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Construction and Demolition Waste Reduction in Austin, TX: A Review of Best Practices, Case Study, and Project Proposal

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Abstract

Construction and demolition (C&D) waste is a significant environmental concern, as a large amount of waste is generated and sent to landfills each year. To address this environmental issue, this article provides an in-depth overview of the best management practices for the reduction of C&D waste materials generated and ending up in landfills. The article covers several critical areas, including current policies and legislation influencing C&D waste management in different states, with a particular focus on Austin, Texas. The review identifies some best practices for managing C&D wastes, such as conducting an inventory of recyclable materials, assessing the economic and environmental benefits of recycling, identifying the best recycling options, establishing a storage and pick-up plan with recycling companies, and educating employees. In addition, the article points out the importance of C&D waste reduction and recycling in promoting environmental stewardship and sustainability. By implementing these best practices, construction companies and contractors can significantly reduce the amount of C&D waste sent to landfills, conserve natural resources, and contribute to a more sustainable future. In general, this article serves as a comprehensive guide for industry professionals, concerned individuals and policymakers seeking to improve C&D waste management practices and promote sustainable practices in the construction industry.

Keywords: *Construction, demolition, waste management, recycle, reuse, policies and regulations, sustainability, Landfills, Austin Texas.*

Introduction and Background

Construction is an important sector for the development of the economy and infrastructure of a country, but it has also been proven to generate a significant amount of waste. Construction and demolition (C&D) waste refers to the materials that are discarded or in excess from construction, demolition, and renovation activities (Thomas & Wilson, 2013). C&D waste can include concrete, metal, wood, glass, asphalt, plastic, tile, drywall, insulation, and roofing materials. These wastes are often bulky, heavy, and difficult to recycle or dispose of. In addition, they can pose environmental and health hazards if they are not responsibly managed. C&D waste can contribute to land degradation, greenhouse gas emissions, water pollution and resource depletion (Thomas & Wilson, 2013). As a result, it is essential to adopt effective strategies for reducing, reusing, and recycling C&D waste materials.

Construction and Demolition waste management is the process of minimizing the generation of wastes particular to construction activities and maximizing its recovery and reuse. C&D waste management can benefit the construction industry by means of cost reduction, increased profitability, and enhanced sustainability. C&D waste management can also benefit the environment and society by conserving natural resources, mitigating climate change impacts, and saving landfill space ("A Critical Literature Review on Construction Waste Management"). C&D waste management can be implemented at various stages of the construction process, such as planning, design, procurement, construction, and demolition. At every stage, careful consideration of the materials used and reused can potentially help to optimize C&D waste management plans.

One of the means to compare and evaluate C&D waste management practices in different regions is to study their policies and regulations. Policies and regulations can provide inducements or requirements for diversion of C&D from landfills. C&D waste diversion refers to the process of separating C&D waste materials at source or at a designated facility for reuse or recycling. C&D waste diversion can significantly reduce the amount of waste disposed in landfills and increase the availability of recycled materials for construction purposes. Different regions in and around the United States have adopted different approaches to C&D waste diversion policies and regulations, depending on their local context and challenges. In this paper, we will review some of the best practices of C&D waste diversion policies and regulations in five regions: Massachusetts, Washington, Ontario, San Jose, and Hawaii.

Austin

In November 2015, the Austin City Council approved the Construction and demolition ordinance and administrative rules to increase reuse and recycling of materials from construction and demolition projects. The ordinance is modeled after the City's Green building efforts and is consistent with the City's Zero Waste goal and the Austin Resource Recovery Master Plan, (Austin Resource Recovery, 2015). Initially, the ordinance affected contractors working on certain construction (not demolition) projects. Projects that meet both conditions will be affected:

i. Permit application submitted on or after October 1, 2016
ii. Permit includes more than 5,000 square feet of new, added, or remodeled floor area.

On Oct. 1, 2019, the ordinance was updated which included commercial demolition projects. Commercial demolition projects of all sizes will have to meet the ordinance requirement.

The Diversion Requirements for General contractors for Affected Projects must do at least one of the following:

i. Divert from the landfill at least 50 percent of the construction project debris.
ii. Dispose no more than 2.5 pounds of material per square foot of floor area in the landfill.

The city of Austin has several options for processing and hauling debris from construction, which makes it easier for contractors to meet the requirement of this ordinance.

When a general contractor requests a final building inspection for an affected project, the contractor must report how much construction debris was landfilled, reused, or recycled. Contractors failing to report are subject to a Class C misdemeanor.

A general contractor who is unable to meet the ordinance requirements for an affected project is expected to request a waiver through the online reporting system. The contractor must show that there was a good faith effort to meet the ordinance diversion requirements.

A general contractor whose affected project did not meet the requirements and thus does not have an approved waiver is subjected to a Class C misdemeanor. Contractors must keep waiver documentation for two years, (Austin Resource Recovery, 2015).

Review of Best-Practices and Research Literature

The aim of this review section is to provide an overview of the best management practices to reduce the amount of construction and demolition (C&D) waste materials generated and entering landfills. Construction and demolition policies and legislation influencing C&D waste management in different States are reviewed. Given the diverse C&D waste materials produced in Austin, Texas, this literature review examines some of the best C&D waste management practices in other states.

Best Management Practices

I. Inventory materials that can be recycled

Before the commencement of building or demolition activities, a physical inventory of all materials that will be encountered should be taken. Inventory should not be limited to known recyclable materials. Include all by-products resulting from either the construction or demolition processes. When taking this inventory, the contractor should note the following:

i. Specific types of materials (i.e., red bricks, pavers, asphalt-based roofing shingles, 2x12 lumber).
ii. Volumes of material expected.
iii. Condition of materials.
iv. Contamination by hazardous materials such as asbestos or lead.

II. Identify the recycler that will accept materials at the best price.

Once materials have been inventoried, research whether the material can conveniently be recycled in the Austin area. This includes contacting recyclers with the materials inventory and assessing the recyclers' ability to accommodate your needs. During this process it is significant to remember that there are numerous C&D recyclers in the State of Texas, each specializing in different materials. When discussing types of materials with potential recyclers, talk about:

i. Quality of the material.
ii. Type of handling considerations to be addressed.
iii. The volume of material the recycler can accommodate.
iv. Does the demolition contractor care about the end use?
v. Price the recycler will charge for their services.

Although it is important to identify a recycler that can address your needs, it is also important to find the most cost-effective opportunity. There will undoubtedly be a number of recyclers to choose from, a good practice is to find the one that is fairly priced and offers a reliable service.

III. Determine Benefits

After identifying recyclable materials and a recycling company that can address your needs, determine the economic and environmental benefits of recycling your C&D material. To do this, it is important to first estimate costs for traditional disposal by taking the following into account:

i. Labor or fees involved with disposal.
ii. Transportation fees for C&D material, including but not limited to gas and mileage; and
iii. Tipping fees for landfilling or disposal at a transfer station.

Once these costs have been accounted for, they should be compared with recycling fees and associated costs for recycling. When performing your cost-benefit analysis, it is recommended to account for the resale of materials and savings on future projects resulting from the reuse of materials.

In addition to cost savings, the incentives associated with recycling C&D material should also be examined. This includes becoming more competitive due to commitment to the environment and becoming more attractive to private sector clients owing to environmental stewardship. Additionally, the United States Green Building Council (USGBC) has a certification program called Leadership in Energy and Environmental Design (LEED) where companies can check eligibility criteria. Visit www.USGBC.org for more information.

IV. Determine storage needs for the project.

After finding a recycler(s) that can address the project's needs, it is important to prepare a plan for the on-site storage and separation of C&D material. This includes identifying how and where recyclable C&D materials will be contained onsite. When considering these factors, it is important to account for:

i. Accessibility: Make sure that containers are in places that are easily accessible by workers.
ii. Safety: Ensure that the containers and storage can be conducted in a safe manner including limiting public access to the site, and
iii. Aesthetics: Make sure that the construction site looks organized and will not cause concern from local residents or businesses.

Once locations for containers have been chosen, the next step is to decide which disposal techniques best suit the project and the recycler. For this decision there are two options:

i. Arrange for all recyclable material to be stored in one roll-off container: This option requires all recyclable materials stored in one roll-off container to be separated at a later date by the recycler.
ii. Separate materials into dedicated containers on site. This option involves using separate containers for each material.

Determining the storage options should be a decision made with the contracted recycler. Some recycling companies may not have the ability to separate materials after pickup, which would require on-site separation of the materials. In addition, there are some forms of C&D waste that may contaminate the other recyclable C&D materials, making it inappropriate for recycling and requiring separate containerization.

V. Establish a pick-up plan with recycler.

Once a material separation and storage plan has been created, establish a pick-up plan with the recycler. If the recycler is unable to pick up C&D material, find a hauling facility that can address these needs. When establishing a pick-up plan, it is important to consider:

i. **Schedule:** This can be either at a pre-agreed upon time or per requests; whichever way, materials should be removed from the site in a timely manner.
ii. **End-use:** It is important to ensure that the hauler is delivering C&D material to the proper recycling destination and not to a landfill.

VI. Educate your employees.

Upon establishing logistical plans for the separation, storage, and recycling of C&D material, employees and contractors should be informed of new operating procedures. Ensure that not only how to properly recycle C&D material is well communicated, but also the reason for recycling C&D material. Educating employees will allow them to assist in choosing which materials are suitable for recycling, and which materials can be reused on future projects. When educating employees how to recycle C&D material, it is important to consider:

i. Potential language barriers and plan for overcoming them.
ii. Oversight and ensuring reusable and recyclable materials are properly separated.
iii. Special training for the supervisor or manager responsible for performing.
iv. Informing new employees if the operation has a high turnover rate; and
v. Educating employees that recycling C&D has both environmental and financial benefits.

Policies and Legislations

San Jose, California

In July 2001, the City of San Jose in California launched its Construction and Demolition Diversion Deposit (CDDD) Program, which was targeted to increase the diversion of C&D waste materials from landfills (City of New York, 2003). The CDDD Program required all projects that needed a permit to build to pay a deposit, which was calculated based on the size of the project and valuation. This was inclusive of both public and private projects, with few exemptions. Public projects were expected to achieve about 75 percent recycling rate, while private projects were required to achieve about 50 percent recycling rate (City of New York, 2003).

To reclaim their deposit, private project developers were required to demonstrate that they had gotten back at least 50 percent of the waste they produced. This could be done by delivering C&D waste to a city-certified processor and providing the necessary documentation, or by reusing materials on-site or elsewhere. The latter option required city approval and verification. It is noteworthy that many large projects reused rubble (brick, concrete, stone, etc.) on site as fill materials.

According to a 2004 report by Cascadia Consulting Group (2004), San Jose achieved around 64 percent diversion rate for C&D materials in the year 2003, exceeding its goal of 50 percent. In the same report, several factors that contributed to the success of C&D waste diversion in San Jose were also identified, such as:

i. Strong demand for recycled materials from local markets and end-users, especially for concrete and asphalt (Cascadia Consulting Group, 2004).
ii. High tipping fees for landfill disposal and lower fees for recycling facilities, creating a financial incentive for diversion (Cascadia Consulting Group, 2004).
iii. Effective enforcement of the CDDD Program by the city and the state (Cascadia Consulting Group, 2004).
iv. Innovation and collaboration among stakeholders in the C&D industry, such as contractors, haulers, recyclers, and regulators (Cascadia Consulting Group, 2004).

Massachusetts

One of the strategies that Massachusetts has used to reduce the amount of C&D waste entering landfills is to implement landfill bans for specific materials (Sonnevera International, 2006). According to the Massachusetts Department of Environmental Protection (DEP), asphalt pavement, brick, metal, concrete and wood were banned from disposal in the year 2006, and clean gypsum board was banned in the year 2011 (DEP, n.d.). These bans were part of a Solid Waste Master Plan named Beyond 2000, which aimed to achieve an almost 90 percent reduction in landfilled non-municipal solid waste by 2010 (Sonnevera International, 2006). Still, the effect of landfill bans on C&D waste reduction in Massachusetts has been mixed. While the recycling rate for asphalt, brick and concrete was already high before the ban, the total volume of non-banned recycled items doubled between the years 2007 and 2009 (DEP, 2011). This suggests that other factors, such as the advancement of recycling processes and the development of recycling markets and have also contributed to the rise in recycling rates.

Hawaii

Hawaii faces unique challenges in managing C&D waste due to its geographic isolation, limited land availability and high transport costs. Compared to other states, Hawaii does not have any statewide regulations or policies to mandate or incentivize C&D waste diversion. Instead, the state relies on voluntary initiatives and local regulations to promote the reduction, reuse, and recycling of C&D waste (Hawaii Department of Health, n.d.).

One of the most active jurisdictions in Hawaii is the City and County of Honolulu, which covers the island of Oahu. Honolulu has implemented several measures to support C&D waste diversion, such as:

i. Providing a green business program and recycling directory to link C&D waste generators with recyclers and end-users (City and County of Honolulu, n.d.).
ii. Implementing a reduced tipping fee for mixed C&D materials that are delivered to a designated material recovery facility (City and County of Honolulu, n.d.).
iii. Requiring contractors to submit a waste management plan for projects that produce more than 100 tons of C&D waste (City and County of Honolulu, n.d.).
iv. Development and supporting of C&D recycling markets and facilities through loans, grants, and partnerships (PVT Land Company, n.d.).

According to a 2010 report by R.W. Beck (2010), Honolulu achieved a 68 percent diversion rate for C&D materials in 2008, exceeding its 50 percent target. The report also identified several factors that led to the success of C&D waste diversion in Honolulu, such as:

i. High demand for recycled materials from local markets and end-users, especially for asphalt, concrete and metals (R.W. Beck, 2010).
ii. Increased tipping fees for landfill disposal and less fees for recycling facilities, creating a financial incentive for diversion (R.W. Beck, 2010).
iii. Productive enforcement of the waste management plan requirement by the county and state (R.W. Beck, 2010).
iv. Collaboration and innovation among the C&D industry stakeholders, such as contractors, haulers, recyclers, and regulators (R.W. Beck, 2010).

Ontario, Canada

To respond to a looming waste disposal crisis caused by scarcity and excessive cost of landfill space, the government of Ontario introduced a Waste Reduction Action Plan (WRAP) in 1994. The idea aimed to divert about 50 percent of the province's total waste from landfills by the year 2000, using 1987 waste production levels as a reference. A key component of the WRAP initiative was the development of the "3Rs" regulations, which were designed to promote the reduction, reuse and recycling of waste generated by the municipal and industrial, commercial, and institutional (IC&I) sectors (Sonnevera International, 2006).

The 3Rs regulations addressed construction and demolition (C&D) waste diversion in two ways. First, they required contractors to conduct a waste audit and a waste reduction work plan for buildings larger than 2,000 square meters that were being built or demolished. The waste audit included identifying and quantifying the types and amounts of waste produced by the project, while the waste reduction work plan included strategies for minimizing, reusing, and recycling

waste. The work plan also included measures for communicating the waste reduction goals and methods to all workers at the site (Sonnevera International, 2006).

Second, they required certain C&D waste materials to be separated at source during the construction or demolition of buildings larger than 2,000 square meters. For demolition projects, these materials included asphalt pavement, brick, concrete, metal, and wood. For construction projects, these materials included cardboard, metal, drywall, and wood. The separated materials had to be recycled or reused, except there were no feasible markets or facilities available (Sonnevera International, 2006).

The 3Rs regulations were intended to stimulate the development of C&D waste recycling markets and facilities in Ontario by creating a steady supply of recyclable materials and reducing the disposal costs for contractors. Nevertheless, the regulations were never enforced due to a lack of political will and industry resistance. As a result, the impact of the regulations on C&D waste diversion in Ontario has been inconsistent and limited (Sonnevera International, 2006).

Washington

The state of Washington faces similar challenges to Ontario in terms of finding adequate and affordable landfill space for C&D waste. However, unlike Ontario, Washington has not adopted any statewide regulations or policies to mandate or incentivize C&D waste diversion. Instead, the state relies on voluntary initiatives and local ordinances to promote the reduction, reuse, and recycling of C&D waste (King County, n.d.).

One of the most active jurisdictions in Washington state is King County, which engirdles Seattle and its surrounding areas. King County has established several measures to encourage C&D waste diversion, such as:

i. Banning certain readily recyclable materials from landfill disposal, such as cardboard, metal, gypsum scrap, asphalt paving, clean wood, concrete and bricks (King County, n.d.).
ii. Requiring mixed C&D materials and non-recyclable wastes generated in the county to be sent to designated C&D material recovery facilities or transfer stations (King County, n.d.).
iii. Providing technical support and tools for green building projects, such as design for disassembly guidelines and construction recycling programs, salvage and deconstruction codes, waste diversion reports (King County, n.d.).
iv. Supporting the development of C&D recycling facilities and market through loans, grants, and partnerships (King County, n.d.).

According to a 2016 report by Cascadia Consulting Group (2017), King County achieved a 62 percent diversion rate for C&D materials in the year 2015, exceeding its 60 percent target. The report also highlighted several factors that contributed to the success of C&D waste diversion in King County, such as:

i. High demand for recycled materials from local markets and end-users, notably for wood, metal, and concrete (Cascadia Consulting Group, 2017).
ii. High tipping fees for landfill disposal and lower fees for recycling facilities, creating financial incentives for diversion (Cascadia Consulting Group, 2017).
iii. Effective enforcement of the landfill bans and designated facility requirements by the county and the state (Cascadia Consulting Group, 2017).
iv. Collaboration and innovation among the C&D industry stakeholders, such as contractors, recyclers, haulers, and regulators (Cascadia Consulting Group, 2017).

Proposed Action

A case study on the Reuse Warehouse in Houston, Texas will provide a model for the proposed project for the City of Austin and aims to enhance clarity for future procedures and waste reduction potentials. In the City of Houston, an average of 650,000 tons of municipal waste is produced annually (Koski, 2017). Construction and demolition waste accounts for 38 percent of the total Houston area waste stream (c40.org, 2016). This waste includes materials coming from construction projects, demolition projects, renovation projects, and remodeling projects. To combat this waste issue, The Reuse Warehouse opened in Houston Texas on April 29, 2009. This city project is funded by a grant from the Houston Galveston Area Council and the City of Houston Solid Waste Management Department (houstontx.gov, 2019). The Reuse Warehouse is designed to minimize the amount of useable construction and building material waste that ends up in landfills and puts it into the hands of community groups and nonprofit organizations to use in the completion of their building projects.

The Reuse Warehouse is located just outside of downtown Houston, north of the 610 Loop and west of Interstate 45 making it a convenient location for those all over the Greater Houston area to access. The Reuse Warehouse allows the drop-off of acceptable building material waste at their location rather than bringing the usable material to a landfill. The donated material is accepted from anyone completing a project that produces construction or building waste, including material from individual projects, large corporations, junk removal companies, city facilities, small and large companies. The person donating the material is responsible for ensuring that the donation items are on the list of acceptable items, and ensuring that the acceptable items are in suitable, usable condition. The Reuse Warehouse does not offer a pick-up service for materials. They do provide some unloading assistance and a forklift upon delivery of donations if necessary.

The Reuse Warehouse provides a list of acceptable material with restrictions on some of the categories to ensure that the material can be easily reused and prevents them from being a large amount of material taking up space on the property in which the collection is being avoided due to the condition. The materials that are accepted by the Reuse Warehouse includes a wide range of building materials such as; lumber, trim, plywood, drywall, sheetrock, insulation, rigid foam, stairwell railing, moldings, siding, hardware, bricks, caulking, roof shingles, cement, pipes, plumbing supplies, stairways, fencing, fireplace screens, tools, gutters, shelving, fasteners, windows, doors, bathrooms, kitchens, flooring, electrical materials, wall coverings and also non-upholstered furniture or furniture that might be missing hardware or drawers that could be repurposed (houstontx.gov, 2019). In the case that wood is being delivered, it is asked that any nails be removed from the wood prior to drop-off. The list of items that are not accepted by the Reuse Warehouse includes paint, appliances, used carpets, loose glass, batteries, hazardous materials, asbestos-containing materials, oil tanks, fluorescent light bulbs, toxic or flammable products, chemicals of any kind or containers that once held chemicals, thermostats containing mercury, or electric baseboard heaters (houstontx.gov, 2019).

The Reuse Warehouse does not sell or give building material to the general public. There are recycling locations in and around the Houston area that serve the general public, which are listed on their website and the locations of which are shown on a map link. The Reuse Warehouse stores the building material that is collected by the donation drop-offs for the purpose of allowing community groups and non-profit organizations to take the supplies that are needed to complete their projects at no cost. Community groups and non-profit organizations wanting to collect building materials from the Houston Reuse Warehouse are required to provide the proper documentation as proof of their status. This documentation can include the organization's tax-exempt form or an IRS letter (houstontx.gov, 2019). The Reuse Warehouse stores this documentation to allow any member of the organization to collect the materials that are needed. The collection of material is a self-service procedure and whoever is collecting the building materials needs to arrive prepared with extra assistance for moving and loading cumbersome load amounts.

The Reuse Warehouse does not limit the amount of building materials an organization is allowed to take (Koski, 2017). The organization can take the amount of material needed to complete their projects. Once the material is collected by the organization, the material is logged according to the material category and weighed to document the amount of material that is being used and diverted from landfills. The Reuse Warehouse requests photographs of the organization's completed project to document how the materials that were collected aided in serving the community. Those collecting materials from the Reuse Warehouse includes churches, schools, affordable housing, homeless shelters, transitional housing, charitable home repairs, community development corporations and centers, veterans, job skills training, medical foundations, physical therapy, museums, theaters, cultural institutions, artists, animal shelters, historic preservation, and community gardens (codegreenhouston.org). Some of the projects that have been completed by using material collected from the Reuse Warehouse includes community and youth gardens, a local church addition construction projects, donated wood shelving from a local library converted to kitchen counter space in a transitional housing project, stage sets for the city ballet theater and many other community projects.

With an annual production of construction and demolition waste in the Houston area totaling around 247,000 tons (Koski, 2017), the Houston Reuse Warehouse is working to reduce the amount of waste that ends up in landfills. With monthly fluctuations of materials donated to the Reuse Warehouse, the average monthly donation totals are around 43 tons (Koski, 2017). In May of 2017, the amount of donations collected totaled 40,979 pounds, around 20.5 tons of material (Koski). Of the material donated in May of 2017, 33 percent was usable wood, 22 percent masonry (brick and stone) material and 16 percent was concrete (Koski, 2017). The remainder of the material donated in May 2017 included an assortment of glass, plastic, ceramic, metal, cardboard, doors, and ceramic (Koski, 2017). The amount of donations, materials brought in from building or demolition projects, is nearly equal to the amount of collections, the materials being taken and used by community groups and nonprofit organizations (Koski, 2017). On average, 90 percent of all material brought in is collected and used in different community projects (Koski, 2017). This indicates that most of the material brought into the Reuse

Warehouse is being put to beneficial use and not creating substantial amounts of unused material that will require extensive storage space.

The Reuse Warehouse in Houston has created a space where anyone can bring acceptable building material waste to be stored at no fee to the donator. This creates an incentive to utilize this warehouse as opposed to using landfills. The Houston Reuse Warehouse is keeping waste out of landfills, while also serving the community by providing the building materials needed to complete community projects.

To work towards the City of Austin's zero waste goals, the city could benefit from a similar center as the Houston Reuse Warehouse. Using the Houston Reuse Warehouse as a model with a focus on utilizing existing facilities in Austin, an expansion of the Austin Recycle & Reuse Drop Off Center's (Austin center) procedures and accepted materials is proposed. The Austin center is located between the South Congress and Southeast Austin area, near the intersection of highways I-35 and 71. The Household Hazardous Waste Facility and the Resource Recovery Center have consolidated into what is now the Recycle & Reuse Drop-off Center (AustinTexas.Gov, 2019). It is run by the city of Austin, making it a prime candidate, and is currently doing similar work as the Houston center with one important exemption, C&D waste.

It is free for anyone to drop off items at the Austin center, ranging from a multitude of categories, though there are some guidelines for acceptable materials. It is free to drop off household hazardous waste, such as cleaning products and batteries, electronics, and appliances, such as televisions and computers, single-stream recyclables, such as cardboard and paper, brush and yard trimmings, clothing and housewares, and tires for a fee (AustinTexas.Gov, 2019).

Located in the adjacent lot as the drop off center, the Reuse Store makes available all the various materials that are dropped off in usable condition free to the public to pick up. While naturally the availability of items in the Reuse store varies by what is dropped off, typically art supplies, cleaning products, household chemicals, automotive fluids, paint, and mulch are found (AustinTexas.Gov, 2019). While the Austin center is benefiting the community by diverting these types of waste products from the landfill, promoting the recycling and reuse of materials is especially important with C&D waste. The incorporation of C&D waste materials at the Austin Recycle & Reuse Drop Off Center is the foundation of this proposal.

Modeled after the Houston Reuse store, guidelines on what constitutes acceptable C&D waste allowed to be dropped off, and restrictions on who can pick up these materials are to be implemented. With consideration to the size of the lots and the two warehouses at the Austin center, it is proposed that C&D waste drop off is allowed for individual-household and other small business level construction, renovation, and demolition materials. Materials are to have already been sorted and ensured they are in acceptable condition per the same requirements as the Houston Warehouse (see above for a complete list of requirements). A list of acceptable materials and acceptable condition of the materials are to be added to the Recycle & Reuse Drop Off Center's section of the City of Austin's website.

Unique to the Houston Warehouse are the specifications for who can pick up C&D materials for reuse. With no restriction on the amount of material that can be collected, but rather who is allowed to pick up, the Austin center will allow only non-profits and community organizations to pick up C&D waste materials. While there are locations in Austin that service the general public for reuse and recycling of building materials, such as the Austin Habitat for Humanity ReStore, picking up of C&D materials at the Austin center would not be available to the general public. With the implementation of small-scale drop off and pick up designated to specified entities, it is hopeful that this method of reusing materials will be beneficial to schools, churches, shelters (etc.) in the Austin community.

It is anticipated that the benefits of the proposed project will be like those of the Houston Reuse store. The documented success of the Houston Reuse Warehouse as a model for community engagement, the low-cost and feasibility of expanding an existing facility's procedures, and the potential waste to be diverted from the landfill make implementing C&D waste in to the drop off and specified pick up at the Austin Recycle & Reuse Drop Off Center a promising venture for achieving Austin's zero waste objectives.

If the proposed proves successful, or to increase success, there is potential for partnership with companies with like-minded goals, such as Absolute Demolition. Absolute Demolition services the public and private sectors by recycling and reusing building materials, from repurposing doors and lights to site pad and road base material (The Bluebook Building & Construction Network, 2019). According to their website, they have reused or recycled over 50% of materials removed from demolition sites (The Bluebook Building & Construction Network, 2019). Partnering with a company that is headquartered in Austin, but services Dallas and San Antonio metro areas, can potentially increase the breadth of materials able to be repurposed for Austin nonprofits and community organizations.

To increase awareness to individual household and small-scale business projects of a new avenue to reduce their waste, as well as to local organizations and nonprofits of materials that could be of use for their projects, Austin Materials Marketplace can be used for marketing purposes. Austin Materials Marketplace is a community driven online platform for businesses and organizations to create a network for local recycle and reuse opportunities (Austin Materials Marketplace, 2019). This popular, easy to navigate website could provide information on what is currently available to a community organizer or nonprofit employee seeking materials from the Austin center and may also increase the frequency of pick up.

In future, it is recommended that a clear path is forged with the employees at the Austin Recycle & Reuse Drop Off Center. Communications about how the incorporation of C&D waste at their facility will be paid for is crucial. Combining C&D waste with an existing tax they may already have in place, or adding these materials into their grant funding could be possible. Monetary discussions have not yet been reviewed and may be considered for future research into this endeavor.

It seems clear that much can be accomplished to reduce waste entering the landfill, with little upfront investment, by simply improving on a current Austin city program and leveraging on their infrastructure. C&D waste is an important type of physical waste to be accounted for when working towards reducing a city's waste and increasing the recycling and reuse of materials. Collaborative efforts amongst city programs, nonprofits, company partnerships, and community organizations can be effective in advancing sustainability initiatives and working towards zero waste management goals in Austin, Texas.

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