



Recycling Infrastructure in Puerto Rico

Closed Loop Partners
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Executive Summary

The Closed Loop Foundation (CLF) aims to further the research and development needed to build a more circular economy. In this report, we focus on materials management challenges using Puerto Rico as a case study. Island nations in particular face acute challenges on the climate crisis frontline, including distance from recycling markets and coastline proximity which can lead to ocean plastic pollution if materials are not managed properly. It's critical that we keep valuable materials in manufacturing supply chains and out of our oceans.

The work in Puerto Rico summarized in this report demonstrates a range of approaches and analytics to solve materials management challenges at scale. We hope the work here presents an initial step toward solving for the particular recycling system in Puerto Rico, and eventually leads to broader, replicable lessons that can be incorporated in other island nations to create better materials management outcomes and foster more circular systems.

Puerto Rico faces a host of well-documented challenges in its recycling and waste management system, including a lack of or aging infrastructure and difficult disposal conditions whereby many of its 29 landfills are operating below regulatory

standards. Recently, catastrophic storms (Hurricanes Irma and Maria) and political and economic upheaval have put further strain on action toward more sustainable materials management.

As an island nation, uplifting the recycling system is critical to yield environmental benefits (e.g., reducing leakage of plastics into the environment), preserve critical resources, and create economic stability. Toward these goals, the Closed Loop Foundation (CLF) received a grant from The Coca-Cola Foundation to carry out a proposed three-step approach to help address recycling and materials challenges faced by Puerto Rico: (1) Conduct detailed research and stakeholder outreach to understand the waste management system, material flows, available infrastructure, and bottlenecks to system improvements, (2) Identify pilot-scale demonstration projects that can help fill knowledge gaps and address bottlenecks in the system, and (3) Identify actions that can substantially increase material recovery in the near and medium term.

CLF constructed a granular, measurement-based layout of Puerto Rico's waste system dynamics,

which produced approximately 4 million tons of waste in 2018 with a diversion rate of approximately 7% - the rest goes to landfill. We estimate that 250,000 households (about 20% of households in Puerto Rico) have access to curbside recycling service, and the contamination rate of curbside-collected recyclables in most areas is 50% or more. Recycling from commercial establishments is almost nonexistent except for cardboard and a few priority materials (e.g., motor oil, toner cartridges, pallets). We identified 103 entities that aggregate, transport, or export one or more recyclables, including 3 material recovery facilities that accept mixed household recyclables.¹

We identified 10 possible pilot projects following an intensive research and outreach effort that included detailed discussions with 120+ stakeholders spanning companies (51% of stakeholder outreach), government and non-profit (25%), capital providers (14%), and technology providers and engineers (10%). After a rigorous screening process, we selected two pilots with strong potential for scalability and sustainability,

¹ The three MRF figure does not include small dump-and-pick operations or very small facilities with limited mechanical conveyance or separation technologies.

Executive Summary

which are essential elements to help support the proper functioning of Puerto Rico's recycling system going forward.

Pilot 1 included developing a first-of-kind digital outreach campaign in Guaynabo to increase the quality and quantity of recyclables placed curbside. We measured individual sentiment from more than 700 households through a triumvirate of digital tools and platforms while measuring collected recyclables at the Guaynabo material recovery facility (MRF) to gauge impact. Results showed residents have a strong will to recycle, a high degree of confusion about what is acceptable, and a lack of faith that collected materials are being recycled. Our waste characterization program, which included two measurements before the communication campaign and two measurements after the campaign, initially showed a high degree of contamination (bagged garbage and non-program materials). Our results showed substantial improvement in a short time – the first measurement showed 64% of materials placed curbside were contaminants (25% non-program materials and 39% bagged garbage). The final characterization measurement after the three-week outreach campaign showed a contamination

rate of 56% (34% non-program materials and 22% bagged garbage). Total material quantity placed curbside declined (4,940 lb in the first week of the program versus 3,920 lb in the final week), but the decline occurred along with the reduction in the fraction of contaminants, strongly showing better adherence to program guidelines and a positive signal about the positive effects enabled by sustained campaigning.

Pilot 2 included the development of a first-of-kind online learning platform, focused on recycling curriculum, that is freely available and targeted toward municipal recycling coordinators and directors in Puerto Rico. These government positions are key in the education, execution, measurement, and improvement in recycling programs across 78 municipalities on the island and have been historically under-supported. Our stakeholder outreach highlighted the need to provide educational support to coordinators and directors. The flagship learning module created on the platform is a 40-minute course providing systematic coverage of waste management and recycling systems broadly and in Puerto Rico. Our vision is to build on this initial effort to address topics and perspectives critical to

others in the system including facility operators, other government organizations, households, and businesses, which are also in great need of educational support.

Our research showed at least \$100 million in investment will be needed across the island's recycling system to make substantive improvements and effectively capture value from materials generated by Puerto Rico's residents, visitors, businesses, and institutions. The most promising opportunities we identified included continued bolstering of education across the system to increase the quantity and quality of recyclables put into the system, provision of collection containers to more households and public areas, upgrading the size and technology stack at multiple MRFs, and building out on-island reprocessing capacity (e.g., for PET). Collectively, we estimate these efforts could enable recovery of nearly 1.5 million tons of valuable commodity recyclables over the next decade.

Waste Generation & Management in Puerto Rico

Laws and public policies related to solid waste management in Puerto Rico evolved in the past several decades. The Solid Waste authority Organic Act (Act 70 of 1978), the Solid Wastes Reduction and Recycling Act of Puerto Rico (Act 70 of 1992), and others established an island-wide framework to encourage waste minimization, a hierarchy for solid waste management, requirements to dispose of waste into landfills with engineered systems to protect the environment. Unfortunately, a combination of factors led to a broad lack of compliance with the established laws and policies, creating a situation of environmental risk and substantial missed opportunities for materials recovery.

We developed an account of waste production and management in Puerto Rico using a combination of on-the-ground data collection, a review of peer-reviewed and grey literature, and scraping a variety of publicly-available databases. Currently, approximately 4 million tons of non-hazardous waste are produced annually – this figure mostly includes household-type wastes but also includes construction and demolition debris and other materials (**Figure 1**). Of the waste materials produced, approximately 93% is sent for disposal

at one of the island’s 29 operating landfills, with the remaining 7% recovered for recycling. The disposal estimate excludes large amounts of debris produced following Hurricane Irma and Maria, the total which is estimated to be about 5 million short tons consisting of household waste, vegetation, and construction and demolition materials.²

The operation and management of landfills has long been a challenge in Puerto Rico, primarily because most sites lack even basic environmental protective features (e.g., low-permeability liners to prevent the discharge of wastewater – referred to as leachate – into the environment). In the early 2000s, the US Environmental Protection Agency’s Region 2, which includes Puerto Rico under its authority, began to issue consent orders to compel landfills to close certain areas and build new, compliant environmental systems. In the subsequent years, several landfills have undergone this closure+compliance model, but many landfills on the island continue operating with limited protective features.

We further estimate that up to 1.7 million tons of recyclable commodities are being sent to landfills

² US EPA Caribbean Division, 2019, presentation to Puerto Rico Recycling Partnership

each year in Puerto Rico (**Table 1**). The amount of waste normally produced in Puerto Rico is somewhat large on a per-capita basis (about 1.3 tons/capita-yr, current population 3.2 million), owing both to its rates of consumption and contributions from tourism, which brings another 3 million+ visitors annually.

Total Waste Generation = 4 million short tons

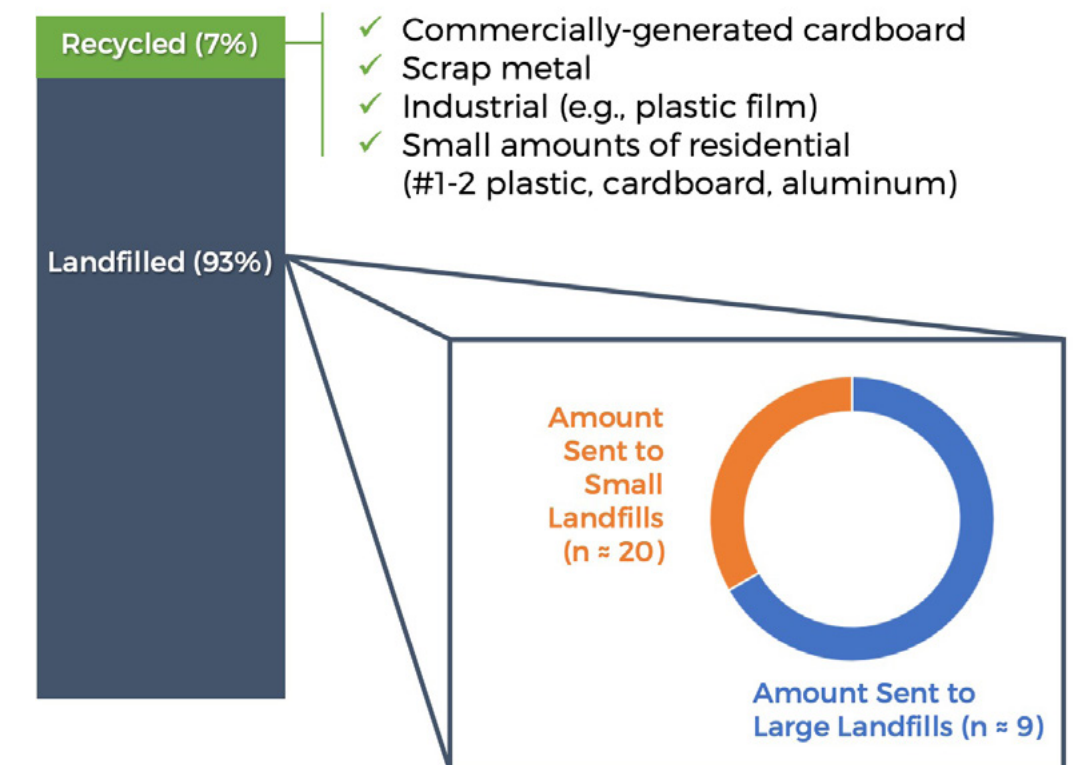


Figure 1 Summary of Waste Generation and Management in Puerto Rico, Year 2018. Fates Shown Derived From a Combination of Primary and Secondary Data Reflecting Estimated and Measured Values, Which May be Subject to Error.

Waste Generation & Management in Puerto Rico

| Material | Midpoint Estimate of Quantity Discarded to Landfill Annually (Short Ton) ³ |
|--------------------------------|---------------------------------------------------------------------------------------|
| Plastics | |
| PET | 150,000 |
| HDPE | 150,000 |
| PP (incl. bulky rigids) | 150,000 |
| #3,4,6,7 resins | 150,000 |
| Paper | |
| Mixed Paper | 450,000 |
| Cardboard | 350,000 |
| Metals | |
| Ferrous | 350,000 |
| Non-Ferrous | 50,000 |
| TOTAL - ALL COMMODITIES | 1,800,000 |

Table 1 Estimated Quantities of Common Recyclable Commodities Discarded to Landfill in Puerto Rico, 2018.

Handling and management of recyclables is addressed by about 103 entities and facilities for which we developed an inventory. **Figure 2** displays the geographic distribution of aggregation points, transporters, and exporters in Puerto Rico. Of the facilities we identified, many are small operations that focus on one or two dedicated material streams (e.g., grease, waste oil, toner cartridges, pallets, etc.). We identified three MRFs that process traditional recyclables using at least some mechanized equipment – several other small, manual “dump and pick” facilities operate in Puerto Rico. Cardboard from commercial establishment (e.g., retailers) and scrap metal comprise the bulk of recycled materials, with relatively smaller quantities from traditional recyclables collections.⁴

We estimate 250,000 households (about 20% of all households) have access to curbside recycling collection services. Hundreds of commercial businesses have recycling services, but

nearly all exclusively include cardboard. Further, some industrial facilities recycle various plastic and paper streams. Large, rigid scrap metal (e.g., from automobiles or construction) enjoys a relatively robust recycling market, owing to favorable economics and a thriving formal and informal recovery network.

³ Derived using available disposal site waste characterization data (Wehran 2003), contemporary disposal amounts, and contemporary material stream adjustments. Commodity estimates may have an error range of 25% or more relative to the quantity listed in the table.

⁴ Defined here as paper, cardboard, plastics, and metal

⁵ Collected via personal contacts and publicly-available data available from the Puerto Rico Solid Waste Management Authority.

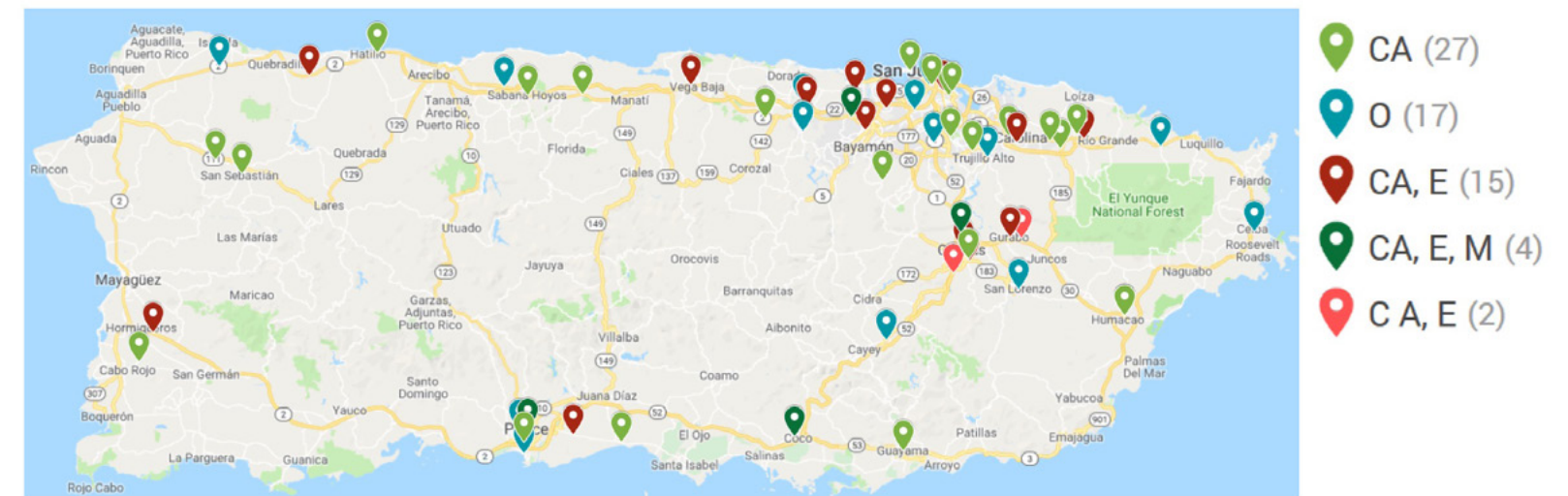


Figure 2 Map of 65 Recyclables Collection and Processing Centers in Puerto Rico⁵. Key: CA = Collection Center, O = Other or combination, E = Electronics, M = (re)Manufacturing

Stakeholder Engagement

Stakeholder engagement involved the systematic, semi-structured outreach to more than 120+ individuals at dozens of organizations spanning the materials management value chain. The objectives of the outreach were to (i) identify bottlenecks in the recycling system in Puerto Rico – what factors are limiting greater material recovery? (ii) gather reports, data, and related information to create a rich contextual picture and validate observations from the stakeholder conversations, and (iii) obtain details on previous recycling efforts that were no longer ongoing. The stakeholders spanned companies (51% of stakeholder outreach), government and non-profit (25%), capital providers (14%), and technology providers and engineers (10%).

Several themes emerged regarding bottlenecks to a better recycling system in Puerto Rico:

1. Lack of educational support across the system

–residents often do not know how to recycle, government officials have limited support to effectively run and execute recycling programs, and disconnects were prevalent between MRFs and

end markets. These conditions limit the quantity, quality, and salability of valuable commodities to end markets.

2. Limited municipal funding – a lack of financial support limits human resources and the ability to fund basic services such as curbside recycling. Recent hurricane relief efforts have drained limited resources and forced the cutback of programs including recycling services in many municipalities. These conditions reduce the amount of recyclables entering the system.

3. Perceived material supply shortage for remanufacturing –on the topic of possible remanufacturing solutions that could be established in Puerto Rico, several stakeholders believed that Puerto Rico did not produce enough waste material to support remanufacturing, such as a PET bottle-to-bottle recycling system. This perception (along with other factors) has prevented serious development of remanufacturing capacity on the island, which limits options available for recyclables that are collected.

Stakeholder Engagement

4. Lack of access to recycling – only 20% of the population has access to curbside recycling services, which is substantially less when compared to the continental US (80%). Most commercial businesses do not have bins for container recycling (e.g., PET, HDPE, polypropylene, aluminum and steel) and other commodity grades, and public-sphere recycling stations are likewise limited. The lack of access limits the amount of recyclables available to enter the system.

5. Aging MRF infrastructure – the operating MRFs that accept mixed recyclables include mostly basic mechanical conveyance systems and do not yet incorporate recent innovations that can supplement or replace manual sorting. Outdated MRF equipment reduces the quality of bales created for various commodities, therefore limiting the marketability of processed recyclables.

6. Challenging waste disposal dynamics – the cost to dispose of waste in Puerto Rico is artificially low (approximately \$20-30 per ton, far less than the continental US average disposal fee of \$55 per ton). Disposal fees are relatively low in Puerto

Rico because many landfills are not constructed with modern pollution control infrastructure that mitigates emissions to the land, water, and air. Further, municipalities that own landfills often count on revenues from disposal, and efforts to reduce landfilled amounts in favor of recycling are challenging because of inertia and other factors listed previously (e.g., disconnects between MRFs and markets).

7. Lack of contemporary material characterization data. The last extensive waste characterization study for Puerto Rico was published in 2003 – material types and amounts generated and disposed of (representing circular recovery opportunities) are largely an unknown. A key initial step to designing and implementing effective recycling programs is measuring the amount and type of materials being discarded by households, institutions, and businesses.

Pilot Projects Supported

Ten different pilot projects were designed on the basis of the research and stakeholder outreach described earlier. We performed a decision analysis using the following criteria to narrow the list of projects:

1. **Scalability**
2. **Executability**
3. **Potential impact**
4. **Sustainability (i.e., can the project sustain beyond the pilot period?)**
5. **Budget**

Based on these five criteria, the list of potential projects was narrowed to two:

(1) A targeted outreach and measurement campaign to increase the quantity and improve the quality of curbside-collected recyclables in Guaynabo, PR, and

(2) An online recycling education academy aimed at municipal recycling coordinators in Puerto Rico.

Ultimately, these projects were believed to have a strong potential to positively impact the overall recycling system, raise awareness in a scalable way with the available pilot project resources, and potentially catalyze action by others in the future. Both projects help to address the lack of educational support on the island, which was the most commonly-cited bottleneck in Puerto Rico's recycling system based on our stakeholder outreach.

Pilot 1

Hyper-Targeted “Recicla Más, Recicla Mejor” Campaign to Increase the Amount and Quality of Residential Curbside Recycling in Guaynabo, Puerto Rico

This pilot was informed by our research and multiple stakeholder meetings that stressed the importance of educating the public to improve the quality and amount of recyclables collected curbside. Recent material characterization efforts by Conwaste, a private integrated waste and recycling company based in Puerto Rico, indicated contamination rates of 50%+ being delivered from some municipalities. Individuals across the value chain indicated a lack of systematically-developed and data-driven educational approaches for residents as a key culprit.

The Pilot Project team included the following participants:

- 1. Municipality of Guaynabo.** The City owns one of the more advanced MRFs in Puerto Rico and collects recyclables from households in the municipality.
- 2. Conwaste.** A private integrated waste and recycling company in Puerto Rico that operates the Guaynabo MRF under contract to the city.
- 3. ByDesign.** A branding and strategy consultancy with experience in designing and executing large-

scale in-person and digital campaigns. The principal goal of the pilot was to measure sentiment, test messaging strategies, evaluate how the target area consumes and interacts with information on the recycling program, and measure current recycling stream characteristics.

A targeted awareness and educational campaign (see Figure 3) launched June 26, 2019 covering approximately 700 households across three neighborhoods in the Municipality of Guaynabo, PR (Palma Real, Villas Reales, and Quintas Reales). The campaign included an all-digital ad campaign, a Facebook page, and mobile-enabled landing page (<http://www.reciclamaspr.com>). Additional integrated resources included direct email outreach and a linked survey. Taken together, the program was designed to (i) raise awareness of the recycling program, (ii) instruct residents using a variety of means to alter behavior to recycle more and recycle only acceptable materials, and (iii) uncover insights on behavior, sentiment regarding the recycling program, and related challenges.



Figure 3 Logo for the Guaynabo recycling outreach campaign

At the heart of the campaign was deep measurement of sentiment, interaction with digital campaign materials, and outcomes in terms of materials placed curbside. Table 2 summarizes key engagement metrics for the approximately 3-week campaign. Results showed a substantial level of engagement across all metrics. We further unearthed key information that will help to inform future campaigns, such as that more than 90% of residents accessed the variety of digital outreach information via mobile.

Pilot 1

Hyper-Targeted “Recicla Más, Recicla Mejor” Campaign to Increase the Amount and Quality of Residential Curbside Recycling in Guaynabo, Puerto Rico

For the recyclables characterization, a dedicated collection truck arrived at the first neighborhood empty and collected curbside-placed recyclables exclusively in three targeted neighborhoods. After completing the route, the truck arrived at the MRF in Guaynabo, where its contents were emptied and approximately 300-500 lb samples were characterized by weight by a sorting team.

Figure 4 displays the results of each of the four characterization events (photos shown in Figure 5), two of which were conducted before the launch of the campaign and two of which were conducted after the launch of the campaign. Notably, the materials shown as “non-recyclables” are “non-program materials”, several of which have robust markets in the mainland US (e.g., polypropylene). Results in Figure 6 show a decline in the absolute and relative amounts of non-recyclables and household garbage (shown as “basura”) after the campaign roll-out. Critically, these results show that change can be affected in a short period with the right mix of outreach and measurement, which gestures to the promise of a larger-scale campaign roll-out.

| Metric | Result |
|--------------------------|---------|
| Total Reach | 45,586 |
| Total Impressions | 460,311 |
| Total Engagements | 26,965 |
| Facebook Leads | 301 |
| Completed Video Views | 9,603 |
| Landing Page Visitors | 3,143 |
| Landing Page Subscribers | 75 |

Table 2 Summary statistics for the month-long recycling awareness campaign in Guaynabo, PR

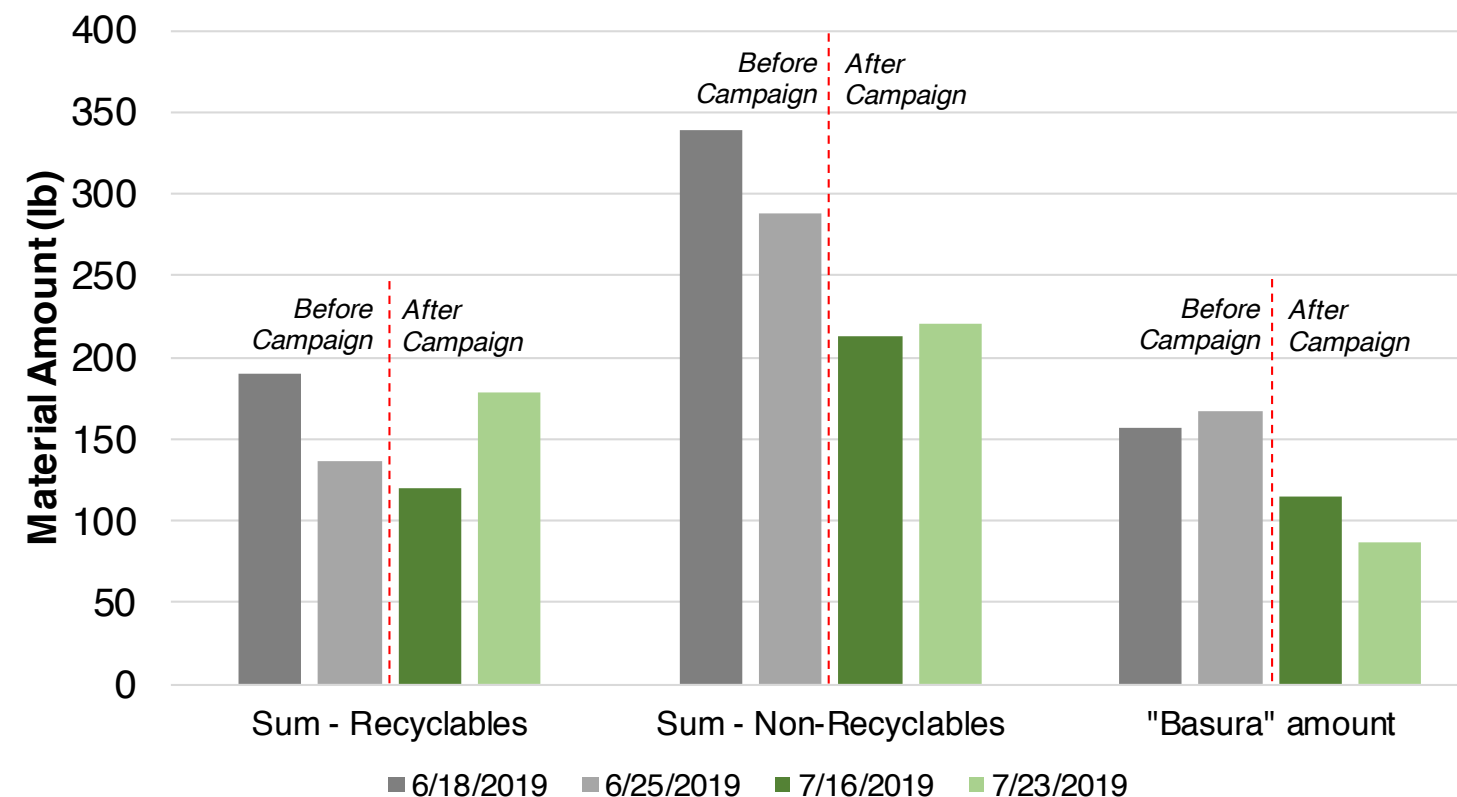


Figure 4 Results of recyclable materials characterization events conducted before and after the digital outreach campaign in Guaynabo, Puerto Rico.

Pilot 1

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Figure 5 Selected photos of recyclables characterization events conducted at the Guaynabo MRF in June and July 2019.

The key outcomes from Pilot 1 are as follows:

1. Nearly all residents accessed the campaign from a mobile device, so future outreach and campaigns must be built assuming mobile-first access
2. There is a substantial will to participate in the recycling program, and messaging results indicated influence in terms of materials placed curbside
3. Targeted residents quickly processed the messaging, as supported by the data on the campaign itself and measurements at the MRF.
4. The campaign was built to be flexible and scalable to other areas, while being open to modification over time to reflect changes in program materials.

Pilot 2

Online Recycling Education Platform

The aim of the pilot was to bolster institutional knowledge development and retention of municipal recycling coordinators in Puerto Rico. Through our detailed stakeholder outreach, we learned that municipal recycling coordinators – a position appointed by the mayor’s office that is responsible for developing, executing, measuring, and improving mandated recycling programs – needed support to help carry out the critical functions that fall under their responsibility.

Creation of a new online learning platform was led by the selected pilot partner, Puerto Rico Science, Technology, and Research Trust. The platform integrates multiple types of curated online, on-demand content and includes a certificate program. Critically, the platform is extensible so that “mini-academies” can be created to bolster knowledge of other stakeholders in Puerto Rico that have different aims or functions (e.g., collectors/transporters, material recovery facilities, etc.). We envision the development of the “mini-academies” model as part of an outgrowth in a future project phase in Puerto Rico.

The curriculum includes the following topics:

- 1. Key waste and recycling definitions, system components, and technologies**
- 2. Waste management frameworks including the circular economy and the waste management hierarchy**
- 3. Educational approaches for recycling programs**

The initial course module includes a detailed survey and measurement system to capture demographic information, job function data, and gather opinions on emerging recycling issues of importance. Results from the surveys will be used to help shape the development of future content that will be rolled out. The platform’s flexibility in enrollment and content development also allows the creation of targeted curricula across the value chain including communications, collections, processing, and materials marketing.

Pilot 2

Online Recycling Education Platform

Approximately 140 municipal recycling directors and coordinators are targeted for initial engagement with the platform – initial outreach began in fall 2019. The Puerto Rico Science, Technology, and Research Trust organized a launch event in San Juan on 6 November, 2019. More than 50 municipal recycling coordinators, government officials, and recycling-focused start-up founders attended the launch. Critically, the event displayed a “positive tension” whereby participants acknowledged the steep challenges with Puerto Rico’s waste management system, while also expressing a desire to do more, incorporate new technologies and approaches, and employ robust data-driven approaches to improve the measurement of the system. These sentiments were echoed from participants across the value chain including practitioners, municipal recycling officials, governmental organizations, and developers of emerging technologies.



Figure 6 The launch event for the Online Recycling Learning Academy Results was held at the Puerto Rico Science, Technology, and Research Trust (The Trust) on November 6, 2019. More than 50 attendees, including municipal recycling coordinators, government officials, and start-up founders attended the event. The event included a briefing on the sign-up process, a workshop to inventory challenges that can be addressed with future learning modules or infrastructure projects, and pitches by multiple Puerto Rico-based start-ups that developed recycling-related technologies and platforms.

Conclusions & Call to Action

Our work presented here reflects an initial effort to engage stakeholders across the system in Puerto Rico to catalyze action and create improved materials management outcomes. Encouragingly, through stakeholder outreach efforts we uncovered an incredibly strong will to improve recycling, and our analysis pointed toward multiple investments and other actions that can make improvements happen. More than \$100 million of investment is needed to increase the amount and quality of recyclables that are collected, bolster on-island reprocessing capability, expand necessary educational programs, and substantially modernize existing MRF infrastructure. Taken together, this series of improvements could result in the recovery of at least 1.5 million tons of valuable commodity recyclables in the next decade.

Puerto Rico is poised to transform its recycling system. Positively, collection infrastructure and a will to make large-scale improvements are in place. We encourage brands, municipalities, government organizations, forward-thinking recycling companies, and non-government organizations to join us and help build on the momentum created in this effort.

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