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Municipal Composting Plan for the Pueblo of Santa Ana

Anna Isabelle Schab  
Worcester Polytechnic Institute

Daniel Jonathan Beckwith  
Worcester Polytechnic Institute

Sierra M. Fowler  
Worcester Polytechnic Institute

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Municipal Composting Plan for the Pueblo of Santa Ana

by
Daniel Beckwith
Sierra Fowler
Anna Schab
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An Interactive Qualifying Project
submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfilment of the requirements for the
degree of Bachelor of Science

by
Daniel Beckwith
Sierra Fowler
Anna Schab

Date:
May 4 2016

Report Submitted to:
Nathan Schroeder
Pueblo of Santa Ana Natural Resources Dept.

Prof. Scott Jiusto and Prof. David Spanagel
Worcester Polytechnic Institute

This report is available at the project's website at https://sites.google.com/site/sf16compost/, where additional files related to the project can also be found.

This report represents work of WPI undergraduate students submitted to the faculty as evidence of a degree requirement. WPI routinely publishes these reports on its web site without editorial or peer review. For more information about the projects program at WPI, see http://www.wpi.edu/Academics/Projects.
ABSTRACT

The cottonwood bosque of the Pueblo of Santa Ana has experienced a steady die-off over the past decade. This calamity has produced wood waste in such excess that the Department of Natural Resources (DNR) decided to launch a composting project to use the waste and generate revenue streams to fund ecosystem rehabilitation. The DNR asked our team to help identify prospective organic waste providers, consumers, and operating partners in a comprehensive composting plan for Santa Ana Pueblo. Our project produced not only this plan, but also a site location recommendation and a materials and financial management spreadsheet tool to predict equipment, labor, and transportation costs. These results support a flexible multi-phased approach to bringing the compost facility up to its full potential.
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EXECUTIVE SUMMARY

The cottonwood woodland, or "bosque", that runs alongside the Rio Grande in the Pueblo of Santa Ana, New Mexico, has experienced a massive die-off that was first identified in 2011 by Brian Wimberly, Restoration Program Manager of the Pueblo's Department of Natural Resources (DNR). This die-off today totals 120 acres of deadwood, expanding from the roughly 80 acres initially discovered. The dead wood has become a major concern as a fire hazard and indicator of poor environmental conditions along the Rio Grande; however, it also presented an opportunity to the DNR to envision a creative solution for disposing of the excess wood waste: a new composting center for the Pueblo.

In order to fund this solution, the DNR applied for a grant from the US Forestry Service's Collaborative Forest Restoration Project (CFRP). The DNR arrived at composting as a solution after taking into account the combination of the excessive amount of wood waste from the bosque and various other forms of wastes, specifically food waste, in the Pueblo that needed better disposal methods. Composting would also produce a locally desired, and therefore sellable, product. The DNR does not seek to maximize profit through the composting project, but only to generate enough revenue to offset the costs of ecosystem rehabilitation projects for the Bosque Restoration Division.

Methodology and Findings

Our team first focused on creating connections with potential partners both within and around the Pueblo as identified by our project's sponsor, Nathan Schroeder, Restoration Division Manager of the DNR. We met with a variety of organizations including the Hyatt Resort, Native Plants Nursery Wholesale and Resale, New Mexico Recycling Coalition (NMRC), Sandoval County Landfill, Santa Ana Golf Course, Santa Ana Star Casino, Stables at Tamaya, Southern Sandoval Investments (SSI), and Tribal Historic Preservation Office (THPO).

We discovered through conversations with local organizations' representatives that a majority of prospective partners were interested in participating in our project in some capacity. Their roles fell into one or more of the following categories: waste provider, equipment provider, customer, seller, and information provider as illustrated in Table 1. The Hyatt Resort, as a food waste provider, and the Stables at Tamaya, serving as a potential composting site location and manure provider, were especially intrigued by our project and excited to work with us.
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Table 1: Partners and their Roles for the DNR’s Project

Next, our team looked into determining what mixture of materials would produce the best compost. Utilizing materials that could be provided by partners within the vicinity of the Pueblo, we came up with a mix of cottonwood, horse manure, and food waste. The mixture would contain one part cottonwood, four parts horse manure, and four parts food waste. We then tried to estimate how much of each material we had available. We estimated there to be 15,700 dead cottonwood trees in the bosque which would produce around 22,000 tons of raw material. The 64 horses at the Stables at Tamaya produce roughly 11 tons per week of horse manure total. The Hyatt Resort produces roughly 150 tons per year of food waste, which is generated by the five restaurants they house.

Accounting for the best mixture of materials, our team researched various composting methods and attended a few site visits to local composting facilities such as the Albuquerque Water Utility Authority, Sandoval County Landfill, and Santa Ana Utilities. Our team decided to recommend windrow composting to the DNR as it was an affordable option for a small-scale composting facility that is capable of growth and it is also the simplest method which would enable the DNR to try multiple mixes and perfect their operations. The windrow composting method is illustrated in Figure 1.
The next step was to locate a suitable site to put the composting facility. Through our review of municipal composting guides and our discussions with current composting practice representatives, we decided that the most important factors for choosing a location were accessibility by truck and subsequent transportation costs, ground surface makeup (material, surface grade, etc.), area, and access to water and power. Our original list of potential composting facilities included four locations; however, after evaluating each of these factors at each prospective facility site, two preferred site locations were selected: the Stables at Tamaya and the Hyatt Resort overflow parking lot.

Finally, our team found and carefully adapted an analytical tool to serve Santa Ana’s specific management needs. The resulting spreadsheet (see APPENDIX C: Spreadsheet) provides finely calibrated answers to all of the following: material flow needed rates to meet compost recipe requirements, facility design and capacity questions, initial and operating cost expectations, and compost output and revenue projections. These analyses led us to recommend a phased plan for the project, including room for expansion if the project continues for more than five to ten years. To support the transition to each new phase, a prioritized list of equipment purchases was also provided to the DNR.
Recommendations

Based on our findings, our team has compiled the following list of recommendations:

1. We recommend that the DNR partner with the Hyatt Resort, Stables at Tamaya, NMRC, SSI, Native Plants Nursery Retail and Wholesale.
2. We recommend that the DNR utilize cottonwood, manure, and food waste as materials for the compost.
3. We recommend that the DNR adopt a phased implementation plan, beginning with only producing mulch from cottonwood and eventually starting composting and expanding the facility.
4. We recommend that the DNR locate the composting facility at the Stables at Tamaya.
5. From our discussion with the New Mexico Recycling Coalition about the various legal procedures involved in starting a composting facility, we recommend that the DNR reach out to Joan Snider at the NMRC to determine which aspects, if any, of the regular permitting and licensing requirements may not apply to Native American Pueblos.

Our team anticipates growth in the composting project over the next ten years, and ultimate success in terms of the DNR’s goal of raising revenue to support continued bosque restoration efforts.

Conclusion

Through creating connections among a variety of partners both within and beyond the Pueblo, we believe that the DNR will be able to secure the materials, the site location, and sellers necessary to form a successful composting business. The DNR hopes to establish this business long-term, over the next five to ten years, and our team thinks that through partnerships with these organizations that ambition will be realized. The DNR can also look forward to increasing revenue streams from the compost that will aid in their ecosystem rehabilitation projects, hopefully restoring the Rio Grande bosque to a sustainable and beautiful state.
CHAPTER 1: INTRODUCTION

The Pueblo of Santa Ana is one of several Native American reservations located along the Rio Grande in New Mexico, and like any small municipality, it struggles with waste management and using resources to their full potential. These communities are challenged by increasing waste production due to increasing populations and decreasing ability to manage the influx of waste. Modern-day tactics have taken to producing more byproducts that, in turn, are not being reused and recycled. Utilization of landfills across the country, while inexpensive, does not offer sustainable waste management solutions; however, communities are looking into alternate options that would be more beneficial in the long run, both in terms of environmental impact and overall cost.

Recently, the Pueblo of Santa Ana has experienced an influx of waste from a die-off of cottonwood trees in the bosque, which in Spanish means forest. In modern times, the building of dams upstream from the Rio Grande have affected the flow of water, which has in turn affected the plants alongside the river. Cottonwood trees, which are found throughout New Mexico, alongside the Rio Grande are dying (Smith, 2009). This die-off has created an excess of wood waste that the Pueblo has chosen to see as an opportunity rather than a problem. The Santa Ana Department of Natural Resources (DNR) is interested in exploring the potential for creating a composting operation with the excess wood to offset costs of other community restoration projects. The economical goal for the sale of the compost is to create revenue streams for these projects. In order for the compost to be a profitable product, an optimal mixture of materials needs to be obtained. There are a variety of resources that would need to be utilized to create a high-quality compost; these resources would need to be located and transported to the composting site from a number of different businesses and organizations within the Pueblo, such as golf courses supplying green waste.

To fund the restoration project of the bosque, the DNR is considering a variety of solutions for the excess bio-waste. Examples from around the world are numerous for dealing with excess material. In some cases, the excess bio-waste was incinerated and used for fuel (Tariq, 2013). In another case, wood waste, like that produced from the cottonwood trees, was chipped and used for mulch without additions or amendments (Tariq, 2013). These past practices could present potential solutions that could dispose of the bio-waste in a sustainable and economical manner. To fund the bosque restoration project, the DNR has applied for a grant to start a composting business. If they were to receive this grant for composting, then a composting plan could be implemented and different waste streams could be used to generate a useful product.

The Worcester Polytechnic Institute team is focused on a composting solution for which we have been looking at several composting guides such as Local Use of Compost and Mulch
Guide and A Practical Guide to Composting (“Local Use of Compost and Mulch Guide,” 2014; “A Practical Guide to Composting,” 2008). In particular, we are utilizing the Highfields Guide to Composting (Platt et al., 2014). The Highfields guide presents a number of objectives that are going to be crucial to the success of our composting project at the Pueblo. Looking at this guide was only the beginning of our project, and we needed to learn more about how businesses, even municipal non-profit ones, were built and operated.

To do so, our team worked with DNR liaison, Nathan Schroeder, as well as others in the DNR, to design a plan for the Pueblo that would help to fund bosque restoration and community development projects through the utilization of bio-waste. We wanted to support them in their goals to create relationships with potential partners and create a sense of community in Santa Ana as these organizations come together to work towards a sustainable solution. This plan will be implemented over the course of 5 to 10 years and hopefully will work to incorporate benefits for the whole community.
CHAPTER 2: HISTORY OF THE AMERICAN SOUTHWEST AND THE PUEBLO OF SANTA ANA

2.0 Introduction

The Pueblo of Santa Ana in New Mexico is situated alongside the Rio Grande about twenty-two miles north of Albuquerque. It is a small community of Native Americans that has existed for centuries, and today functions with a sovereign government. The Pueblo is semi-sovereign because, while it does function independently, it cannot maintain its own military force or system of currency (Smith, 2016). The Pueblo land, like much of the Southwestern United States, has a semi-arid climate and receives, on average, between 8-12 inches of rain per year (Schroeder, 2016). With so little rainfall, the region often suffers from droughts which, when combined with other factors such as damming of rivers, can cause die-off of susceptible plant species in the area.

The Santa Ana Department of Natural Resources directed by the Tribal Council has taken action to restore the environment, especially along the Rio Grande riverbank which runs through the Pueblo. Faced with these restoration needs as well as the modern-day problems of waste management and sustainability, the Pueblo has formed organizations to address these problems. For example, the Pueblo of Santa Ana Department of Natural Resources has applied for a grant to fund a composting project.

This chapter discusses some of the general history of the American Southwest as well as the Pueblo of Santa Ana, a small but deeply rooted community whose ancestors endured a long series of hardships and persecution.

2.1 A Brief History of the Southwestern United States

European colonization of North America began in the 1500s with the arrival of the Spaniards. There has been an influx of people from across the Atlantic Ocean since then. During the mid-1800s the United States began expanding westward to fulfill its aggressive land acquisition policy, which contemporaries regarded as the fulfillment of “Manifest Destiny.” Major conflicts troubled the region, disrupting the lives of native peoples and American frontiersmen alike. The internal US conflicts are described in depth by Hampton Sides in his book: Blood and Thunder (Sides, 2006). Set between the years of 1846 and 1865, Sides tells the story of Native Americans who became upset with the settlers taking over their land where they have lived for centuries. Manifest Destiny was a policy that came about from the election of President James Polk in 1844 as he sought to turn America into a confident nation.
In 1845, Texas was annexed and a year later, Polk declared war on Mexico because Mexico would not sell the land of present-day New Mexico and Arizona to the US. As the war continued across the American southwest, it only stirred further conflict with the Natives. The American frontiersmen adopted a "scorched-earth" policy, which is a military strategy that targets and destroys anything that is of use to the enemy, to drive the Natives into reservations to control them. These instances of extreme episodic violence were juxtaposed with continuous infections. It was a horrible situation for the Natives as they contracted diseases such as syphilis and smallpox from the Americans.

Although this information is stressed in America’s schooling systems, the entire history of the Native people extends much further back before the American frontiersmen’s westward expansion.

2.2 The History of the Pueblo of Santa Ana

The original settlers of Santa Ana inhabited the land since at least the 1500s, with some artifacts dating back to as early as 1000 CE (THPO 2016). Having descended from Keresans who migrated in different directions, they were part of the faction that moved south and settled on the land of present-day the Old Pueblo of Santa Ana (“A Brief History of Santa Ana,” 2001). The new location was beneficial as it was nestled between the walls of a mesa, which provided shelter, and the Jemez River that provided water and attracted wildlife for hunting. Today, the Old Pueblo of Santa Ana has not changed much, except for the restoration of some buildings, including the church (Wimberly, 2016). The surrounding landscape, however, has changed quite a bit due to a chain reaction of phenomena. Overgrazing decreased fire hazards that cause brush fires that controlled the juniper population which has now increased astronomically. Also runoff from the Jemez River depleted the topsoil which makes it difficult for underbrush to grow (Wimberly, 2016)

The Santa Ana people of the 1500s called themselves Tamaya and this name is still used today by the people of the tribe; however, in 1598, invading Spaniards renamed the Pueblo "Santa Ana" after the patron Saint of Homemakers (“A Brief History of Santa Ana,” 2001). During their reign, the Spanish demanded tributes, overworked the land, and sold natives as slaves. They forced the Pueblo Indians to give up their religions and to convert to Christianity. It was not until about eighty years later that Popé, of the Taos Pueblo, led a revolt that spread across the region from the Santa Fe area Pueblos to as far west as the Hopi territory nearly 300 miles away. By the end of the fighting, 2,500 Indian warriors had killed upwards of 400 Spaniards and forced the remaining back into El Paso (“Revolt of the Pueblo Indians, 1680,” 2016).

In the following years, community leaders reestablished their religion and a Pueblo government until the Spaniards came to reclaim the land in 1692 and the people of Santa Ana were forced to Black Mesa and the Jemez Mountains; however, the people of Santa Ana
continued to practice their religion in secret for possibly centuries or else they would face persecution. In 1693, they were able to move to their current homestead known as Santa Ana (“A Brief History of Santa Ana,” 2001).

2.3 The Pueblo Today

Today, the Pueblo is located in North-Central New Mexico running along the sides of the Rio Grande. The community consists of around 800 people and 79,000 acres of land in the county of Sandoval (Santa Ana Department of Natural Resources, 2007). The Old Pueblo of Santa Ana is largely uninhabited year round while other members of the community come back for ceremonies, holidays, etc. (Wimberly, 2016). There is no electricity or running water in the Old Pueblo of Santa Ana so each house is equipped with an outhouse and families bring power generators in upon visits (Wimberly, 2016). There is a strict "no cameras" law enforced in the Old Pueblo of Santa Ana and this rule resonates throughout the entirety of the Pueblo excepting official or government business.

Within the Pueblo there are three villages: Rebahene, Ranchitos, and Chicale. They are governed by a Tribal Council, consisting of each village's head of household. Each year a Governor and Lt. Governor are appointed by a religious leader. In addition to English, many citizens speak the Keresan language which is the native language of the Santa Ana people ("Pueblo Lands, Pueblo Governance," 2010). People that live in Santa Ana typically work in Albuquerque or on tribal and federal projects (“A Brief History of Santa Ana,” 2001). There are a variety of economic entities in the Pueblo including the Hyatt Tamaya Resort, Hyatt Tamaya Stables, Santa Ana Star Casino, gas stations, Twin Warriors and Santa Ana Golf Courses, and Native Plants Nursery.
Businesses within the Pueblo, such as Native Plants Nursery, always try to offer positions to Native members first to ensure economic growth for their community and, more importantly, to give back, and therefore offer respect, to the original owners of the land: the Natives (Zickefoose, 2016). Farming made a comeback in the 1980s as illustrated by the utilization of greenhouses throughout the area ("Santa Ana Pueblo (Native Americans of the Southwest)"). Family run farms utilize tribal fields for agricultural purposes with the most common crops being corn and alfalfa. Blue cornmeal is a big export for the Pueblo (Wimberly, 2016).

2.4 The Pueblo's Environmental Challenges

New Mexico developmental growth has put a strain on waterways. On the Pueblo, there is the Jemez Dam and Reservoir that is operated by US Army Corp of Engineers (Schroeder, 2016). The Pueblo entered into an agreement with the Corps of Engineers in 1952 that allowed for the construction of Jemez Canyon Dam and Reservoir on what was at the time Bureau of Land
Management land and was reacquired by the Pueblo in 1978. The upper reaches of the reservoir pool crossed into Pueblo lands just downstream of the Pueblo’s historic village of Tamaya which necessitated the construction of a ring levee around Tamaya for protect it from flooding during a full pool scenario. A persistent pond has formed behind the levee due to surface flows from within the village of Tamaya and seepage through the levee which presents health and human safety issue. The Corps of Engineer has been pumping water to keep it from filling up which then causes a nuisance due to the sound of the diesel powered pumps and the smell from the newly exposed decomposing vegetation and sediments. When the water recedes it leaves salt behind. The area around the dam also experiences head cutting, which is when a stream experiences erosion that forms a vertical drop in the bed, and erosion (Wimberly, 2016). Some other environmental issues that the Pueblo has faced include: bio-control beetle infestation, loss of habitat, and invasive plant species (Schroeder, 2016).

![Image of Jemez Dam 2016]

**Figure 3: Jemez Dam 2016**

In 1973, the Cochiti Dam on the Rio Grande River was constructed for sediment retention and flood control. The man-made alterations to the river flow have contributed to the degradation of the channel bed downstream allowing for the infestation of non-native, invasive plants, such as Russian olive and salt cedar (Richard & Julien, 2003). These dams capture the water and release it at various times throughout the year, especially the spring. This release causes floods that cause the banks of the river to erode quickly; however, in some locations along the river flooding is beneficial (Schroeder, 2016).

Flood control, in addition to recent well installations and the long, ongoing drought in New Mexico, has contributed to a widespread die-off of Rio Grande cottonwood along the river. Rio Grande cottonwood, or *Populus wislizeni* is found throughout New Mexico, in wet areas because they are they require high water intake to live ("Rio Grande Cottonwood," 2013). Cottonwoods are relatively quick-growing; however, this causes them to have weak wood
especially since they usually grow as tall as 80 feet (Smith, 2009). The dead trees and shrubs present a concerning fire hazard as they will burn quickly and at high temperatures which can cause a fire to become out of control very easily (Wimberly, 2016). That being said, the live bushes still within the bosque would be important to keep around as they would contribute to the soil. Juniper tree reduction in rangeland is also a necessity for the Pueblo (Wimberly, 2016). The massive growth in the number of juniper trees is a product of grazing and is killing the grasslands. The juniper population jump is being looked into by the Santa Ana Department of Natural Resources and excess juniper wood is being given to the native community for individual or communal use (Wimberly, 2016).

2.5 The Department of Natural Resources

In 1996 The Santa Ana Department of Natural Resources began the Bosque Restoration Project by clearing a salt cedar infestation for the Hyatt Tamaya Resort (Schroeder, 2016). The Department is currently divided into five main divisions: the Environmental Education Division, the GIS & IT Division, the Range & Wildlife Division, the Water Resources Division, and the Bosque Restoration Division (Santa Ana Department of Natural Resources, 2007). The Bosque Restoration Division was founded in 1998 to manage the restoration projects of various ecosystems along the Rio Grande. Their first major project included cutting out invasive species from the bosque (Schroeder, 2016). An example of an engineering marvel that is now eroding ecosystems is a Kilner Jack. Kilner Jacks used to look like beams and netting and in the past were used to channelize rivers, such as the Rio Grande. The Midwest have them as well but they are called A-Jacks. Originally they were viewed as a great solution to channelizing a river; however they are not ecologically sound. They were supposed to keep the bank of the river together but now they just are destructive so they are being taken out. They are massive structures that all cabled together so it takes time (Schroeder, 2016). Some techniques designed to repair these issues and prevent future ones include removal of invasive species, adding gypsum to the soil, planting native grasses and cottonwood, widening the river channel, and mechanical lowering of floodplains (Hanscom, 2001; Wimberly, 2016). However, the problem persists and the increase in dead cottonwood has left the Pueblo with an excess of waste wood material.

In 2011, a member of the DNR, Brian Wimberly, noticed a section of the cottonwood bosque that had experienced a die-off. At this time the section was around 50 acres and has now grown to approximately 120 acres. The trees that are located further south on the Rio Grande are older and roughly 80 years old with the average lifespan of a cottonwood tree between 100-150 years old (Schroeder, 2016).

The restoration of plants to a location can be quick utilizing the "pole" method, which is when shoots at the base of the tree are cut off, replanted into rows, and grow into new trees (Zickefoose, 2016). It is possible to plant a few acres in a week using this technique; however, a
lack of groundwater in the Pueblo makes the pole method not usable for the bosque location. There is also a greater emphasis placed upon the rehabilitation of the bosque and a greater restoration of the ecosystem of that area. It is with that mindset that funding for this project is being considered.

Funding for the Bosque Restoration Project used to fall upon national system funds; however, a diversity of funds is desirable for any program (Schroder, 2016). To continue efforts of restoration, the DNR has procured funding from several government and private organizations (Santa Ana Department of Natural Resources, 2007). In 2015, they applied for a grant that will help to begin a long-term composting program to create a revenue stream that will supplement the restoration funding; however, the grant is pending approval and though composting seems to be the most viable course of action, alternative options could still be possible (Schroeder, 2015).

<table>
<thead>
<tr>
<th>DNR Employee</th>
<th>Title/Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nathan Schroeder</td>
<td>Restoration Division Manager</td>
</tr>
<tr>
<td>Brian Wimberly</td>
<td>Director of DNR</td>
</tr>
<tr>
<td>Alan Hatch</td>
<td>Restoration Program Manager</td>
</tr>
<tr>
<td>Maxine Paul</td>
<td>Environmental Program Manager</td>
</tr>
</tbody>
</table>

Table 2: Relevant Members of the DNR
CHAPTER 3: METHODS

3.0 Introduction

Our team was tasked with finding a sustainable, economical, and community-friendly way to dispose of the excess wood waste produced by the cottonwood die-off. We conducted an interview with our liaison, Nathan Schroeder, before we came to Santa Fe, to get a better idea of what he really wanted from the project. By listening to his ideas for the project as well as providing our own, we learned a lot more about his goals and came up with various ways that this project could be designed to create a substantial and effective composting plan. The project we were charged with was one of a number started by the DNR in recent years with the purpose of creating a revenue stream that would support restoration projects for the bosque.

The Highfields Guide to Community Composting illustrates a comprehensive composting plan that our team utilized and altered to fit our project's individual needs (Platt et al., 2014). The seven steps in our methodology are modified and adapted from Highfields’ to better fit our specific situation:

1. Clarify Goals
2. Identify Potential Partners
3. Determine Composting Materials and Sources
4. Select Composting Method
5. Select Composting Site
6. Learn Local Legal Procedures
7. Analyze and Manage Finances

In this chapter, we discuss these major steps, as well as some key sub-steps, that are visualized in Figure 4.
3.1 Clarifying Goals

3.1.1 The Goals of Our Sponsor and Guide

The Santa Ana DNR views the cottonwood die-off as not just a problem but an opportunity to motivate the creation of a composting program that would benefit the community. The bosque restoration project is a large one to undertake and will need substantial funds to be completed. To that end, any profits from the composting project are intended to help support the restoration project. By combining the goals outlined by Highfields for a general composting
center with the more specific goals of the DNR, we compiled a list of goals that indicated the direction of our project:

- Dispose of cottonwood in a "green" and economical manner
- Work with organizations to dispose of food waste in a sustainable way
- Offset costs of restoration efforts by selling compost product
- Continuously reevaluate goals and objectives to ensure we have adhered to the scope of this project

3.1.2 Overall Timeline

While working on this project, it was important to remember that this project is going to continue on as the DNR was looking for a project that would be around for 5 to 10 years. We came up with a timeline, Table 3, for once the operation gets off the ground adhering to the time length the DNR is looking for.

<table>
<thead>
<tr>
<th>Operation Timeline</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
<th>Year 6</th>
<th>Year 7</th>
<th>Year 8</th>
<th>Year 9</th>
<th>Year 10</th>
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<tr>
<td>Mulching</td>
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<td>Small-scale</td>
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<td>Composting</td>
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<tr>
<td>Medium-scale</td>
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<td>Composting</td>
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<tr>
<td>Large-scale</td>
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<tr>
<td>Composting</td>
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</tr>
</tbody>
</table>

Table 3: Operation Timeline

3.2 Identify Potential Partners

3.2.1 The Importance of Collaboration in Composting

The process of composting involves much more than just green waste. Composting requires a variety of materials to create a good mix including food wastes, organic wastes, yard waste, etc. To acquire these materials, our team reached out to potential partners in the community to explore mutually beneficial relationships that their partnership would provide for the composting center and their organization. Some potential partners would provide the materials needed to create a high-quality composting product for them and the community at large to use. In return, the composting center would provide an alternative outlet for
organizations’ waste streams and would keep by-products out of landfills which, while inexpensive, are not as sustainable.

In a variety of composting projects across the globe, organizations often reach out to businesses for the exchange of these typical wastes that go into composting and this creates a cycle of give, take, and give back, which the recycling process exemplifies ("Global Compost Project," 1998). In the DNR's case, they had already identified a number of organizations and local businesses interested in being considered potential partners; however, others were considered as well.

3.2.2 The Importance of Potential Partners

There are potential partners both within and outside the Pueblo. Some examples within the Pueblo include the Hyatt Tamaya Resort, Santa Ana Golf Course, and the Native Plant Nursery Retail and Wholesale locations. These organizations all produce a variety of wastes that would be useful to combine with the wood waste to form a well-mixed compost.

Nathan Schroeder presented us with a list of contacts he thought might have usable waste to donate to our cause, have valuable information and advice for a composting process, or would help us to understand the history of the Pueblo. Once in Santa Fe, we met organization representatives in person, by phone, or on a facility tour.

Table 4 lists the contact names and corresponding organizations that our liaison presented to us.
<table>
<thead>
<tr>
<th>Organization</th>
<th>Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Natural Resources (DNR)</td>
<td>Nathan Schroeder, Restoration Division Manager</td>
</tr>
<tr>
<td></td>
<td>Alan Hatch, Director of DNR</td>
</tr>
<tr>
<td></td>
<td>Brian Wimberly, Restoration Program Manager</td>
</tr>
<tr>
<td></td>
<td>Maxine Paul, Environmental Program Manager</td>
</tr>
<tr>
<td>Hyatt Tamaya Resort</td>
<td>Gail Schwanitz, Assistant to the General Manager</td>
</tr>
<tr>
<td>New Mexico Recycling Coalition (NMRC)</td>
<td>Jessi Just, Deputy Director</td>
</tr>
<tr>
<td></td>
<td>Sarah Pierpont, Interim Executive Director</td>
</tr>
<tr>
<td>Southern Sandoval Investments (SSI)</td>
<td>David Naquin, General Manager</td>
</tr>
<tr>
<td>Sandoval County Landfill</td>
<td>Michael Scialdone, Bosque Project Manager</td>
</tr>
<tr>
<td>Sandoval County Extension Service</td>
<td>Linda Garvin, Agri/Hort Agent</td>
</tr>
<tr>
<td></td>
<td>John Zorrola, Volunteer Compost Master</td>
</tr>
<tr>
<td>Native Plants Nursery Retail Location</td>
<td>Aaron Lamb, Manager</td>
</tr>
<tr>
<td></td>
<td>Katie Zickefoose, Head Grower</td>
</tr>
<tr>
<td>Native Plants Nursery Wholesale Location</td>
<td>Mike Halverson, Manager</td>
</tr>
<tr>
<td>Soilutions</td>
<td>Joe Baker, Owner</td>
</tr>
</tbody>
</table>

**Table 4: Organizations and Contacts**

### 3.2.3 Defining the Role of our Potential Partners

A mutually beneficial relationship was formed between our potential donation partners and the DNR. The donation of material to the composting project presents an opportunity not only to get rid of waste that a business would have to pay money to ship off, but also to form a connection to another organization.

A positive relationship was formed between the DNR and potential partners that have offered their advice and insight such as other composting centers, experts on the Pueblo history, etc. Facilitating this connection not only allowed us to become more knowledgeable in terms of the composting process, legalities, and history; but, also to connect more closely with the Pueblo community and to build partnerships that could be utilized in the future to help both organizations.

### 3.2.4 Interviewing Potential Waste Donors

Our goal in interviewing potential waste donors was to evaluate:

- Their interest/knowledge in our project
• Their current waste disposal habits/schedule
• Their willingness to donate some form of waste to our project
• The amount of waste that they produce
• The amount of waste that they could donate to us (not necessarily all that they produced)

We intended to evaluate these criteria through a set of formal interview questions that we would ask them during a meeting and possible tour of their facility. However, the actual interviews we ended up conducting, usually including several members of the DNR (Nathan Schroeder, Brian Wimberly, Alan Hatch, and Bart Vanden Plas), were more informal. They were conducted as a casual conversation about our project and the interviewee's operations. This process was beneficial as we still obtained the information we needed; but, we also built a more personal relationship with the potential partners. A few examples of the questions we used for each interview include:

• What type of waste does your organization produce?
• About how much a year is produced?
• What is being done currently with the waste?
• How often do you get dispose of your waste normally?
• How much do you currently pay for waste removal?
3.2.5 Interviewing Experts and Potential Customers

Experts and potential customers served a slightly different role as partners than waste donors, so we had to adjust our questions to better obtain relevant information from them. We were more interested in learning more about the Pueblo, both historically and culturally as well as more recent information about environmental issues, past composting projects, uses of compost in the area, and any other information that might be relevant that we could not easily obtain elsewhere. These partners provided a much larger variety of information that helped guide our decision-making elsewhere.

These interviews were conducted in an identical manner to the waste providers. A few examples of the questions we used for each interview include:
• How much compost do you produce in a certain amount of time?
• What type of machinery do you use?
• What regulatory entities must be contacted in order to operate a compost facility?
• How has the Jemez Dam altered the ecosystem?
• What type of crops are grown in the agricultural field within the Pueblo?

3.3 Determine Compost Materials and Sources

3.3.1 Optimal Composting Considerations

Once partners were established, the next step was to determine which materials could be used to create the compost. In determining this, it was necessary to revisit the goals of our project. Since cottonwood waste is essential to the project, and is in such excess, it was the best starting point to create our compost mixture.

An optimal composting process should keep certain properties of the compost piles within experimentally determined ranges. Some operations will also use values based entirely on experience and their specific conditions or requirements. The Sandoval County Landfill uses a 60% moisture content for their compost which is for landscaping and residential use (Sanchez, 2016). Compost from the Albuquerque Water Utility that is used by the Department of Transportation for erosion control, among other things, requires a 40% moisture content (AWUA, 2016). The importance of these properties can vary depending on the situation, but it has been shown that carbon-to-nitrogen ratio, moisture content, temperature, particle size, oxygen concentration, and acidity can affect both the quality of the end product and the time it takes for the pile to cure (Pace et al., 1995). Some general acceptable ranges for these properties are shown in Table 5. The desired value for some of these properties changes depending on the situation and the age of the pile.

<table>
<thead>
<tr>
<th>Property</th>
<th>Reasonable Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon to nitrogen ratio</td>
<td>20:1 – 40:1</td>
</tr>
<tr>
<td>Moisture content</td>
<td>40% – 65%</td>
</tr>
<tr>
<td>Oxygen concentration</td>
<td>&gt;5%</td>
</tr>
<tr>
<td>Particle size (diameter)</td>
<td>1/8 in. – 1/2 in.</td>
</tr>
<tr>
<td>Acidity (pH)</td>
<td>5.5 – 9.0</td>
</tr>
<tr>
<td>Temperature</td>
<td>110°F – 150°F</td>
</tr>
</tbody>
</table>

Table 5: Relevant Ranges of Properties (Pace et al., 1995)
3.3.2 Calculating Moisture Content and Nitrogen Ratio

Since cottonwood was the base material for the compost, a selection of additional materials to complement the properties of wood was made. Wood is a dry, carbon-rich material, so to maintain a proper balance of moisture and carbon-to-nitrogen ratio, a corresponding amount of wet food scraps and other organic matter was necessary. Any wet material with a high nitrogen content would suffice to complement the wood, but food waste lent itself especially well to other goals of our project, namely reducing costs (both economic and environmental), and decreasing the amount of food waste in landfills (Pace et al., 1995).

There are derived formulas for determining the moisture content and carbon-to-nitrogen ratio of a mixture of materials given their respective total weights in the mixture (Richard & Trautmann, 1996). These formulas can be found in APPENDIX A: Moisture Content and Nitrogen Ratio. When rearranged, these formulas allowed our team to calculate the necessary weight ratio of two materials to achieve a desired moisture content or carbon-to-nitrogen ratio.

Average values for cottonwood (softwood) and food waste are shown in Table 6.

<table>
<thead>
<tr>
<th>Material</th>
<th>% N by weight</th>
<th>% C by weight</th>
<th>Moisture % by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Softwood</td>
<td>0.09%</td>
<td>57.69%</td>
<td>0%</td>
</tr>
<tr>
<td>Food waste</td>
<td>2.4%</td>
<td>36%</td>
<td>69%</td>
</tr>
</tbody>
</table>

Table 6: Average Chemical Percentages (Zhu, 2007)

Actual values would be determined for typical materials on hand. Moisture content can be calculated using the following procedure:

1. Weigh a small oven-proof container and record as $W_c$.
2. Place about 10 g of the material into the container and record the total weight as $W_w$.
3. Dry sample for 24 hours in a 220-230°F oven.
4. Reweigh container and sample, record as $W_d$, and calculate the moisture content $M$ using the following formula:

   \[ M = \frac{W_w - W_d}{W_w - W_c} \]

Using these values, approximate weight ratios of cottonwood to food waste was calculated. With a goal moisture content of about 60%, we got about a 6.67:1 weight ratio. With a goal carbon-to-nitrogen ratio of about 25:1, we got about a 7.45:1 weight ratio. These calculations show that we needed different weight ratios to maintain moisture content and
carbon-to-nitrogen ratio. This was not a problem since the target carbon-to-nitrogen ratio changes throughout the compost pile’s lifespan (Zhu, 2007).

The choice of which materials to use varied depending on the availability of the materials. If the required weight ratio cannot be maintained based on the amount of materials available, other materials or other methods of hydrating the compost piles would be considered.

3.4 Select Composting Method

3.4.1 Types of Composting Methods

There are a number of different composting processes that have been developed, and we needed to evaluate all of them based upon total cost, which is inclusive of equipment, material transportation, labor, etc., and their overall effectiveness in creating a high-quality compost. The three main methods that were researched, accompanied with site visits, were: windrow composting, barrel, or drum, composting, and reactor composting.

*Windrow Composting*

![Figure 6: Albuquerque Indoor Windrows](image)

Windrow composting is the simplest of the three methods. The process begins by laying the compost material out into elongated piles known as windrows. Every three days or so, the piles must be turned by shovel or machine so that they are properly aerated. Correct oxygen levels can also be maintained by forced aeration through the use of air blower pipes underneath the piles (Richard & Trautmann, 1996). Since windrows are typically placed outdoors, their internal temperatures should be monitored to make sure they stay within acceptable ranges. Internal temperatures that reach the 180°F and 190°F range can cause a fire or potentially cause harmful bacteria to grow (AWUA, 2016). On the other hand, if the internal temperatures drop too low, important microbes that are needed to break down the material will freeze and die.
Windrow composting lends itself well to a relatively small-scale community composting center, as the equipment cost can be almost negligible and community volunteers can be utilized for turning the piles, allowing for more community involvement in the program. Windrows are the most common method of composting and also provide simple organization of the piles as the windrows can be separated by age or material type (Platt et al., 2014).

**Drum Composting**

Drum composting involves the use of large rotatable drums that contain the compost material. The drums provide a somewhat more controlled environment than the outdoor windrows as they use a built-in turning mechanism, usually in the form of a crank or automatic motor, to mix the compost. Like the windrows, the drums need to be turned regularly to better aerate the composting material. This allows material on the outside of the pile to experience the higher temperatures and moisture content of the inner section of the pile that leads to faster overall decomposition. Drums can be costly to set up since the purpose-built drums themselves need to be purchased; however, they offer better control of the compost's environment as they are mostly sealed (Platt et al., 2014).

**Reactor Composting**

Reactor composting, also called in-vessel composting, is the most advanced technique for composting, typically used by large commercial composting centers to produce the highest quality compost. Composting reactors are fully controlled environments that can precisely control the temperature, moisture, and mixture of the compost; however, they are typically expensive and too high of a risk for a small composting operation to purchase during its first few years of operation (Platt et al., 2014).

### 3.4.2 How to Determine the Composting Method

To determine which type of composting method best suits our project, we had to determine what the approximate cost of each would be to setup and maintain versus the benefits each provides in the long run. Costs were broken down into several categories:

1. Initial materials (i.e. shovels, drums, reactors)
2. Setup labor (i.e. laying out windrows, constructing reactors)
3. Maintenance labor (i.e. turning windrows and drums, fixing/unclogging reactors)
4. Maintenance materials (i.e. replacing shovels, repairing reactors)

Benefits were harder to quantify; but, they were broken down into categories:

1. Compost quality (decomposition and nutrient value)
2. Composting speed
3. Variety of materials used

Our team got more of an idea of the value of these different categories of costs and benefits after talking to existing composting programs in nearby areas such as the Sandoval County Landfill and Albuquerque Water Utility Authority. The Sandoval County Landfill implemented their composting plan in phases. Phase one consisted of five digesters and biofilters. The biofilters are recycled wood chips that, once they have been used up, are put into the compost. The first phase cost $1.3 million. Phase two was completed in 2010 and cost $800,000. It included adding several more digesters. They started out with a grant for $1.9 million dollars, and are hoping that for phase three they will be able to take their operation vertically and stack the in-vessel composting bins on top of each other. The in-vessel composting bins are enclosed spaces for the compost to cook in its own controlled environment (Sanchez, 2016).

3.5 Select a Composting Site

3.5.1 How Composting Centers Operate

Composting centers are locations where the composting of organic materials occurs using mechanical handling techniques such as turning, windrowing, aeration, or other management techniques. The centers may be operated by governmental or private entities. Large-scale compost facilities closely monitor and have practices in place to ensure conditions are ideal for composting. (“Compost Facilities”, 2009)

Nearby businesses, such as Soilutions in Albuquerque, sell different types of compost such as Premium Compost, Topsoil Blend, and Wood Mulch, at different prices. These are sold in bags by the cubic yard (“Soilutions. Complete the Cycle.,” 2016). Another is the Albuquerque Water Utility Authority which offers $25 a ton for screened material (AWUA, 2016). The scale of this project is community-wide because most municipal solid waste composting facilities in New Mexico are source separated operations where yard wastes are separated from other wastes such as cans and plastic (“Water Division,” 2015).

For our connections with other composting centers to be built, communication was essential to determine the cost of pick up, the vehicles used, and where the compost would be dropped off. Additionally, the size of containers that the compost would come in was considered (Platt et al., 2014).

3.5.2 Aspects of Composting to Consider while Choosing a Site

Location can critically affect a business’s success regardless of whether they are profit or non-profit. The fact that the DNR is handling a compost project only added to the list of
considerations that needed to be taken into account. When considering composting, the following were important to include in planning ("How to Compost," 2013):

- Increase the surface area of the piles as much as possible to aid in decomposition of materials through continuous and even aeration
- Moisture content of the compost pile should be at constant level of about 50-60%
- Temperatures of piles typically range between 100°F and 140°F (Sanchez, 2016)
- Piles have to spend 15 days at 130°F or higher (AWUA, 2016)
- Higher temperatures inhibit work speed of key bacteria and slows entire process
- Temperatures of piles between 180°F and 190°F can cause fires (AWUA, 2016)
- Outside of the pile is cooler than the inside; therefore, piles may steam (AWUA, 2016)
- There are some bacteria that function during cooler temperatures that will maintain the decomposition process at a slower pace
- Large-scale operations use the open windrow system that takes place outside and requires a 2-5% ground slope to allow drainage during storms

![Figure 7: Cottonwood Bosque Location Map](image)

There are a variety of factors that had to be accounted for to choose the right location for this project. To do this, our team first came up with a list of questions that addressed those.

The questions considered included:

1. What type of scale are we looking at based on the availability of materials?
2. Is there room to grow if we want to?
3. Are there places that are underutilized that would garner public support?
4. Is it easily accessibility to possible shipping routes?
5. Does the space we are looking at have necessary amenities like water and electricity?
6. Is the ground solid enough that it will not mix into the compost?
7. Are there neighborhoods nearby that will take issue with its proximity?

To build upon this question list, our team consulted additional literature, spoke with local developers that had a say in site location approval, and visited some of the proposed sites to gain a better understanding. Site visits were crucial as our team and the DNR were able to eliminate some locations immediately. Taking a closer look into the characteristics, such as ground type and specifications, like surface grading, it became clear that some sites would not be plausible. Table 7 lists the people our team spoke with, to gain a better idea of our potential sites and general knowledge about the Pueblo.

<table>
<thead>
<tr>
<th>Organization</th>
<th>Contact Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Sandoval Investments (SSI)</td>
<td>David Naquin</td>
</tr>
<tr>
<td>Tribal Historic Preservation Office (THPO)</td>
<td>Dr. Phil Shelley</td>
</tr>
<tr>
<td>The Hyatt Tamaya Stables</td>
<td>Connie Collis</td>
</tr>
</tbody>
</table>

Table 7: Potential Site Informants

3.6 Learn Local Legal Procedures

3.6.1 Environmental Impacts of Composting

Santa Ana is self-governed by a Tribal Council and learning about their legal system helped to determine any limitations our team would encounter. Composting has some environmental impacts that will need to be considered to comply with ethical and legal restrictions regarding health and safety.

The process of composting can expose living things and the surrounding environment to contaminants that can directly impact health and safety. The process of composting inherently involves the handling of municipal solid waste, which can carry many varieties of contaminants with potential negative health effects, as well as dangerous microorganisms (Déportes et al., 1995).

Many heavy metal contaminants (mercury, chromium, lead etc.) can be reduced by sorting source materials before composting which means discarding or recycling common household objects that may have found their way into municipal waste. As for microorganisms, care must be taken during the composting process to keep the temperature of the pile at a
consistent level that will guarantee that most of the harmful microorganisms will be eliminated. Lethal temperatures for some harmful organisms are shown in Table 8.

<table>
<thead>
<tr>
<th>Organism</th>
<th>Lethal temperature and necessary time</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Salmonella</em> spp.</td>
<td>15-20 min at 140°F; 1 h at 131°F</td>
</tr>
<tr>
<td><em>Escherichia coli</em></td>
<td>15-20 min at 140°F; 1 h at 131°F</td>
</tr>
<tr>
<td><em>Entamoeba histolytica</em></td>
<td>154°F; time not given</td>
</tr>
<tr>
<td><em>Taenia saginata</em></td>
<td>5 min at 160°F</td>
</tr>
<tr>
<td><em>Necator americanus</em></td>
<td>50 min at 122°F</td>
</tr>
<tr>
<td><em>Shigella</em> spp.</td>
<td>1 h at 131°F</td>
</tr>
</tbody>
</table>

Table 8: Contaminants and Lethal Temperatures (Déportes et al., 1995)

Microorganisms can also give off various greenhouse gases as part of the composting process. Studies have shown that greenhouse gases such as carbon dioxide, nitrous oxide (N₂O), and methane (CH₄) can be released during aerobic organic matter decomposition. During this stage of composting, various microbes grow in the high temperatures inside the compost pile and break down organic matter such as plant material and human waste into various humus-like substances and mineral products. The organic matter also reacts with oxygen to form nitrous oxide. During the process of denitrification, ammonia (NH₄) and nitrogen oxides (NOₓ) are also produced. Ammonia is usually the gas produced in the highest quantity during composting and is known for damaging forests and having negative effects on natural ecosystems if produced in significant enough amounts (Peigné & Girardin, 2004).

3.6.2 Reporting and Paperwork

Health and ecosystem impacts must be reported somehow to proper authorities and be monitored closely for the duration of the composting processes. To determine what type of permits and licenses the DNR would need, our team had to know more about the composting process. Once this knowledge was obtained, our team talked with Nathan Schroeder and members of the New Mexico Recycling Coalition to help us find the correct paperwork that needs to be filled out to remain compliant with legalities.

3.7 Analyze and Manage Finances

3.7.1 Business Models

To ensure a purposeful, efficient, and profitable business plan for selling compost, there are many aspects of business models and marketing to consider. These aspects are dependent
upon the type of business being created; in this case, the business model is based upon an
organization, the Santa Ana Department of Natural Resources, making and selling bags of
compost to local communities.

To create specifically a composting business, one has to focus on the amount of raw
material that they have at their disposal. It is by accounting for the amount of plant material that
one can figure out how far they can go with their business and how much product (compost) they
can actually produce. Glen Mar Forest Products presents their business plan for "Wholesale
Landscape Products" including background research on how their product is invaluable to the
current state of the US population, their mission statement and objectives, and they then launch
into estimated cost analysis along with their sales tactics which outline how they see the business
succeeding. Glen Mar Forest Products illustrates a substantial, thorough, and detailed step-by-
step initiative of how their business is going to work incorporating the management decisions
outlined above ("Wholesale Landscape Products Business Plan").

There are a variety of examples of successful compost businesses online that illustrate
how the process of a composting business would work. A crucial factor to consider while creating
a business plan is to remember the region that one is building the plan for. Nathan Schroeder
indicated that the primary function of the business plan is not to make a profit, but to give back
the compost created to the community and to offset other costs related to the Santa Ana DNR's
Bosque Restoration Project.

The Pueblo is made up of three villages and it is important to account for these
communities while formulating a composting plan. Keeping past practices as well as their wants
and needs in mind, our team needed to design a plan that would allow for the maintenance of
community development as well as a successful composting business. This plan would
incorporate the collaboration of people beyond the villages of the Pueblo as well. The DNR looked
to partner with organizations such as the Hyatt Tamaya Resort, local golf courses, and the Santa
Ana Star Casino. It is through their partnership with these organizations that they would want to
be able to create a steady stream of materials for composting consisting of organic wastes.
("Pueblo Lands, Pueblo Governance," 2010)

3.7.2 Costs and Labor of a Composting Site

There are many different types of equipment that can be used in the composting process.
To determine what the DNR would need, our team talked with Nathan Schroeder and Brian
Wimberly to figure out what types of machinery the DNR already had to use. We also talked to
the stables and Sandoval County Landfill about whether or not the DNR would be able to use
some of their equipment. We found that the DNR has access to wood chippers, pickup trucks,
tractors, shovels, and a screen.

Once we knew what the DNR had for equipment, determining what we would need in the
future was our next step. Our team talked to Nathan Schroeder about what type of equipment
they would like to have in the future and looked up possible models and specifications. Calling companies was a good way to find out about prices and capabilities of their machinery as well as whether or not they were available in the area.
CHAPTER 4: RESULTS

4.0 Introduction

Research, interviews, site visits, and analysis provided valuable information and useful results for outlining the DNR’s options going forward. These results contain the extent of what the DNR now has as a collection of deliverables.

4.1 Potential Partners

<table>
<thead>
<tr>
<th>Organization</th>
<th>Contact Person</th>
<th>Service Provided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Natural Resources (DNR)</td>
<td>Nathan Schroeder</td>
<td>Project Information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waste – Cottonwood</td>
</tr>
<tr>
<td>Hyatt Resort</td>
<td>Jeff Heid</td>
<td>Waste – Food Waste</td>
</tr>
<tr>
<td>Hyatt Stables at Tamaya</td>
<td>Connie Collis</td>
<td>Waste – Manure Potential Site</td>
</tr>
<tr>
<td>Native Plants Nursery (Retail &amp; Wholesale)</td>
<td>Aaron Lamb, Katie Zickefoose, Mike Halverson</td>
<td>Pueblo Information Potential Customer</td>
</tr>
<tr>
<td>New Mexico Recycling Coalition (NMRC)</td>
<td>Jessi Just, Joan Snider, Sarah Pierpont, Mike Smith</td>
<td>Legal Issues, Permits, Licensing</td>
</tr>
<tr>
<td>Southern Sandoval Investments (SSI)</td>
<td>David Naquin</td>
<td>Planning/Land Location Potential Customer</td>
</tr>
<tr>
<td>Sandia Pueblo</td>
<td>Michael Scialdone</td>
<td>Present Composting Practices</td>
</tr>
<tr>
<td>Sandoval County Extension Service</td>
<td>Linda Garvin, John Zorrola</td>
<td>Present Composting Practices</td>
</tr>
<tr>
<td>Santa Ana Golf Course</td>
<td>-</td>
<td>Waste – Green Waste</td>
</tr>
<tr>
<td>Santa Ana Star Casino</td>
<td>Peggy Morrell</td>
<td>Waste – Food Waste</td>
</tr>
<tr>
<td>Tribal Historical Preservation Organizations (THPO)</td>
<td>Dr. Phil Shelley</td>
<td>Pueblo History</td>
</tr>
</tbody>
</table>

Table 9: Potential Partners
4.1.1 Promising Waste Donors

The Pueblo of Santa Ana is home to many promising sources of compostable organic materials. The partners that are able to supply materials include the Hyatt Tamaya Stables, the Santa Ana and Twin Warriors golf courses, and the Hyatt Tamaya Resort.

**Hyatt Tamaya Stables**

Connie Collis from the stables was eager to rid the stables of their manure. They already have a rudimentary composting system that was made for them by a Boy Scout as his Eagle Scout Project. The project was too small scale for the needs of the stables, but it does show promise for their material. A lot of raw organic material is produced in the form of horse bedding. To give an idea of how much, the horses go through thirty bales of hay per day. Currently the manure is spread around the fields surrounding the stables; however, spreading it around the property is discouraged because the nutrient-rich manure allows weeds to grow (Hyatt Tamaya Stables, 2016).

**Santa Ana Golf Course**

After talking to a maintenance worker from the Santa Ana Golf course, there was material for use; however, sorting between the woody and non-woody trimmings would be necessary before chipping. Currently the golf course burns their green waste about once a year. Typically the green waste is collected in the winter; although, they do not produce a lot of it. The pile that they have now has taken two years to build; but, they would be willing to haul their material to a centralized pile, if it were not too far away (Santa Ana Golf Course, 2016).

**The Hyatt Tamaya Resort**

The Hyatt Tamaya Resort would be willing to contribute their food waste to the project. They presently are paying Soilutions to take away their waste averaging $1,200/month. In the month of March 2016 they had three pickups from Soilutions totally fifteen 50 lb containers called carts. These pickups totaled in cost $786. In 2014 they produced 149.2 tons of food waste in 789 carts. In 2015 they produced 133.4 tons in 900 carts. The carts are not always full when they are picked up. The Hyatt food waste is not sorted, it includes all of their food including meat. However, strictly food waste comes from about five different restaurants in the resort. The staff at the Hyatt recycle as much as they can. Food waste is just a small part of their recycling plan. Jeff Heid the Engineering Coordinator, is who we talked to and he was very enthusiastic about the prospect of helping with the project. Even going so far as to say, “It’s not about the money it’s about giving back to the community and the earth,” (Heid, 2016).
Santa Ana Star Casino

At the Santa Ana Star Casino they are currently looking into purchasing and installing several digesters to their kitchens. Digesters are machines that continuously turn the waste that is put in them while the enzymes that are added break down the waste. The use of digesters will allow the Casino to turn their food waste into gray water that is safe to send down the drain. However, because of this the possibility of a partnership is not something the Casino is interested in because the additional step of separating waste for the digester from waste for the DNR would not be feasible at this time (Morrell, 2016).

4.1.2 Promising Institutional Partners

There have been several partners that have been interested in aiding the project in ways other than material ones. These partners include: Southern Sandoval Investments (SSI), Sandoval Composting, Tribal Historic Preservation Organization (THPO), Water Utility Authority, and New Mexico Recycling NMRC.

Two of these partners, Sandoval Composting and ABQ Composting, have already provided invaluable advice towards the Pueblo's composting efforts and have illustrated what a large-scale composting operation is capable of doing. Although, even when factoring in to be anticipated in Santa Ana’s composting efforts over 5 to 10 years, this project proposes no more than to have a successful small-scale operation.

Sandoval Composting Center

Sandoval Landfill also has a large composting center, and they seemed willing to lend the DNR use of their equipment. The composting center provides various services including the selling of mulch and compost, as well as accepting green waste drop-offs. They create a static pile of compost that is 60% moisture and use piping to aerate the floor. This operation involves a vacuum that sucks air above the compost and sent to the bio-filter. A typical container contains 72,000-74,000 pounds and it takes 17-20 days for the compost to be finished (Sanchez, 2016).

The Albuquerque Water Utility Authority

The AWUA's composting center is a large operation and still only controlled by two employees thanks to their equipment and experience. They have 12 windrows in the warehouse currently with a strip on the ground used for aeration. They also have large machines called a Scarab which is used for turning windrows. There are 21 spaces for windrows which are roughly 300 yds³. Their compost is sold at $25/yd³ and deliver it to certain customers via semi-truck that holds 25-27 yd³ (AWUA, 2016).
Tribal Historic Preservation Office

THPO helped project team members to learn about the history of the Pueblo of Santa Ana and understand the impact that our project could make on the Pueblo as a whole. The history of the Pueblo stretches back centuries, and by being immersed in the rock art and general environment of the Pueblo, we came to understand the rich history of the people of the Pueblo.

Southern Sandoval Investments

Talking with David Naquin, the General Manager of the Southern Sandoval Investments (SSI), was crucial to our understanding of the layout of the Pueblo of Santa Ana. David went over land divisions and the rules regarding land usage and access to water and power from those sites. It was by utilizing this information that we were able to develop an idea of which potential sites would serve best for a composting project (Naquin, 2016).

New Mexico Recycling Coalition

Regarding legal issues, including permitting and licensing, talking with the New Mexico Recycling Coalition (NMRC) is a great resource. At first we talked to Sarah Pierpont, the Executive Director at the NMRC. However, after our discussion she suggested we talk to Joan Snyder.

4.2 Compost Material

The dead cottonwood trees are a driving force for the composting project, and the main source of carbon in the compost. The dead trees have approximately 600 lb/yd\(^3\) carbon content. Though there is an abundance of dead wood, they still need to be moved and chipped. The area effected by the die-off is slowly falling as the trees collapse on their own. The ground is littered with branches and debris. There are about 131 trees per acre and they are about 40 ft tall. The total amount of dead wood in the 120 acres of dead bosque is about 22,000 tons. (Wimberly, 2016).

The manure is another plentiful material source. It is a good source of nitrogen for the compost. Typically horse manure with bedding is 46% dry matter, and has 4 lbs of ammonium-N per ton. Its total nitrogen is about 14 lbs per ton. It is 20% organic nitrogen (Rosen & Beirman). At the stables there is also already some equipment for moving the material, therefore transporting it to the composting site will be doable. However, because of the amount of manure produced, not all of it will be able to be composted.

The Hyatt is a big contributor to the project. They produced 240.6 cubic yards of food waste in 2014 and 218 cubic yards in 2015. They currently have the company Soilutions pick up their waste about three times a month, typically 5 carts per pick up. The carts, provided by Soilutions are shrink wrapped once they are full and ready for collection to lesson to keep the
smell in and flies out. Once the carts are picked up, Soilutions leaves replacement carts. Soilutions also provides a carbon footprint report, found in APPENDIX D: Hyatt Carbon Footprint Graphic, based on the collected waste (Heid, 2016).

The Hyatt at Tamaya already has a reputation for being a green facility, they recycle much of the waste they produce including, paper, plastics, metals, cardboard, batteries, and toiletries. The DNR would be able to pick up food waste from the Hyatt before Soilutions takes the rest of it. At first, the composting project will not be able to collect all of the food waste from the Hyatt. Also though the Hyatt does separate food waste from other types it does not separate the food waste by type therefore it will not include other kinds of food such as meats that could alter the compost composition (Heid, 2016).

Other usable materials would include trimmings from the Pueblo of Santa Ana Vineyard and the Santa Ana Golf Course. The Vineyard produces a shed sized pile of trimmings every day for three months. Currently the waste is burned. The Golf courses, as well, burn their green waste which they collect throughout the winter.

Finally, there is a possibility that in the future biosolids could be added to the composting mixture. After talking with the Santa Ana Utilities Department about the biosolids produced by the Wastewater Treatment Plant, the department is currently in the process of building a new treatment plant the will increase the efficiency of many of their processes. However, a polymer are introduced to the water to separate it from the biosolids and therefore end up in the waste produced. How the polymer will affect the biosolids ability to compost is a little unclear. The polymer itself will not break down on its own and the biosolids already have a rather low moisture content at around 30% (Santa Ana Utilities Department, 2016).

### 4.3 Compost Method

Vermeer’s *A Practical Guide to Composting* lists several windrow composting methods as shown in Table 10.

<table>
<thead>
<tr>
<th>Method</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive windrow</td>
<td>Materials mixed at first into windrows, perforated to allow airflow</td>
</tr>
<tr>
<td>Windrow composting</td>
<td>Windrows turned periodically to aerate and mix</td>
</tr>
<tr>
<td>Aerated static windrow</td>
<td>Like passive windrow but pipes used for active aeration</td>
</tr>
<tr>
<td>Extended (continuous) windrow stacking</td>
<td>One continuous windrow covering entire area, maximizes space use</td>
</tr>
</tbody>
</table>

*Table 10: Composting Methods ("A Practical Guide to Composting, 2008)*
The Albuquerque Water Utility Authority has large machines for grinding green waste. When they create a compost pile, they test each pile which takes typically 15-20 days, but they let them sit for 20-30 days for continued mixing. The piles are continuously turned until they are screened. Their primary customer, the Department of Transportation requires that it contains 40% moisture. A major hazard that can happen is if the piles are above 180 degrees since they could cause a fire (AWUA, 2016).

The Sandoval Landfill Composting Center is an in-vessel operation. They use converted shipping containers from Minnesota that are hooked up to a bio-filter system. Air is pumped into the bottom of the containers through a pyramid pattern of holes and vacuumed out the top to aerate the compost. Water is gravity fed into the container and drained from the bottom and recycled. The vessels’ temperatures are monitored via a probe plugged into the side of the containers and typically kept between 110°F and 145°F for 17 to 20 days while they are turned. Static piles are left for 30 days to cure (Sanchez, 2016).

### 4.4 Compost Site

<table>
<thead>
<tr>
<th>Site</th>
<th>Water</th>
<th>Electric</th>
<th>Distance from Bosque</th>
<th>Size</th>
<th>Ground type</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNR Shop</td>
<td>Yes</td>
<td>Yes</td>
<td>0.89 miles</td>
<td>Small</td>
<td>Concrete</td>
<td>2.4%</td>
</tr>
<tr>
<td>Effluent Pond</td>
<td>No</td>
<td>No</td>
<td>2.33 miles</td>
<td>Small</td>
<td>Dirt</td>
<td>3.0%</td>
</tr>
<tr>
<td>Hyatt Overflow Parking Lot</td>
<td>Maybe</td>
<td>No</td>
<td>0.38 miles</td>
<td>Medium</td>
<td>Dirt</td>
<td>6.6%</td>
</tr>
<tr>
<td>Tamaya Stables</td>
<td>Yes</td>
<td>No</td>
<td>2.00 miles</td>
<td>Large</td>
<td>Dirt</td>
<td>1.8%</td>
</tr>
</tbody>
</table>

Table 11: Site Characteristics

After talking with David Naquin at the Southern Sandoval Investments (SSI) and driving around with Nathan Schroeder, Allen Hatch, and Brian Wimberly all over the Santa Ana Pueblo landscape, the team narrowed its options down to four specific sites for further analysis as places to consider situating a composting facility. These sites included: the DNR shop, the Hyatt overflow parking lot, the "pond", and the Tamaya Stables.

In selecting sites, water and location were the most important considerations. To reduce the burden on DNR vehicle use (transportation of the 1,000 gallon tank), sites already equipped with a water supply, or ones capable of being so equipped, moved to the top of the list or prospective locations. However, just because a site lacked a water source did not mean it was
immediately dismissed. Location was another important factor; the sites were judged upon their accessibility as well as their proximity to potential partners.

Doing the composting on site at the Tamaya Stables is a good option. It would not have issues with odor, and the location is close to most of the other material sources. The bosque and golf courses are right up the road and the manure is already there. There is water and electric in the area as well.

![Image of Tamaya Stables]

**Figure 8: Hyatt Tamaya Stables**

Another site that has potential is the Hyatt overflow parking lot. It is typically used by employees and rarely more than half full, so smell and space would not be an issue. It was also the location of previous projects utilizing the cottonwood. The dirt there is well packed which is good for a compost pile's base. The location is centralized for a green waste pile; however, the area does not have water or power. Water may be able to be routed to the area from the line, parallel to the Twin Warrior access road.
In regards to the DNR shop location, the major benefit is the concrete ground base, which would decrease seepage into the ground and the amount of contaminants, such as sand, into the compost. Along with this the location has water and power and is accessible to machinery. It was also a good location for a centralized green waste pile. The stables would be the furthest contributor; however, in most cases this is true and it is close enough that they would still be able to haul manure to it on a fairly regular basis. On the other hand, it is possible that the second season of *Graves* may be filmed here which could pose an issue, as well as generally limited space.
used. The additional transportation cost of materials to this site was since it is a distance away from partners was also a negative. The almost immediate dismissal of this site was helpful, however because it defined the qualities that were necessary for a good site.

Figure 11: Wastewater Treatment Plant Effluent Pond

4.5 Legal Procedures

Compost, being composed of waste products, carries an inherent potential to contain hazardous wastes. For this reason, the production and sale of compost is regulated by various governmental organizations to ensure that it is safe for both those who produce it and those who purchase and use it. In most states, all composting facilities must register for various permits and be approved by various organizations for health and safety purposes. Some permits only apply when composting certain materials, but most apply to all composting facilities.

Some of the relevant regulatory bodies are listed below. These organizations either enforce regulations or provide additional information about the composting process. See APPENDIX B: Links & Contact Information for organizations’ contact information.

- New Mexico Environment Department (NMED)
  - Solid Waste Bureau
  - Groundwater Bureau
  - Surface Water Bureau
- New Mexico Recycling Coalition (NMRC)
- New Mexico Organics Recycling Organization (NMORO)
- New Mexico Department of Transportation (NMDOT)
- New Mexico Department of Agriculture (NMDA)
• US Environmental Protection Agency (EPA)
  o Region 6
• US Occupational Safety and Health Administration (OSHA)
• Local organizations such as the Sandoval County Fire Department, Pueblo of Santa Ana Tribal Historic Preservation Office, etc.

All composting facilities in New Mexico must register with the NMED Solid Waste Bureau before they can operate by filing the registration form found on our project’s website. This form requires the facility to provide information about its operation, management, training, reporting, methods, equipment, nuisance and hazard prevention, location, and safety practices (“Local Use of Compost and Mulch Guide,” 2014). This registration process takes a couple months. However, the Pueblo is not required to register with the NMED Solid Waste Bureau (Snider, 2016).

To determine that groundwater contamination from composting is controlled, facilities must file a Notice of Intent to Discharge or possibly a Groundwater Discharge Permit with the NMED Ground Water Quality Bureau. The Notice of Intent to Discharge still needs to be filled out regardless of leachant being collected and reused. The Notice will show this and it is likely that the facility will not need a permit. Surface runoff control as well must be determined through the National Pollutant Discharge Elimination System. See APPENDIX B: Links & Contact Information 1.2 and 1.3 for more information. For tribe this applies as well for when more than once acre of land is disturbed.

Compost facilities must also have at least one operator on site at all times who has been certified under the Compost Facility Operator Certification Course, a three-day course that is offered twice a year by the NMRC and NMED. The course covers the composting process, design and production methods, regulations, specifications, compost use, and more. See APPENDIX B: Links & Contact Information 2.1 for schedules, locations, and more information.

By selling compost facilities are required to register with the NMDA annually for a $5 fee. They must also submit a monthly tonnage report and pay a $0.35 per ton fee to the NMDA on all compost sold. See APPENDIX B: Links & Contact Information 5.1 to learn more. Whether this applies to the Pueblo or not needs to be looked into with the NMDA.

Facilities that use biosolids in their compost must adhere to even stricter EPA regulations, since these materials are particularly hazardous. The extent and nature of their regulation depends on the type of biosolids used, and is intended to reduce the spread of pathogens, heavy metals, and other chemicals, as well as reduce vector attraction (the characteristic of a material to attract organisms capable of transporting infectious diseases). Class A biosolids are those that are deemed by the EPA to be safe for land application without restriction, and require that compost piles containing them be kept at a temperature of at least 131°F for 15 days with 5 turns. Class B biosolids have less restrictions on their content, and so are more hazardous, because of this even though there is less restrictions on what they are made of, there are more restrictions
on how they can be used. They require that the compost pile be kept at a temperature of at least 104°F for at least 5 days, during which it must be at least 131°F for at least 4 hours. This lesser restriction means that Class B biosolids are more likely to contain health hazards. If compost is to be determined safe for use, it must contain only Class A biosolids. See APPENDIX B: Links & Contact Information 6.1 for more information.
CHAPTER 5: RECOMMENDATIONS

5.0 Introduction

Our team recommends to the DNR that they implement their composting project by partnering with the Hyatt Tamaya Resort, the Hyatt Tamaya Stables, and the Native Plant Nursery. We suggest they compost dead cottonwood, horse manure, and food waste using the windrow composting method. They should file forms with the NMRC, NMDA and EPA so that they will be able to implement a four-phase scale-up operation.

5.1 Project Partners

<table>
<thead>
<tr>
<th>Partner</th>
<th>Primary Role</th>
<th>Benefits to Them</th>
<th>Benefits to DNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stables at Tamaya</td>
<td>Composting Site Waste Provider</td>
<td>Inexpensive waste removal</td>
<td>Composting site Organic waste for product</td>
</tr>
<tr>
<td>Hyatt Resort</td>
<td>Waste Provider Customer</td>
<td>Inexpensive food waste removal Good reputation Compost product</td>
<td>Food waste for product</td>
</tr>
<tr>
<td>Native Plants Nursery Retail &amp; Wholesale</td>
<td>Seller</td>
<td>Product Community exposure</td>
<td>Sales outlet</td>
</tr>
<tr>
<td>Sandoval County Landfill</td>
<td>Equipment Provider</td>
<td>Mulch</td>
<td>Use chipper in exchange for mulch</td>
</tr>
<tr>
<td>Vineyard</td>
<td>Waste Provider</td>
<td>Inexpensive waste removal</td>
<td>Green waste</td>
</tr>
<tr>
<td>Santa Ana Golf Course</td>
<td>Waste Provider</td>
<td>Inexpensive green waste removal Compost product</td>
<td>Green waste</td>
</tr>
</tbody>
</table>

Table 12: Recommended Partners and Benefits

Our team recommends that the DNR work with the organizations listed in Table 12 as initial partners to start their composting business. This table shows the most involved partners in dark green and less involved partners in light green.
5.1.1 Hyatt Tamaya Stables

The Hyatt Tamaya Stables will play a major role as, foremost, a potential composting site and, secondly, as a waste provider. The stables have a huge source of waste in the form of manure. They also have plenty of space for the DNR’s composting project to take place as we could extend back from their land to the bosque and this would also mean that the manure would only have a few hundred feet to travel at the most to be added to the compost. Currently, the stables already house a small composting facility (which resulted from a past Eagle Scout project) whose built-in bins can be directly repurposed by the DNR. In looking into our alternative option for a composting site, the overflow parking lot would require the furthest distance to travel and since it is such a steady influx of material it would be extremely beneficial to have the composting site at the stables.

5.1.2 The Hyatt Tamaya Resort

The Hyatt Tamaya Resort would also play a large role in this project as the resort has five restaurants that generate a lot of food waste that would be an invaluable addition to the compost mixture. The cottonwood bosque contains an excess of green waste which is high in carbon; however, to have a good compost mixture there must be a good carbon-to-nitrogen ratio. Food waste is much higher in nitrogen and therefore is pertinent for a compost mixture. The Hyatt Tamaya Resort is eager to partner with the DNR for this inexpensive removal of their food waste.

5.1.3 Native Plants Nursery Retail and Wholesale

The Native Plants Nursery Retail and Wholesale are two locations that the DNR could sell the compost. Both locations have already agreed to sell the compost and this will guarantee local, and thereby inexpensive, transportation of the product. Having Native Plants sell this product will provide additional support to local economic development since both nursery locations are within the Pueblo.

5.1.4 Sandoval County Landfill

Sandoval County Landfill has made an offer that would make them a valuable partner for the DNR. In exchange for use of their large chipper, which is an expensive piece of equipment especially for a compost start up, we would have to leave an amount of wood chips for them that they could use for mulch. Use of this equipment would speed up the process immensely as their chipper is capable of going through a lot more wood in a given time than the chipper the DNR currently has. This would mean a faster turnover rate for wood chips which would mean more material for compost which would result in more product and faster expansion for the composting project overall.
5.1.5 The Vineyard

The Vineyard’s green waste consists of pruning from the trees that over the course of each day could fill a small shed. This happens consistently over the span of a few months and therefore makes a significant contribution towards the total amount of carbon for this project.

5.1.6 Santa Ana Golf Course

Santa Ana Golf Course has a pile of green waste that they have compiled over the past few years from yard clippings, tree clippings, etc. This pile would be a good source of carbon for the project in addition to the cottonwood bosque and Vineyard’s pruning.

5.3 Composting Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity Generated</th>
<th>How to Get it to Site</th>
<th>Chemical Contribution</th>
<th>Chemical Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottonwood</td>
<td>278 yd³/yr</td>
<td>Truck</td>
<td>Carbon</td>
<td>69%</td>
</tr>
<tr>
<td>Horse Manure</td>
<td>584 yd³/yr</td>
<td>Tractor</td>
<td>Nitrogen</td>
<td>2%</td>
</tr>
<tr>
<td>Food Waste</td>
<td>161 yd³/yr</td>
<td>Truck</td>
<td>Nitrogen</td>
<td>Variable</td>
</tr>
</tbody>
</table>

Table 13: Recommended Materials

We recommend that the DNR use the dead cottonwood, the manure from the Hyatt Tamaya Stables, and the Hyatt Tamaya Resort’s food waste as the materials for the compost. The cottonwood from the bosque die-off is one of the main reasons that the DNR began to look into a composting project. The cottonwood would provide most of the carbon in the compost’s 40:1 ratio. The DNR has a wood chipper and tractor available for chipping the wood into mulch and transporting it from the chipper to the composting site.

The Hyatt Tamaya Stables have expressed enthusiasm about this project. There is currently a total of 64 horses at the stables so manure is being produced in abundance so they are eager to transport the manure to a composting site regularly. Manure is a nitrogen source in compost, containing 2% organic nitrogen.

The Hyatt Tamaya Resort generates about 160 tons per year of organic waste from its five restaurants, including all food wastes, such as vegetables, grains, and meats. The DNR will not be able to compost all their food waste at first since it is in excess; therefore, they plan to pick up bins of waste from the Hyatt Tamaya Resort before Soilutions collects theirs. We recommend that there be space on the composting pad for this very reason as those raw materials could be
stored before composting. This way the materials can be treated as ingredients and can be added in certain amounts desired for a variety of composting mixtures.

5.4 Composting Process

We recommend that the DNR use the windrow composting method which follow the steps found in Figure 11.

![Windrow Composting Flowchart](figure12.png)

**Figure 12: Windrow Composting Flowchart**

**Step 1: Collect Materials**

The first step in the composting process will be to set up a regular collection schedule for the needed materials. Contact each source of material and set up times during the week or month that a truck could be sent to load up material and haul it back to the composting site.
### Table 14: Recommended Material Sources

<table>
<thead>
<tr>
<th>Material Source</th>
<th>Material</th>
<th>Distance</th>
<th>Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyatt Tamaya Resort</td>
<td>Food Waste</td>
<td>1.56 miles</td>
<td>Jeff Heid</td>
</tr>
<tr>
<td>Hyatt Tamaya Stables</td>
<td>Horse Manure</td>
<td>(on site)</td>
<td>Connie Collis</td>
</tr>
<tr>
<td>Cottonwood Bosque</td>
<td>Cottonwood</td>
<td>2.0 miles</td>
<td>Nathan Schroeder; DNR</td>
</tr>
</tbody>
</table>

**Figure 13: Routes to Material Sources**
**Equipment Needed**: Trucks for hauling material. Depending on volume of collection, may need multiple or larger types of trucks.

After the material is brought to the site, it needs to be processed before it can be mixed into compost. The raw material should be *sifted* to ensure a consistent particle size, then *sorted* into different types. This process also allows easier and more accurate measurement of certain properties of the material, such as bulk density.

**Equipment Needed**: Sifter to remove large particles, grinder to break up chunks of material (especially cottonwood), and bins/piles for storing raw material.

**Step 2: Mix Raw Material**

Next the materials need to be mixed properly to create compost that has the desired properties. The raw materials themselves have certain properties, such that mixing them in certain ratios will give the resulting mixture the desirable properties. For example, carbon-to-nitrogen ratio is one of the most important properties to maintain in compost. Since cottonwood is very high in carbon content, and food waste and manure are moderately high in nitrogen, they should be mixed accordingly. A desired carbon-to-nitrogen ratio of about 40:1 can be obtained by mixing 1 part cottonwood, 4 parts food waste, and 4 parts horse manure (by wet weight). See APPENDIX C: Spreadsheet for details on calculating this ratio and how to adjust it based on individual needs.

![Recommended Compost Mixture](image)

*Figure 14: Recommended Compost Mixture*
**Equipment Needed:** Shovels/front-end loader/specialized compost mixing equipment, depending on volume of material needed to process.

**Step 3: Spread Material into Windrows**

Once the proper mix has been made, the material is ready to begin the composting process. The compost will be made in **windrows**, which are long, even piles that allow for easy management of the material. The raw mix should be spread into windrows approximately **3 feet 3 inches tall** and **6 feet 6 inches wide** (see Figure 15 for an approximate cross-section of an ideal windrow). The length of the windrow can vary based on the available space, but generally should be about **25 feet long**. Based on our calculations (see APPENDIX C: Spreadsheet), the DNR should only need to use up to **4 windrows** of this size. The area required to lay out these windrows with adequate work space would fit in a **96 foot by 45 foot area**.

![Figure 15: Windrow Pile Size](image)

**Equipment Needed:** Shovels/front-end loaders to spread compost out into windrows. Can be done by hand but may be time-consuming depending on volume.

The material now sits in the windrows for about **5 weeks** to let it break down into compost. This chemical process requires both oxygen and water to work effectively, so the windrows must be turned to allow air to filter through the material and allow the center of the windrow, which tends to be the more active part, to be mixed with the outer material. This turning should happen every **3 days** (AWUA, 2016). The length of this active period can be adjusted based on experience as well as experimental measurements of the windrows' internal temperature.
While turning the windrows it is also necessary to water the material to maintain the moisture content at around 65%, or whatever level experience dictates. See APPENDIX C: Spreadsheet for details on maintaining moisture content.

Another property of the compost that must be monitored is the pile's temperature. If the temperature rises above 190°F, the compost is in danger of catching fire. In general the compost should be kept below 150°F, otherwise key microbes will die. Turning the compost is the best way to dissipate this heat. If the temperature stays too low for too long, certain pathogens in the raw material will not be killed off. The usual minimum temperature for an active windrow is about 110°F, but the material should be kept at higher temperatures for certain amounts of time in order to kill certain pathogens; see 3.6.1 Environmental Impacts of Composting for more information on these temperatures.

Equipment Needed: Two options:

1. Turn windrows with shovels or front-end loader. Windrows will need to be watered separately as well by hose or sprinkler.
2. Use a specialized compost turner, such as the Mighty Mike from Frontier Industrial Corporation (quoted at $19,035) which turns, mixes, and hydrates the compost all at once. A tractor is needed to pull the Mighty Mike along the windrow.

Step 4: Move Compost to Curing Stage

After about 5 weeks have passed in the active composting stage, the compost should be moved to a different area where it will cure. During this part of the process, the compost is less active and will require less maintenance. The compost should still be stored in windrows, but they can be larger to store more in a smaller area. Curing windrows should be 8 feet high, 16 feet wide, and about 30 feet in length (see Figure 16 for an approximate cross-section of an ideal curing windrow). The needed space for the curing pad should fit 2 windrows in an 82 foot by 50 foot (4,100 square foot) area.
Curing compost still needs to be turned, although less often, to ensure it is mixed thoroughly, but hydration and aeration are no longer necessary. The compost should be allowed to cure for about 30 weeks in order to allow key fungi to grow in the material and for the material to stabilize (Masley, 2013; Richard & Trautmann, 1996)

**Equipment Needed:** Front-end loader is best for this scale of windrow, shovels would not be feasible. If only shovels are available, windrows can be made smaller to accommodate.

**Step 5: Move Compost to Storage**

After about 30 weeks in the curing stage, the compost can be considered a finished product. At this point, it can be moved from the curing stage to a storage area. This finished compost should be kept in piles so it does not dry out or lose nutrients.

**Equipment Needed:** Front-end loader for hauling material to storage area.

**Step 6: Sell Finished Product**

The finished compost product will be sold in two ways: in bags and in bulk.

Bagged compost will be sold through the Santa Ana Native Plant Nursery Retail. The compost will be bagged at the compost facility and trucked to the nursery (about 4.6 miles, see Figure 17). The compost bags should be sold to the nursery at a price which competes realistically with the wholesale prices for similar products available in the local market. Something on the order of $8.00/bag might be a reasonable amount, to start.
Figure 17: Route to the Nursery

**Equipment Needed:** Heavy-duty bags (200 for $108.30, **$0.5415 per bag** from PolyPak America), eventually a bagging machine (about **$48,000** from Rotochopper, Inc.)

Bulk purchases can be fulfilled directly from the composting facility. Customers can come with their own trucks and have compost loaded from storage. Compost sold in bulk in this way should be sold for **$3.70 per cubic foot**, or if sold by weight, **$0.27 per ton**. This price can be subject to change based on current market value of compost and as the quality of the compost improves over time.
**Equipment Needed:** Shovels or a front-end loader for loading compost onto customers' truck beds.

### 5.5 Composting Site

We recommend that the composting center be situated at the Hyatt Tamaya Stables for the following reasons:

- The stable’s staff are willing to house the project
- The manure material is readily available on site, which saves on transportation cost
- The stables are a spacious area allowing for expansion
- Composting odor would not be a problem in the area
- There is water on site
- There is power on site
- There is access to equipment for use
- It is close to other material sources
- We can use of some stables equipment such as a tractor

If for any reason the top choice proves untenable, a second choice site that could be used as an alternative is the Hyatt Tamaya Resort overflow parking lot. This site presented a large space as well as a solid ground level that would not interfere much with the compost mixture. However, there is no water at this site so the DNR's 1,000 gallon tank would have to be utilized and there is also no power. The smell of the compost would not be an issue as it is only employees that use the parking lot during the peak months, but material transportation would be more expensive for this site as the stables are further away.

<table>
<thead>
<tr>
<th>Site</th>
<th>Water</th>
<th>Electric</th>
<th>Transportation Distance</th>
<th>Size</th>
<th>Ground type</th>
<th>Equipment</th>
<th>Odor Issue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stables</td>
<td>Yes</td>
<td>Yes</td>
<td>Close</td>
<td>Spacious</td>
<td>Dirt</td>
<td>Tractor</td>
<td>No</td>
</tr>
<tr>
<td>Parking Lot</td>
<td>No</td>
<td>No</td>
<td>Pretty close</td>
<td>Spacious</td>
<td>Dirt</td>
<td>None</td>
<td>No</td>
</tr>
</tbody>
</table>

*Table 15: Composting Facility Sites*

### 5.6 Permitting and Licensing

We recommend that the following forms be filled out by the DNR and that they talk to a NMDA as well as Groundwater Quality Bureau and Surface Water Quality Bureau about whether or not they require a few more forms.
• Application for Registration of Commercial Fertilizer or Soil Conditioner
• Ground Water Quality Bureau Notice of Intent to Discharge Form
• Compost Facility Registration Form

Through our meeting with Sarah Pierpont and Mike Smith, we began to understand the ways that the NMRC could benefit the DNR in the future. The DNR does not have a strong connection with the state because the Pueblo is a sovereign government and thereby functions as its own entity. While this usually does not affect much, in the case of large grant-based projects such as this one.

After talking with the NMRC, it was clear that they are eager to help facilitate a connection between the Pueblo of Santa Ana and the state of New Mexico on the grounds of this project as it is beneficial to all parties involved. Since the Pueblo functions as a sovereign government, the DNR, as a part of the Pueblo of Santa Ana, would most likely not be held to typical permit and license qualifications that a place in the surrounding United States would (Pierpont, 2016). However, although these standards do exist, to create a substantial and expanding composting business, some licenses and permits may be necessary to facilitate growth.

Joan Snider, of the NMRC, suggests that the DNR check in with the NMDA to determine whether or not they need to register as a compost seller. Similarly, whether the DNR has to comply with National Pollutant Discharge Elimination System or not is questionable and should be looked into with the Groundwater Quality Bureau and Surface Water Quality Bureau. These two bureaus are also the ones that should be consulted on which regulations are state administered federal regulations because though the pueblo is not necessarily held to state law, it is subject to federal law (Snider, 2016). Finally though the Pueblo is not required to complete the compost facility registration application, it is a good learning tool and designed to help applicants write an operations and nuisance prevention plan.

5.7 Cost Analysis

Our recommendation to the Santa Ana DNR will be composed of four phases: mulching, small-scale composting, medium-scale composting, then large-scale composting. The DNR’s budget constraints restrict their capability to hire the labor and purchase the equipment needed for a large-scale composting operation. The phased approach allows them to start out with a much smaller, simpler operation, and scale up over time as they both gain experience with the composting process and are able to build up profits and secure more funding. There are four phases in our plan that increase in both complexity of operation and cost, but will also produce higher volumes of compost.
Phase 1 – Mulching (1 year)

The DNR’s CFRP grant application dictates that for the first year, the DNR will produce only mulch. The mulch will be composed of mainly dead cottonwood hauled, chipped, sifted, and bagged by the DNR and sold to the local nursery for resale (Nathan’s CFRP grant). This phase is the easiest to start out at because the DNR already possesses much of the equipment needed, and the process can be run almost in parallel with the DNR’s bosque restoration efforts. No other material collection besides the cottonwood or equipment besides trucks, chippers, and sifters are necessary for this phase. The cottonwood should be collected and brought to the stables about five times a week.

<table>
<thead>
<tr>
<th>Material</th>
<th>Collection Site</th>
<th>collections/month</th>
<th>tons/collection</th>
<th>tons/month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottonwood</td>
<td>Bosque</td>
<td>22</td>
<td>1.07</td>
<td>23.19</td>
</tr>
</tbody>
</table>

Table 16: Phasing 1 Mulching Material Collection

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Cost</th>
<th>Brand/Model#</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck</td>
<td>$</td>
<td>Ford F350</td>
<td>Hauling material from bosque</td>
</tr>
<tr>
<td>Woodchipper</td>
<td>$</td>
<td>Vermeer BC 1000</td>
<td>Chipping dead cottonwood</td>
</tr>
<tr>
<td>Front-end Loader</td>
<td>$</td>
<td>Kubota M6800</td>
<td>Moving large cottonwood pieces</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tractor + LA1162</td>
<td></td>
</tr>
<tr>
<td>Sifter</td>
<td>$</td>
<td>homemade</td>
<td>Filtering out large woodchips</td>
</tr>
<tr>
<td>Total</td>
<td>$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 17: Phase 1 Equipment Specifications and Uses

Phase 2 – Small-Scale Composting (6 months – 1 year)

At this point the DNR should be comfortable enough with the process of chipping cottonwood and hauling material regularly to the stables to begin rudimentary composting. Composting requires a larger variety of materials and a more complex process, but starting off with a small output goal will give the DNR time to improve the process through trial and error. While our recommendations are a good starting basis, actual field experience usually gives more accurate results. To this end, the DNR should start out with a small operation so that any inconsistencies in the process will not cause large-scale problems.
For materials, the DNR will begin to collect horse manure and food waste as well as the continuous stream of cottonwood. Some of the cottonwood will be redirected to be used in compost, while the rest will continue to be used in mulch. Food waste will be collected from the Hyatt Tamaya Resort, who already sort their food waste for shipping to Soilutions. They fill and have hauled away about five bins of food waste three times per month (Heid, 2016). During this phase the DNR will take only one of those bins per pickup. The only extra equipment needed for this phase will be shovels to assist in creating and turning compost windrows.

<table>
<thead>
<tr>
<th>Material</th>
<th>Collection Site</th>
<th>collections/month</th>
<th>tons/collection</th>
<th>tons/month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottonwood</td>
<td>Bosque</td>
<td>22</td>
<td>1.07</td>
<td>23.19</td>
</tr>
<tr>
<td>Manure</td>
<td>Stables</td>
<td>22</td>
<td>0.11</td>
<td>2.36</td>
</tr>
<tr>
<td>Food Waste</td>
<td>Hyatt</td>
<td>3</td>
<td>0.79</td>
<td>2.36</td>
</tr>
</tbody>
</table>

Table 18: Phase 2 Composting Material Collection

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Cost</th>
<th>Brand/Model#</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shovels</td>
<td>$</td>
<td>-</td>
<td>Piling/turning compost</td>
</tr>
<tr>
<td>Woodchipper</td>
<td>$</td>
<td>Vermeer BC 1000</td>
<td>Chipping dead cottonwood</td>
</tr>
<tr>
<td>Front-end Loader</td>
<td>$</td>
<td>Kubota M6800 Tractor + LA1162 Loader</td>
<td>Piling/turning compost</td>
</tr>
<tr>
<td>Total</td>
<td>$</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Table 19: Phase 2 Equipment Specifications and Uses

Phase 3 – Medium-Scale Composting (about 3 years)

Once the DNR is confident in its ability to consistently produce a good-quality compost at a small scale, the operation can be expanded to produce a higher volume. The experience of the composting center’s operators should by now be enough so that they can handle a higher output with less risk of producing large amounts of poor product. The method and materials in this phase will remain relatively the same when scaling up the operation, however, equipment and labor will need to change, as the larger scale requires more maintenance and upkeep.
### Table 20: Phase 3 Composting Material Collection

<table>
<thead>
<tr>
<th>Material</th>
<th>Collection Site</th>
<th>collections/month</th>
<th>tons/collection</th>
<th>tons/month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottonwood</td>
<td>Bosque</td>
<td>22</td>
<td>1.07</td>
<td>23.19</td>
</tr>
<tr>
<td>Manure</td>
<td>Stables</td>
<td>22</td>
<td>0.33</td>
<td>7.07</td>
</tr>
<tr>
<td>Food Waste</td>
<td>Hyatt</td>
<td>3</td>
<td>2.36</td>
<td>7.07</td>
</tr>
</tbody>
</table>

### Table 21: Phase 3 Equipment Specifications and Uses

The largest investment in this phase is a dedicated compost turner. The Frontier Mighty Mike is a good turner for smaller-scale operations. It is a pull-behind turner, so a tractor must pull it alongside the windrow. It also includes a water tank on top that hydrates the compost as it turns it.

#### Equipment

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Cost</th>
<th>Brand/Model#</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compost Turner</td>
<td>$19,035</td>
<td>Frontier Mighty Mike</td>
<td>Turning compost</td>
</tr>
<tr>
<td>Woodchipper</td>
<td>$</td>
<td>Vermeer BC 1000</td>
<td>Chipping dead cottonwood</td>
</tr>
<tr>
<td>Front-end Loader</td>
<td>$</td>
<td>Kubota M6800 Tractor + LA1162 Loader</td>
<td>Piling compost</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$</td>
<td></td>
<td>$19,035.00</td>
</tr>
</tbody>
</table>

### Phase 4 – Large-Scale Composting (5 or more years)

This phase is one that the DNR may not actually reach, and contains recommendations that should only be followed if the DNR wishes to make the composting center a long-term commitment. For this phase, other parts of the composting process can be automated, such as the bagging of the final compost product and mixing/sorting of the raw material.

### Table 22: Phase 4 Composting Material Collection

<table>
<thead>
<tr>
<th>Material</th>
<th>Collection Site</th>
<th>collections/month</th>
<th>tons/collection</th>
<th>tons/month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottonwood</td>
<td>Bosque</td>
<td>22</td>
<td>1.07</td>
<td>23.19</td>
</tr>
<tr>
<td>Manure</td>
<td>Stables</td>
<td>22</td>
<td>0.54</td>
<td>11.78</td>
</tr>
<tr>
<td>Food Waste</td>
<td>Hyatt</td>
<td>3</td>
<td>3.93</td>
<td>11.78</td>
</tr>
<tr>
<td>Equipment</td>
<td>Cost</td>
<td>Brand/Model#</td>
<td>Use</td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>------</td>
<td>------------------------------</td>
<td>-------------------------------</td>
<td></td>
</tr>
<tr>
<td>Compost Turner</td>
<td>$</td>
<td>- Frontier Mighty Mike</td>
<td>Turning compost</td>
<td></td>
</tr>
<tr>
<td>Woodchipper</td>
<td>$</td>
<td>- Vermeer BC 1000</td>
<td>Chipping dead cottonwood</td>
<td></td>
</tr>
<tr>
<td>Front-end Loader</td>
<td>$</td>
<td>- Kubota M6800 Tractor + LA1162 Loader</td>
<td>Piling compost</td>
<td></td>
</tr>
<tr>
<td>Bagging Machine</td>
<td>$48,000.00</td>
<td>Rotochopper, Inc.</td>
<td>Bagging finished compost</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>48,000.00</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 23: Phase 4 Equipment Specifications and Uses

5.8 Final Recommendation: Good Luck!

Our team believes that by utilizing this plan, the DNR will be able to create a long-term composting business that is capable of generating revenue streams for bosque restoration projects. Extending beyond the four-phase plan, we recommend that the DNR purchase additional equipment to automate, and thereby speed up, the composting process so they are able to produce more. Additionally, we believe that the incorporation of biosolids as a compost material in the future is a possibility as this would create richer, and therefore more desirable, mixtures. We hope that this report together with the analytical tools and guides we have produced and gathered to support it, will assist the DNR with their composting business plan and wish them the best of luck with their future composting endeavors!
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Sanchez, B. (2016). Interview conducted on March 21 while on tour at the Sandoval Landfill Composting Center in Sandoval, NM.


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Santa Ana Utilities Department. (2016). Interview conducted on April 5 at the Santa Ana Utilities Department in the Pueblo of Santa Ana, NM.

Schroeder, N. (2016). Informal interview conducted over the duration of 7 weeks between March 14 and May 4 in the Pueblo of Santa Ana, NM.


Snider, J. (2016). Email reply from New Mexico Recycling Coalition employee received by Sierra Fowler on April 25.


Tribal Historic Preservation Office (THPO). (2016). Focus Group discussion with members of THPO on April 4 in the Pueblo of Santa Ana, NM.


Wimberly, B. (2016). Informal interview conducted on March 18 in the Pueblo of Santa Ana, NM.


Zickefoose, K. (2016). Informal interview conducted on March 15 at the Native Plant Nursery: Whole in the Pueblo of Santa Ana, NM.
The following equations from Richard and Trautmann (1996) can be used to determine the moisture content and carbon to nitrogen ratio of a compost pile.

**Moisture content:**

\[
S = \frac{(W_1 \times M_1) + (W_2 \times M_2)}{W_1 + W_2}
\]

- **S** Moisture content of pile
- **W**\textsubscript{n} Weight of material \(n\)
- **M**\textsubscript{n} Moisture content of material \(n\)

The weight ratio of the two materials can be calculated by:

\[
\frac{W_2}{W_1} = \frac{M_1 - S}{S - M_2}
\]

**Carbon to nitrogen ratio:**

\[
R = \frac{W_1 \times (C_1 \times (1 - M_1)) + W_2 \times (C_2 \times (1 - M_2))}{W_1 \times (N_1 \times (1 - M_1)) + W_2 \times (N_2 \times (1 - M_2))}
\]

- **R** Carbon to nitrogen ratio of pile
- **W**\textsubscript{n} Weight of material \(n\)
- **M**\textsubscript{n} Moisture content of material \(n\)
- **C**\textsubscript{n} Carbon content of material \(n\)
- **N**\textsubscript{n} Nitrogen content of material \(n\)

The weight ratio of the two materials can be calculated by:

\[
\frac{W_2}{W_1} = \frac{N_1 \times \left( R - \frac{C_1}{N_1} \right) \times (1 - M_1)}{N_2 \times \left( \frac{C_2}{N_2} - R \right) \times (1 - M_2)}
\]
APPENDIX B: LINKS & CONTACT INFORMATION

2. New Mexico Recycling Coalition (NMRC): http://www.recyclenewmexico.com/
   2.1. Compost Facility Operator Certification
       Course: http://www.recyclenewmexico.com/cert_classes/
   2.2. New Mexico Organics Recycling Organization
       (NMORO): http://www.recyclenewmexico.com/nmoro.htm
3. New Mexico Department of Transportation (NMDOT): http://dot.state.nm.us/
4. New Mexico Department of Agriculture (NMDA): http://www.nmda.nmsu.edu/
5. US Environmental Protection Agency (EPA): https://www.epa.gov/
   6.1.1. Sandoval County Fire Department: http://www.sandovalcounty.com/fire
APPENDIX C: SPREADSHEET

The composting calculations spreadsheet is available at the following URL:
https://drive.google.com/open?id=0B6WORCer-muTRXRmZ3FhWXRPXzg
Hyatt Carbon Footprint Report from Solutions based on 133 tons of food waste in 2015

Hyatt Carbon Footprint Report from Solutions based on Year to Date food waste in 2016