AC 2008-779: MUNICIPAL SOLID WASTE MANAGEMENT PRACTICES GLOBALLY ADAPTABLE FOR SUSTAINABLE DEVELOPMENT IN GROWING DEVELOPING COMMUNITIES

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Municipal Solid Waste Management Practices globally adaptable for Sustainable Development in Growing Communities

Abstract

This study focuses on the municipal solid waste management practices globally adaptable for sustainable development in growing communities. The paper begins by looking at the history and recent developments of solid waste and recycling practices. In order to better understand the inner workings of local county governments, one will look at the examples of Alachua and Escambia Counties in Florida as a case study applicable globally to support sustainable waste development practices in developing countries. Both counties are relatively similar in demographic and population qualities (as will be presented in the study). The level of service provided by these counties is examined as well as the benefits of programs undertaken by these counties, such as county-owned landfills, curbside recycling, and rural drop-off centers. Upon completion of the analysis, a model is created to be used globally outside of the United States as well as within for local growing communities. The model generated draws on aspects recommended by the United States Environmental Protection Agency. The model puts a major focus on county centralization of municipal solid waste management, volume based rates for disposal and collection, regional landfill practices which use new environmentally conscious technologies, and drop-off centers for the rural areas of the county. A cost-benefit examination is looked at as to verify the feasibility of the generated model and its long-term effects on the county. The intention of this paper is for growing and developing communities across the world to use the model as a means of creating an efficient solid waste department capable of reducing waste and increasing the usage of waste alternatives like recycling, thereby promoting good health and an environmentally sustainable community.

Introduction

In a growing trend towards sustainability and encouraging stable environmental operations within public works, one of the major components of this trend is solid waste pickup and disposal. More importantly, the many facets of solid waste management have become more visible to the public eye as citizens look to have waste disposed of in a proper way without too many limitations on disposal. Municipal systems must be efficient enough to ensure manageability and prevent excessive service or provide higher levels of service on a restricted budget. As such, in this paper, one will discuss the current levels of solid waste operations in these case studies to generate a globally applicable model for solid waste pickup and disposal practices of growing communities. The cases to be examined are the levels of service in Alachua County, Florida and Escambia County, Florida. This comparative study will help us determine the measures taken to improve sustainability as well as cost effective measures to produce the most efficient solid waste operations in these growing communities of Escambia and Alachua County and apply these measures to developing nations.

A Brief History of Solid Waste Operations

Like most of the public works fields, solid waste concepts were initially designed by the Greeks and Romans as early as 3000 BC. Although rudimentary, the first landfills were simple piles of waste with layers of earth piled on top to remove odor from the air.[11] This stands in stark contrast to the high-tech waste facilities within the modern societies of the world. During the 1800's, a report in England linked disease to environmentally unsanitary conditions. Meanwhile, in newly urbanized cities, people were dumping waste out their windows. This report launched a new era in sanitation as cities began taking proactive measures to curb the growing levels of waste buildup in the cities. By 1874, the first municipal solid waste incinerator was built in Nottingham, England aptly termed, "the destructor".[11] By 1895, New York City became the first American city to develop a public works sector for waste management. Following into the 1900's and up until the 1960's, "piggeries" were established which relied on pigs to consume food refuse. It was estimated that 75 pigs can consume 1 ton of food waste per day.[8]

Figure 1: An early 1920's photo of a city street covered in garbage

A transition towards more environmentally sound waste management operation began its first steps back in 1909[8.] The levels of noxious smoke emitted from waste incinerators quickly became a growing problem as immigrants and rural farmers began moving towards the urban, industrial centers of cities which increased the level of waste disposal at a rapid rate. In 1909, nearly 100 incinerators were now being closed (especially in more urbanized areas) due to these fume buildups. However, after this shaky start for incinerators, they became more popular and grew to almost 300 incinerators by 1914[8]. Environmentalists were happy when, in 1934, the Supreme Court banned the dumping of municipal waste into the ocean, which was common practice at the time.[11] The initial concept of a "sanitary landfill" stems from World War II where soldiers would bury their waste products in the ground in layers. By 1945, almost 100 sanitary landfills are in usage across the United States. During 1959, the American Society of Civil Engineers published its articles pertaining to sanitary landfills, which emphasized the use of compaction and covers to reduce odor and rodents.

At the federal level, the Solid Waste Disposal Act of 1965 became the first piece of federal legislation to support the means of sanitary landfills and increase the number of these sites across the nation[11]. In 1970, the Environmental Protection Agency (EPA) was established and began producing reports giving information on proper disposal methods, programs to reduce refuse output (like the Pay-As-You-Throw program which currently operates in Alachua County and the City of Gainesville), and recycling policies. Since the establishment of the EPA, it has helped

provide an accurate source of information for the protection of groundwater systems beneath landfills and post-closure care of landfills.

Trends in Municipal Solid Waste for the Untied States

Today's municipal solid waste network deals with over 245 million tons of waste products. The types of goods handled by municipal waste systems have changed slightly over the past 10 years[2]. As seen in Figure 1, the relative values have fluctuated only slightly in some areas. Most notably, the proportions of consumer products like plastics, metals, rubber, and textiles have gained an increase in the share of total waste since 1994.

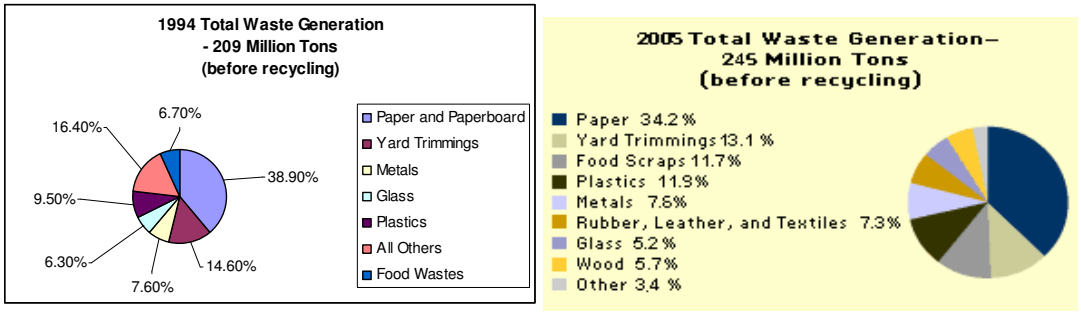

Figure 2: Comparison of Generated Waste Composition (1994-2006)

However, these numbers vary significantly from the amount of wasted that reaches today's landfills. Instead, according to Figure 3, roughly 55% of all waste generated in the United States is sent to a landfill while 34% is recycled and 14% is used in combustion (or incinerated) as a means of energy production.[13] Again these values can vary on location around the United States. For example, Alachua County recycles 100% of the yard trimmings received as well as seen an increase in the amount of "white goods" (or small appliances that are disposed of) which are being recycled. Other counties may rely more heavily on landfills or recycling depending on the levels of service for the particular municipality.

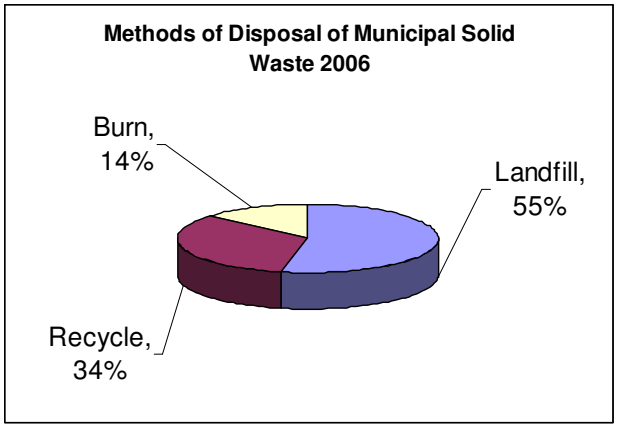

Figure 3: Methods of Disposal in United States

The amount of trash generated in the United States has risen since 1960. However, as seen in Figure 4, the rate at which trash levels are increasing has slowed drastically. When looking at

trash levels in a per capita generation (meaning lbs/person/day), the amount of trash generated has stayed relatively constant at 4.5 since 1990.[12] Observations about these changes largely stem from an increased usage and reliance on recycling and composting efforts which continue to become more popular.

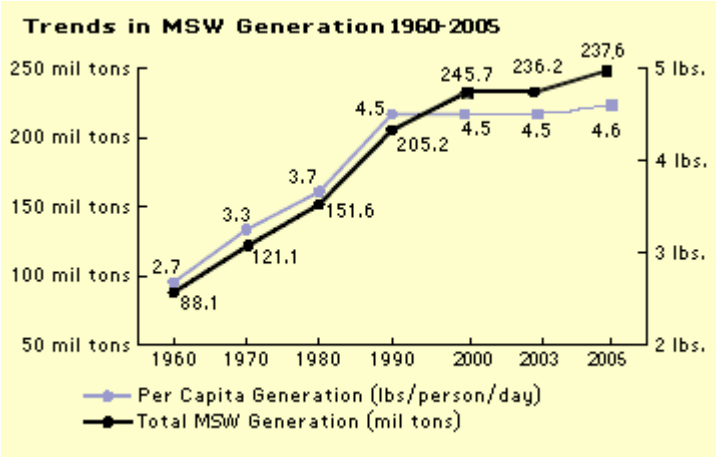

Figure 4: Amount of Trash Generation (1960-2006)

Perhaps one of the most notable trends in solid waste management is a decreased number of landfills across the United States. Landfill numbers have continually decreased since 1988 where there were 7,924 landfills open in operation, and today only 1,654 landfills are currently operational[2]. Unfortunately, this decreasing number of landfills is offset by the fact that the average landfill size has increased over this same period. The EPA notes that there is a good amount of landfill capacity for the United States as a whole, but capacity may be limited in some regional areas.

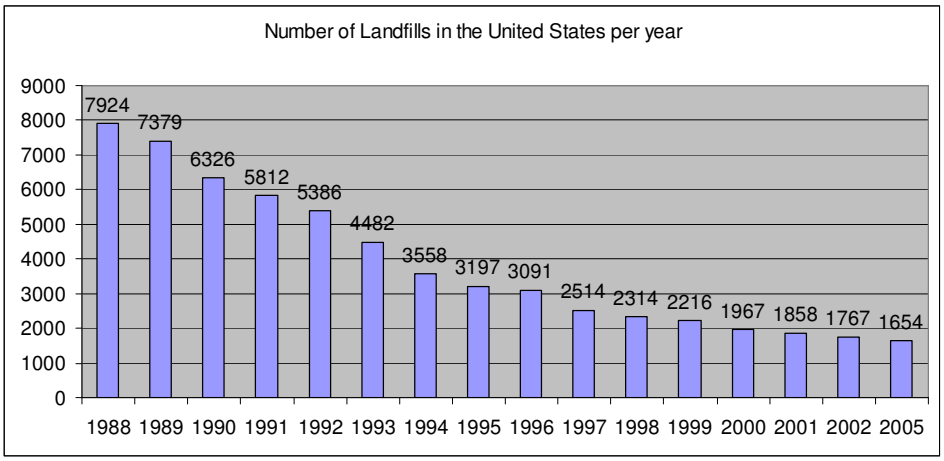

Figure 5: Landfills Decreasing Over Time in United States

Regarding landfill technologies, one of the most innovative and technologically advanced landfill systems is the bioreactor landfill[3].The premise behind such a bioreactor landfill is that its internal structure is designed to help rapidly decompose organic materials within a landfill cell. Figure 6 shows a graphical representation of the structure of a bioreactor landfill. This increase

in degeneration is caused by adding air and leachate solutions within the cell to help chemically breakdown the organic mass within the system. Other additives including stormwater, wastewater, and wastewater treatment sludges can be added to the system in order to increase the rate of stabilization within the fill. The moisture content of the bioreactor landfill is the most important aspect. Proper moisture is required in order to facilitate an even more productive degradation of organic waste and a sequestering of inorganic elements. Additional leachate and other reactive chemicals are inserted into the cell in order to maintain the desired cell moisture content.

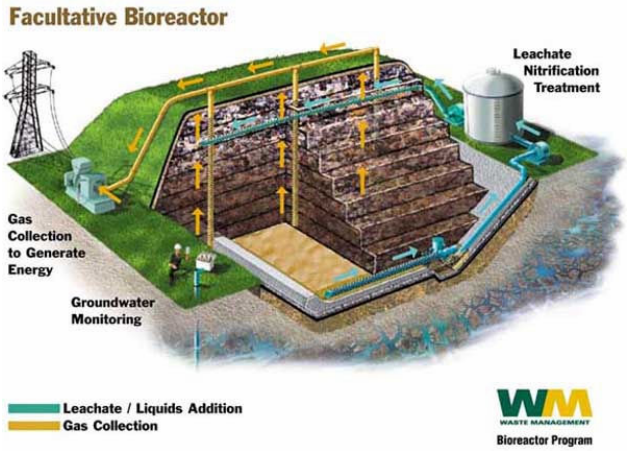

Figure 6: Example of a Bioreactor Landfill

What makes the bioreactor so much more desirable is that it is capable of increasing available landfill space by 15-30%, has potential energy creation opportunities via the excess gas generated by the chemical breakdown process, and can ultimately reduce post-closure care costs for the landfill[3]. As such, the EPA is currently studying the effects of bioreactor landfills and their implications for the municipal solid waste management system. The United States Department of Energy is looking into the energy generation aspect of the landfill gas that is emitted from the bioreactor landfill. It has been proven that if 50% of the waste being put into landfills was subjected to a bioreactor facility, one would produce 270 billion ft^3 of methane which (when converted to usable energy) is equivalent to 1% of the entire United States energy supply[3]. The State of Florida is currently taking a lead role in the usage of bioreactor landfills and has the most number of bioreactor landfills in the world. There are currently four in operation in the state: New River Regional Landfill, Polk County Landfill, and Highlands County Landfill, and Alachua County Southeast Landfill[3].

A Brief History of Recycling Operations in the United States

Since the beginning of civilization people have recycled. They reused water buckets and melted down statues to make bullets or different statues. In this day and age, recycling has evolved into collecting and reprocessing used plastic and glass bottles, aluminum cans, and used paper. With regards to modern recycling systems, its origin can be estimated to be in 1896 when the first recycling center was established in New York City [10].

After the first recycling center, the cities of Chicago and Cleveland opened large scale aluminum recycling centers in 1904[3].These centers were able to make more aluminum cans without using as much virgin ore. By 1908, the Waldorf Paper Mill was using scrap paper to make new paper[15].After the aluminum and paper recycling was established, many cities around the country implemented similar centers. There was very little new technology until the 1960's.

In 1968, aluminum recycling evolved into making window blinds[10]. Oregon became the first city with a "Bottle Bill" which offered refunds for returned containers[11]. This idea rapidly spread to many other states. Within a few years, cities needed a new way of implementing recycling programs. University City, Missouri implemented the first city-wide curbside recycling pickup for newspapers in 1974[10].This event lead to the approximately 8,550 curbside programs that were in effect as of 2005[9].

As of 2003, fifty percent of all paper used nationwide was recycled. Almost all paper can be recycled. The only paper that is not useable is paper that has food products on it. One example of unusable paper is a pizza box. Since paper can be recycled numerous times before the fibers become too short to recycle, a piece of paper can be used in numerous paper products[15].In the United States, recycling one ton of used paper saves 17 trees. It also saves two barrels of oil, enough energy to power a home for six months, 3.2 cubic yards of landfill space, 7,000 gallons of water and sixty pounds of air pollution[2].

Figure 7: Recycled Cans at Escambia County Center

Aluminum is one of the most commonly recycled materials in the United States even though approximately only 50% of all aluminum cans are recycled. When an aluminum can is recycled, enough energy is saved to light a 100-Watt light bulb for almost four hours or to power a TV for three hours. This is because making a new can from used cans can take 95% less energy than making it from virgin ore. To add to the benefits of recycling aluminum, there is an extremely short turnaround time. The aluminum in one recycled soda container can be back on a shelf as a new can in as little as 60 days[6].

In a similar fashion to aluminum, using waste glass bottles to make new ones saves energy. The energy saved by recycling one glass bottle produces enough energy to light a 100-Watt light bulb for four hours. One drawback of recycling glass is that broken glass cannot be used because the colors of the different types of glass cannot be separated. However, this waste broken glass can be used as daily cover material for a landfill once it is ground into a sand-like material[15]. In 2005, 25.3% of waste glass was recycled[2].

Plastic has a very different way of being recycled. Instead of being recycled numerous times, plastic is recycled in a process called down-cycling. This means that of the 34.1% of plastic soda bottles recycled in 2005, the plastic was converted into lumber, lawn, and landscaping products[2]. Also, filling for sleeping bags and polyester carpets are made from used plastics.

Using plastics in these ways and many others keeps millions of pounds out of landfills. Recycling plastics is evolving continuously and is becoming more economical to do[15].
Two relatively new forms of recycling are electronics and white goods recycling. In electronic recycling, electronic devices are taken apart. After the individual items are put into their respective groups, they are either destroyed by pulverization or sent to be reused. White goods are recycled in a similar manner. Since white goods consist of household appliances including refrigerators, washing machines, and stoves, there is a lot of scrap metal to be recycled. To get all of the scrap metal, the appliances have to be taken apart. Most of the appliances have some sort of hazardous waste in it. One example is refrigerators that have refrigerants that have to be disposed of properly. Both electronic and white goods recycling will continue to develop even more efficient ways to recycle[4].

Figure 8: Old Computers have significant amounts of materials that are recyclable

A County Analysis of Municipal Solid Waste: Alachua County

Alachua County is a predominantly metropolitan county (as defined by the Office of Management and Budget) whose major industrial, commercial, and residential hub is the city of Gainesville. County operations predominantly rely on a close working relationship between the City of Gainesville and Alachua County. With a population of 227,120 in 95,897 households estimated in 2006[14],the county is responsible for many of the services provided to its residents including police, fire, parks and recreation, solid waste, and road and bridge construction. The county prides itself on pursuing environmentally sustainable programs that benefit the ideals of preserving the rural, natural surroundings of the county[1].

The overall solid waste collection system in Alachua County is much decentralized. The survey of values taken from the entire county, as presented in Table 2, come from a general survey provided by Gainesville Regional Utilities as an internal study of waste levels for the county.

Alachua County Solid Waste Amounts 2006	
Municipal Solid Waste	192,417 tons
Recycling	30,149 tons
Yard Waste	20,642 tons

Table 1: Total Volumes of Waste in Alachua County

However, the actual county operations of trash collection are only for areas of unincorporated Alachua County. Meanwhile, local municipalities are responsible for their own collection programs. Thus, the City of Gainesville may have separate rates and policies regarding

municipal waste than the Town of Micanopy. As such, in later discussion the loose term of "the county" implies only to these unincorporated portions of Alachua County. Local municipalities will be discussed in general and one will look at the City of Gainesville at a more in-depth approach. When determining the volume of trash per household in Alachua County, it can be determined that each household contributes 2 tons of garbage per year.

With regards to trash collection policies, Alachua County now follows one of the EPA-approved policies known as Pay-As-You-Throw. The premise behind the program is that citizens will pay a monthly service bill for the amount of trash they dispose of each month. Predetermined size bins are given monthly values (corresponding to their volume) and citizens may select which volume meets their waste needs. Alachua County rates are listed in Table 2 and show a consistent volume based method for collection.

Alachua County Waste Pickup Rates	
20 gallon bin	$135.39/year
35 gallon bin	$162.95/year
64 gallon bin	$208.30/year
96 gallon bin	$256.49/year

Table 2: Unincorporated Alachua County Pick-up Rates

More importantly, this "volume-based method" of waste collection has a major effect on the amount of waste each citizen generates. The more waste generated, the more that citizen must pay to have it removed and disposed of properly. This method of payment is similar to road construction taxes imposed at tolls (as those who use the road more often will pay more for its upkeep). From this, there has been a steady decrease in the volume of waste produced by each citizen in the county.

The county also provides what are known as rural drop off centers for the most rural portions of the district [1]. At these sties, citizen may pay a disposal fee instead of curbside residential pickup rates. These rural collection centers are a major focus for unincorporated Alachua County and account for almost half of the county operations, according to Alachua County Solid Waste Manager Karen Deeter. Also, these drop-off centers are also utilized by the more urban citizens as centers for depositing excess waste from specific events. According to county surveys, the county's drop off centers account for 36% of its waste from citizens of urban areas (like the City of Gainesville) using these centers as locations for bulk drop off.

Recycling in the county system of municipal waste is included in the cost of solid waste pickup. The emphasis on recycled goods has increased in the past. According to county officials, the level of recycling in the county has increased at an astonishing rate. A ten percent increase has been found over the past twenty years. A growing trend in the county is found in its increased level of recycling of "white" goods. These goods tend to be appliances that can be salvaged and recycled as a form of scrap metal. Yard waste products are now considered "land applied"

recycled products as these wastes are used as composting devices and mulch which is then resold by the county. For the county, 100% of the yard waste generated is "land applied" in some fashion.. An increase in environmental awareness has also promoted a growing trend in which the county is no longer accepting construction and demolition waste products, from commercial and industrial projects, at both curbside locations and drop off centers. This new program has helped reduce the quantity of waste being cycled through the county operations. Instead, these waste products must be dealt with privately via separate contracts between builders and waste service providers.

The City of Gainesville is the largest and most populous county in Alachua County, comprising of 122,671 people (a total of 54% of the population of Alachua County) living in 45,730 households[14]. As such, their municipal solid waste policies are the ones that affect the county's levels of service the most. The City of Gainesville also utilizes the volume based collection system the county provides. However, Gainesville resident pay monthly on their utility bill at the rates listed in Table 3.

City of Gainesville Pickup Rates	
20 gallon bin	$13.21/month
35 gallon bin	$17.18/month
64 gallon bin	$21.14/month
96 gallon bin	$26.42/month

Table 3: City of Gainesville Pick-up Rates

The volume based method has been utilized in the City of Gainesville to an extent that the amount of trash within the city has decreased enough for the city to only need one curbside pickup per week for the entire city. This has been a goal of the Solid Waste Department of the City of Gainesville for the past twenty years, according to Steve Joplin (the interim Solid Waste Director). The city also does not manage waste pickups at the city level. Instead, collection and disposal services are contracted out and the private firm must deal with the disposal of waste form the city. This same condition applies to the unincorporated areas of Alachua County as well. The total cost of collection (which includes the recycling pickups) was $3,343,786 for FY07. In addition to the costs of administration, disposal, and upkeep of retired landfills, the total operating cost to the City was determined to be $6,331,560 for FY07.

When talking about waste disposal and recovery methods, the city has also increased its ability to collect electronic waste. These are electronic devices like old computers and printers that have specific components within them that have the ability to be recycled. For example, some computer processors have a significant amount of gold within them that extracting the gold may be cost-effective[4]. Table 4 illustrates the tonnages of municipal solid waste and recycling efforts taken by the city of Gainesville.

City of Gainesville Solid Waste Amounts 2006

Municipal Solid Waste	90,256 tons
Recycling	15,116 tons
Yard Waste	11,775 tons

Table 4: City of Gainesville Collection Totals

Given the 45,730 households within the city, it can be deduced that the average household produces .33 tons of recycled waste per year. When combined with the 15,033 tons produced outside of Gainesville, the entire Alachua County produces approximately .314 tons of recycled goods per household.

Recycling programs within the City of Gainesville stems from a citizen effort to be more environmentally conscious. As such, local population hubs (like college campuses, schools, and community centers) have individual recycling and sustainability programs to further support the City's efforts for an efficient solid waste system. For example, local recycling containers can be left throughout the campus as a means of collecting more recyclable material and removing it from potential landfill usage.

The City of Gainesville does not operate a city level landfill for solid waste. The county maintains a joint-ownership enterprise landfill with 3 other counties in the North Central Florida region. However, there are no landfills within the district of Alachua County that are currently operational. As with most landfill developments, once the original landfills became filled to capacity in the 1990s, Alachua County residents did not want to open more landfills within the county and instead opted to develop alternatives like exporting solid waste outside of the county. All solid waste collected within Alachua County (including local municipalities) is sent to a transfer station where it is then distributed out to the New River Regional Landfill. As described earlier, this landfill is a bioreactor landfill as Alachua County continues to promote environmentally conscious and cost effective solid waste policies. Alachua County has also put plans into motion to begin modifying the current Southeast and Southwest landfills to use the leachate technologies utilized by bioreactor landfills an begin collecting the landfill gas generated from these closed landfills[5].

A County Analysis of Municipal Solid Waste: Escambia County

Escambia County is located on the very tip of the panhandle of Florida. It is a city that contains 64,000 households. Since there are 111,100 households, the city of Pensacola accounts for 57.6% of Escambia County[9]. This made it a good candidate for comparison to Alachua County. Like Alachua County, the city's residential and yard waste collections are contracted to a company. Unlike Alachua County, Escambia County's Solid Waste Management Department does run the recycling collections program.

Escambia County contracted the collections of residential and yard waste to the Emerald Coast Utilities Authority or ECUA. Residential waste is collected twice a week and yard waste is

collected once a week. For this service, the 64,000 customers pay $18.35 per month or $220.20 per year for residential and yard waste collections. For the fiscal year 2007 or FY07, there were 80,639 tons of residential waste collected. ECUA's budget for collecting this waste was $6,197,050.00 for FY07. This means that it cost them $76.85 per ton and there were 1.26 tons produced per household during FY07. Assuming there were two collections per week all year, there would have been 104 collections for residential waste. This means it cost ECUA $0.95 per household per collection and were 775.38 tons per collection. Also, there were 0.0242 tons per household per week.

Yard waste is also collected by ECUA, but only once a week. Like Alachua County, all of the yard waste is used. Most of the waste is ground up and used as mulch. If there is an excess, the leftovers are used as cover for the landfill.

Recyclables are collected in a very different way. Since Escambia County's Solid Waste Management Department is responsible for recyclable waste collections, they have 17 drop off sites that residents can take their recycling to. These drop-off sites are placed around the county to make recycling easier for the public. Since these drop-off centers are used by all residents of the county, the number of households will be changed to reflect the entire county. The number of households is 111,100[14]. Once a week these bins are emptied and the contents are taken to the recycling center. For the FY07, there were 3,477 tons of recyclable materials collected. The Solid Waste Department's budget for collecting the recyclables was $900.000.00. It costs the county $258.84 per ton and there were 0.0313 tons produced per household. Since collections were done once a week, there were 0.0006 tons per household per week which is also the amount collected per collection.

Conclusions and Comparisons for Municipal Solid Waste Management Operations within Case Study

When looking at the two counties, it is clear that there are basic underlying differences between their operations and the policies put in place by each. Thus, one will begin to create an "ideal" model county solid waste management operation based on the findings within the two counties. The model generated can be applied to other communities within the United States and through the global community in developing countries. Although the municipal solid waste management model created does not apply directly to communities excessively more populous and urbanized (like major cities), the model is still applicable when looking within the districts of urbanized regions as a means of creating a series of "model" districts within these urbanized regions. The "model" districts emulate the structure of the county model described but remain within the scope of city management as opposed to higher level regional government control.

The first scope of the model arises from the amount of centralization and coordination within the county and the enclosed municipalities. When looking at the structures of municipal waste management operations, these two counties differ in the level of centralization and the overall

services provided by each level of public works (local municipalities versus county operations). The best method of structure is seen in Escambia County, Florida. The county is responsible for waste collection and recycling programs. The local municipalities have the option of contracting to other waste service providers. However, the county maintains a stronger level of centralization of services than does Alachua County whose cities define waste services through individual private contracts. Structurally, the network of services is better coordinated when county practices are standardized. County records become more complete and valid than those counties who have separate numbers for each individual municipality. Better records and a centralized infrastructure help create efficiency within this model.

The model does not imply a public sector solid waste management operation. Instead, it suggests that counties ought to have standardized waste collection and recycling efforts to avoid miscommunications, citizen contempt, and varied disposal systems. The model suggests that counties work with private waste management firms to reduce county operating costs from tax payments (much like Alachua County and the City of Gainesville do not direct any tax revenue to manage solid waste instead this is done by a volume-based method).

The next scope of the model is in its revenue system. As endorsed by the EPA Pay-As-You-Throw program, the volume based method of payments (currently operating in unincorporated areas of Alachua County and the City of Gainesville) is seen as the ideal model for these growing communities. The special assessment places limits on the amount of waste produced by each citizen and encourages conservation as a means of saving money for individual citizens. The evidence is not visible in the amounts of trash per household. This is due to the differences in collection policies within other municipalities (The Cities of Newberry and Alachua do not currently use a volume based rate of payment). This also refers to the first aspect of the model which is a county standard for solid waste management policies. For the model, it is best to encourage the volume based rates for garbage service as a means of retarding the level of waste within the county and making those who waste more, pay more for waste disposal services.

Landfill policy in the model is also taken into account. The model suggests that landfills be limited to regional landfills which make use of the most recent technologies including the bioreactor landfill systems like the New River Regional Landfill which services Alachua County, Florida. This reduces the number of landfills within a regional area, while also reduces the risk of citizen complaints like “Not in my Backyard” syndrome, which often plagues the development of waste disposal facilities. Increase coordination with neighboring counties is vital to the success of these co-op landfills. Using more modern technologies, like the bioreactor landfill, not only reduces the environmental fingerprint and health associated issues of the landfill, but it also reduces the counties’ costs of upkeep and post closure care costs for the landfill once at capacity. The energy generating possibilities also provide some efforts of sustainability within the landfills operation.

When discussing the role of drop-off centers within a county's network of municipal waste infrastructure, it is important to consider their usefulness in the outer extremities of the county as well as a center for bulk service drop-off locations. The model suggests that drop off centers be available at an additional charge to citizens for bulk drop-off needs as well as a viable alternative for citizens where either curbside pickup is not available or unwanted. The drop off centers can play a vital role in the waste management system. They are centers for collection of bulk items with the potential for white goods and electronic waste recovery systems to be put in place, and serve as outlets for excess garbage above the preset volume allotted a curbside pickup.

With regards to the number of collections, there is no preset, automatic number of collections built into the model. Instead, a desired collection amount of one collection per week is stipulated as a means to curb waste production and cut down on operating costs in these communities. It is stated that those counties making a transition to this model are encouraged to keep their level of service as was prior to the transition as a means of making citizens more comfortable with a shift in payment system. Public outcry can have a major impact on the ability to apply the model especially in communities where an unlimited volume, multiple collections per week schedule is implemented. When looking at developing countries that are unable or do not currently have curbside pickup waste management, citizens often resort to dumping of waste on city streets with no collection system. In these cases the model would support more frequent drop off centers within the community until more resources become available to transition to the development of curbside collection. Citizens of developing regions can carry waste in woven bags or other receptacles (like a rickshaw or wheel barrow) and bring waste products to these drop-off centers.

Another scope of the model is the approaches taken towards recycling services and the methods of collection for these models. From the generated information in each county, it can be determined that the drop-off center recycling service is much less desirable for these counties. The focus on recycling efforts has increased drastically in the recent years within Alachua County as the average household produces .314 tons of recycled waste per year. This shows us that Alachua County produces approximately 9 times more recycled waste per household than Escambia County, which produces .033 tons per year. This difference can also be accounted for in their levels of service for recycled goods. Citizens in Alachua County are given curbside pickups for recycled goods, while citizens in Escambia County must use the drop off centers to accommodate recycled goods. With these smaller communities, it can be assumed that providing for recycling pickups can be much more environmentally sustainable than drop off centers which discourage recycling efforts, increase waste amounts within the municipal waste system fostering greater inefficiency, and ultimately increases the demand for landfill space. The increased cost of recycling services (by providing curbside pickup) can be offset by increasing rates in the volume based method of payments for waste services, as described above. Those who waste more will pay more for recycling service which encourages those citizens to conserve and recycle. For communities who do not have curbside capabilities and rely on drop-off centers for all waste disposal, recycling efforts can be made at these drop off centers by increasing rates of disposal

for waste to promote recycling at drop off centers where there should be no charges for recycling to support sustainability.

Summary of the Small Metropolitan County Model

Looking at Table 5, one will see a list of criteria for the proposed model growing communities around the world. The premise behind developing this model is that an efficient municipal solid waste management profile is important for the growth and expansion of any region or municipality. Not only does solid waste management affect the quality of the community, but these waste programs offer the distinct advantage of becoming more environmentally sustainable. This is especially true given today's technologies where more and more goods can be recycled and landfills are lessening their environmental impact. Instead, when looking at the generated model described, one will see the greater potential to foster conditions for an eco-friendly community. Citizens are encouraged to produce less waste when communities provide curbside recycling pickups and a volume based method of payment for solid waste services. The municipality becomes more streamlined and an efficient management system is put in place when the municipality maintains authority over solid waste management and recycling services. The municipality should make a concerted effort to make landfill usage more efficient and sustainable.

Table 5: Model for Municipal Solid Waste Management in Growing Communities

County centralized management system (with little local municipality involvement)	Volume based method of payment for waste services
Curbside recycling offered (using drop-off centers if applicable)	Support regional landfills with neighboring counties and high-technology practices like bioreactor landfills
Drop-off centers available for outer regions and bulk waste (and promote usage in areas where no other pickup service is available)	Support initial pickup schedule to begin a transition towards one pickup per week

When doing a cost-benefit analysis on the impact of the model, one will see that the increased costs of transition to the program may in fact be offset by the long term costs for the municipality. Increased costs for recycling pickups will be offset by decreasing the number of regular residential waste pickups. Municipality centralization reduces the overhead costs of management of municipal solid waste. Regional landfills with the newest technologies provide a means of shared costs with neighboring counties for waste disposal and reduce the need to create additional county-owned landfills. The long terms savings on upkeep, managements, and pickup services will make adjusting to the model significantly cost effective.

To conclude, the model presented is a framework for development of municipal solid waste policies for communities. The model provides a means of sustainability in the local community,

and it promotes the ideas of conservation and recycling in these developing regions. Following this model is a cost-effective approach to manage municipal waste and can have long-term benefits to the nearby environment within the community.

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