 20 years)	$400,000	$500,000
Annual O&M Costs	$1,500,000	$2,100,000
Total Annual Cost	**$1,800,000**	**$2,600,000**
Total Cost per Ton Processed ($/ton)	$39	$55
Total Cost per Ton Diverted ($/ton)	$52	$72

Note: Table prepared by ARR/LJC and checked by EAA (11/14/2022).

Table 5-4. C&D Mixed Waste Processing (High-Level Technology) opinion of probable costs

	Low Range	High Range
Total Capital Costs	**$27,400,000**	**$38,100,000**
Annualized Capital Cost (4%, 20 years)	$2,000,000	$2,800,000
Annual O&M Costs	$3,100,000	$4,300,000
Total Annual Cost	$5,100,000	$7,100,000
Total Cost per Ton Processed ($/ton)	$76	$106
Total Cost per Ton Diverted ($/ton)	$107	$148

Note: Table prepared by ARR/LJC and checked by EAA (11/14/2022).

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6 Mixed Waste Processing

Mixed waste processing sorts mixed MSW and extracts recyclable and reusable materials that would otherwise be sent to the landfill. The City has high recycling contamination and a high percentage of recyclable material in its landfilled waste stream. MWP offers a technology-based alternative to increase diversion.

6.1 Technology Description

There are several types of MRFs in operation in the United States and around the world. Most can be classified into two groups: those that accept and process source-separated recyclables, sometimes referred to clean MRFs, and those that take a mixed MSW stream, referred to as a Mixed Waste Processing Facility (MWPF) or an advanced materials recovery system. These facilities are used to capture select materials, depending on the feedstock and established markets, and may not recover all the materials noted below. Yields from MWPF per ton of material input are typically much lower than conventional MRFs due to the nature of the feedstock, but they can provide significant landfill diversion depending upon the amount of waste directed to the facility and the level of sorting technology implemented.

In a MWPF, MSW from residential and/or commercial collection vehicles is off-loaded onto a tipping floor. Materials are first sorted on the floor using mobile and fixed equipment with some manual labor to remove or break up larger or bulky items such as dimensional wood, metal, or large pieces of plastics that might clog or interrupt processing system operations. In most cases, either a mechanical device or manual labor is used to open bags and containers prior to screening and sorting. Loaders or grapples then load a conveyor or surge hopper to convey the material to the sort lines with mechanical equipment and/or labor for separation. Systems can be adapted to C&D waste or other mixed waste materials.

Similar to MRFs, MWPF can be developed and implemented with mostly manual sorting from conveyors (low-level technology) or for greater diversion of several materials processed through multiple stages of mechanical, optical, and pneumatic screening equipment (high-level technology).

6.1.1 Low-Level Technology MWPF

Low-level technology MWPFs typically focus on select loads and the highest quantity material that is easiest to separate. MWPF requires a building large enough with vertical clearance for garbage trucks to unload waste on the tipping floor, a loader to feed waste to the primary infeed conveyor and sort line, manual sorting stations, magnets, and possibly eddy current separator. Process equipment is generally basic, relying mostly on manual labor to separate recyclable materials from the waste stream. Several manufactures develop pre-packaged systems for various throughput capacity. The facility would include a baler for baling the recovered metals, aluminum, papers, and cardboard. Several years ago, Puente Hills MRF implemented a recycling system to capture recyclables from mixed commercial waste. Similarly, C&D recycling systems discussed in Section 5.1 are low-level technology MWPFs, and these MWPFs can be designed to divert C&D-type materials in addition to traditional recyclables.

An example of more mixed waste processing in a low-level technology MWPF is the upfront sorting at the Pope-Douglas WTE facility located in Alexandria, Minnesota, with a magnet for ferrous metals, labor-pulling cardboard, containers (materials with value or items not wanted in WTE), and eddy current separator for non-ferrous metals. Pope-Douglas claims that they diverted 7 percent from the MSW directed onto the conveyor line. They try to direct as much of the total waste received at their WTE to the mixed waste processing line. The Prairie Lakes WTE facility in Perham, Minnesota, also operates a front-end mixed waste sorting process with manual sorting to remove bulky waste detrimental to the WTE facility, a trommel screen separating into fines, containers, and overs, an eddy current separator and magnets removing metals, and recovery of cardboard. Over 1,500 tons of recyclable materials are pulled from the waste annually.

6.1.2 Mid-Level Technology MWPF

A mid-level technology MWPF processes the waste with screening equipment (such as auger screens, trommels, shakers, pneumatic screens, etc.), to help separate the mixed waste into multiple streams of fibers, containers, and fines for separate sorting lines. Sorting is usually accomplished with a mix of labor, mechanical screen and separation, magnets, and ECS. This mid-level MWPF is assumed not to include optical sorters or robotic equipment. Many MWPFs in existence prior to the development of optical and robotic equipment are similar to mid-level technology.

6.1.3 High-Level Technology MWPF

Material is usually processed through multi-stage screens to separate fiber (cardboard, newspaper, and mixed paper), plastic, metal, glass, and small contaminants. This is usually accomplished using mechanical, optical, or pneumatic screening equipment and/or labor to separate materials. Materials may be separated into size or weight classifications. Fiber is usually sorted optically or manually from elevated conveyor platforms and dropped into bunkers. Containers are processed through ferrous magnets, optical sorters, robotic sorters, manual sorting, and ECS. The fines, usually less than two inches and consisting of dirt, rocks, broken glass, ceramics, bottle caps, etc., may be further processed by magnets, ECS, and pneumatic sorting steps to recover metals, fiber, and a glass-rich stream.

Sorted material is moved from bunkers and baled (fiber, plastic, metal) or loaded directly into roll-off bins (glass, wood, scrap metal). Some MWPFs also isolate the organic fraction of the MSW stream to be used in a composting or AD process. The organic fraction can be difficult to separate from the fines. The organic fines have been used as alternative daily cover at landfills. The remaining residue material from a MWPF is shipped to a local landfill or used for another appropriate waste reduction application.

MWPFs usually recover 10 to 25 percent of the original feedstock, although some facilities have reported recovery of 50 percent or more. The optimal capacity is between 200 tons per day (TPD) and 1,500 TPD using multiple sort lines and operating multiple shifts. MWPFs can have a useful operating life of 20 to 30 years if proper maintenance is provided. Many MWPFs are retrofitted throughout their life with new processing equipment and technology, as needed.

The Newby Island Resource Recovery Park in San Jose, California shown in Figure 6-1, has infeed lines for residential single stream, commercial single stream, commercial wet recyclables, and a common container line that accepts materials from all the other streams. Incoming material can be characterized in this manner and routed to the appropriate processing system.

Figure 6-1. Newby Island Resource Recovery Park, California

Photo by Republic Services

6.2 Diversion Potential

Based on waste characterization studies prepared on behalf of the Cities of Tucson and Phoenix, some of the material disposed of as trash could be recycled using existing recycling streams. Tucson's estimated waste stream includes 14.3 percent recyclable material and approximately 40 percent organic materials. After accounting for rejects removed and process residue, construction of a MWPF would potentially divert approximately 2 to 20 percent of waste that is currently landfilled depending on the level of technology implemented. The mid-level technology and high-level technology MWPFs include multiple screens to separate out fines and organics for recovery. These organic fines are assumed to be used for alternative daily cover at the Los Reales Landfill. Typically, fines cannot be cleaned up enough for use in compost facilities.

6.3 Risk Considerations

There are several commercial-scale MWPFs operational in North America. Examples include facilities in Montgomery County, Alabama; San Jose, California; and Edmonton, Alberta, Canada. However, the current downward trend in commodity pricing has impacted the ongoing financial viability of some of these projects.

6.4 Opinion of Probable Cost

The costs for the MWPF assume that the facility will include unloading bays, a tipping floor, a processing system area, recovered material storage, remaining waste storage, a load-out area for recyclables, and load-out areas for rejects and fines. It will also include space for an office, breakrooms, restrooms, and a shop room.

The initial capital costs include site preparation, building construction, site utilities, processing equipment, artificial intelligence (AI) or optical sorters and robotics, equipment installation and startup, a dust collection system, contingency, engineering design, construction quality assurance, and permitting costs. Mobile equipment, including loaders, skid loaders, roll-off trucks and containers, forklifts, and yard tractors, is also included in the capital cost opinion. The costs are presented as a range to account for market variability factors.

Operations and maintenance costs include labor (employee salaries), utilities, maintenance and repairs of equipment, supplies, fuel, ongoing consulting and engineering services, and facility insurance. They also include cash reserves for equipment maintenance and replacement.

Residue hauling costs include driver labor, fuel costs, tires, maintenance and repairs, and truck and trailer amortization. Also included are costs for insurance, licensing, and taxes. The opinion of probable cost assumed that 2 to 7 drivers would be used to haul residue based on the estimated distances for travel and the number of trailer loads resulting from the different MWPF technology and sizing.

Estimated revenue for the MWPFs are not included in the total cost estimates. Revenue would be based on the market prices of recovered materials, including ferrous and non-ferrous materials, plastics, papers, and old corrugated cardboard (OCC). Recovered wood, concrete, dirt, carpet, mattresses, and organic fines assume net revenues of zero. Using available market values and assumptions about the composition of the recovered material, an average revenue of approximately $5 to $7 per ton processed could be considered but is not incorporated.

Table 6-1 provides the preliminary sizing considerations for the different types of MWPFs at LRSC. The opinions of probable costs for each MWPF option are provided in Table 6-2, Table 6-3, and Table 6-4. More detailed parameters and probable costs are provided in Appendix A.

Table 6-1. Preliminary sizing considerations for mixed waste processing

	Low Tech MWPF	Mid Tech MWPF	High Tech MWPF
Total Received/Processed Waste, TPY	120,700	201,400	491,500
Total Received/Processed Waste, TPD	394	658	1,606
Processed Waste, TPH	45	50	91
Processed Waste/Line/Shift, TPH	45	50	45
Percent Diversion of Waste Processed through MWPF	10.2%	27.4%	32.2%
Reduction/Diversion from Total Waste Currently Landfilled	1.5%	7.2%	20.4%
Required Land (acres)	4 to 5	5 to 7	7 to 10

Note: Table prepared by ARR/LJC and checked by EAA (11/14/2022).

Table 6-2. Low-Level Technology MWPF opinion of probable costs

	Low Range	High Range
Total Capital Costs	**$10,800,000**	**$14,900,000**
Annualized Capital Cost (4%, 20 years)	$800,000	$1,100,000
Annual O&M Costs	$2,500,000	$3,500,000
Total Annual Cost	**$3,300,000**	**$4,600,000**
Total Cost per Ton Processed ($/ton)	$27	$38
Total Cost per Ton Diverted ($/ton)	$269	$373

Note: Table prepared by ARR/LJC and checked by EAA (11/14/2022).

Table 6-3. Mid-Level Technology MWPF opinion of probable costs

	Low Range	High Range
Total Capital Costs	**$26,200,000**	**$36,400,000**
Annualized Capital Cost (4%, 20 years)	$1,900,000	$2,700,000
Annual O&M Costs	$4,600,000	$6,400,000
Total Annual Cost	**$6,500,000**	**$9,000,000**
Total Cost per Ton Processed ($/ton)	$32	$45
Total Cost per Ton Diverted ($/ton)	$114	$158

Note: Table prepared by ARR/LJC and checked by EAA (11/14/2022).

Table 6-4. High-Level Technology MWPF opinion of probable costs

	Low Range	High Range
Total Capital Costs	**$76,500,000**	**$106,300,000**
Annualized Capital Cost (4%, 20 years)	$5,600,000	$7,800,000
Annual O&M Costs	$10,300,000	$14,300,000
Total Annual Cost	$15,900,000	$22,100,000
Total Cost per Ton Processed ($/ton)	$32	$45
Total Cost per Ton Diverted ($/ton)	$97	$135

Note: Table prepared by ARR/LJC and checked by EAA (11/14/2022).

7 Waste-to-Energy

WTE is a process that produces electrical power or steam by combusting waste. WTE can substantially reduce the volume of material being sent to the landfill while also recovering energy. Volume reduction of MSW to the ash residuals is approximately 90 percent before any ash reuse, resulting in significant savings in landfill space.

The section focuses on key considerations for a WTE facility with the potential to be fully owned and operated by the City at LRSC. Responses to the LRSC RFI were received from companies that offer their own proprietary WTE technologies; however, those specific proposals were not evaluated as part of this report.

7.1 Technology Description

Thermal technologies, including WTE, are designed to convert the carbonaceous combustible materials in MSW feedstocks into electrical power or steam. Direct combustion of waste involves the complete oxidation of fuel by combustion under controlled conditions using more than stoichiometric levels of oxygen (also known as excess air combustion). The latent heat generated from the combustion process is recovered in a boiler to generate steam, which can be used directly for heating/industrial purposes or passed through a steam turbine generator to create electricity.

MSW is fed directly into a boiler system with little to no pre-processing other than the removal of large bulky items such as furniture. MSW is typically pushed onto a grate by a ram connected to hydraulic cylinders where it is combusted. Air is admitted under the grates into the bed of material, and additional air is supplied above the grates to thoroughly complete combustion of the MSW. The resulting flue gases pass through the boiler, and the heat energy is recovered in the boiler tubes to generate steam. This creates three streams of material: steam, flue gases, and ash.

Direct combustion technologies have a long history of reliable commercial-scale operation and are flexible enough to handle a variety of feedstocks with little to no pre-processing requirements. The benefits of this technology include local energy production and potential uses of the byproducts, which include ferrous metals, nonferrous metals, and in some cases, may include the use of ash as landfill daily cover. Ash is also typically disposed of in monofills. Developing the technology can create construction jobs over one to three years of construction and 40 to 80 permanent jobs over the life of the project. This technology generally requires a large waste stream (200,000 tons per year or more) to be economically beneficial. Normally the feedstock is municipal solid waste, but most combustible wastes can be processed. In addition, although the technology recycles and re-uses water on-site, it also requires a moderate use of water.

Direct combustion technologies with energy recovery have been used since the 1950s. The technology was first introduced to the United States in the 1970s, and many of the facilities currently in operation have been online for 25 to 40 years. WTE is the most widely demonstrated and commercially viable of the thermal conversion technologies available. There are approximately 4,000 WTE facilities worldwide and over 70 in the United States.

Few new WTE plants have been constructed since the 1990s in North America, but several existing WTE facilities in Minnesota, Florida, and Hawaii have undergone recent expansions. Two new greenfield facilities have been constructed using modern WTE combustion technology. These include a 3,000 TPD mass burn facility in West Palm Beach, Florida (2015) and a 480 TPD mass burn facility in Clarington, Ontario, Canada (Durham York Region, 2015), shown in Figure 7-1.

Figure 7-1. Durham York Energy Center, Ontario, Canada

Photo by HDR

7.2 Diversion Potential

The diversion from WTE technology is a result of the weight and volume reduction of material going to the landfill. The weight (in tons) of the original waste is reduced by approximately 75 percent. However, not all materials received at the WTE facility are appropriate for WTE, and an estimated 5 percent of material received would be rejected at the facility and landfilled. Metals may be recovered from the waste stream before and after WTE processing to increase diversion. Overall, the construction of a WTE facility is anticipated to result in a 57 percent reduction by weight of waste currently sent to the landfill.

7.3 Risk Considerations

WTE can result in the release of impurities and constituent air emissions. Thermal technologies can yield gases such as CO_2, water vapor, nitrogen oxides (NO_x), sulfur oxides (SO_x); hydrogen chloride (HCl), particulate and particulate-related emissions (such as heavy metals), and trace amounts of products of incomplete combustion, such as carbon monoxide (CO), dioxins, and furans. The quantities vary depending on the type of technology and must be controlled or removed through refining or cleaning.

Emission control systems are required to reduce emissions from WTE below any regulatory emission standards. The most common examples of air pollution control equipment used at traditional WTE facilities include NO_x emissions control technology (various forms of selective catalytic reduction or selective non-catalytic reduction), spray dryer absorbers or dry sorbent scrubbers for acid gas reduction, activated carbon injection for mercury and dioxins reduction, and a fabric filter baghouse for particulate and heavy metals removal.

WTE facilities tend to have high capital and operating costs, particularly for smaller-scale facilities. The current low pricing for electricity and natural gas makes the energy produced from these technologies (steam and/or electricity) of low value. Steam is only valuable if there are industries within approximately one mile that want to utilize the steam. This technology produces an ash residue stream of approximately 25 to 30 percent by weight of the incoming waste stream; however, development efforts are underway to utilize portions of the ash stream.

One of the major concerns with WTE is that the technology is often described publicly as “burning garbage” and can be perceived by the public as not environmentally friendly or sustainable.

7.4 Opinion of Probable Cost

The costs for the WTE facility assume that the facility will include unloading bays, space for interior maneuvering, a pit for waste storage, a tipping floor, WTE combustion units, air pollution control equipment, stack, steam generation auxiliaries, and a turbine generator room. It also includes an ash management building.

The initial capital costs include the construction of a WTE facility, contingency, engineering design and commissioning, construction quality assurance, and permitting. Mobile equipment, including loaders, skid loaders, roll-off trucks and containers, and dump trucks, to haul ash to on-site landfill. The costs are presented as a range to account for market variability factors.

Operations and maintenance costs include labor (employee salaries), utilities, maintenance and repairs of equipment, consumables, supplies, fuel, contingency, ongoing consulting and engineering services, and facility insurance. They also include cash reserves for equipment maintenance and replacement.

Hauling costs for the short ash haul include driver labor, fuel costs, tires, maintenance and repairs, and dump trucks amortization. It also includes the cost of insurance, license, and taxes. If the facility was located offsite, haul costs would be higher.

As with other facility estimates, disposal costs are not included in the total costs. Ash residue could be placed separately in a dedicated monofill cell separate from MSW. WTE ash residue in northeastern states have also been used for alternative daily cover, which would reduce disposal costs.

Estimated revenue for the WTE facility is not included in the total estimates. Revenue would be based on the market prices of recovered materials, including ferrous and non-ferrous materials, and revenues from energy generation. For example, if approximately 395,000,000 net kilowatt-hours of electricity were to be generated during the first year of operation and sold at 6 cents per kilowatt-hour, the cost per ton processed could be offset by $37 per ton. Revenue from recovered materials may be able to increase this to over $40 per ton. As market rates are variable, this should not be considered as guaranteed, particularly in early planning stages.

Table 7-1 provides the preliminary sizing considerations for a WTE facility at LRSC. The opinions of probable costs are provided in Table 7-2. More detailed parameters and probable costs are provided in Appendix A.

Table 7-1. Preliminary sizing considerations for waste-to-energy

	WTE
Total Received/Processed Waste, TPY	639,300
Total Received/Processed Waste, TPD	2,089
Percent Reduction/Diversion of Waste Processed through WTE Facility	71%
Reduction/Diversion from Total Waste Currently Landfilled	57%
Required Land (acres)	7 to 12

Note: Table prepared by ARR/LJC and checked by EAA (11/14/2022).

Table 7-2. Waste-to-energy opinion of probable costs

	Low Range	High Range
Total Capital Costs	**$789,100,000**	**$1,096,000,000**
Annualized Capital Cost (4%, 20 years)	$58,100,000	$80,600,000
Annual O&M Costs	$28,100,000	$39,000,000
Total Annual Cost	**$86,100,000**	**$119,600,000**
Total Cost per Ton Processed ($/ton)	$135	$187
Total Cost per Ton Diverted ($/ton)	$189	$263

Note: Table prepared by ARR/LJC and checked by EAA (11/14/2022).

8 Single Stream Recyclables Processing Considerations

The Hudson Baylor MRF was contracted in 2012 with a 15-year contract with the City. The facility was originally designed to process more than 40,000 tons of recyclable materials per year. Hudson Baylor was acquired by ReCommunity early in the contract term, and in 2017, Republic acquired the MRF and the operating contract to process the single-stream recyclables collected by the City from its residential and commercial customers through June 2027. The MRF also serves other communities and haulers in the region. Materials accepted by the MRF consist of OCC, old newsprint (ONP), other paper (MP), aluminum (UBC), tin, other metal, various plastics including polyethylene terephthalate bottles (PET), high-density polyethylene natural bottles (HDPE-N) and pigmented bottles (HDPE-C), #5 plastics (PP), rigid plastics, and glass. [17] Although glass is accepted at the MRF, the City stopped accepting glass in its collection program in February 2021. In lieu of curbside collection, the City offers source-separated collection bins where residents can drop off their glass to be recycled as part of a different City program.

The City is interested in opportunities to lower the contamination in the recyclables it collects, as well as increase the capture of recyclable commodities. Contamination is a costly issue for the City, as Republic Services charges the City an excess contamination charge (residue charge) of $1 per ton for each percentage point above 18.7 percent contamination. In 2021, Republic processed just under 30,000 tons of recyclables from the City of Tucson, and the contamination rate was estimated to be 29 percent. This resulted in an additional cost to the City of $314,085.[18]

MRF technology has been rapidly advancing in recent years with the advent of better optical sorters, sorting screens, robotics, and AI. At the same time, the physical properties of recyclables have greatly changed. Some examples of these changes include the significant reduction in the quantity of newspaper while cardboard has generally increased, lightweighting of plastic bottles, and increased variability of sizes, shapes, and properties of all types of containers and recyclables. Equipment and sorting systems that are designed for a particular feedstock composition and characteristics will not perform as well when the feedstock changes. Equipment also wears out, with some items, particularly electronics, sensors, and controls, becoming obsolete over time. As a general rule of thumb, a state-of-the-art MRF has the potential to see significant improvements in performance when assessed and upgraded after about ten years of operation, if not sooner.

The Recycling Partnership (Partnership) lists improving MRF infrastructure as one of the key things that can be done to increase the capture of recyclables. The Partnership launched the Aluminum Can Capture MRF Grant Program in 2020, citing research from the Can Manufacturers Institute that found up to 25 percent of aluminum beverage cans are missorted at a typical MRF. The grant program invests in eddy current separators,

[17] Governmental Advisory Associates. 2016-2017 Database on Material Recovery Facilities and Mixed Waste Processing Facilities in the United States, with 2019 updates.

[18] Based on the “Tons and Revenue MRF Report thru FY2021,” provided by Republic Services to the City.

robotic sorters, other equipment, and process improvements for grant recipients. The Partnership's Polypropylene Recycling Coalition also provides grants for sorting equipment at MRFs.[19]

Republic has implemented some level of upgrades at the facility since assuming ownership in 2017, with the most recent improvement being a new OCC screen designed to improve the capture of the increasing quantity of cardboard in the feedstock.[20] The Republic MRF may still have a lot of potential for improved performance. In order to determine how much potential, a coordinated assessment, and review of the MRF, with both the City and Republic participating, will be required. Often this analysis is best completed by a third party since both capital and operating costs will be impacted.

The following discussion addresses some of the more common potential options that could be implemented at a MRF commissioned approximately 8 to 10 years ago, similar to the commission date of the Republic MRF. These are derived from HDR industry knowledge, as no assessments specific to the Republic MRF have been performed at this time. All of the concepts discussed below are intended to increase efficiency by increasing throughput, reducing contamination, and improving commodity quality or both, and thus advance the City's Zero Waste Goals. Which options are determined to be cost-effective will vary based upon the facility constraints, regional commodity markets, and other factors.

- Optical sorting technology has improved in the last ten years, allowing better recognition of the target materials and better arrangements that do not require as much maintenance to sustain performance. Optical sorters have the potential to capture the desired commodities much more cost-effectively than manual sorters or first-generation optical sorters. In addition, the technology's capability, experience, and processing techniques with more types of commodities, such as fiber materials, have greatly improved, improving commodity quality while using fewer manual sorters and less quality control.
- Glass breakers and cleaning systems today do a better job of separating glass from other commodities and producing a marketable product while increasing glass recycling throughput. However, glass recovery should be reviewed carefully, weighing the diversion potential, glass quality, and the cost of source separation, as well as the potential cost for shipping to buyers and commodity price potential.
- Newer screening technology may be able to eliminate or reduce the need for presorting stations. Presorting is designed to remove materials that might damage downstream equipment and injury operators. Removing oversized materials is also an injury-prone task exposing workers to strains, cuts, and abrasions, as well as hidden needles and other hazards. New screening technology is capable of scalping the larger materials from smaller ones so both streams can be managed more safely and with less manpower.

[19] "Impact Report 2022." The Recycling Partnership. Released in 2022. recyclingpartnership.org/impact.
[20] Republic Services. RFI Response submitted by Republic Services of Arizona Hauling, LLC, dba Republic Services, Tucson. June 30, 2022.

- A review of potential markets for film plastics and other harder to recycle plastics could be completed. If markets do exist, recovery of these materials could increase the range of acceptable materials at the MRF and increase the diversion potential while reducing residue and contamination.
- Usually, producing high-quality single-class plastics (e.g., Number 1 or Number 2) and metals is the most effective and commands the highest commodity price. However, the lack of nearby markets may raise shipping costs and mean the effort to make a single commodity bale is not cost-effective, particularly for lower-value commodities. For instance, it may or may not be cost-effective to capture Number 5 PP separately from mixed Number 3, 4, 6, and 7 plastics and film plastic. An alternative approach may be to determine if there is a demand for mixed plastic or mixed metal containers at another processing facility. An analysis evaluating whether a simplified sorting system that provides feedstock for that facility outweighs the benefits of a more sophisticated system could be completed.
- Robotics and AI have improved and may be suitable for certain quality control applications. One example is removing impurities from key commodities such as UBC, PET, and HDPE so these higher-value commodities command a higher price or avoid quality deductions. These technologies may also be used on residue lines to not only make a last-chance recovery of commodities missed earlier on the sorting line but also to monitor system performance by providing an advanced notice that something might be wrong with the sorting equipment. The improved access to performance information can be used to identify and evaluate other system improvements and to demonstrate to local residents the benefits of recycling and avoiding placing the wrong materials with their recyclables.

These types of improvement considerations require a capital investment but should be weighed against reduced operating costs, as the number of sorters are reduced while improving commodity quality and processing capacity. The upgrades may require substantial re-design of the sorting line and potentially a shutdown for certain key changes that may mean recyclables need to be diverted for a short time.

A potential opportunity might be possible if the City develops a MWPF. While a MWPF likely will not be able to effectively recover each type of traditional recyclable individually from mixed waste, it may be possible to collectively concentrate containers of all types and/or fiber or other recyclables as a “synthetic single stream mix” that could then be resorted at the MRF using some of the facility’s excess capacity and automation to then sort by commodity in a system designed for the task.

Some of the residue that currently contaminates the recyclables processing system might be turned into a fuel product if a suitable market can be identified. These materials might be combined with some of the other materials recovered from the MWPF. For instance, it may be possible to provide a plastic film collection system designed to recover film plastics. These materials and possibly some other hard-to-recycle plastics could be jointly marketed with film plastic and other plastics recovered from the MWPF. Fines recovered from a glass cleanup system may be suitable for use as feedstock for an AD system. However, these and other residual material processing systems are emerging technologies that are not yet well-established commercially in the U.S. yet.

9 Comparison of Technology Options

The technologies reviewed in this report may be used individually or in combination to increase diversion at the LRSC. Technologies with a range of levels (low to high) can be implemented in phases in order to reduce costs and startup times while still allowing for expansion and upgrades as new or improved feedstock collection programs are established.

The high-level estimates for diversion, land requirements, and probable cost are meant to inform the City's decision on which options should be further evaluated for implementation or construction. For each option, Table 9-1 shows the percentage of processed waste diverted at each individual facility, as well as the corresponding level of diversion from the total waste projected to be sent to disposal at LRSC under the current waste management system. Total capital (startup) costs and annual costs (amortized capital costs, annual operations and maintenance cost, and annual residue hauling cost) are presented for the operating capacities assumed for each option. Annualized capital costs were estimated by amortizing the capital costs over 20 years at an assumed 4 percent interest rate. Estimated ranges of costs per ton of waste processed were developed based on the assumed processing capacity. Estimated ranges of costs per ton of waste diverted represent the cost of using each facility type to remove one ton of waste from a waste stream that is currently sent to disposal at the landfill. Costs do not include collection costs, only costs incurred to operate the facility itself. More details for the opinions of probable costs for each technology can be found in their respective report sections and in Appendix A.

Organic materials make up a large portion of the waste fraction, and the City may elect to use mulching, composting, anaerobic digestion, or some combination of the three. These technologies result in approximately 7 percent diversion from landfill for dry AD or approximately 16 to 18 percent diversion for active aerobic composting. Various combinations of AD and composting technologies were not explored in the scope of this report but could be expected to obtain a similar total diversion rate to the 18 percent from ASP composting. However, estimates assumed that not all the organic waste generated would be directed to the composting or AD facility; if more material was diverted through mandatory collection programs or due to increasing outreach and education, the diversion percentage could potentially increase. Organic waste processing also produces either compost or digestate that could be sold or provided to citizens for beneficial use. AD is a technology that has a slightly smaller footprint, which may be useful if multiple technologies are implemented at the LRSC. However, AD has higher startup and O&M costs compared to composting. AD is more feasible when there are higher volumes of industrial food waste sources in the region that can no longer take their materials to the public wastewater treatment plant or other outlets.

Mixed waste processing has the potential to divert from 2 to 20 percent of waste currently going to the landfill, depending on the level of investment in processing technology. All of the MWP options have a high cost per ton of waste diverted, though there is the potential to offset that with revenue from the recycling markets, which have been volatile. MWP uses established recycling markets, which may be an advantage.

Waste characterization studies prepared on behalf of the Cities of Phoenix and Tucson have suggested that there is a high percentage of recyclable materials in the waste stream, and MWP provides an opportunity to capture those.

C&D materials recovery is estimated to divert approximately 4 to 6 percent of waste currently going to the landfill, depending on the level of investment in sorting technology. Though limited in the total amount of potential diversion, the low-level and mid-level technology levels of C&D waste processing have lower capital costs, and lower costs per ton diverted than many of the other processing technology options. There are established markets for some C&D materials that may offset some of the costs. Co-locating a C&D facility on the LRSC could capture and divert heavy materials.

The technology that individually represents the highest diversion is waste-to-energy, with a diversion/reduction of 57 percent from landfill. Most of the diversion is the result of a reduction in volume after combustion. The byproduct of the WTE process is ash and would need to be disposed. WTE is also the most expensive technology to implement and operate, with an approximate capital cost of $790 million to $1.1 billion and an annual operating cost of approximately $135 to $187 per ton processed. WTE has potential to offset some of the cost with revenues due to metals recovered during processing and energy revenues, but the revenues could be variable and do not fully offset the O&M costs. Revenues also depend on partnering with other entities or utilities to use the energy generated by the WTE process.

The recommended next step is to determine which individual or combinations of processing technologies should be further evaluated for implementation at the LRSC. Further evaluations may be part of the development of the Zero Waste Plan and should include more refined planning and design based on additional information sources such as additional waste composition data, potential changes to collection services or other programs affecting feedstock quantity and quality, specific site locations, and utility availability. These may lead to or be performed in conjunction with Requests for Proposals from vendors offering specific types of processing technologies and/or operating agreements.

Table 9-1. Technology summary (Opinion of Costs presented in million dollars)

Technology	Processing Capacity (TPY)	Diversion Potential		Total Capital Costs ($ Million)		Total Annual Costs ($ Million)[3]		Cost per Ton Processed ($/Ton)[3]		Cost per Ton Diverted ($/Ton)[3]	
		Percent Diversion of Feedstock at Each Facility[1]	Percent Diversion of Total Waste Streams to Landfill[2]	Low	High	Low	High	Low	High	Low	High
Organics Processing Options											
Windrow Composting	132,000	95%	16%	$12.9	$17.9	$2.8	$3.9	$21	$30	$23	$31
ASP Composting	150,600	95%	18%	$30.0	$41.6	$4.9	$6.8	$32	$45	$34	$47
Dry Anaerobic Digestion	70,700	82%	7%	$50.1	$69.6	$7.8	$10.8	$110	$153	$135	$187
C&D Waste Processing Options											
C&D Pad & Bunkers	33,600	86%	4%	$1.3	$1.9	$0.9	$1.2	$27	$37	$31	$43
C&D Sorting System	47,000	76%	4%	$4.8	$6.7	$1.8	$2.6	$39	$55	$52	$72
C&D Mixed Waste Processing	67,100	71%	6%	$27.4	$38.1	$5.1	$7.1	$76	$106	$107	$148
Mixed Waste Processing Options											
Low Tech MWPF	120,700	10%	2%	$10.8	$14.9	$3.3	$4.6	$27	$38	$269	$373
Mid Tech MWPF	201,400	27%	7%	$26.2	$36.4	$6.5	$9.0	$32	$45	$114	$158
High Tech MWPF	491,500	32%	20%	$76.5	$106.3	$15.9	$22.1	$32	$45	$97	$135
Waste-To-Energy											
Waste-To-Energy Facility	639,300	71%	57%	$789.1	$1,096.0	$86.1	$119.6	$135	$187	$189	$263

Note: Table prepared by ARR/LJC and checked by EAA (11/14/2022).

[1] This represents the percentage of each facility's feedstock that is expected to be diverted from disposal by being processed through the facility.

[2] This represents the percentage of total waste currently being sent to disposal at Los Reales Landfill that would be diverted by the operation of the facility.

[3] Annual costs and costs per ton do not include the disposal costs for rejects and process residue, or potential revenues from tipping fees, recovered materials or energy. Potential revenues could lower the net cost per ton. Costs to haul the rejects and process residue are included. Additional disposal costs would increase the net cost per ton.

Appendix A. Opinions of Probable Cost

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Composting Cost Summary

	Turned Windrow	ASP
Sizing Considerations	**Year 2030**	**Year 2030**
Operating days per year	306	306
Total Waste to LRSC, TPY	799,000	799,000
Total Received/Processed Waste, TPY	132,000	150,600
Total Received/Processed Waste, TPD	431	492
Total Diverted Waste, TPY	125,400	143,070
Total Diverted Waste, TPD	410	468
Percent Diversion from Processed Waste	95%	95%
Reduction/Diversion from Total Waste Landfilled	16%	18%
Receiving & Preprocessing Building Size (SF)	0	24,900
Required Land, Including Buffer (Acres)	28	23
Opinion of Probable Cost (rounded to nearest $1,000)		
Capital Costs		
Site Preparation, Utilities, and Construction	$8,100,000	$2,300,000
Receiving & Preprocessing Building	$0	$5,000,000
ASP System	$0	$15,400,000
Subtotal Capital Costs	**$8,100,000**	**$22,700,000**
Contingency for Site Improvements (20%)	$1,600,000	$4,500,000
Soft Costs (Eng., Design, Constr. Admin & CQA) (12%)	$1,000,000	$2,700,000
Mobile Equipment	$3,700,000	$3,400,000
Total Capital Costs	**$14,300,000**	**$33,300,000**
Annual O&M Costs		
Labor (7 FTE for Windrow, 9 FTE for ASP)	$600,000	$800,000
Utilities	$100,000	$300,000
Additional Operations and Maintenance Costs	$400,000	$900,000
Subtotal Annual Direct Operations Costs	**$1,100,000**	**$1,900,000**
Operations Contingency (10%)	$100,000	$200,000
Annual Cash Reserves	$900,000	$800,000
Annual Hauling Costs	$50,000	$60,000
Total Annual O&M Cost	**$2,100,000**	**$3,000,000**
Total Costs		
Annualized Capital Cost (4%, 20 yrs.)	$1,100,000	$2,500,000
Annual O&M Costs	$2,100,000	$3,000,000
Total Annual Cost	**$3,100,000**	**$5,400,000**
Total Cost per Ton Processed ($/ton)	**$24**	**$36**
Total Cost per Ton Diverted ($/ton)	**$25**	**$38**

Composting Cost Summary (Continued)

Total Opinion of Probable Annual Cost Range		
Low (-10%)	**$2,800,000**	**$4,900,000**
High (+25%)	**$3,900,000**	**$6,800,000**
Total Opinion of Probable Cost per Ton Processed Range		
Low (-10%)	**$21**	**$32**
High (+25%)	**$30**	**$45**
Total Opinion of Probable Cost per Ton Diverted Range		
Low (-10%)	**$23**	**$34**
High (+25%)	**$31**	**$47**

Anaerobic Digestion (Dry, High Solids) Cost Summary

Sizing Considerations	Year 2030
Operating days per year	306
Total Waste to LRSC, TPY	799,000
Total Received/Processed Waste, TPY	70,700
Total Received/Processed Waste, TPD	231
Total Diverted Waste, TPY	58,000
Total Diverted Waste, TPD	190
Percent Diversion from Processed Waste	82%
Reduction/Diversion from Total Waste Landfilled	7%
Receiving & Preprocessing Building Size (SF)	20,200
Digester System Size (SF)	18,900
Required Land, Including Buffer (Acres)	4
Opinion of Probable Cost (rounded to nearest $100,000)	
Capital Costs	
Site Preparation, Utilities, and Construction	$1,800,000
Anaerobic Digester Building	$4,200,000
Anaerobic Digester Equipment	$38,500,000
Subtotal Capital Costs	**$44,500,000**
Contingency for Site Improvements (20%)	$1,200,000
Contingency for Anaerobic Digester Equipment (10%)	$3,900,000
Soft Costs (Eng., Design, Constr. Admin & CQA) (12%)	$5,300,000
Mobile Equipment	$800,000
Total Capital Costs	**$55,700,000**
Annual O&M Costs	
Labor (4 FTE)	$400,000
Utilities	$100,000
Additional Operations and Maintenance Costs	$700,000
Subtotal Annual Direct Operations Costs	**$1,100,000**
Operations Contingency (10%)	$100,000
Annual Cash Reserves	$3,200,000
Annual Hauling Costs	$100,000
Total Annual O&M Cost	**$4,600,000**
Total Costs	
Annualized Capital Cost (4%, 20 yrs.)	$4,100,000
Annual O&M Costs	$4,600,000
Total Annual Cost	**$8,700,000**
Total Cost per Ton Processed ($/ton)	**$123**
Total Cost per Ton Diverted ($/ton)	**$150**

Anaerobic Digestion (Dry, High Solids) Cost Summary (Continued)

Total Opinion of Probable Annual Cost Range	
Low (-10%)	**$7,800,000**
High (+25%)	**$10,800,000**
Total Opinion of Probable Cost per Ton Processed Range	
Low (-10%)	**$110**
High (+25%)	**$153**
Total Opinion of Probable Cost per Ton Diverted Range	
Low (-10%)	**$135**
High (+25%)	**$187**

C&D Cost Summary

	Low Tech C&D Pad & Bunkers	Mid Tech C&D Sorting System	High Tech C&D MWPF
Sizing Considerations	**Year 2030**	**Year 2030**	**Year 2030**
Operating days per year	306	306	306
Total Waste to LRSC, TPY	799,000	799,000	799,000
Total Received/Processed Waste, TPY	33,600	47,000	67,100
Total Received/Processed Waste, TPD	110	154	219
Processed Waste, TPH	-	-	26
Processed Waste/Line/Shift, TPH	-	-	26
Total Diverted Waste, TPY	28,730	35,720	47,810
Total Diverted Waste, TPD	94	117	156
Percent Diversion from Processed Waste	86%	76%	71%
Reduction/Diversion from Total Waste Landfilled	4%	4%	6%
Building and/or Canopy Size (SF)	0	4,000	44,000
Required Land, Including Buffer (Acres)	7	7	9
Opinion of Probable Cost (rounded to nearest $100,000)			
Capital Costs			
Site Preparation, Utilities, and Construction	$500,000	$900,000	$2,300,000
Building and/or Canopy	$0	$200,000	$10,300,000
Sorting Equipment	$0	$2,400,000	$9,600,000
Subtotal Capital Costs	**$500,000**	**$3,500,000**	**$22,200,000**
Contingency for Site Improvements (20%)	$100,000	$700,000	$4,400,000
Soft Costs (Eng., Design, Constr. Admin & CQA) (17% for Low, 12% for Mid and High)	$100,000	$400,000	$2,700,000
Mobile Equipment	$800,000	$800,000	$1,100,000
Total Capital Costs	**$1,500,000**	**$5,400,000**	**$30,500,000**
Annual O&M Costs			
Labor (6 FTE for Low, 13 FTE for Mid, 12 FTE for High)	$500,000	$900,000	$1,000,000
Utilities	$1,000	$10,000	$100,000
Additional Operations and Maintenance Costs	$200,000	$200,000	$600,000
Subtotal Annual Direct Operations Costs	**$600,000**	**$1,000,000**	**$1,700,000**
Operations Contingency (10%)	$100,000	$100,000	$200,000
Annual Cash Reserves	$200,000	$400,000	$1,500,000
Annual Hauling Costs	$30,000	$40,000	$60,000
Total Annual O&M Cost	**$900,000**	**$1,700,000**	**$3,400,000**
Total Costs			
Annualized Capital Cost (4%, 20 yrs.)	$110,000	$400,000	$2,200,000
Annual O&M Costs	$900,000	$1,700,000	$3,400,000
Total Annual Cost	**$1,000,000**	**$2,000,000**	**$5,700,000**
Total Cost per Ton Processed ($/ton)	**$30**	**$44**	**$85**
Total Cost per Ton Diverted ($/ton)	**$35**	**$57**	**$119**

C&D Cost Summary (Continued)

	Low Tech C&D Pad & Bunkers	Mid Tech C&D Sorting System	High Tech C&D MWPF
Total Opinion of Probable Annual Cost Range			
Low (-10%)	$900,000	$1,800,000	$5,100,000
High (+25%)	$1,200,000	$2,600,000	$7,100,000
Total Opinion of Probable Cost per Ton Processed Range			
Low (-10%)	$27	$39	$76
High (+25%)	$37	$55	$106
Total Opinion of Probable Cost per Ton Diverted Range			
Low (-10%)	$31	$52	$107
High (+25%)	$43	$72	$148

Mixed Waste Processing Facility Cost Summary

	Low Tech MWPF	Mid Tech MWPF	High Tech MWPF
Sizing Considerations	**Year 2030**	**Year 2030**	**Year 2030**
Operating days per year	306	306	306
Total Waste to LRSC, TPY	799,000	799,000	799,000
Total Received Waste at MWPF, TPY	120,700	201,400	491,500
Total Received Waste at MWPF, TPD	394	658	1,606
Processed Waste, TPH*	45	50	91
Processed Waste/Line/Shift, TPH*	45	50	45
Total Diverted Waste, TPY	12,340	57,270	163,140
Total Diverted Waste, TPD	40	187	533
Percent Diversion from Received/Processed Waste	10.2%	27.4%	32.2%
Reduction/Diversion from Total Waste Landfilled	1.5%	7.2%	20.4%
Building Size (SF)	22,000	40,000	108,000
Required Land, Including Buffer (Acres)	4	5	9
Opinion of Probable Cost (rounded to nearest $100,000)			
Capital Costs			
Site Preparation, Utilities, and Construction	$1,100,000	$1,900,000	$2,300,000
Building and/or Canopy	$2,200,000	$9,500,000	$24,600,000
Sorting Equipment	$4,800,000	$9,600,000	$36,000,000
Subtotal Capital Costs	**$8,100,000**	**$21,000,000**	**$62,900,000**
Contingency for Site Improvements (20%)	$1,600,000	$4,200,000	$12,600,000
Soft Costs (Eng., Design, Constr. Admin & CQA) (17% for Low, 12% for Mid and High)	$1,400,000	$2,500,000	$7,600,000
Mobile Equipment	$800,000	$1,500,000	$2,000,000
Total Capital Costs	**$11,900,000**	**$29,200,000**	**$85,000,000**
Annual O&M Costs			
Labor (16 FTE for Low, 24 FTE for Mid, 40 FTE for High)	$1,100,000	$1,800,000	$3,200,000
Utilities	$100,000	$100,000	$300,000
Additional Operations and Maintenance Costs	$400,000	$900,000	$1,800,000
Subtotal Annual Direct Operations Costs	**$1,600,000**	**$2,800,000**	**$5,200,000**
Operations Contingency (10%)	$200,000	$300,000	$500,000
Annual Cash Reserves	$800,000	$1,600,000	$4,600,000
Annual Hauling Costs	$300,000	$400,000	$1,100,000
Total Annual O&M Cost	**$2,800,000**	**$5,100,000**	**$11,400,000**

Mixed Waste Processing Facility Cost Summary (Continued)

	Low Tech MWPF	Mid Tech MWPF	High Tech MWPF
Total Costs			
Annualized Capital Cost (4%, 20 yrs.)	$900,000	$2,100,000	$6,300,000
Annual O&M Costs	$2,800,000	$5,100,000	$11,400,000
MWP Facility Annual Cost	**$3,700,000**	**$7,200,000**	**$17,700,000**
Total Cost per Ton Processed ($/ton)	**$31**	**$36**	**$36**
Total Cost per Ton Diverted ($/ton)	**$299**	**$126**	**$108**
Total Opinion of Probable Annual Cost Range			
Low (-10%)	**$3,300,000**	**$6,500,000**	**$15,900,000**
High (+25%)	**$4,600,000**	**$9,000,000**	**$22,100,000**
Total Opinion of Probable Cost per Ton Processed Range			
Low (-10%)	**$27**	**$32**	**$32**
High (+25%)	**$38**	**$45**	**$45**
Total Opinion of Probable Cost per Ton Diverted Range			
Low (-10%)	**$269**	**$114**	**$97**
High (+25%)	**$373**	**$158**	**$135**

*Note: Assumes 2 shifts and 2 process lines, with 16-hour days.

Waste-to-Energy Cost Summary

Sizing Considerations	Year 2030
Operating days per year	306
Total Waste to LRSC, TPY	799,000
Total Received/Processed Waste, TPY	639,300
Total Received/Processed Waste, TPD	2,089
Total Diverted Waste, TPY	455,400
Total Diverted Waste, TPD	1,488
Percent Diversion from Received/Processed Waste	71%
Reduction/Diversion from Total Waste Landfilled	57%
Building Size (SF)	101,100
Required Land, Including Buffer (Acres)	12
Opinion of Probable Cost (rounded to nearest $100,000)	
Capital Costs	
WTE Facility, Site Preparation, Utilities, and Construction	$700,000,000
Contingency for Site Improvements (20%)	$140,000,000
Soft Costs (Permitting and Owner's Engineer) (5%)	$35,000,000
Mobile Equipment	$1,800,000
Total Capital Costs	**$876,800,000**
Annual O&M Costs	
Labor (50 FTE)	$5,300,000
Utilities	$200,000
Additional Operations and Maintenance Costs	$14,000,000
Subtotal Annual Direct Operations Costs	**$19,600,000**
Operations Contingency (10%)	$2,000,000
Annual Cash Reserves	$9,200,000
Annual Hauling Costs	$500,000
Total Annual O&M Cost	**$31,200,000**
Total Costs	
Annualized Capital Cost (4%, 20 yrs.)	$64,500,000
Annual O&M Costs	$31,200,000
Total Annual Cost	**$95,700,000**
Total Cost per Ton Processed ($/ton)	**$150**
Total Cost per Ton Diverted ($/ton)	**$210**

Waste-to-Energy Cost Summary (Continued)

Total Opinion of Probable Annual Cost Range	
Low (-10%)	**$86,100,000**
High (+25%)	**$119,600,000**
Total Opinion of Probable Cost per Ton Processed Range	
Low (-10%)	**$135**
High (+25%)	**$187**
Total Opinion of Probable Cost per Ton Diverted Range	
Low (-10%)	**$189**
High (+25%)	**$263**

Appendix B. Environmental Justice Snapshot Reports

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EJScreen Report (Version 2.1)

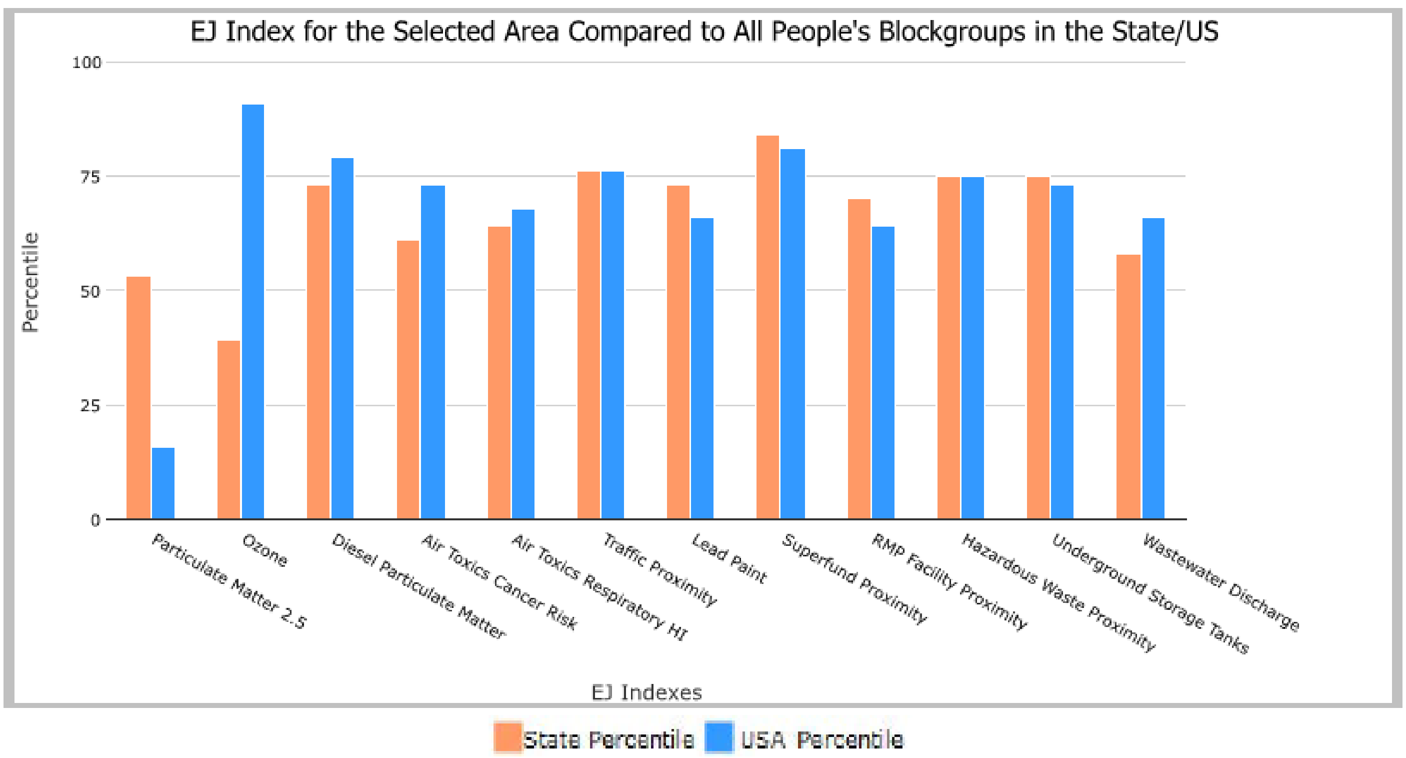
10 miles Ring Centered at 32.121054,-110.886556, ARIZONA, EPA Region 9

Approximate Population: 505,795

Input Area (sq. miles): 314.03

Los Reales Landfill (The study area contains 2 blockgroup(s) with zero population.)

Selected Variables	State Percentile	USA Percentile
Environmental Justice Indexes		
EJ Index for Particulate Matter 2.5	53	16
EJ Index for Ozone	39	91
EJ Index for Diesel Particulate Matter*	73	79
EJ Index for Air Toxics Cancer Risk*	61	73
EJ Index for Air Toxics Respiratory HI*	64	68
EJ Index for Traffic Proximity	76	76
EJ Index for Lead Paint	73	66
EJ Index for Superfund Proximity	84	81
EJ Index for RMP Facility Proximity	70	64
EJ Index for Hazardous Waste Proximity	75	75
EJ Index for Underground Storage Tanks	75	73
EJ Index for Wastewater Discharge	58	66



This report shows the values for environmental and demographic indicators and EJSCREEN indexes. It shows environmental and demographic raw data (e.g., the estimated concentration of ozone in the air), and also shows what percentile each raw data value represents. These percentiles provide perspective on how the selected block group or buffer area compares to the entire state, EPA region, or nation. For example, if a given location is at the 95th percentile nationwide, this means that only 5 percent of the US population has a higher block group value than the average person in the location being analyzed. The years for which the data are available, and the methods used, vary across these indicators. Important caveats and uncertainties apply to this screening-level information, so it is essential to understand the limitations on appropriate interpretations and applications of these indicators. Please see EJSCREEN documentation for discussion of these issues before using reports.

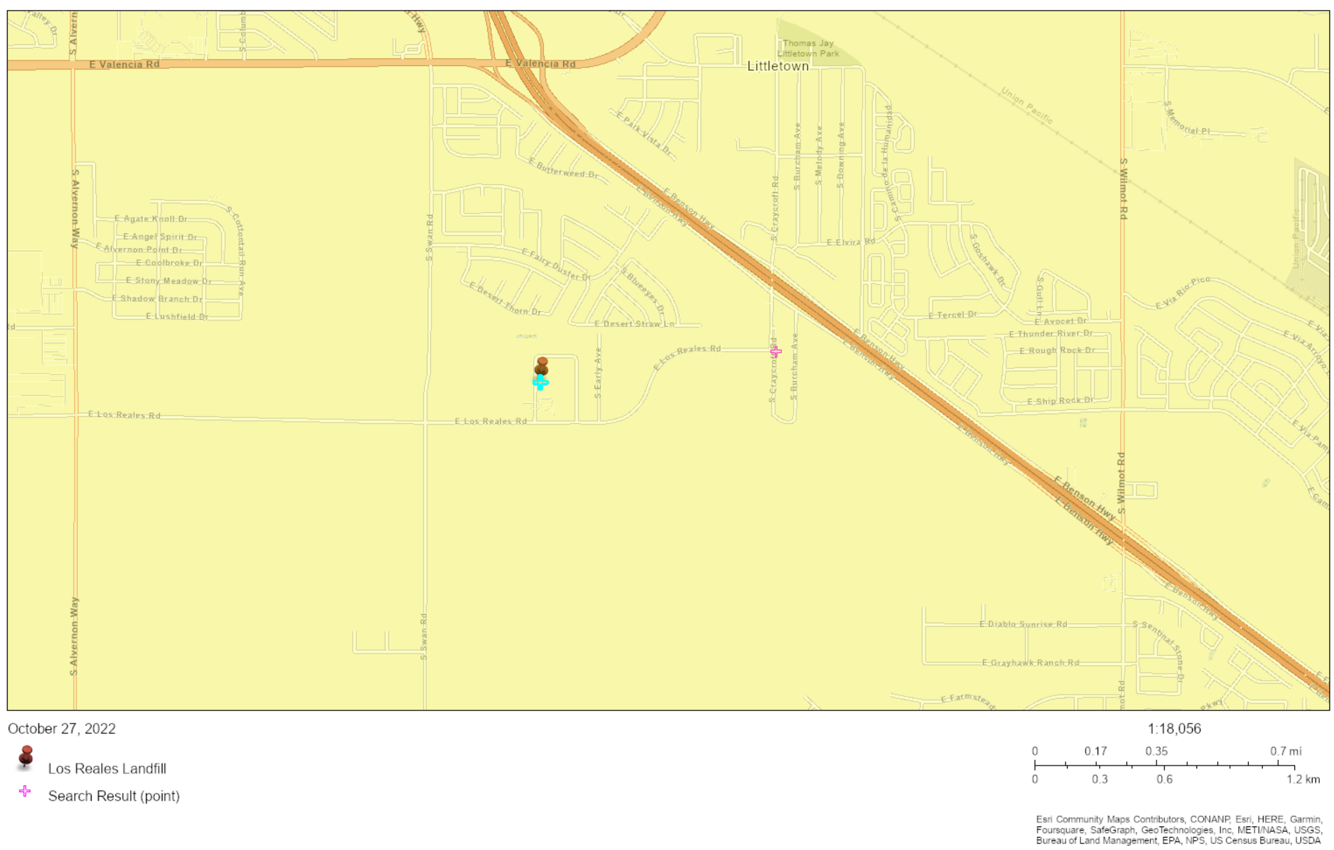
EJScreen Report (Version 2.1)

10 miles Ring Centered at 32.121054,-110.886556, ARIZONA, EPA Region 9

Approximate Population: 505,795

Input Area (sq. miles): 314.03

Los Reales Landfill (The study area contains 2 blockgroup(s) with zero population.)



Sites reporting to EPA	
Superfund NPL	1
Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDF)	20

EJScreen Report (Version 2.1)

10 miles Ring Centered at 32.121054,-110.886556, ARIZONA, EPA Region 9

Approximate Population: 505,795

Input Area (sq. miles): 314.03

Los Reales Landfill (The study area contains 2 blockgroup(s) with zero population.)

Selected Variables	Value	State Avg.	%ile in State	USA Avg.	%ile in USA
Pollution and Sources					
Particulate Matter 2.5 ($\mu g/m^3$)	6.08	7.24	28	8.67	5
Ozone (ppb)	52.4	54.2	21	42.5	90
Diesel Particulate Matter* ($\mu g/m^3$)	0.333	0.318	47	0.294	60-70th
Air Toxics Cancer Risk* (lifetime risk per million)	27	32	48	28	60-70th
Air Toxics Respiratory HI*	0.32	0.37	46	0.36	50-60th
Traffic Proximity (daily traffic count/distance to road)	550	570	74	760	69
Lead Paint (% Pre-1960 Housing)	0.22	0.08	86	0.27	50
Superfund Proximity (site count/km distance)	0.099	0.077	81	0.13	66
RMP Facility Proximity (facility count/km distance)	0.34	0.62	60	0.77	51
Hazardous Waste Proximity (facility count/km distance)	1.4	1.4	61	2.2	62
Underground Storage Tanks (count/km^2)	2.1	1.7	72	3.9	59
Wastewater Discharge (toxicity-weighted concentration/m distance)	14	6.7	96	12	98
Socioeconomic Indicators					
Demographic Index	51%	38%	72	35%	75
People of Color	59%	46%	71	40%	72
Low Income	44%	33%	69	30%	73
Unemployment Rate	7%	6%	70	5%	72
Limited English Speaking Households	6%	4%	78	5%	77
Less Than High School Education	15%	12%	70	12%	71
Under Age 5	6%	6%	60	6%	60
Over Age 64	15%	18%	53	16%	48

*Diesel particular matter, air toxics cancer risk, and air toxics respiratory hazard index are from the EPA's Air Toxics Data Update, which is the Agency's ongoing, comprehensive evaluation of air toxics in the United States. This effort aims to prioritize air toxics, emission sources, and locations of interest for further study. It is important to remember that the air toxics data presented here provide broad estimates of health risks over geographic areas of the country, not definitive risks to specific individuals or locations. Cancer risks and hazard indices from the Air Toxics Data Update are reported to one significant figure and any additional significant figures here are due to rounding. More information on the Air Toxics Data Update can be found at: https://www.epa.gov/haps/air-toxics-data-update.

For additional information, see: www.epa.gov/environmentaljustice

EJSCREEN ACS Summary Report

Location: User-specified point center at 32.121054, -110.886556
Ring (buffer): 10-miles radius
Description: Los Reales Landfill

Summary of ACS Estimates	2016 - 2020
Population	512,316
Population Density (per sq. mile)	1,601
People of Color Population	296,987
% People of Color Population	58%
Households	193,215
Housing Units	214,867
Housing Units Built Before 1950	17,032
Per Capita Income	25,175
Land Area (sq. miles) (Source: SF1)	320.02
% Land Area	100%
Water Area (sq. miles) (Source: SF1)	0.09
% Water Area	0%

	2016 - 2020 ACS Estimates	Percent	MOE (±)
Population by Race			
Total	512,316	100%	1,628
Population Reporting One Race	467,299	91%	4,485
White	354,304	69%	1,640
Black	25,170	5%	609
American Indian	17,655	3%	573
Asian	12,445	2%	408
Pacific Islander	1,053	0%	254
Some Other Race	56,671	11%	1,001
Population Reporting Two or More Races	45,017	9%	1,459
Total Hispanic Population	239,954	47%	1,578
Total Non-Hispanic Population	272,362		
White Alone	215,329	42%	1,594
Black Alone	23,109	5%	581
American Indian Alone	8,608	2%	469
Non-Hispanic Asian Alone	11,796	2%	407
Pacific Islander Alone	919	0%	254
Other Race Alone	922	0%	268
Two or More Races Alone	11,679	2%	773
Population by Sex			
Male	254,228	50%	1,339
Female	258,087	50%	1,043
Population by Age			
Age 0-4	31,285	6%	469
Age 0-17	112,485	22%	743
Age 18+	399,831	78%	1,044
Age 65+	76,287	15%	429

Data Note: Detail may not sum to totals due to rounding. Hispanic population can be of any race.
N/A means not available. **Source:** U.S. Census Bureau, American Community Survey (ACS) 2016 - 2020 .

EJSCREEN ACS Summary Report

Location: User-specified point center at 32.121054, -110.886556
Ring (buffer): 10-miles radius
Description: Los Reales Landfill

	2016 - 2020 ACS Estimates	Percent	MOE (±)
Population 25+ by Educational Attainment			
Total	326,050	100%	1,174
Less than 9th Grade	18,141	6%	272
9th - 12th Grade, No Diploma	30,062	9%	517
High School Graduate	77,698	24%	594
Some College, No Degree	85,438	26%	610
Associate Degree	28,781	9%	541
Bachelor's Degree or more	85,930	26%	480
Population Age 5+ Years by Ability to Speak English			
Total	481,031	100%	1,569
Speak only English	319,166	66%	1,392
Non-English at Home[1+2+3+4]	161,865	34%	1,241
[1]Speak English "very well"	111,554	23%	800
[2]Speak English "well"	25,118	5%	389
[3]Speak English "not well"	15,981	3%	465
[4]Speak English "not at all"	9,212	2%	349
[3+4]Speak English "less than well"	25,193	5%	514
[2+3+4]Speak English "less than very well"	50,311	10%	554
Linguistically Isolated Households*			
Total	10,848	100%	339
Speak Spanish	8,799	81%	321
Speak Other Indo-European Languages	630	6%	74
Speak Asian-Pacific Island Languages	698	6%	103
Speak Other Languages	721	7%	158
Households by Household Income			
Household Income Base	193,215	100%	539
< $15,000	26,275	14%	479
$15,000 - $25,000	23,744	12%	439
$25,000 - $50,000	51,349	27%	319
$50,000 - $75,000	35,525	18%	497
$75,000 +	56,321	29%	422
Occupied Housing Units by Tenure			
Total	193,215	100%	539
Owner Occupied	108,134	56%	553
Renter Occupied	85,081	44%	494
Employed Population Age 16+ Years			
Total	411,817	100%	1,309
In Labor Force	251,032	61%	1,166
Civilian Unemployed in Labor Force	17,427	4%	581
Not In Labor Force	160,785	39%	816

Data Note: Datail may not sum to totals due to rounding. Hispanic population can be of anyrace.
N/A means not available. **Source:** U.S. Census Bureau, American Community Survey (ACS)
*Households in which no one 14 and over speaks English "very well" or speaks English only.

EJSCREEN ACS Summary Report

Location: User-specified point center at 32.121054, -110.886556

Ring (buffer): 10-miles radius

Description: Los Reales Landfill

	2016 - 2020 **ACS Estimates**	**Percent**	**MOE (±)**
Population by Language Spoken at Home*			
Total (persons age 5 and above)	481,031	100%	1,569
English	319,166	66%	1,536
Spanish	139,254	29%	1,352
French, Haitian, or Cajun	1,664	0%	173
German or other West Germanic	1,346	0%	103
Russian, Polish, or Other Slavic	1,532	0%	283
Other Indo-European	2,294	0%	179
Korean	750	0%	257
Chinese (including Mandarin, Cantonese)	2,516	1%	179
Vietnamese	1,386	0%	198
Tagalog (including Filipino)	1,497	0%	407
Other Asian and Pacific Island	2,174	0%	251
Arabic	2,441	1%	764
Other and Unspecified	5,011	1%	372
Total Non-English	161,865	34%	2,196

Data Note: Detail may not sum to totals due to rounding. Hispanic popultion can be of any race.
N/A meansnot available. **Source:** U.S. Census Bureau, American Community Survey (ACS) 2016 - 2020.
*Population by Language Spoken at Home is available at the census tract summary level and up.

APPENDIX E

Tucson Zero Waste Roadmap Survey Results

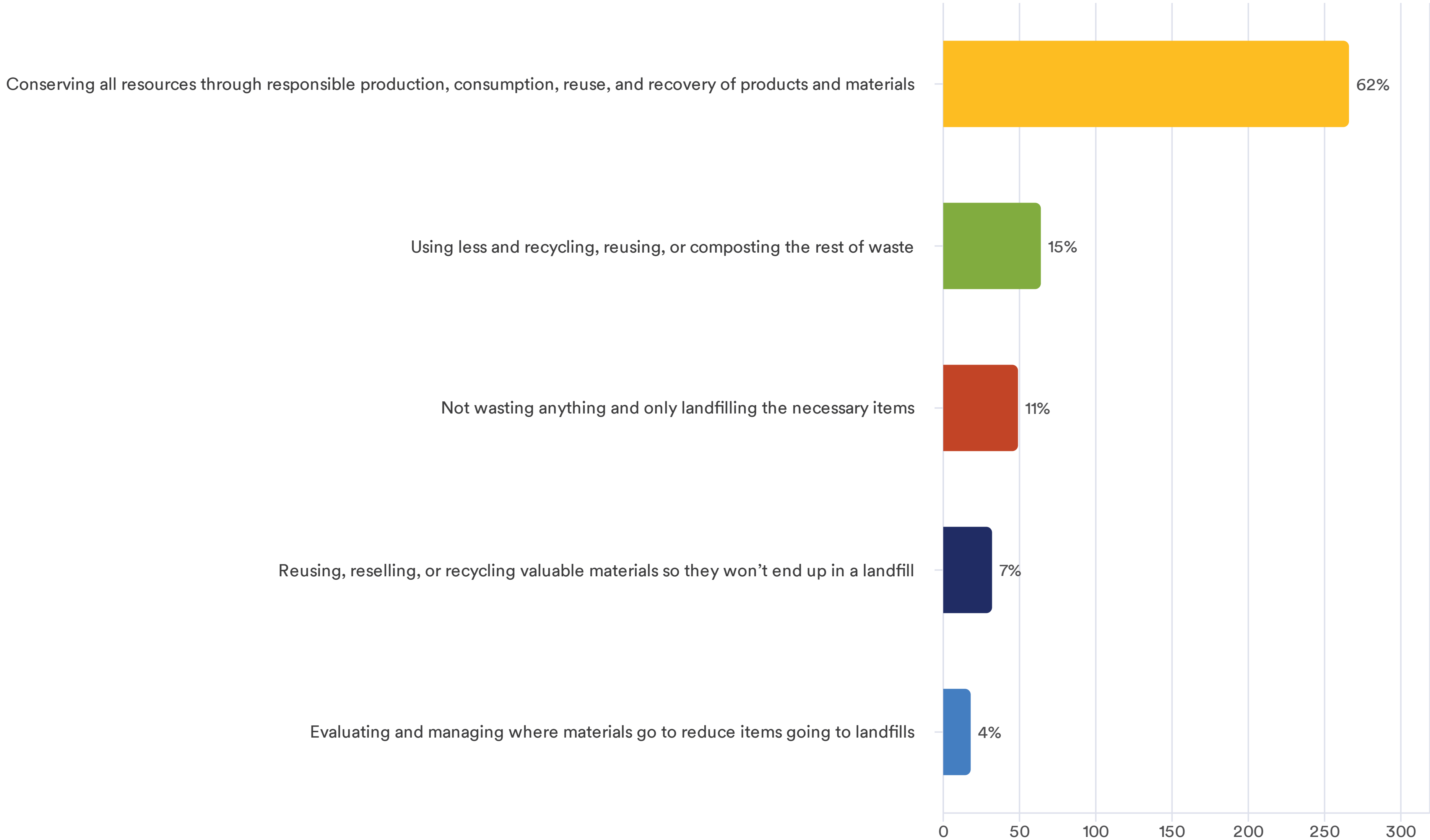
Tucson Zero Waste Roadmap Survey

Fall 2022

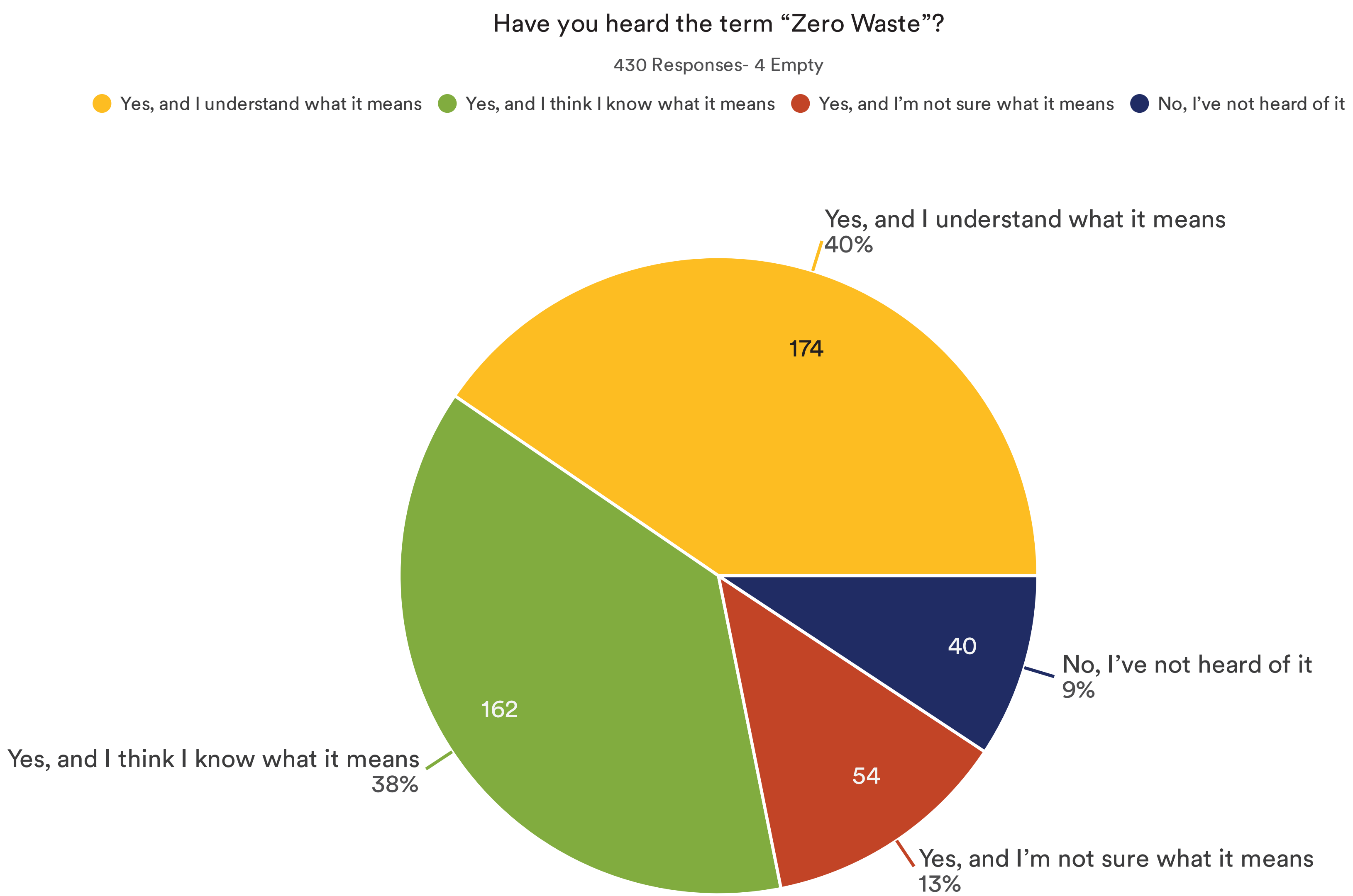
Tucson Zero Waste Roadmap Survey

Which definition most closely aligns with how you define Zero Waste?

429 Responses- 5 Empty

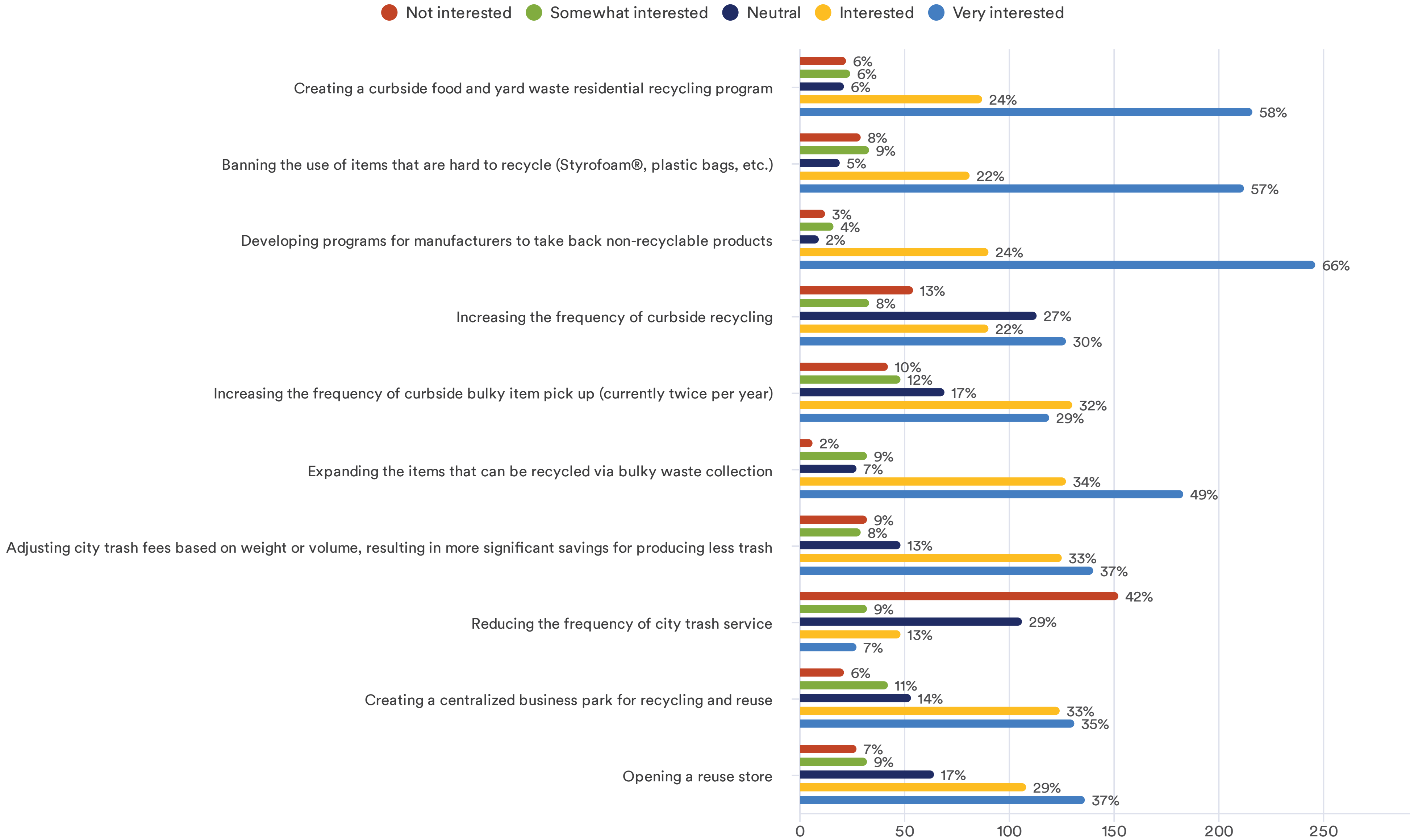


Tucson Zero Waste Roadmap Survey



How interested are you in the City of Tucson completing the following items?

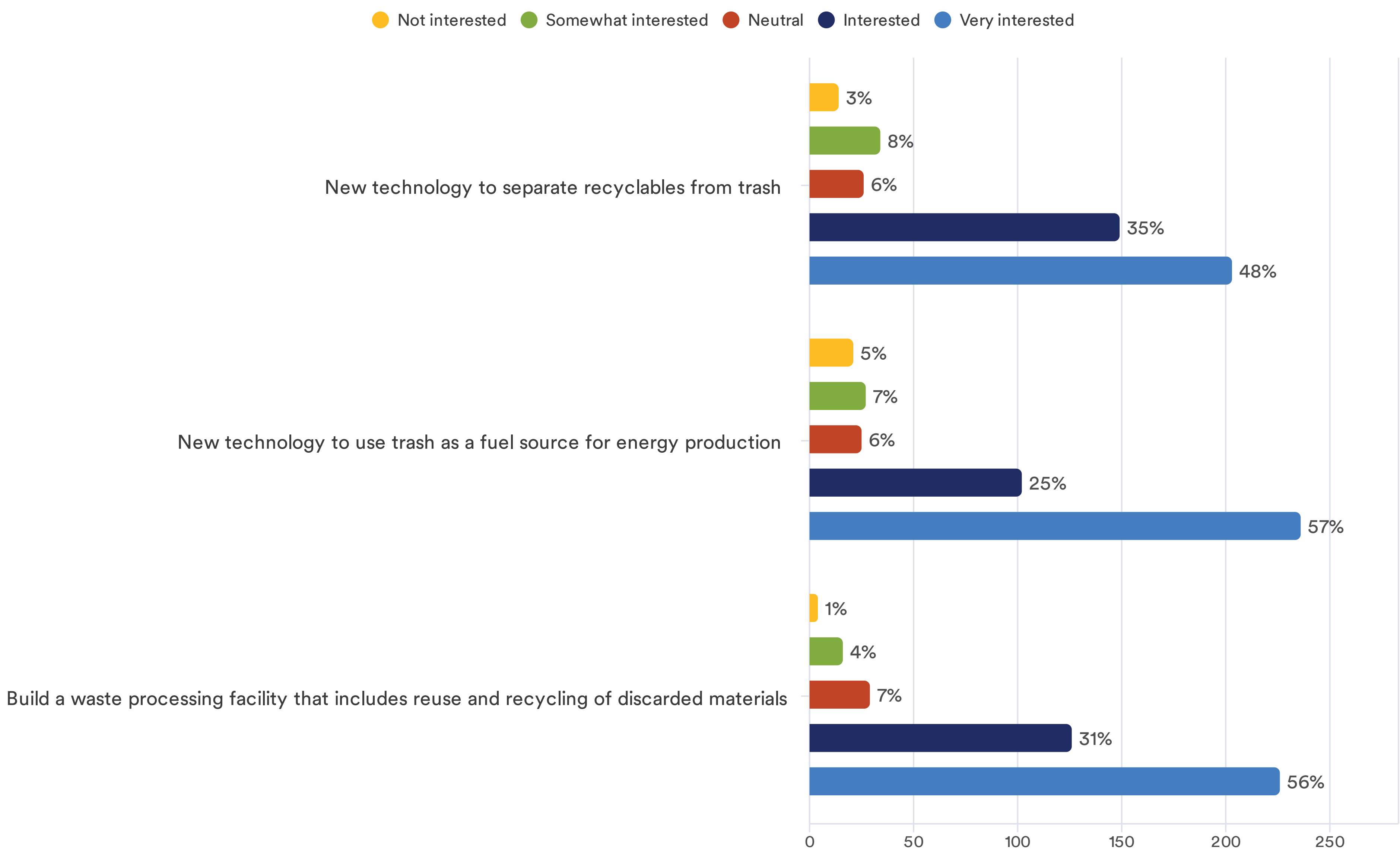
427 Responses- 7 Empty



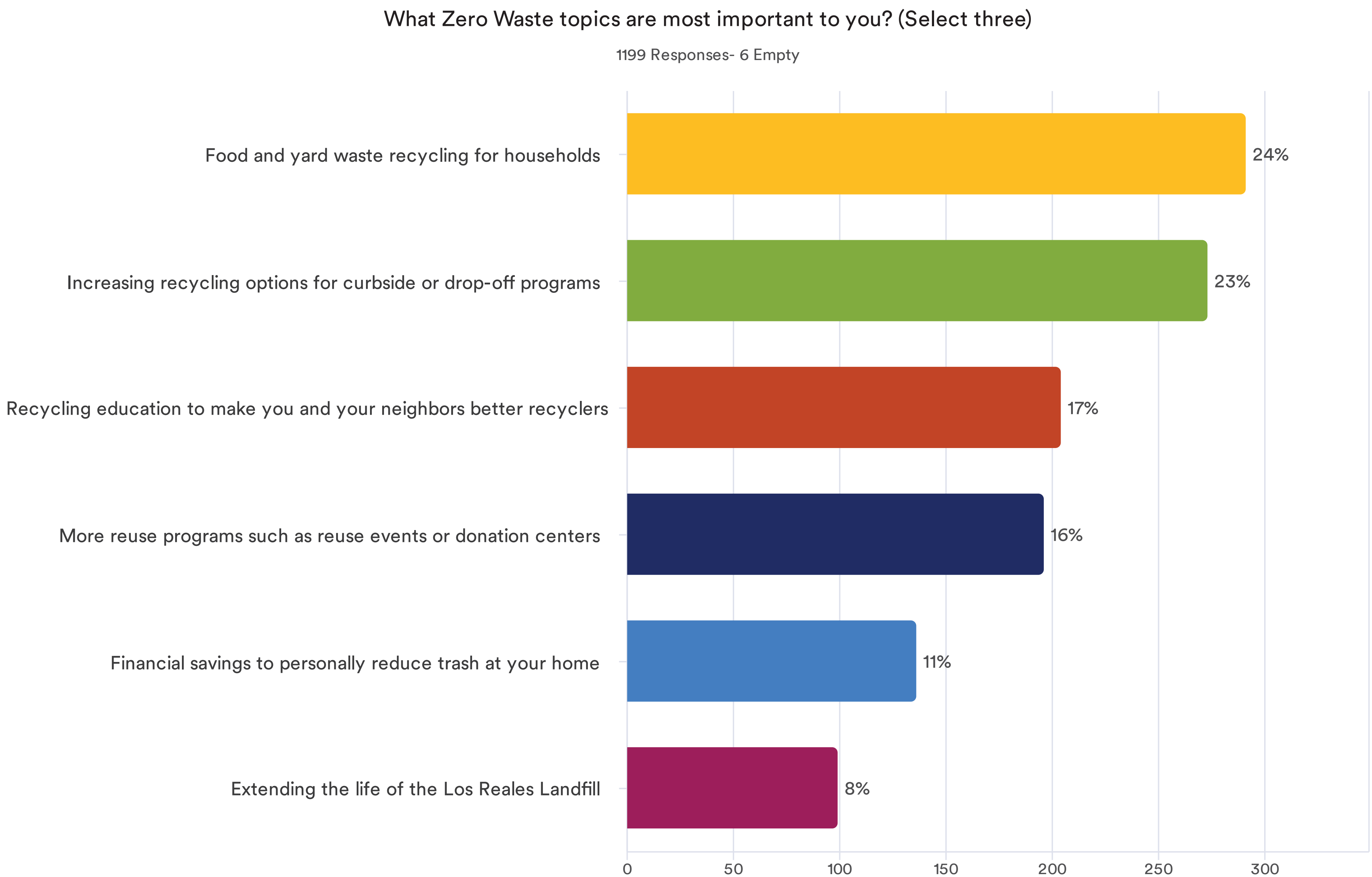
Tucson Zero Waste Roadmap Survey

How interested are you in the City of Tucson investing in the following technology solutions related to Zero Waste?

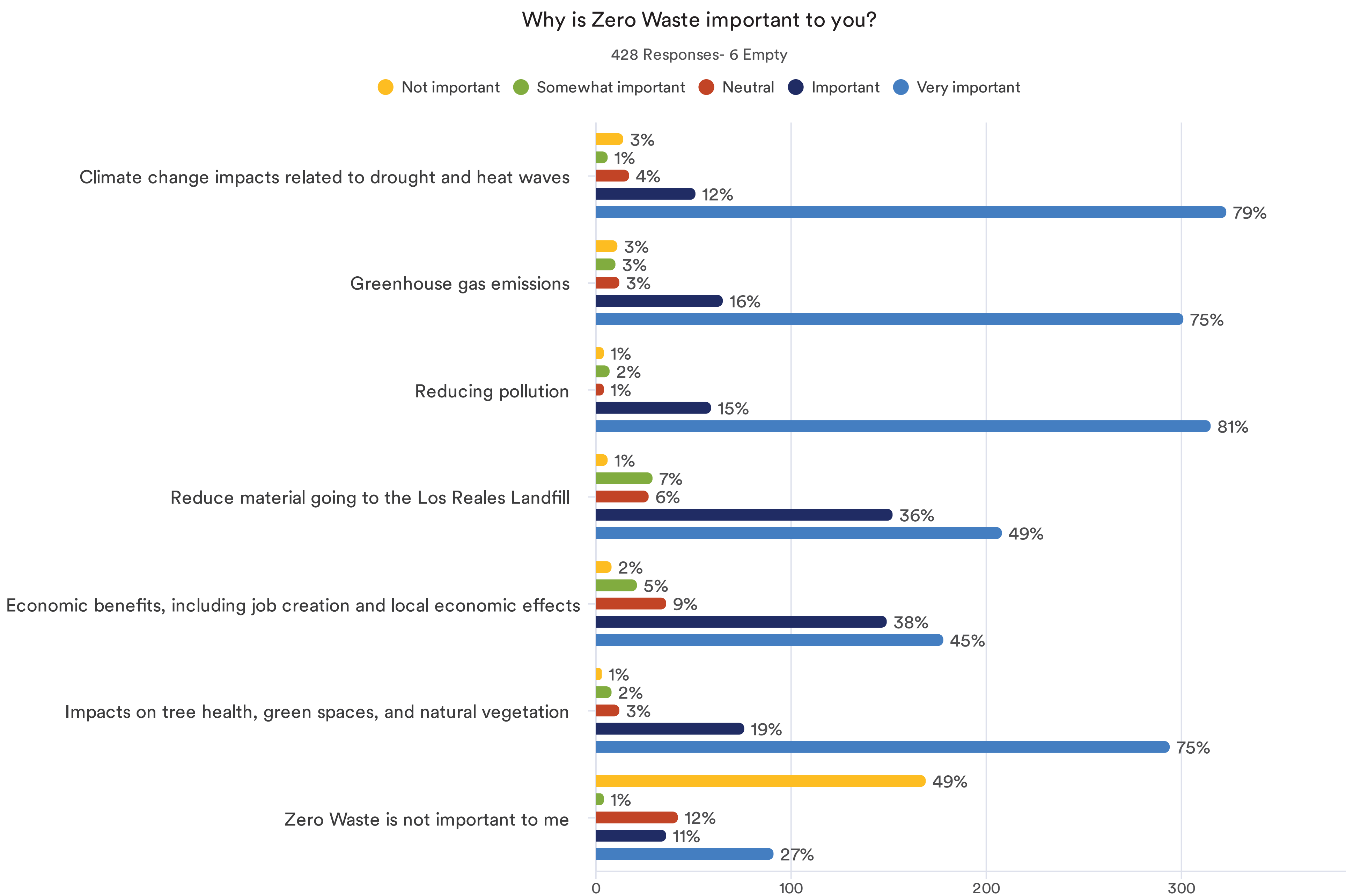
429 Responses- 5 Empty



Tucson Zero Waste Roadmap Survey



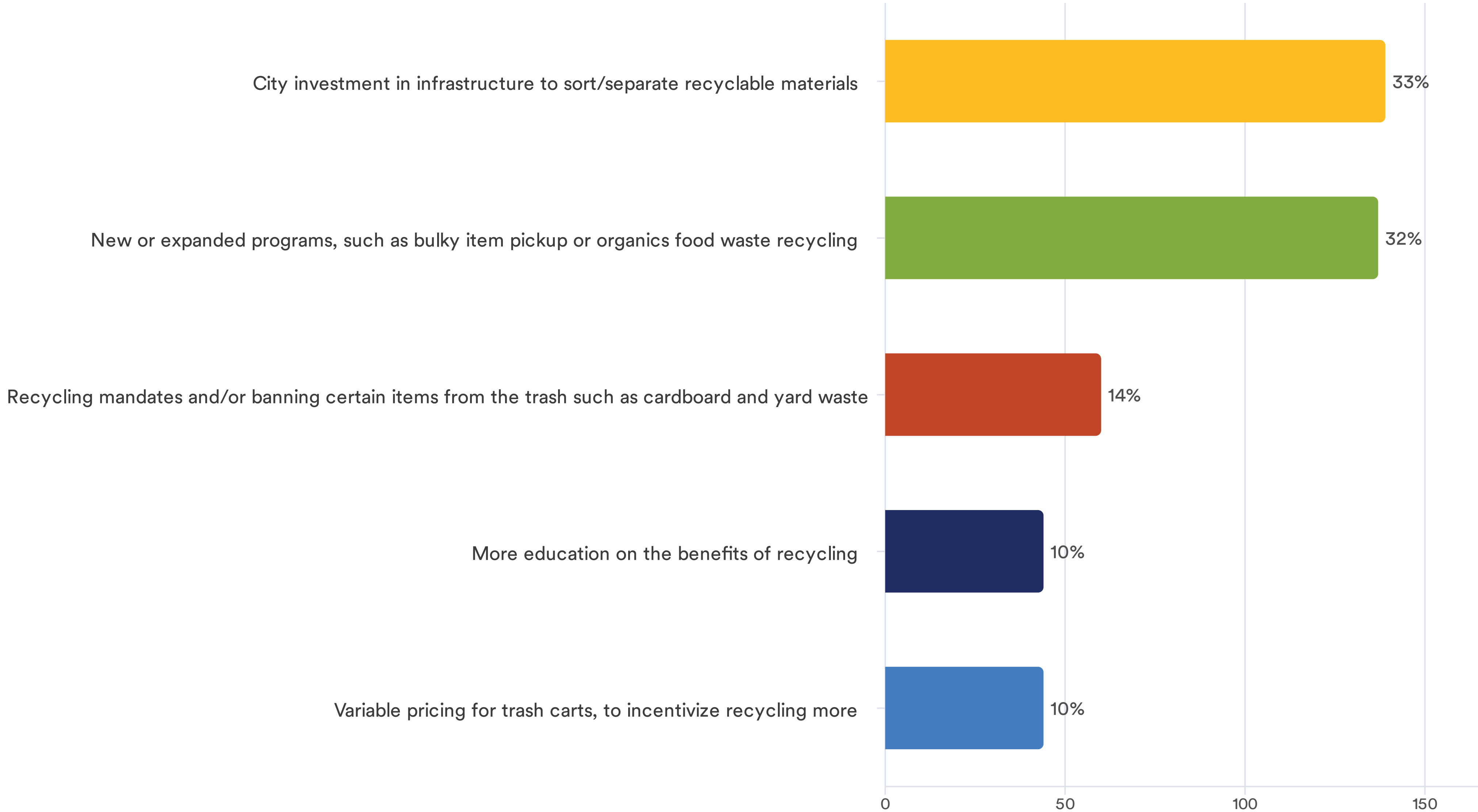
Tucson Zero Waste Roadmap Survey



Tucson Zero Waste Roadmap Survey

What do you think is the best way for Tucson to reduce trash and increase recycling?

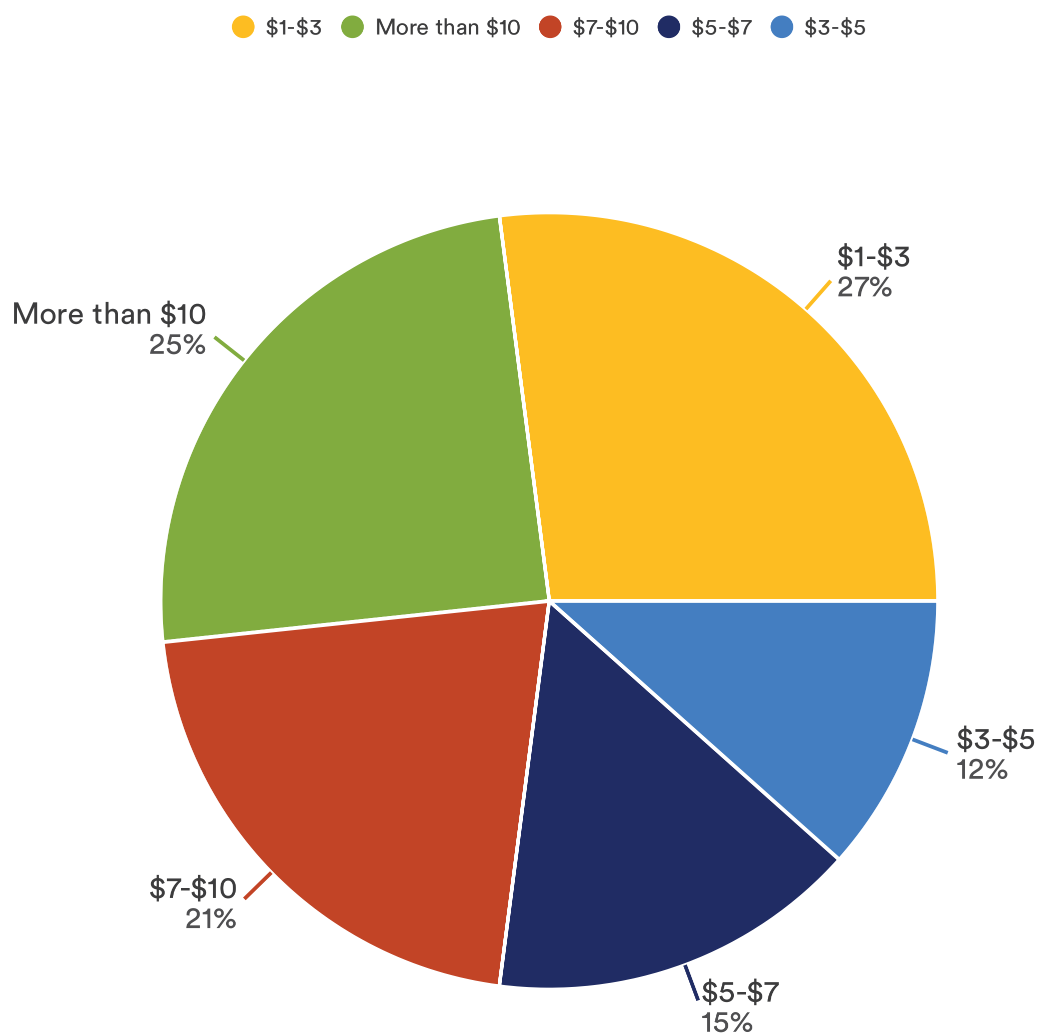
424 Responses- 10 Empty



Tucson Zero Waste Roadmap Survey

How much savings would you need to receive monthly to switch to a smaller trash cart? (20-30-gallons smaller)

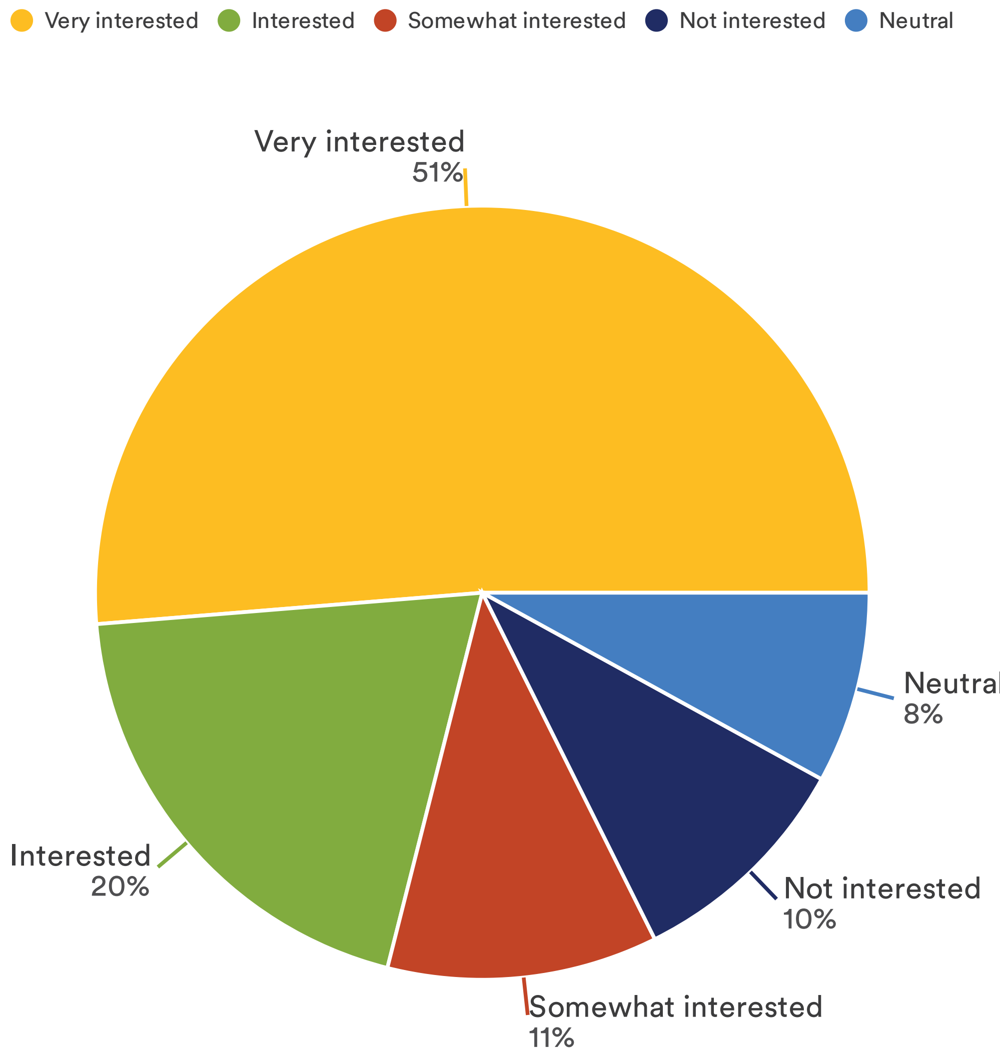
414 Responses- 20 Empty



Tucson Zero Waste Roadmap Survey

Would you be interested in participating in a curbside organics/food waste recycling program?

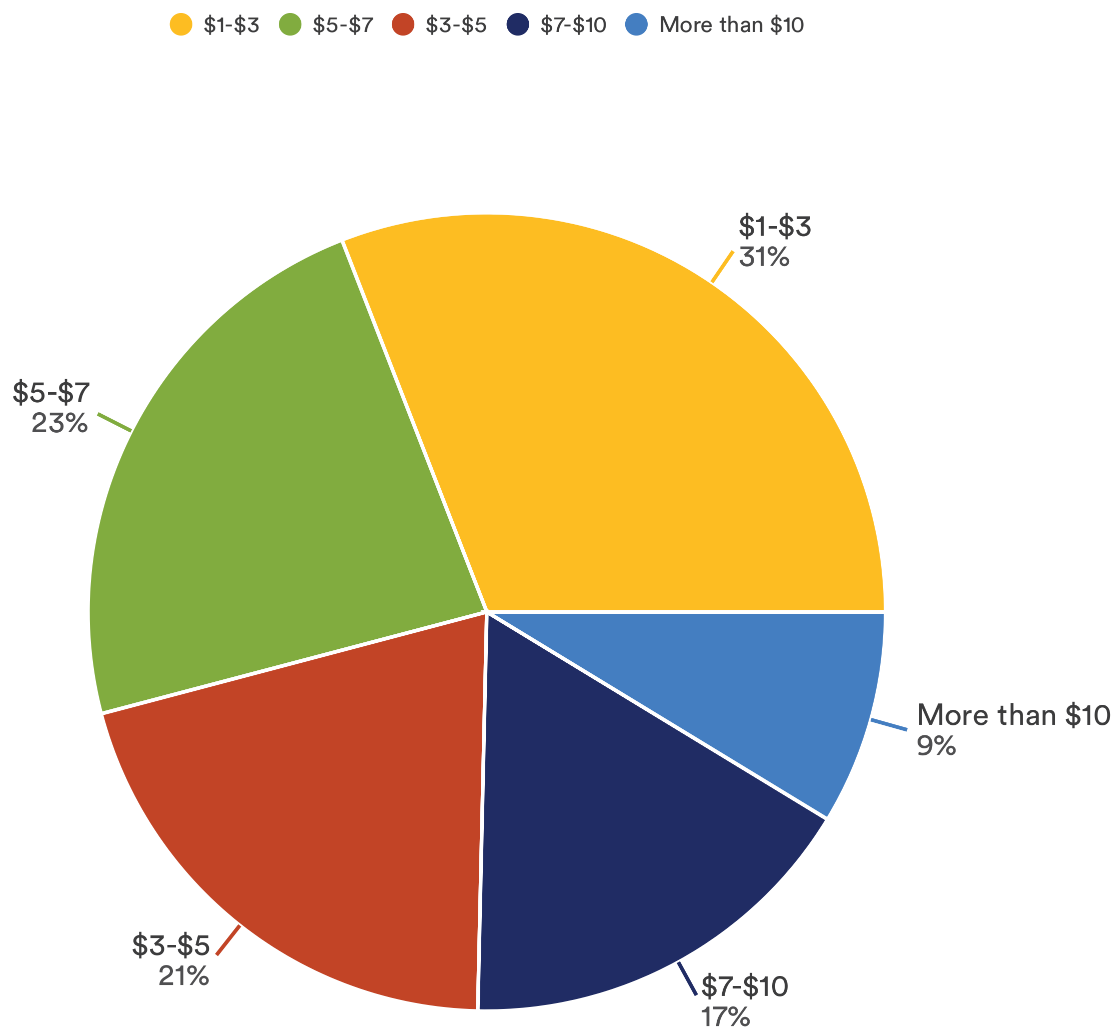
425 Responses- 9 Empty



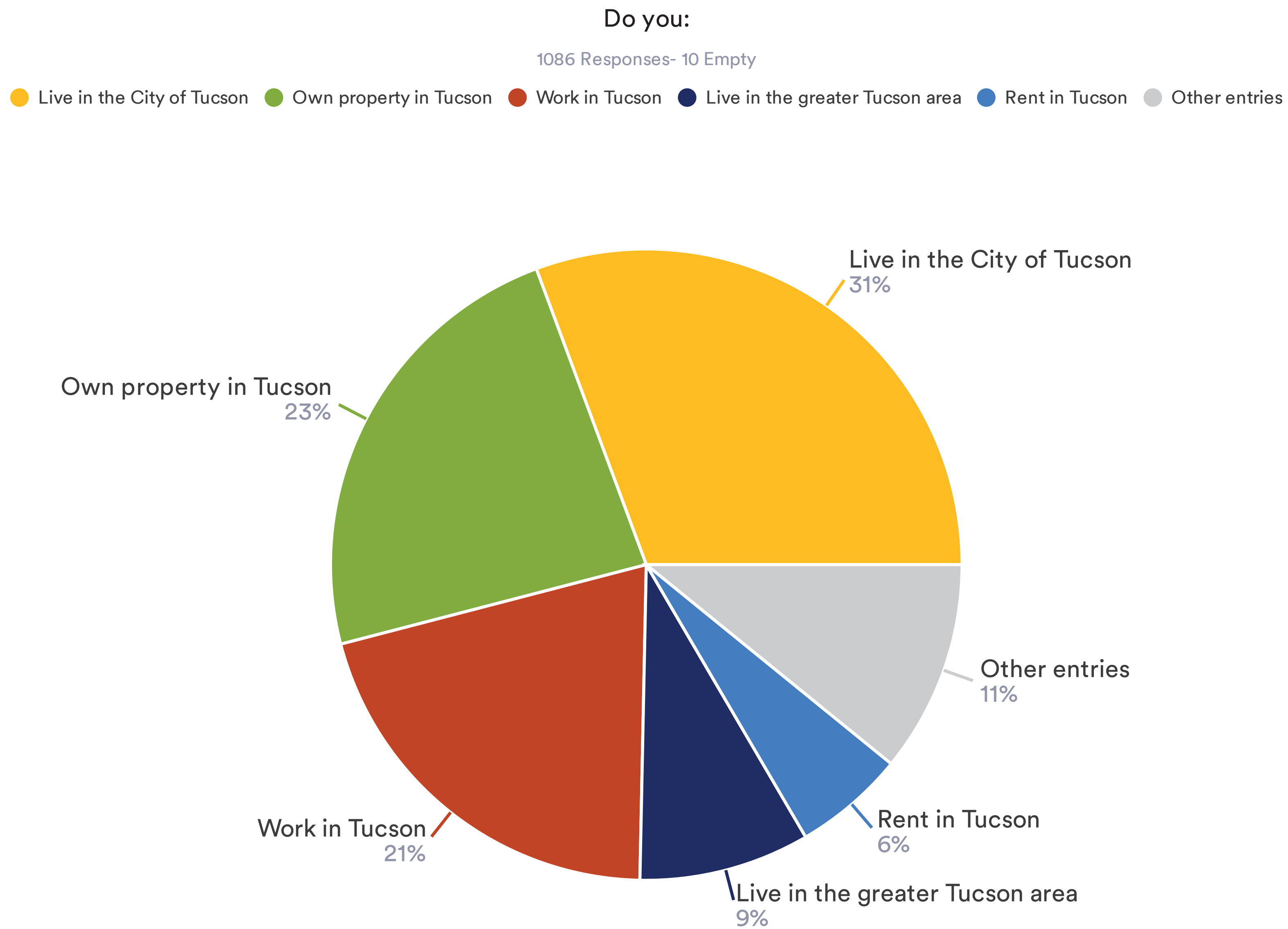
Tucson Zero Waste Roadmap Survey

How much are you willing to pay per month for a curbside organics/food waste collection program?

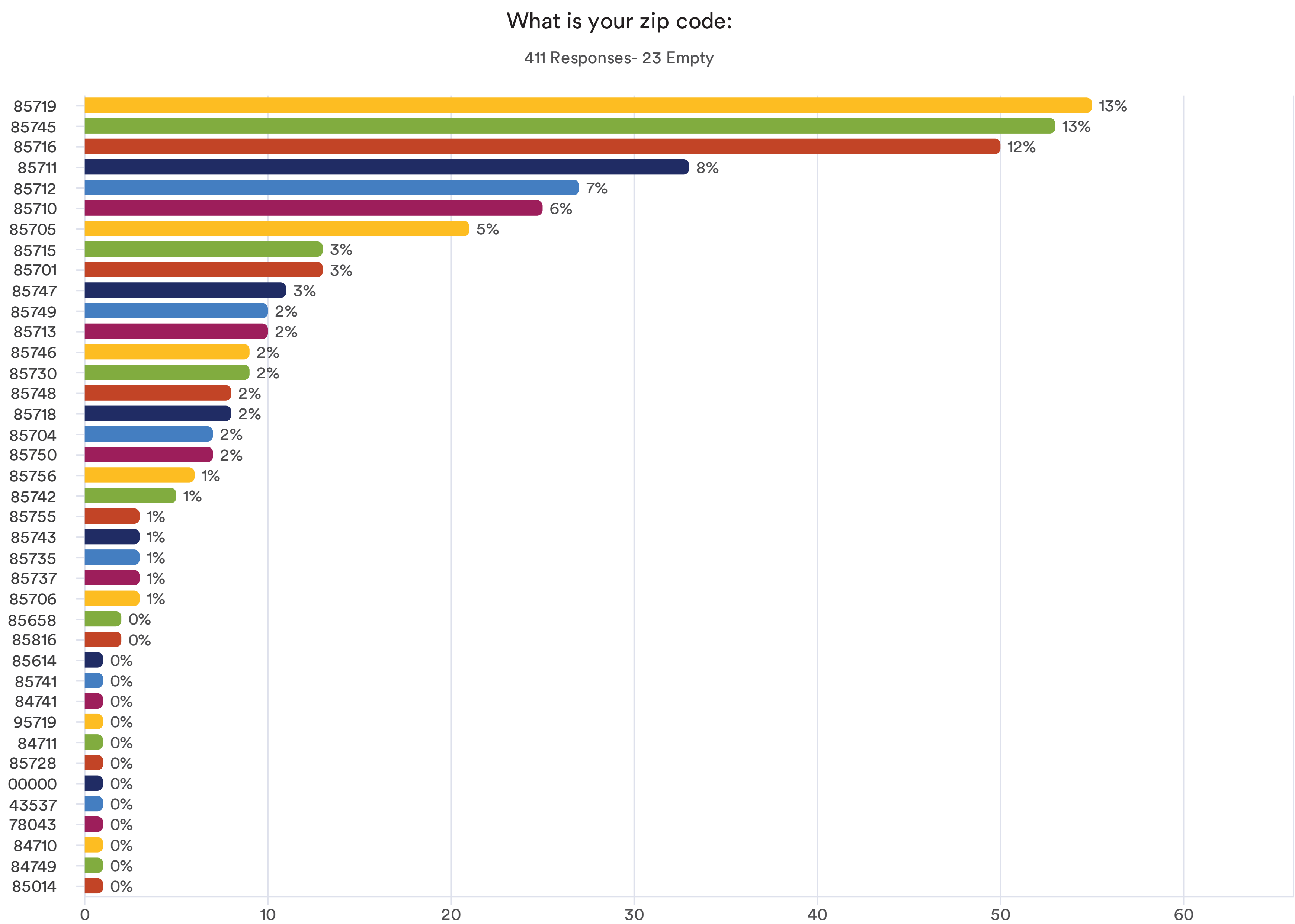
414 Responses- 20 Empty



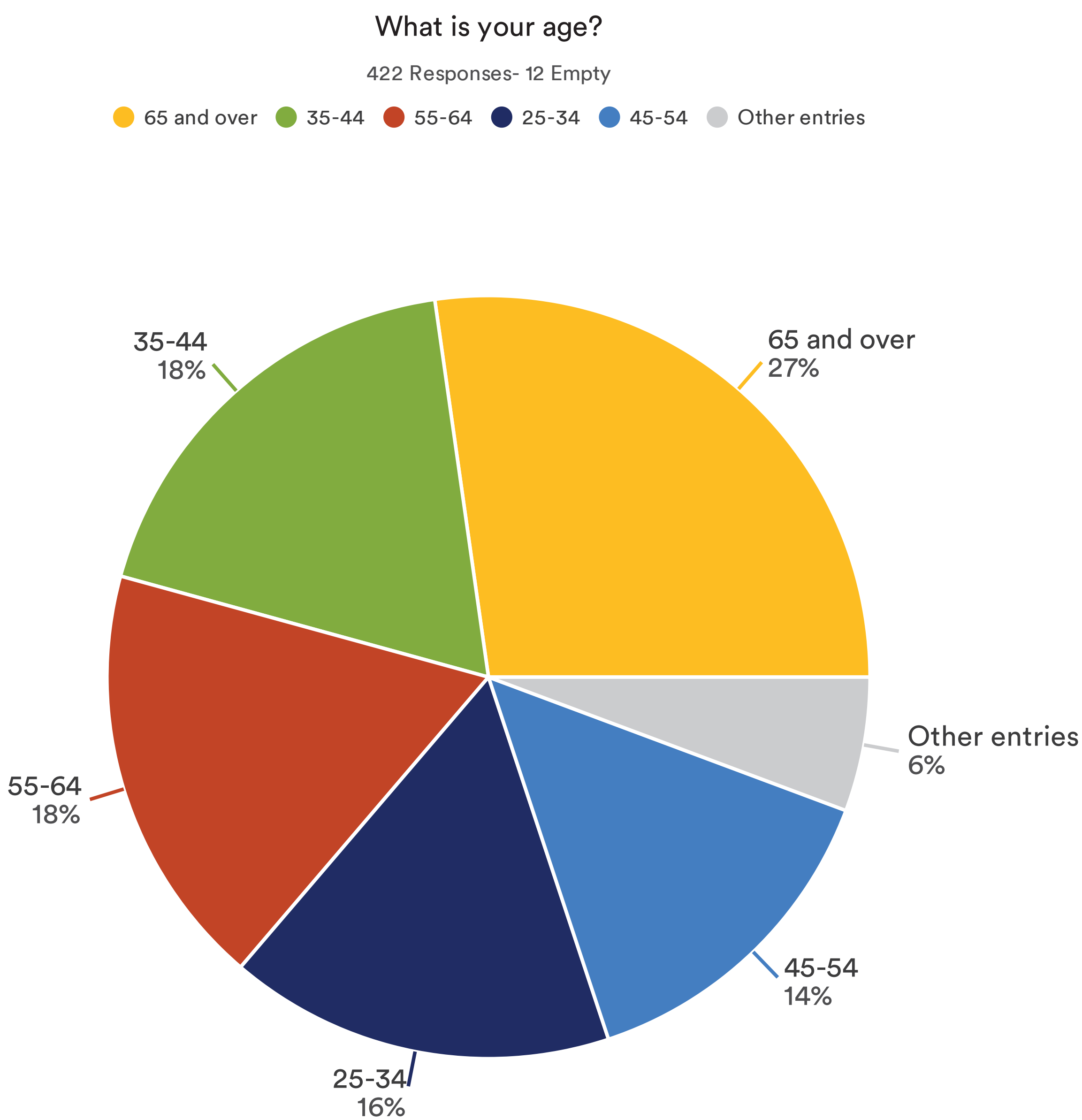
Tucson Zero Waste Roadmap Survey



Tucson Zero Waste Roadmap Survey



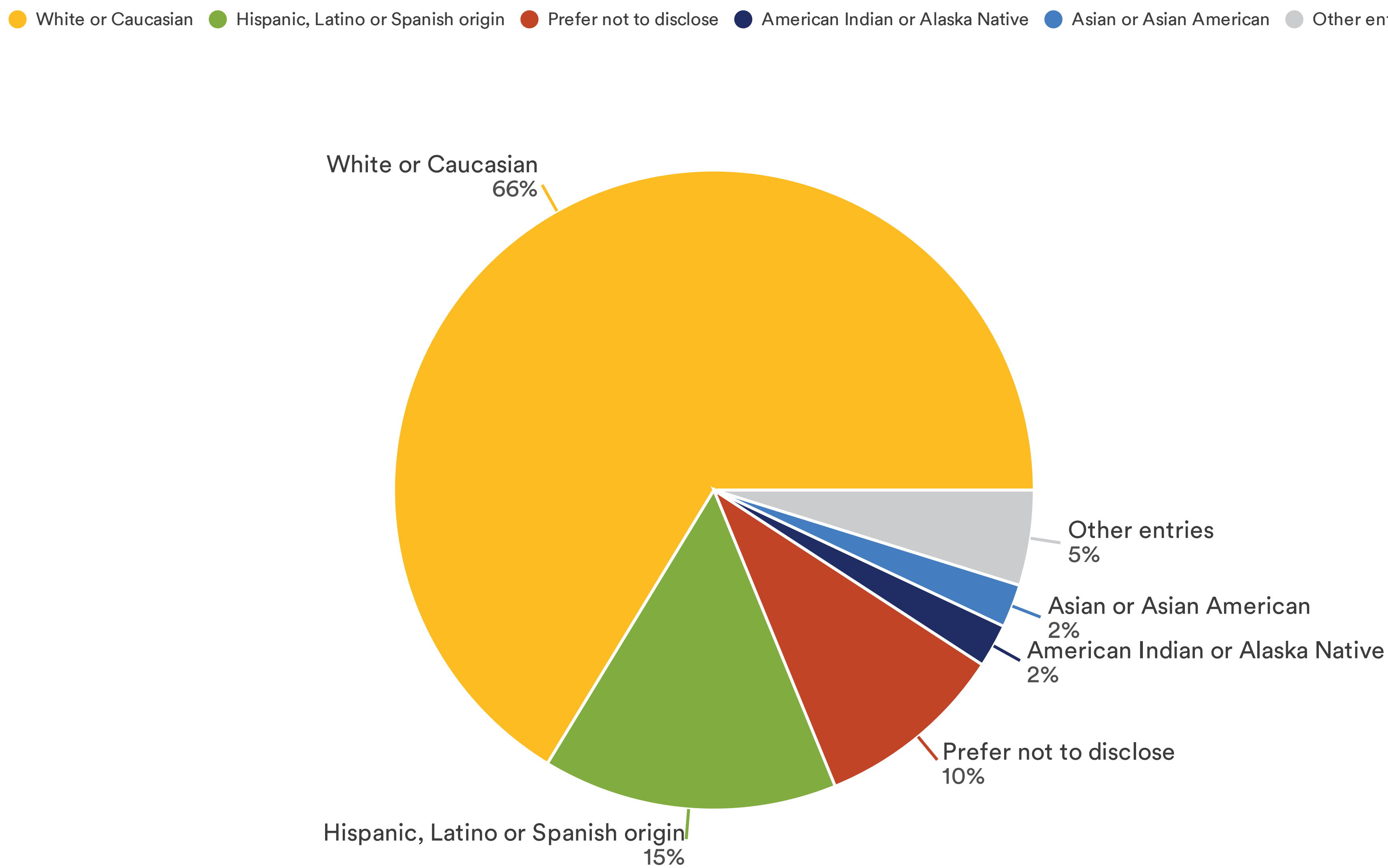
Tucson Zero Waste Roadmap Survey



Tucson Zero Waste Roadmap Survey

With which racial and ethnic group do you identify?

457 Responses- 8 Empty



Thank You!

Tucson Zero Waste Roadmap Survey

APPENDIX F

Zero Waste Workshop Summary

Zero Waste Workshop Summary

Tucson Zero Waste

October 12, 2022

Contents

Introduction

The City of Tucson is working to create a Roadmap to Zero Waste and developing strategies and programs to meet the goals set by the Mayor and Council of 50% Waste Diversion by 2030 and Zero Waste by 2050. A survey was opened to the public to provide input, and then a series of workshops with local groups was scheduled to help guide the development of the Tucson Zero Waste Roadmap.

Roadmap Workshops Overview

The City of Tucson Environmental and General Services Department (EGSD) hosted two interactive workshops to help guide the development of the Tucson Zero Waste Roadmap. The workshops were held on Wednesday, October 12, 2022, from 9 – 11 a.m. and 1 – 3 p.m. at Tucson Central (300 S. Fire Central Place, Tucson, AZ 85701).

Attendees

Invitees to the first workshop included City of Tucson staff members from Water Conservation, the Mayor's Office, and Economic Initiatives. Members of the City of Tucson Environmental Services Advisory Committee were also invited. In total, ten people attended the morning workshop.

The second workshop included local stakeholders, including representatives from the University of Arizona, the Commission on Climate, Energy, and Sustainability, the Mayor's Climate Action Committee, Pima County, local businesses, and local environmental groups. In total, 25 people attended the afternoon workshop.

A full list of invitees and attendees can be found in Appendix A.

Notifications

Invitations to the workshop were emailed out on September 26, 2022, and invitees were asked to respond by October 3. Additional invitations and reminders were sent out leading up to the workshops. ***A copy of the invitations can be found in Appendix A.***

Detailed Workshop Information

Values Activity

Upon arrival at the workshops, attendees were asked to identify their three top Zero Waste Values by placing stickers on specific posters. The options were:

- Impacts to tree health, green spaces, and natural vegetation
- Economic benefits, including job creation and local economic effects
- Reducing pollution
- Reduce material going to the Los Reales Landfill
- Greenhouse gas emissions
- Climate change impacts related to drought and heat waves
- Zero Waste is not important to me.

These results were compared to the community survey results during the presentation. Details of this activity can be found in the **Results** section below.

Presentation

Both workshop sessions began with a brief presentation. The presentation included the goals of the workshops, an overview of zero waste, the community input survey results, and identified potential Zero Waste near-term development options. ***A copy of the presentation can be found in Appendix B.***

Breakout Session

Following the presentation, each attendee was assigned a breakout group where they had the opportunity to discuss one of the near-term development options. These near-term development options include:

- Brush and Bulky Program Modifications
- Residential and Commercial Organics Collection
- Recycling Collection Changes
- Pay As You Throw
- Reuse Store

The purpose of the activity was to help identify benefits, considerations, key stakeholders or influencers, and unknowns of their near-term development option and identify as a group if their near-term option would help Tucson succeed with the goal of Zero Waste. A worksheet guided these sessions to help foster conversation and insights. ***A copy of the worksheets can be found in Appendix B.***

Near-Term Development Activity and Report Out

After the breakout sessions, attendees were asked to identify their two most important near-term developments by placing stickers on posters that listed each near-term development options.

The group at large then reconvened, and a designated person from each breakout group presented their group's findings for each near-term development. They walked through the worksheet and concluded by sharing whether they thought the development would advance Zero Waste in Tucson.

Once all the groups had presented, the facilitator asked the attendees to identify their most important Zero Waste near-term development option by placing another sticker (in a different color) on the posters. The results of this vote were then discussed, and final questions were answered.

Results

Throughout the workshops, attendees were asked to participate in multiple activities to help them understand what they value in Zero Waste and identify what near-term development options were most important to them. The results of these activities are summarized below.

Zero Waste Values

As mentioned above, the attendees were asked to identify their top three values related to Zero Waste in Tucson. Attendees placed stickers on their top values and then discussed how they related to the input we received from the community survey. The results of this activity and the community survey are below.

Workshop #1 (top three values)[1]

1. Impacts to tree health, green spaces (7 votes)
2. Economic benefits, including job creation and local economic effects (6 votes)
3. Reduce material going to the Los Reales Landfill (6 votes)
4. Climate change impacts related to drought and heat waves (6 votes)

Workshop #2 (top three values)

1. Greenhouse gas emissions (16 votes)
2. Economic benefits, including job creation and local economic effects (13 votes)
3. Reduce material going to the Los Reales Landfill (12 votes)

[1] Three values tied at second place, therefore four top values were identified in the first workshop.

For comparison, the public survey participants identified the following top three values as being very important.

1. Climate change impacts related to drought and heat waves (323 votes)
2. Reducing pollution (315 votes)
3. Greenhouse gas emissions (301 votes)

Preliminary Near-Term Development Activity (two most important)

Following the breakout sessions, attendees were asked to identify their two most important near-term development options. The results of this activity are below.

Workshop #1 (results ranked in order)

1. Brush and Bulky: 8 votes
2. Residential and Commercial Organics Collection: 7 votes
3. Recycling Collection Changes: 3 votes
4. Reuse Store: 2 votes
5. Pay As You Throw: 0 votes

Workshop #2 (results ranked in order)

1. Residential and Commercial Organics Collection: 14 votes
2. Recycling Collection Changes: 13 votes
3. Reuse Store: 9 votes
4. Brush and Bulky: 7 votes
5. Pay As You Throw: 5 votes

Report Out

Following the breakout session, attendees were asked to summarize their conversation and share key themes based on their discussion and the guided worksheet. The results of the report out are shown below.

Workshop #1

- **Brush and Bulky Program Modifications**
    - **Barriers:**
        - Hard for the elderly to get items to the curb
        - Increased scavenger activity in the neighborhood
        - Potential for illegal dumping by non-City residents
        - Pickup frequency/timing
        - High number of rental property communities
    - **Benefit:**
        - Reusable items could be picked up by people before collection, keeping them out of landfills
    - **Suggestion:**
        - Gather information from current users for enhancement ideas

- **Residential and Commercial Organics Collection**
  - **Barriers:**
    - Odors
    - Collection Frequency
    - Contamination (non-organics)
  - **Benefits:**
    - Reduce landfill tonnage
    - Reduce greenhouse gases
  - **Concerns:**
    - Needs infrastructure
    - Food waste needs to go to animals
- **Recycling Collection Changes**
  - **Barriers:**
    - Been in place for 40 years, not working
    - Contamination (non-recyclables in bins)
    - Apathy
    - Current MRF has lack of technology for sorting
  - **Benefits:**
    - Opportunity to bring in business
    - Volume market opportunities
  - **Suggestions:**
    - Better tracking/monitoring
    - Infrastructure improvement
    - Automated trucks vs. in-person bin selection
- **Pay As You Throw**
  - **Barriers:**
    - What about shared container neighborhoods? Would have to pay for individual bins
    - Does this actually incentivize less waste?
    - Could be considered a penalty for families
    - Equity, size matters, inherent cost
    - Pay for pickups
  - **Suggestion:**
    - Need to focus on education and outreach
- **Reuse Store**
  - **Barriers:**
    - How do you monitor trash vs. reusable items
    - Where will it be located?
    - How can people access it?
  - **Benefit:**
    - Keeps items out of landfills
  - **Suggestions:**
    - Potential for partnerships with Salvation Army or Habitat for Humanity

Workshop #2

- **Brush and Bulky Program Modifications**
  - **Barriers:**
    - Some items are hazardous (cacti)
    - Many items are ineligible to be picked up
    - Encourages excessive pruning of trees
    - Encourages waste, throwing out something because pick up is coming rather than reusing/repurposing
    - Streets can look junky before pickup day
    - Too few pickups
  - **Benefits:**
    - Convenient
    - Picks up diverse materials
    - Can be an alternative to illegal dumping
    - Informal reuse of items
    - Encourages neighborhood-wide cleanups
  - **Suggestions:**
    - Potential partnerships with community groups and secondary users of materials to divert materials before they get picked up
    - Green material chipping option to repurpose green waste rather than just dumping it in a landfill
    - Yard signs with QR Codes that alert neighbors when pickup is coming
- **Residential and Commercial Organics Collection**
  - **Barriers:**
    - Ordinances that prohibit
    - Lack of communication/Education
    - Costs
    - Barrier to entry
    - Odor/insects
  - **Benefits:**
    - Food diversion, addressing food insecurity
    - Community awareness of waste production
    - Water retention
    - Mulch
    - Partnership opportunities for food waste to farms/animal sanctuaries
  - **Suggestions:**
    - Potential partnerships with non-profits, HOAs, schools, Environmental Services
    - How do we get people involved/excited? Need to get the community onboard through marketing
- **Recycling Collection Changes**
  - **Barriers:**
    - Higher cost for multi-stream
    - Lack of education

        - Who are the end users?
        - Personal responsibility/getting people to change habits
    - **Benefits:**
        - Keeps items out of the landfill
        - Cleaner materials for resale/economic benefit
        - Adding glass back to the system
    - **Suggestions:**
        - Needs more education about what can be recycled
        - Needs mandates and legislation
        - Potential partnerships with local advocacy groups, schools, non-profits, churches, chambers, manufacturers
- **Pay As You Throw**
    - **Barriers:**
        - Including recycling
        - Inequities (access)
        - Multifamily homes/apartments not eligible
        - Neighborhood recycling centers aren't accessible
        - Routes for picking up/greenhouse gas
        - Behavior change
    - **Benefit:**
        - Control is in your hands to reduce costs
    - **Suggestions:**
        - Need more education and communication
        - Needs youth influencers
- **Reuse Store**
    - **Barriers:**
        - Funding
        - Valuable items made to store and not trash
        - Number of people needed to function/resources
        - Education of qualifying items
        - Participation
    - **Benefits:**
        - Keeps items out of landfills
        - Revenue generator
        - Interest in sustainability
        - Creates jobs
        - Products more accessible to lower incomes
    - **Suggestions:**
        - Maybe tie in with bulk pick up. Separate pickups for reuse vs. landfill
        - Allow drop-offs in multiple locations
        - Needs to be easy for donors
        - Offer incentives for donations
        - Online or virtual marketplace to decentralize

- Partner with large employers, schools, marketing professionals, Pima County, schools
- Trucking capabilities

Final Near-Term Development Activity (most important)

Following the report-outs, attendees were asked to now identify their most important near-term development option based on what they learned in their breakout and from the report-outs. The results of this activity are below.

Workshop #1 (results ranked in order)

1. **Residential and Commercial Organics Collection: 4 votes**
2. **Brush and Bulky: 3 votes**
3. **Recycling Collection Changes: 1 vote**
4. Pay As You Throw: 0 votes
5. Reuse Store: 0v votes

Workshop #2 (results ranked in order)

1. **Residential and Commercial Organics Collection: 11 votes**
2. **Recycling Collection Changes: 8 votes**
3. **Brush and Bulky: 3 votes**
4. Pay As You Throw: 2 votes
5. Reuse Store: 0 votes

Summary of Results

After the workshops, the groups were asked to give their opinions on the near-term development options and whether they would be a good fit for the Zero Waste Roadmap:

Workshop #1

- Reuse: yes, it helps reach the goal of Zero Waste
- Brush and Bulky: optimistic; room for enhancements
- Pay As You Throw: Unsure this would help reach the goal of Zero Waste, limited support
- Recycling: Yes, it helps reach the goal of Zero Waste
- Organics: Yes, this is the number one priority to reach the goal of Zero Waste

Workshop #2

- Reuse: Somewhat unsure if it will help Zero Waste
- Brush and Bulky: yes, help reach the goal of Zero Waste
- Pay As You Throw: Unsure this would help reach the goal of Zero Waste, limited support
- Recycling: room for enhancements and changes such as mandates; somewhat sure it helps reach the Zero Waste goal
- Organics: yes, it helps reach the goal of Zero Waste

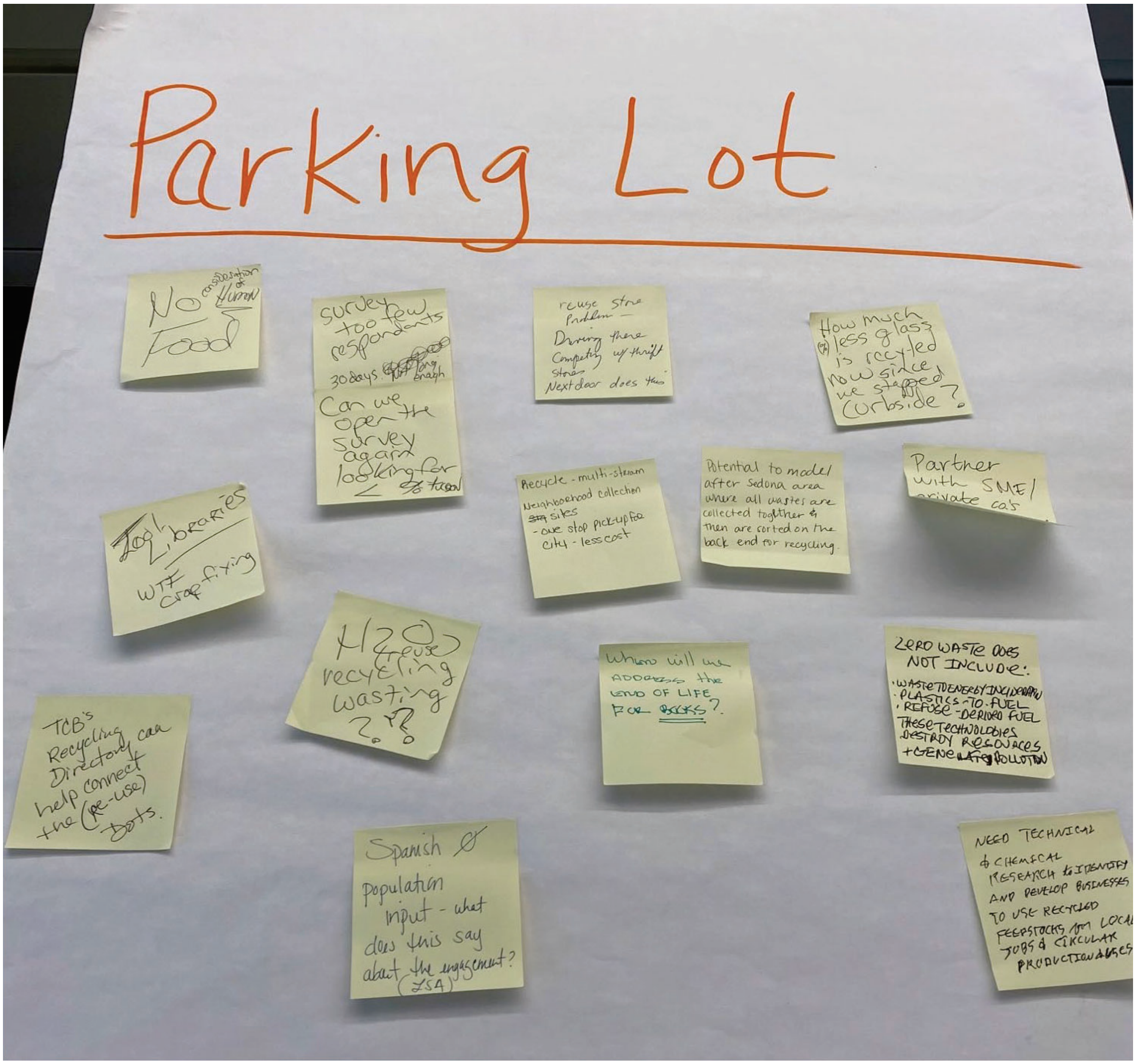
Post Workshop Comments

Following the workshops, an email was sent to all workshop attendees with a brief comment form to allow them to provide their final thoughts on Zero Waste. One comment was received and can be found below:

"*I want to congratulate the City on addressing the issue of food waste as part of their Zero Waste initiative, however, I believe they need to rethink their approach. I would suggest having a closer look at the recommendations put forth in the EPA's report "From Farm to Kitchen: The Environmental Impacts of U.S. Food Waste" in which the agency makes clear that in terms of food waste the greatest environmental benefits are achieved through prevention rather than recycling, which appears to be the City's approach. The City might also want to consult with the terrific nonprofit National Resources Defense Council. NRDC has worked with cities across the country to develop innovative programs that not only deal with the environmental impacts of food waste but also the ways in which wasted food can help feed the City's food insecure population. If the City hasn't already considered the cost benefits of prevention and rescue over recycling I would highly suggest that they do. Many thanks."*

Parking Lot

Throughout the workshop, attendees had the opportunity to share additional insights, questions, and information on the “Parking Lot,” a poster used to capture thoughts outside of the current conversation. The “Parking Lot” is shown below:



Appendix A – Workshop Attendance

Workshop Invitee List

Workshop Attendee List

Workshop Invitation

Tucson Zero Waste Workshop

Invitees

Two general groups of stakeholders (internal staff and key stakeholders) were invited to participate in the Zero Waste Roadmap Workshops. Below are the stakeholder groups invited to each. Stakeholder groups with representatives that attended the workshops are shown in bold.

MORNING SESSION (9 – 11 AM)

- **Environmental and General Services Staff**
- **City of Tucson Economic Initiatives**
- **City of Tucson Staff**
- City of Tucson Water Conservation Staff
- **Environmental Services Advisory Committee**
- **Mayor's Climate Action Committee Chair**
- Ward 1
- Ward 2
- **Ward 3**
- Ward 4
- Ward 5
- Ward 6

AFTERNOON SESSION (1 – 3 PM)

- Cero Store
- **Commission on Climate, Energy, and Sustainability**
- Downtown Partnership
- Fourth Ave. Merchants Assn
- **Freepoint Eco-Systems**
- **Iskashitaa Refugee Network**
- **Mayor's Climate Action Committee**

AFTERNOON SESSION CONT'D (1 – 3 PM)

- **Ms. Greens World**
- National Association of Residential Property Managers-Southern Arizona-Tucson
- **Pima Community College**
- Pima County
- Pima County Community and Economic Development
- **Raytheon**
- **Recyco Inc.**
- **Repair Café**
- **Republic Services**
- **Rotary Club of Tucson Verde**
- **Southwest Gas**
- **Sustainable Tucson**
- **Tucson Association of Realtors**
- **Tucson Clean and Beautiful**
- Tucson Electric Power (TEP)
- Tucson Hispanic Chamber of Commerce
- Tucson Metro Chamber
- Tucson Southern Arizona Black Chamber Of Commerce
- **UCC Recycling**
- **University of Arizona**

Attendees

A total of 10 attendees joined us at the morning session, and 25 attendees joined us at the afternoon session.

From:	Tucson Zero Waste project
To:	Tucson Zero Waste project
Cc:	Lisa Rotello; Cristina Polsgrove
Subject:	RSVP Today: Tucson Zero Waste Workshop - Oct. 12
Date:	Monday, September 26, 2022 2:45:53 PM

Join Us!

The City of Tucson Environmental and General Services Department is pleased to invite you to be a part of an interactive workshop to help guide the development of the Tucson Zero Waste Roadmap.

- **When:** Wednesday, October 12, 2022
- **Time:** 1 PM - 3 PM
- **Where:** Fire Central | 300 S. Fire Central Place, Tucson AZ 85701

The City of Tucson is working to create a roadmap to Zero Waste and we want **your valuable input** to help us move forward. Your insight will support the City's development strategies and programs to meet the goals set by Mayor and Council of 50% Waste Diversion by 2030 and Zero Waste by 2050.

We understand this is an important topic for the Tucson community, so if others from your organization or community are interested in providing input, please feel free to share our public survey link below. This input, and input from our workshop, will guide the development of our Tucson Zero Waste Roadmap.

Please RSVP by October 3, 2022, by clicking here.

>> Take our survey: bit.ly/tucsonzw

Thank you,

Tucson Zero Waste Team

Kristi Shepherd,
Strategic Communications Manager

From: Tucson Zero Waste project
To: [redacted]
Cc: Tucson Zero Waste project
Subject: RSVP Today: Tucson Zero Waste Workshop - Oct. 12
Date: Monday, September 26, 2022 2:30:10 PM

Join Us!

The City of Tucson Environmental and General Services Department is pleased to invite you to be a part of an interactive workshop to help guide the development of the Tucson Zero Waste Roadmap.

- **When:** Wednesday, October 12, 2022
- **Time:** 9 AM - 11 AM
- **Where:** Fire Central | 300 S. Fire Central Place, Tucson AZ 85701

The City of Tucson is working to create a roadmap to Zero Waste and we want **your valuable input** to help us move forward. Your insight will support the City's development strategies and programs to meet the goals set by Mayor and Council of 50% Waste Diversion by 2030 and Zero Waste by 2050.

Please RSVP by October 3, 2022, by clicking here.

Thank you,

Tucson Zero Waste Team

Kristi Shepherd,
Strategic Communications Manager

Appendix B – Workshop Materials

Presentation

Worksheet

Zero Waste Roadmap Workshop

October 12, 2022

9 am - 11 am | Fire Central

CITY OF TUCSON
ENVIRONMENTAL & GENERAL SERVICES

Native Lands Acknowledgement

- Hohokam Territory known for their stability
- “Masters of the desert”
- Villages were continuously occupied for up to 1,500 years or more
- Largest-scale farming irrigation in North America
- 500 miles of interconnected irrigation canals

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ENVIRONMENTAL & GENERAL SERVICES

Welcome HDR Facilitators

Kate Bartelt
Senior Waste/Environmental Project Manager

Kristi Shepherd
Strategic Communications Manager

HDR

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Housekeeping

Safety

- Emergency exits
- Outdoor rally location

Comfort

- Restroom locations
- Breaks

Flow

- Agenda & parking lot process

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GENERAL SERVICES

Zero Waste Workshop #1 Agenda

Agenda & Timing	Time
I. Welcome & Introductions	9:00 am
II. Zero Waste Overview & Meeting Goals	9:05 am
III. Facilitated Breakout Group Activity	9:35 am
IV. Break	10:05 am
V. Group Activity Report Out	10:15 am
VI. Action Items & Next Steps	10:55 am

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Goals for the Day

Objectives:

- Learn about the roadmap process and survey input
- Learn about the five identified near-term developments and understand the importance of each
- Discover benefits and barriers to near-term developments
- Develop support for the near-term developments and gather insight into other considerations and potential influencers/audiences for future engagement

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What is Zero Waste?

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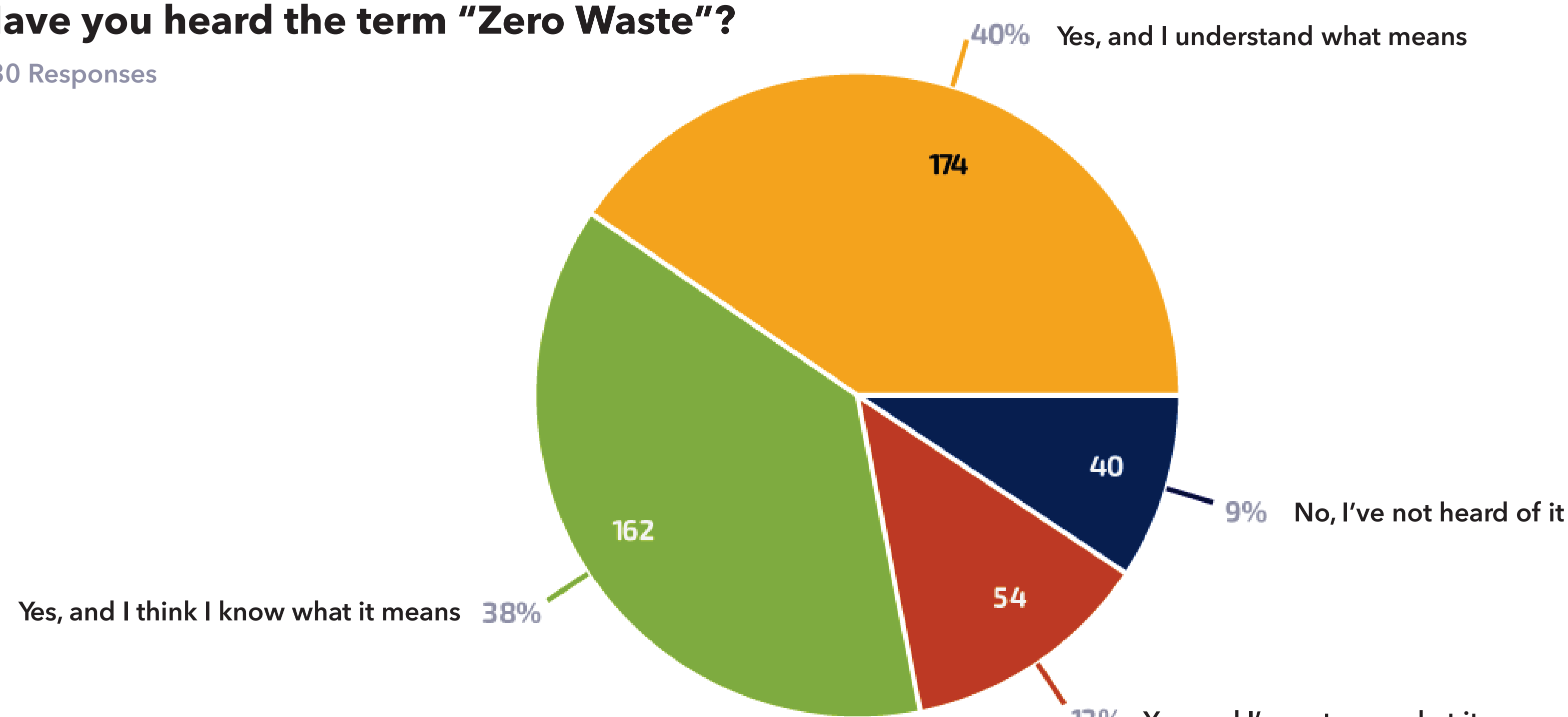
GENERAL SERVICES

What Do Tucsonans Think Zero Waste Is?

Have you heard the term "Zero Waste"?

430 Responses



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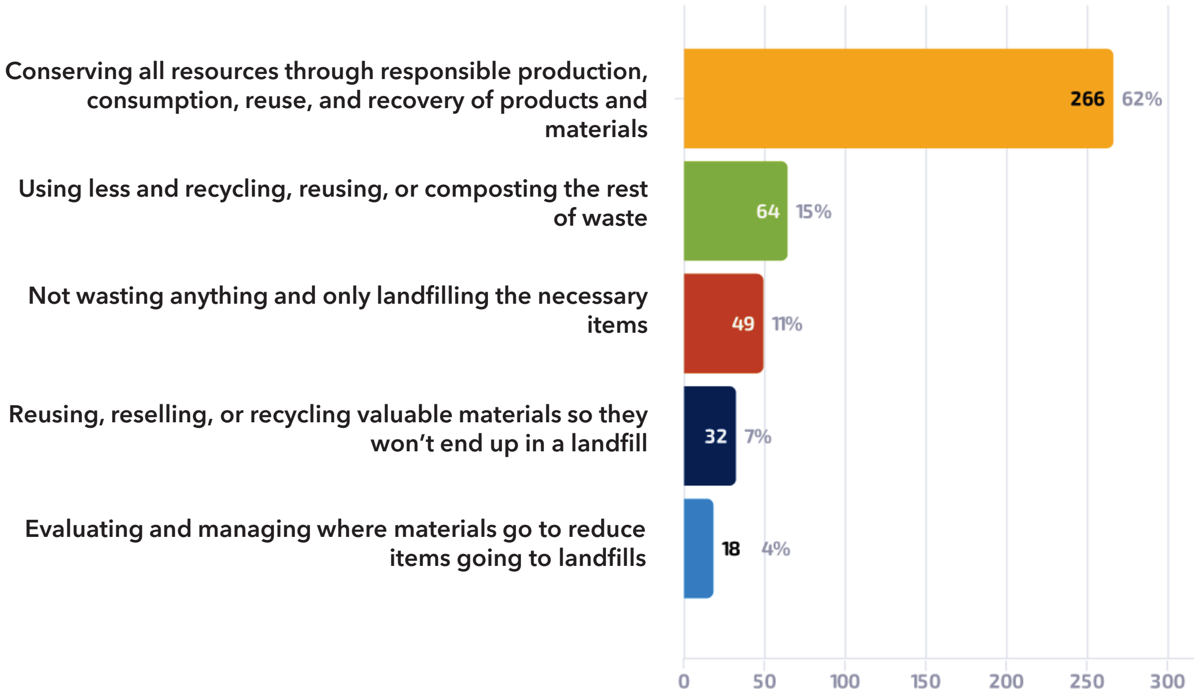
What Do Tucsonans Think Zero Waste Is?

Which definition most closely aligns with how you define Zero Waste?

429 Responses



Conserving all resources through responsible production, consumption, reuse and recovery of products and materials

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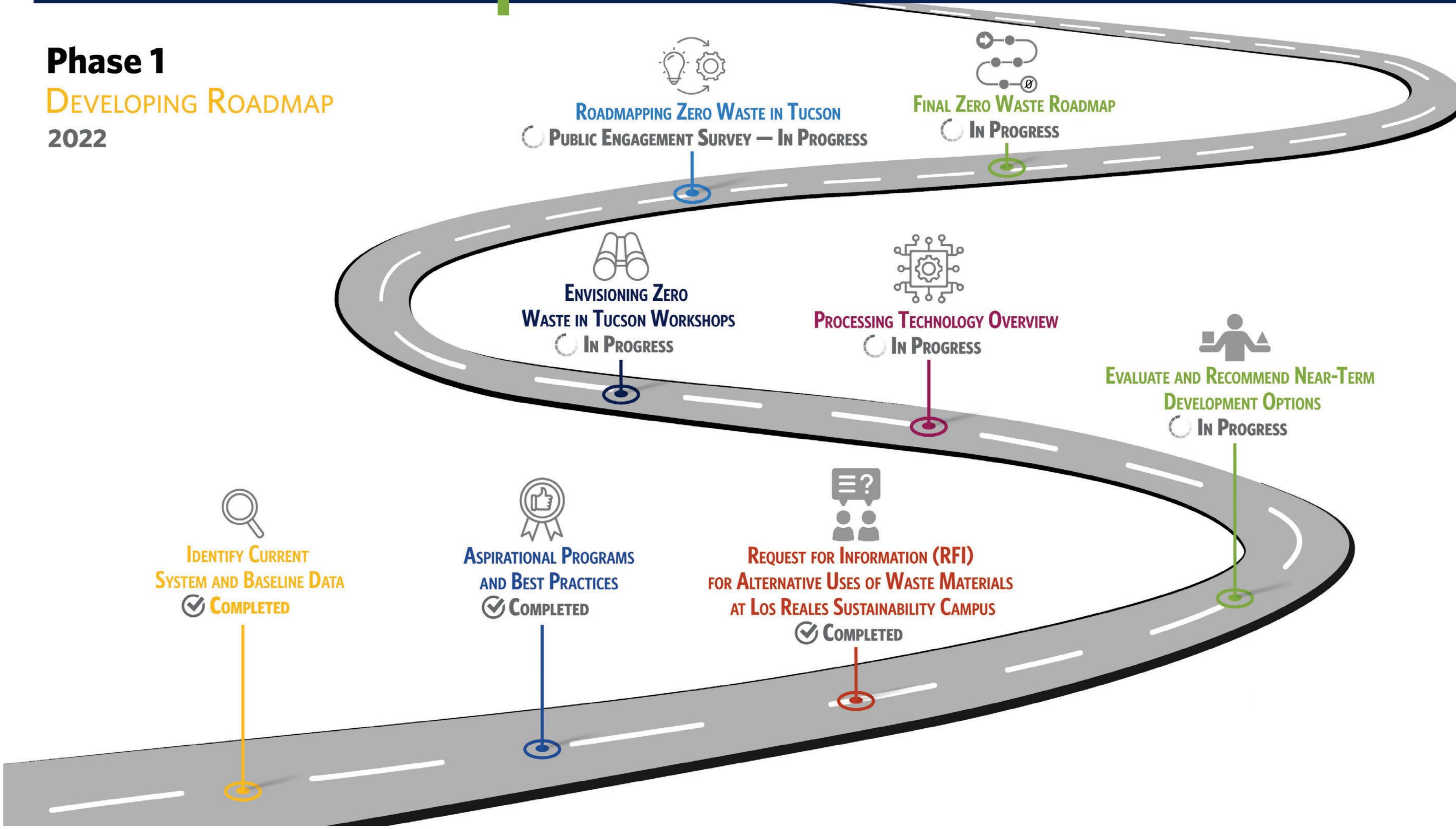
Roadmap to Zero Waste

Phase 1
Developing Roadmap
2022



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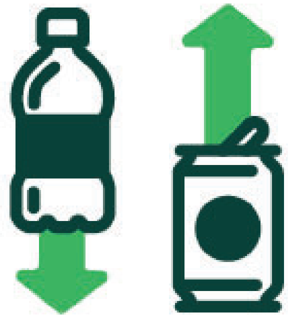
Near-term Developments

Brush & Bulky Waste

Residential & Commercial Organics Collection



Recycling Collection Changes (Multi-Stream)

Incentivized Reduced Disposal (Pay-As-You Throw)

Reuse Store

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Near-term Developments

Current Program

- Convenient service for residents to dispose of brush and bulky household items curbside **twice per year at no cost**

- **Brush:** yard waste up to 5 feet long and 24 inches in diameter, cacti, etc.

- **Bulk:** Items too big for the trash can, lumber, appliances, tires, scrap metal, furniture, and carpet

Possibilities:
- Collect brush and yard waste separate from bulky items
- Track recycled tons of brush and yard waste diverted
- Easy implementation due to current collection

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Near-term Developments

Current Program

- Small pilot commercial program, FoodCycle program, 260 tons annually

Possibilities:

- Food waste drop off
- Food waste Curbside-long term
- Markets needed for organics with food waste

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Near-term Developments

Current Program

- Single-stream or Mixed Recycling where all recyclable materials go in one container every other week
- Accepted materials: Flattened cardboard, paper, plastic bottles, aluminum, and steel food and beverage containers
- Items are sorted at a Material Recovery Facility or MRF

Possibilities:

- 10-20% of landfilled material could be recycled
- Dual-stream Collection paper and cardboard separate from plastic and metal containers
- Cleaner recyclables but higher program start-up costs

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Near-term Developments

Current Program

- No official program
- Non-affiliated, non-profit programs for textile recycling and household items reuse

Possibilities:

- Creating a space on the campus to conveniently divert material from landfill disposal for reuse
- Collect items directly from residents for reuse or resale, etc.
- Encourages community involvement and local economic benefit

Near-term Developments

Current Program

- Offers 48, 65, and 96-gallon trash carts ranging from $15-$16.75/month
- Every other week recycling
- Twice a year brush and bulky waste pick up

Possibilities:

- Pay-as-you-throw (PAYT) program more robust to shift customer behaviors
- Recommended greater financial differentiation for smaller carts
- Encourages recycling and waste reduction

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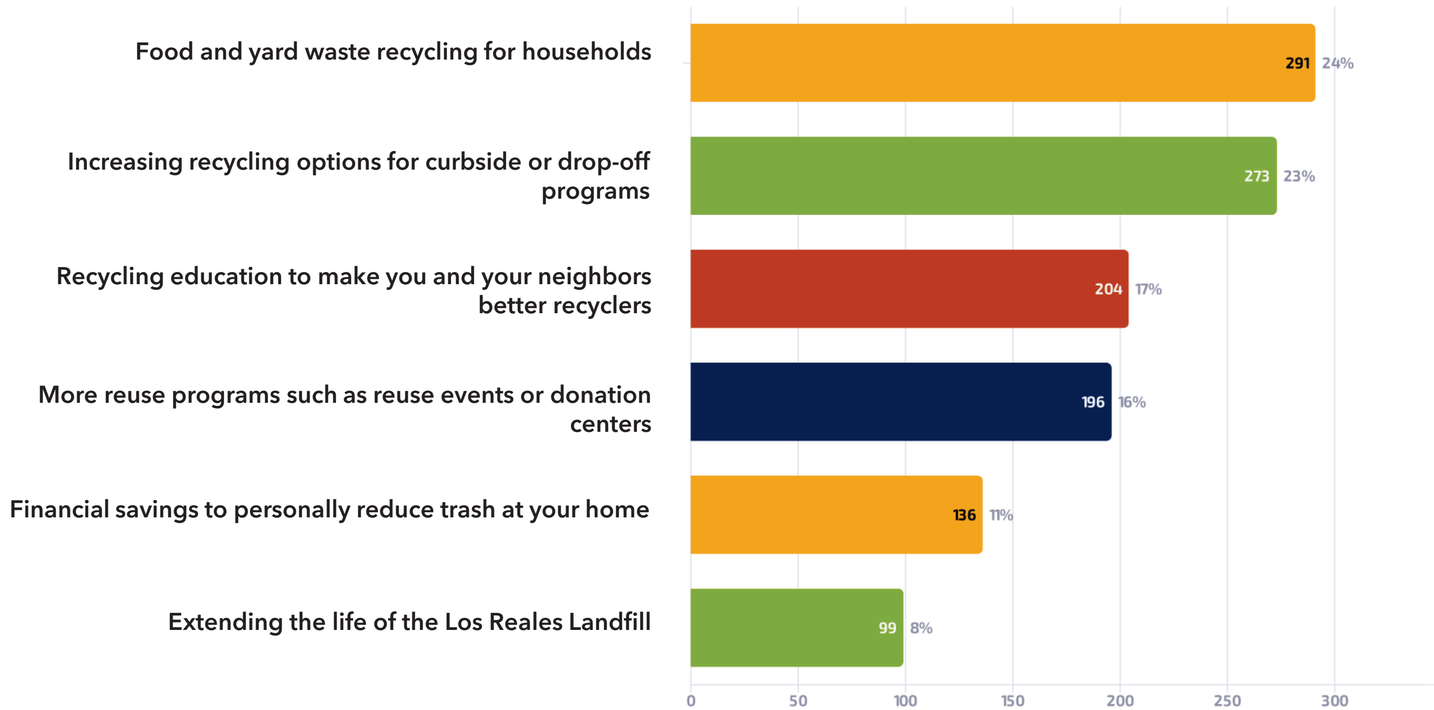
What ZW Topics Are Most Important?

What Zero Waste topics are most important to you? (Select three)

1199 Responses



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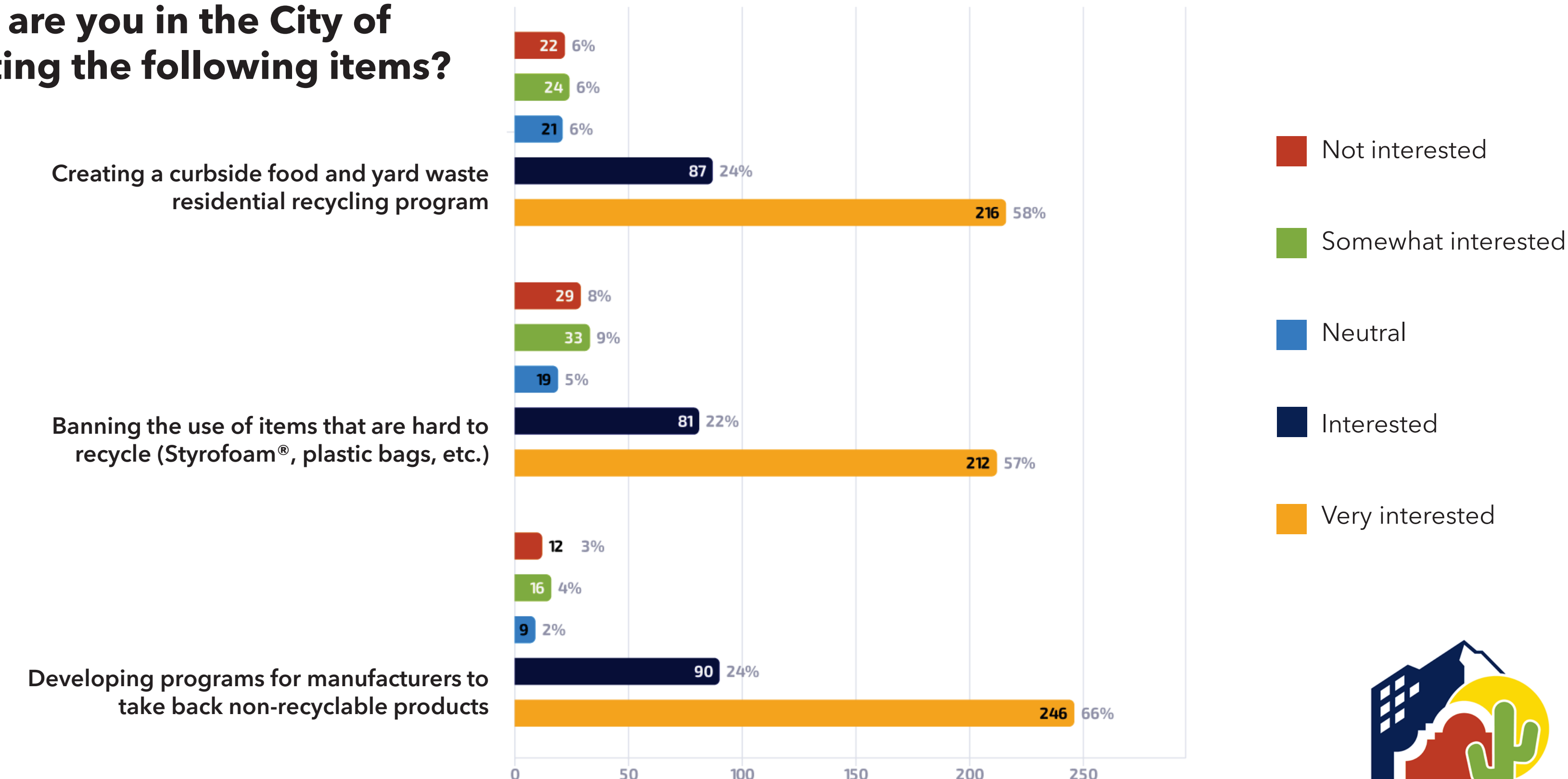
Interest in Zero Waste Initiatives

How interested are you in the City of Tucson completing the following items? (Top three)

427 Responses



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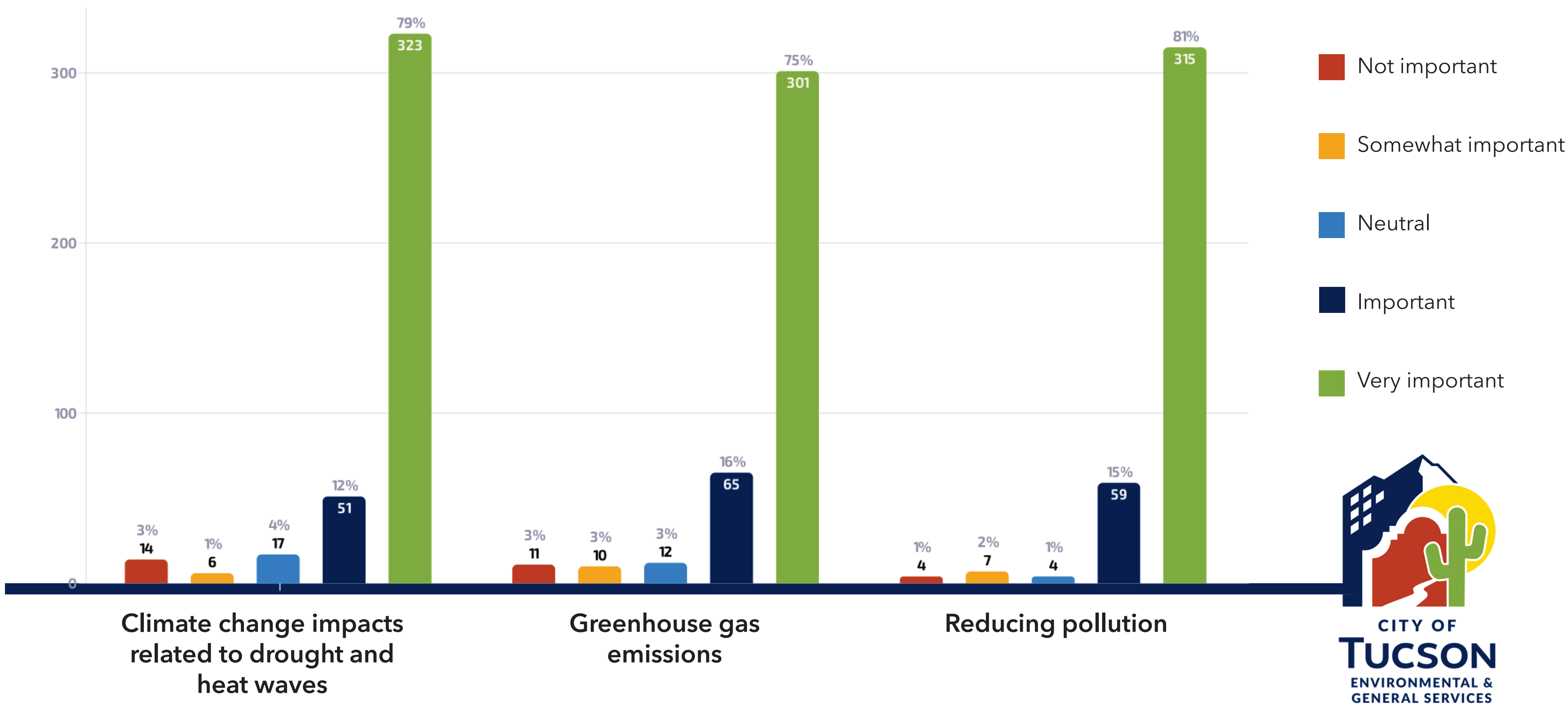
What do you value most?

Why is Zero Waste Important to you (Top three)

428 Responses



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Breakout Group Instructions	
	Smile at fellow group members
	Everyone listens & engages
	Use the Parking Lot for issues not specific to your topic
	Be open to this collaborative process

Breakout Sessions

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In Your Groups

- *Introduce yourself:*
  - Name, title, & sustainability superpower
- Determine who will take notes & report out
- Review your table's near-term development
- Follow the prompts from the worksheet

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Breakout Sessions

Brush & Bulky Waste

Residential & Commercial Organics Collection

Recycling Collection Changes (Multi-Stream)

Incentivized Reduced Disposal (Pay-As-You Throw)

Reuse Store

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- Locate the papers in the room with a near-term development

- Use stickers to choose your two most important

- Think about why they are important

Break- 10 Minutes

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Report Out

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- Return to the papers in the room with a near-term development
- Use the final sticker to choose your top-most important
- How have they changed?

Next Steps

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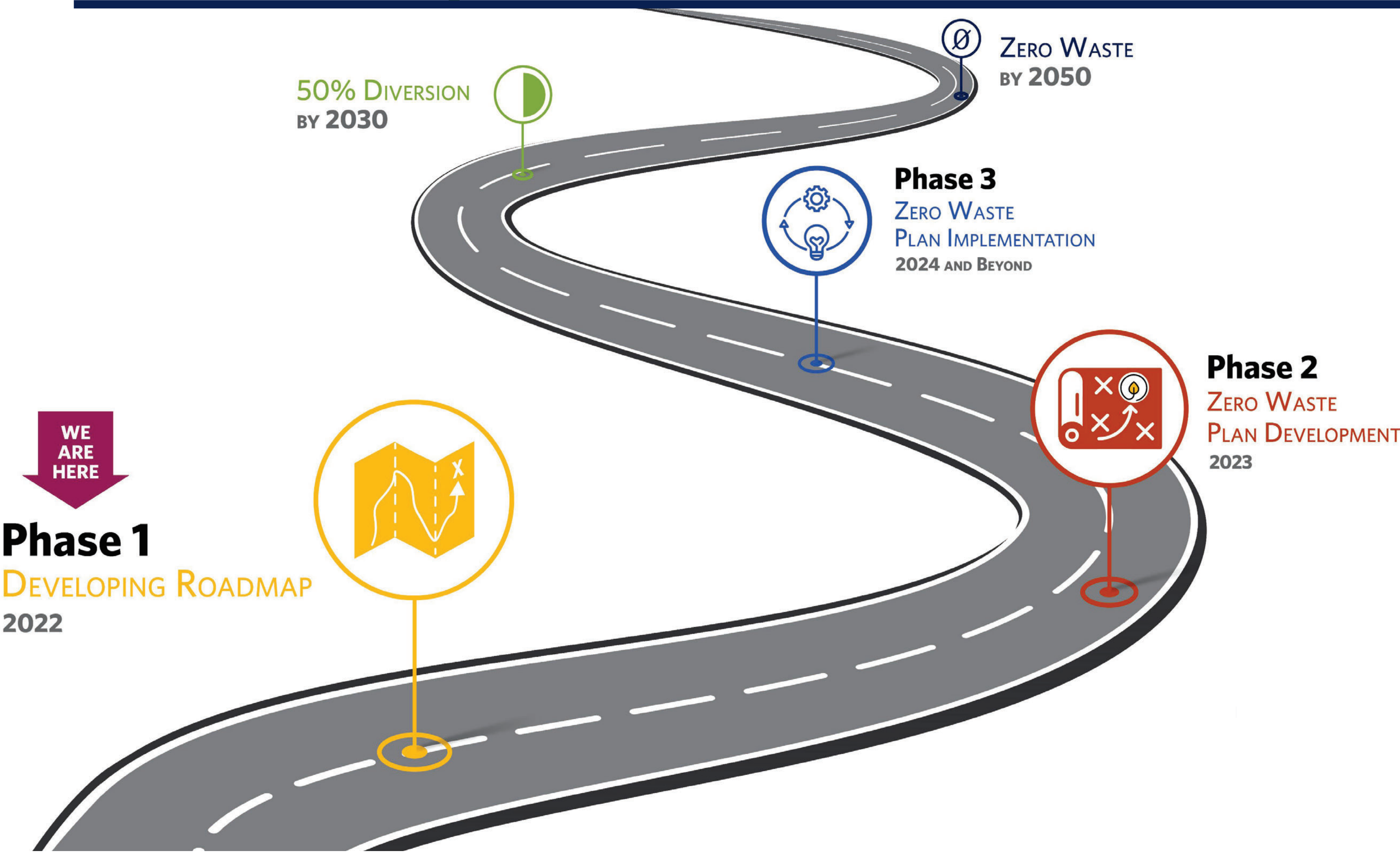
Next Steps



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Thank You!

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Zero Waste Roadmap Workshop

October 12, 2022

1 pm – 3 pm | Fire Central

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CITY OF TUCSON ENVIRONMENTAL & GENERAL SERVICES

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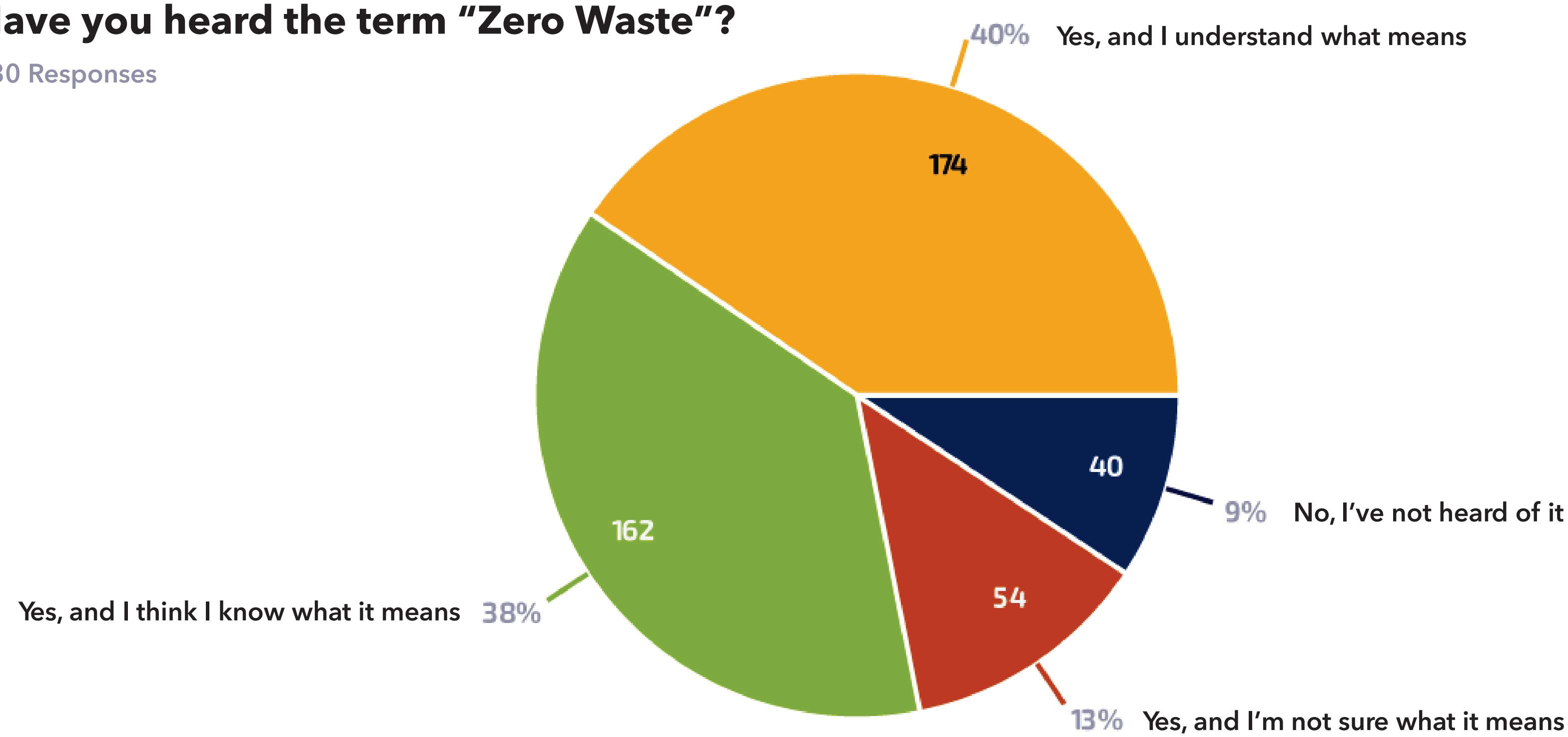

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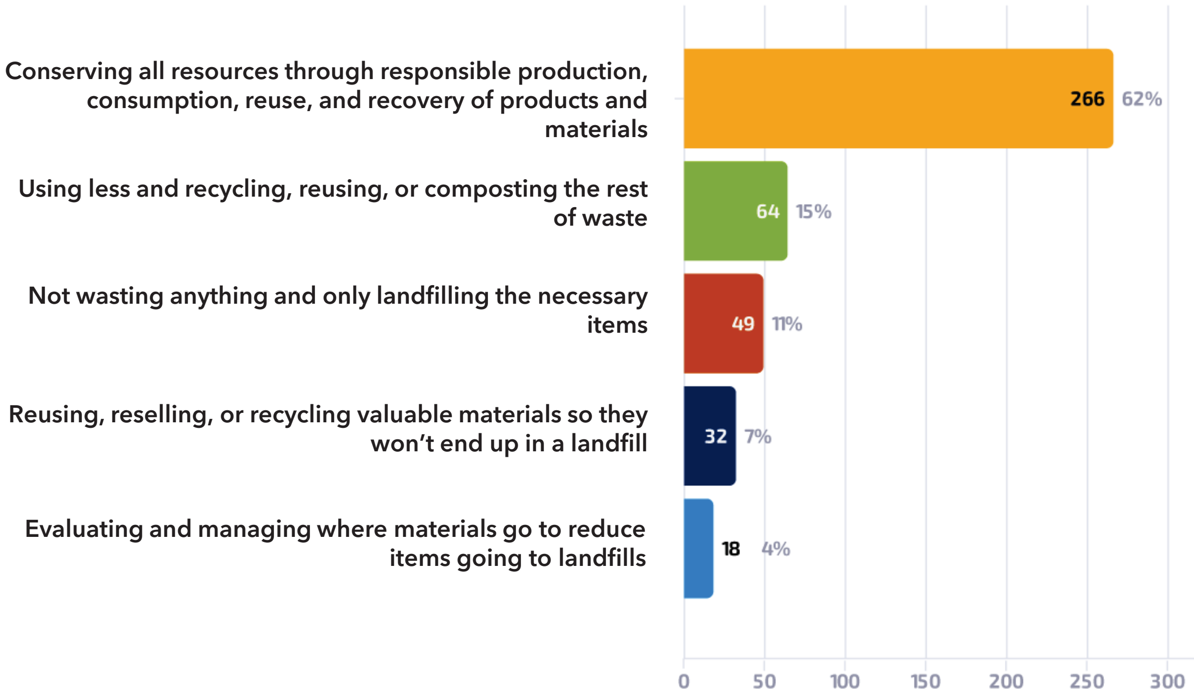

Conserving all resources through responsible production, consumption, reuse and recovery of products and materials

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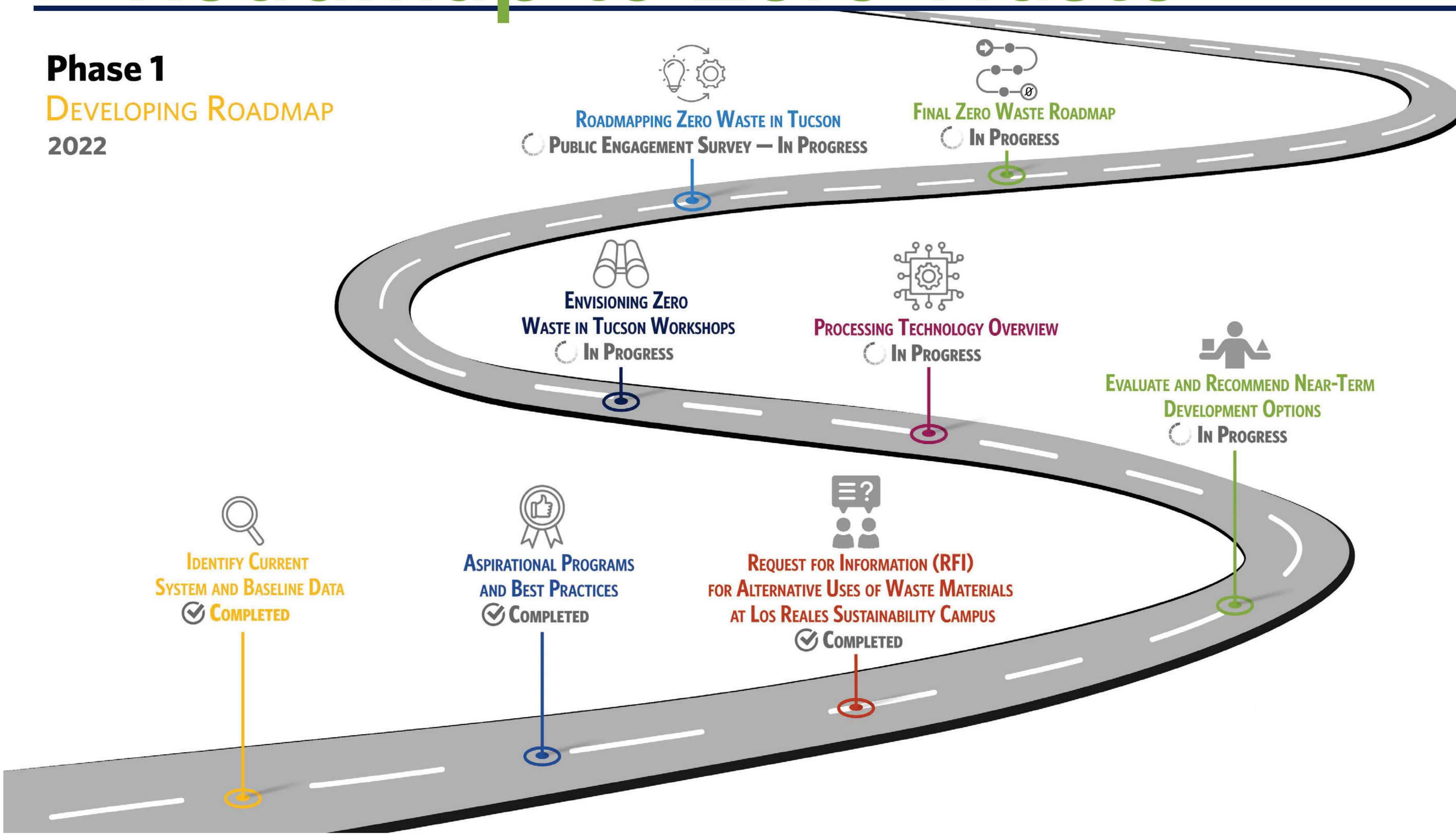
Roadmap to Zero Waste

Phase 1

DEVELOPING ROADMAP

2022



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Near-term Developments

Brush & Bulky Waste

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- Encourages recycling and waste reduction

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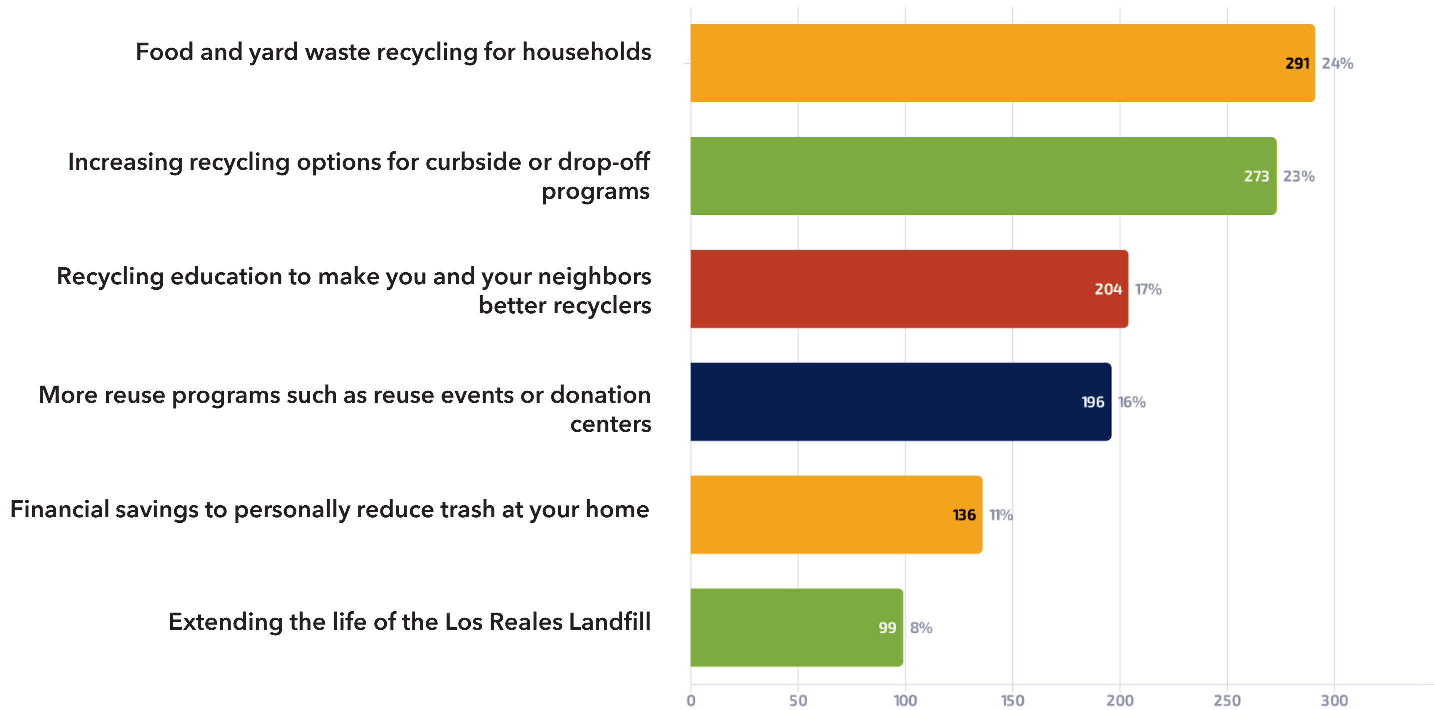
ENVIRONMENTAL & GENERAL SERVICES

What ZW Topics Are Most Important?

What Zero Waste topics are most important to you? (Select three)

1199 Responses



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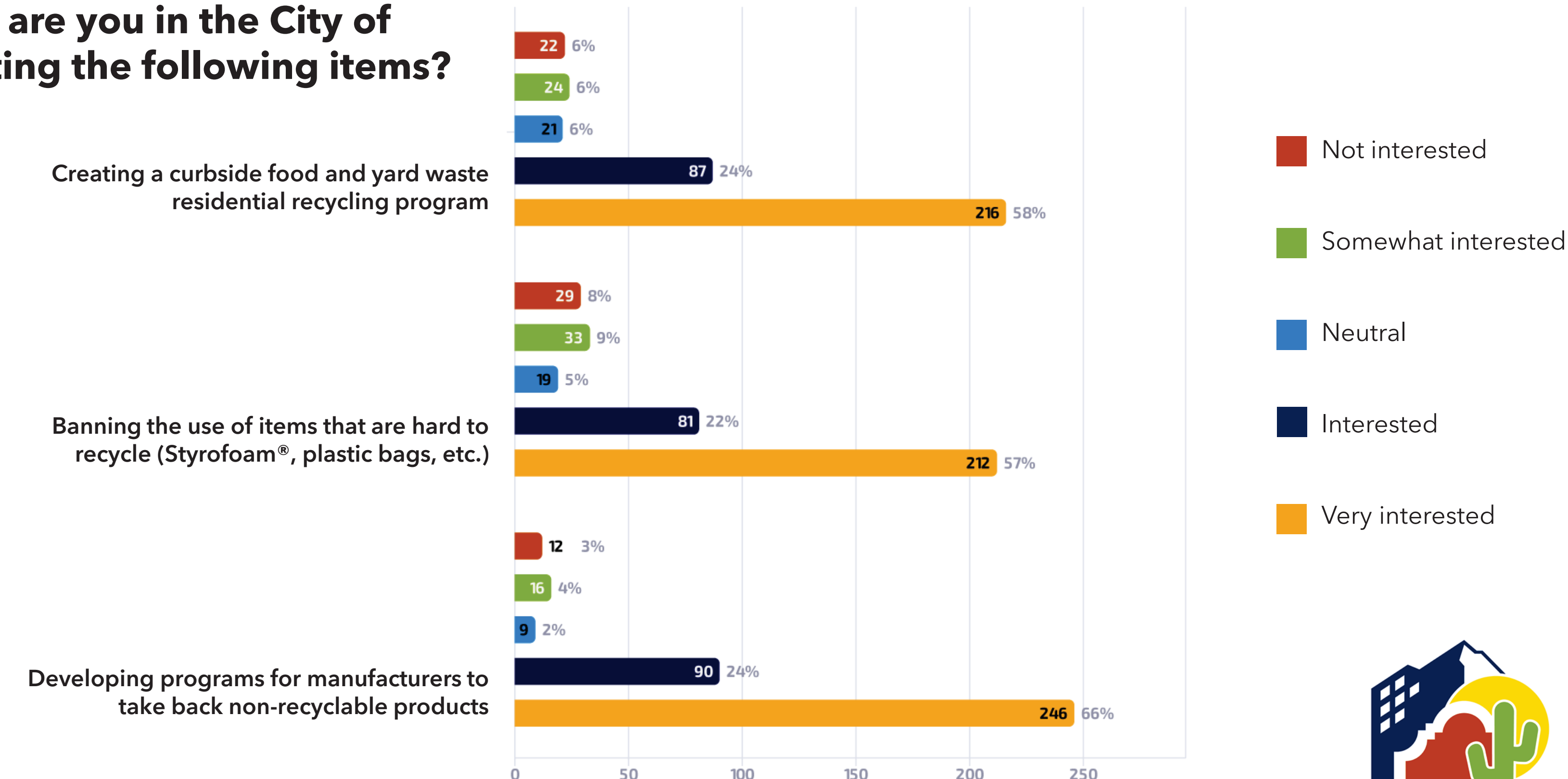
ENVIRONMENTAL & GENERAL SERVICES

Interest in Zero Waste Initiatives

How interested are you in the City of Tucson completing the following items? (Top three)

427 Responses



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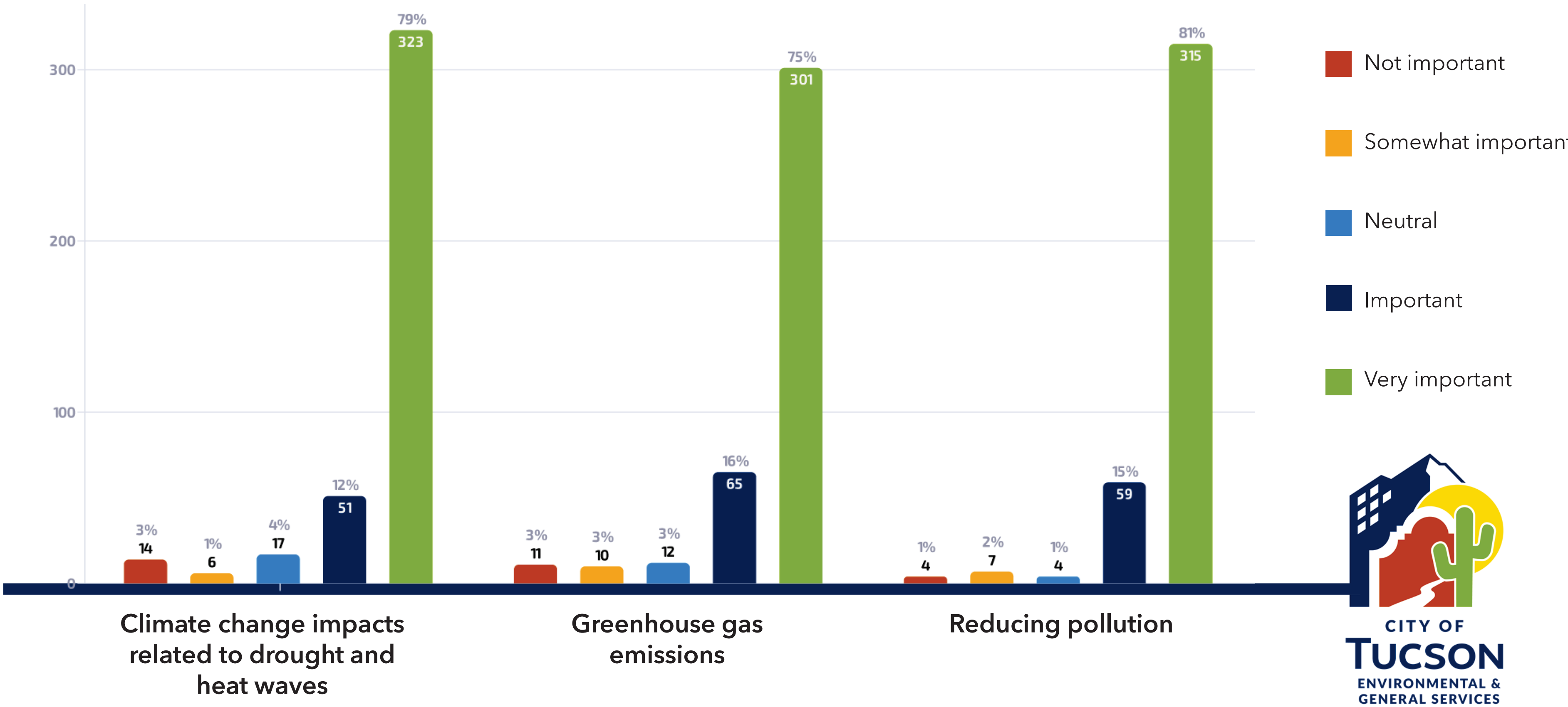
What do you value most?

Why is Zero Waste Important to you (Top three)

428 Responses



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Breakout Group Instructions	
	Smile at fellow group members
	Everyone listens & engages
	Use the Parking Lot for issues not specific to your topic
	Be open to this collaborative process

Breakout Sessions

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In Your Groups

- *Introduce yourself:*
  - Name, title, & sustainability superpower
- Determine who will take notes & report out
- Review your table's near-term development
- Follow the prompts from the worksheet

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Breakout Sessions

Brush & Bulky Waste

Residential & Commercial Organics Collection

Recycling Collection Changes (Multi-Stream)

Incentivized Reduced Disposal (Pay-As-You Throw)

Reuse Store

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- Locate the papers in the room with a near-term development
- Use stickers to choose your two most important
- Think about why they are important

Break- 10 Minutes

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Report Out

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- Return to the papers in the room with a near-term development
- Use the final sticker to choose your top-most important
- How have they changed?

Next Steps

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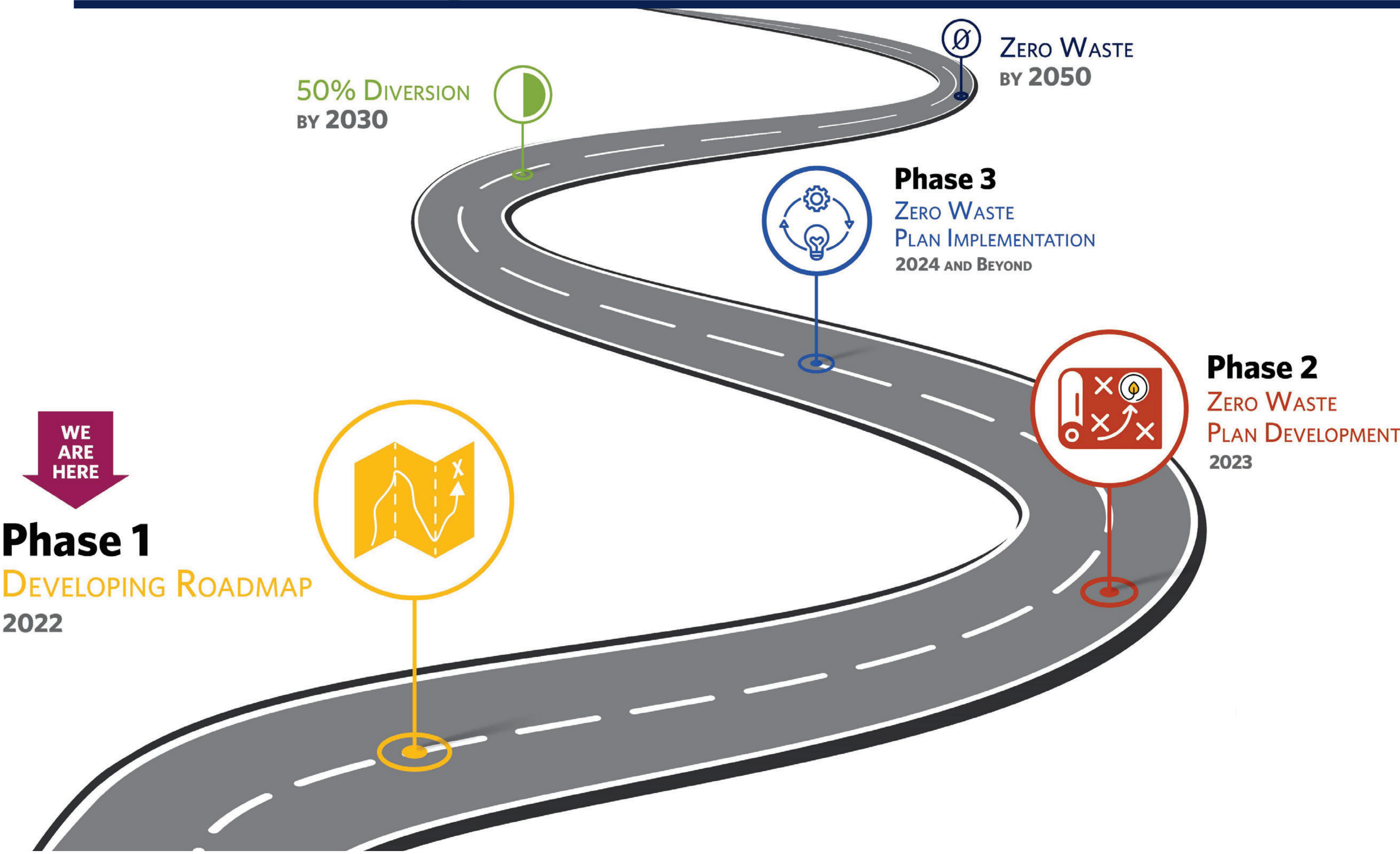
Next Steps



City of Tucson
Environmental & General Services

Thank You!

CITY OF
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GENERAL SERVICES

Tucson Zero Waste Roadmap Workshop Worksheet

Near-Term Development: Brush and Bulky Collection

Instructions: Complete this worksheet with your group. Be prepared to have one master copy for the group to turn in at the end of the workshop.

Benefits	Barriers	What concerns do you have with this initiative?
Who needs to be involved? (Partners, influencers, participants)	**What do we need to make this successful? (Budget, education, infrastructure, etc.)**	**Unknowns (add your questions here)**

How confident is your table that this activity would advance zero waste in Tucson? (Circle one)				
Very Confident	**Somewhat Sure**	**Neutral**	**Somewhat Unsure**	**Very Unsure**

Tucson Zero Waste Roadmap Workshop Worksheet

Near-Term Development: Residential & Commercial Organics Collection

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How confident is your table that this activity would advance zero waste in Tucson? (Circle one)				
Very Confident	**Somewhat Sure**	**Neutral**	**Somewhat Unsure**	**Very Unsure**

Tucson Zero Waste Roadmap Workshop Worksheet

Near-Term Development: Recycling Collection Changes (Multi-Stream)

Instructions: Complete this worksheet with your group. Be prepared to have one master copy for the group to turn in at the end of the workshop.

Benefits	Barriers	What concerns do you have with this initiative?
Who needs to be involved? (Partners, influencers, participants)	**What do we need to make this successful? (Budget, education, infrastructure, etc.)**	**Unknowns (add your questions here)**

How confident is your table that this activity would advance zero waste in Tucson? (Circle one)				
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Tucson Zero Waste Roadmap Workshop Worksheet

Near-Term Development: Incentivized Reduced Disposal (Pay-As-You Throw)

Instructions: Complete this worksheet with your group. Be prepared to have one master copy for the group to turn in at the end of the workshop.

Benefits	Barriers	What concerns do you have with this initiative?
Who needs to be involved? (Partners, influencers, participants)	**What do we need to make this successful? (Budget, education, infrastructure, etc.)**	**Unknowns (add your questions here)**

How confident is your table that this activity would advance zero waste in Tucson? (Circle one)				
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Tucson Zero Waste Roadmap Workshop Worksheet

Near-Term Development: Reuse Store

Instructions: Complete this worksheet with your group. Be prepared to have one master copy for the group to turn in at the end of the workshop.

Benefits	Barriers	What concerns do you have with this initiative?
Who needs to be involved? (Partners, influencers, participants)	**What do we need to make this successful? (Budget, education, infrastructure, etc.)**	**Unknowns (add your questions here)**

How confident is your table that this activity would advance zero waste in Tucson? (Circle one)				
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Tucson Zero Waste Roadmap Workshop Worksheet

Near-Term Development: Brush and Bulky Collection

Instructions: Complete this worksheet with your group. Be prepared to have one master copy for the group to turn in at the end of the workshop.

Benefits	Communications channels best to engage residents about this initiative	What concerns do you have with this initiative?
Who needs to be involved? (Partners, influencers, participants)	**What do we need to make this successful? (Budget, education, infrastructure, etc.)**	**Unknowns (add your questions here)**

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Tucson Zero Waste Roadmap Workshop Worksheet

Near-Term Development: Residential & Commercial Organics Collection

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Tucson Zero Waste Roadmap Workshop Worksheet

Near-Term Development: Recycling Collection Changes (Multi-Stream)

Instructions: Complete this worksheet with your group. Be prepared to have one master copy for the group to turn in at the end of the workshop.

Benefits	Communications channels best to engage residents about this initiative	What concerns do you have with this initiative?
Who needs to be involved? (Partners, influencers, participants)	**What do we need to make this successful? (Budget, education, infrastructure, etc.)**	**Unknowns (add your questions here)**

How confident is your table that this activity would advance zero waste in Tucson? (Circle one)				
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Tucson Zero Waste Roadmap Workshop Worksheet

Near-Term Development: Incentivized Reduced Disposal (Pay-As-You Throw)

Instructions: Complete this worksheet with your group. Be prepared to have one master copy for the group to turn in at the end of the workshop.

Benefits	Communications channels best to engage residents about this initiative	What concerns do you have with this initiative?
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Tucson Zero Waste Roadmap Workshop Worksheet

Near-Term Development: Reuse Store

Instructions: Complete this worksheet with your group. Be prepared to have one master copy for the group to turn in at the end of the workshop.

Benefits	Communications channels best to engage residents about this initiative	What concerns do you have with this initiative?
Who needs to be involved? (Partners, influencers, participants)	**What do we need to make this successful? (Budget, education, infrastructure, etc.)**	**Unknowns (add your questions here)**
How confident is your table that this activity would advance zero waste in Tucson? (Circle one)		

Very Confident **Somewhat Sure** **Neutral** **Somewhat Unsure** **Very Unsure**