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Construction And Demolition Debris Recovery And Recycling In Orange County, Fl

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CONSTRUCTION AND DEMOLITION DEBRIS RECOVERY AND RECYCLING IN ORANGE COUNTY, FL

by

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ABSTRACT

In 2008, the State of Florida established a recycling goal of 75% to be achieved by 2020. In response to the Florida goal Orange County (OC), Florida has made the development and implementation of an efficient strategy for landfill diversion of its solid waste a top priority. The Florida Department of Environmental Protection (FDEP) estimated that 23 % of municipal solid waste was generated by construction and demolition (C&D) activities in 2009, with only 30 percent of C&D debris being recycled. Therefore, OC decided to create a solid waste integrated resource plan (SWIRP) initially focused on the recovery and recycling of C&D materials (2010). For SWIRP development, OC decision makers need the best available data regarding C&D debris generation and composition and an understanding of the potential markets available for recycled materials.

In this investigation debris generation was estimated over the period of 2001 to 2009 for the largest single governing body within OC, unincorporated OC (UOC), representing 65 percent of county population. The debris generation model was constructed for years 2001-2010 using area values for C&D activities in six sectors obtained from building permits and debris generation multipliers obtained from literature values. The benefit of the model is that as building permit information is received, debris generation estimations can also be expediently updated.

Material composition fractions obtained from waste characterization studies of landfills in the Central Florida area were applied to the debris generation model resulting in a material

composition for all sectors for years 2001-2010. The material composition of the debris stream was found to be, on average, concrete (53%) drywall (20%), wood (12%), a miscellaneous fraction (8%), asphalt roofing material (4%), metal (2%), cardboard (1%) and carpet and padding (1%).

A market analysis was performed for concrete, drywall, wood, asphalt roofing shingles and residual screened materials (RSM). It was found that statewide, markets existed for 100 percent of the materials studied and could replace significant amounts of natural material feedstocks, but that the development of more local markets was vital to meeting OC's diversion goal to minimize the cost of transporting recyclables.

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LIST OF ACRONYMS/ABBREVIATIONS

$/Ton	Dollars per Ton
AASHTO	American Association of State Highway and Transportation Officials
APP	Atactic Polypropylene
ASTM	American Society for Testing and Materials
BMP	Best Management Practices
C&D	Construction and Demolition
CCI	Consumer Confidence Index
CSPE	Chloro Sulfonated Polyethylene
ENGlink Interactive	Engineers Link Interactive
EPDM	Ethylene Propylene Diene Monomer
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FDEP-FL	Florida Department of Environmental Protection- Florida
FDEP-OC	Florida Department of Environmental Protection- Orange County
FDOT	Florida Department of Transporation
FEMA	Federal Emergency Management Agency
FCGDP	Florida Construction GDP
FGDP	Florida Gross Domestic Product
ft^2	Square Feet
GDP	Gross Domestic Product
GIS	Geographic Information Systems
Hazus-MH	Hazards United States- Multi Hazard
HDPE	High-Density Poly Ethylene
HMA	Hot Mix Asphalt
ISS	Information Systems and Services
IWMPRT	Incident Waste Management Planning & Response Tool
lb/ft^2	Pounds per Square Feet
LCD	Land Clearing Debris
LEED	Leadership in Energy and Environmental Design
Mi	Mile
MMRF	Multiple Material Recovery Facility
MRF	Materials Recovery Facility
MSW	Municipal Solid Waste
MW	Mega Watt

NAHB	National Association of Home Builders
NARC	National Association of Roofing Conctractors
Non-MSW	Non-Municipal Solid Waste
NR_{Add}	Nonresidential Additions
NRD	Nonresidential Demolition
NRNC	Nonresidential New Construction
NRR	Nonresidential Renovations
OC	Orange County
PCD	Pounds per Capita Day
PVC	Poly Vinyl Chloride
R^2	Correlation Coefficient
RA	Residential Additions
RAS	Recycled Asphalt Shingles
RD	Residential Demolition
RNC	Residential New Construction
R_{RRep}	Residential Roof Replacements
RR	Residential Renovations
RSM	Residual Screened Materials
SHS	State Highway System
SBS	Styrene-Butadiene-Styrene
SWIRP	Solid Waste Integrated Resource Plan
UOC	Unincorporated Orange County
US	United States
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WTE	Waste to Energy

CHAPTER 1: INTRODUCTION

1.1 Motivation

Florida currently has implemented a solid waste recycling goal of 75 percent by the year 2020. In response to the state goal, Orange County (OC) has invested significant resources in developing a solid waste integrated resource plan (SWIRP) for determining ways in which it can meet the new standard on the County level. The Florida Department of Environmental Protection (FDEP) reported in 2009 that 23 percent of municipal solid waste was generated by construction and demolition (C&D) activities and only 30 percent of C&D debris was recycled (FDEP, 2010a), making C&D debris a major area of opportunity for the County. Achieving better recycling efficiency of C&D materials requires an estimation of the amount of debris generated and a sense of the amount of debris expected to be generated in the future so that markets for recyclable materials can be identified and promoted.

Before attempting to estimate generation, it is important to define C&D debris. In the state of Florida, there are two classifications for C&D debris, municipal solid waste (MSW) and non-municipal solid waste (non-MSW). Section 62-701.200 of the Florida Administrative Code (FAC) defines MSW C&D debris as "discarded materials generally considered to be not water soluble and non-hazardous in nature, including but not limited to steel, glass, brick, concrete, asphalt material, pipe, gypsum wallboard, and lumber from the construction or destruction of a structure as part of a construction or demolition project or from the renovation of a structure, including such debris from construction of structures at a site remote from the construction and demolition project site. The term includes rocks, soils, tree remains, trees, and other vegetative matter which normally results from land clearing or land development operations for a construction project; clean cardboard, paper, plastic, wood, and metal scraps from a construction project; effective January 1, 1997, except as provided in Section 403.707(13)(j), F.S., unpainted, non-treated wood scraps from facilities manufacturing materials used for construction of structures of their components and unpainted, non-treated wood pallets provided the wood scraps and pallets are separated from other solid waste where generated and the generator of such wood scraps or pallets implements reasonable practices of the generating industry to minimize the commingling of wood scraps or pallets with other solid waste; and de minimis amounts of other nonhazardous wastes that are generated at construction and demolition projects, provided such amounts are consistent with best management practices of the construction and demolition industries. Mixing of construction and demolition debris with other types of solid waste will cause it to be classified as other than construction and demolition debris." The FDEP summarizes the FAC definition by stating that MSW C&D debris includes building related construction, renovation, and demolition debris (FDEP, 2001a). Conversely, non-MSW C&D debris includes roadways, bridges, and other non-building related C&D debris generation (FDEP, 2001a). Throughout this report, MSW C&D debris will simply be referred to as C&D debris unless otherwise specified.

1.2 Project Objectives and Scope of Work

The objectives of this research include:

1) Estimating a building-related C&D debris inventory representative of Orange County (OC), Florida using the method set forth by Reinhart et al. (2002),
2) Estimating the composition of the C&D debris stream using data from Florida composition studies, and
3) Assessing the recyclables market for C&D materials and determine ways to increase material diversion from landfills.

The first project objective involved estimating a C&D debris inventory based on information contained in building permits. OC has 14 governing bodies, 13 incorporated and one unincorporated, each with a separate procedure for the dissemination of building permit information. Because there is no uniform reporting standard among the municipalities, obtaining necessary information can be a lengthy process. For example obtaining the permit information for the unincorporated section of OC took over three months, making the acquisition of permit information from all the 13 remaining municipalities impractical. An inventory was therefore created for the largest OC entity, unincorporated OC (UOC) which represented approximately 65% of the County's population and was assumed to be applicable to the rest of OC. This inventory was prepared for the years between the years of 2000-2011. It is important to note that a debris generation model based on the building-related portion of the C&D debris stream excludes the estimation of debris from non-MSW sources such as land clearing and road and bridge construction.

1.3 Organization of Thesis

This thesis is comprised of four chapters. Chapter 1 contains the motivation and the scope for the work as well as a definition for important terms used throughout this document. Chapter 2 outlines the methodology and results of the building-related C&D debris inventory model for UOC and of the composition analysis. Chapter 3 discusses historical recycling efficiencies in OC, provides current outlets for the diversion of C&D materials, and the possible markets for C&D materials. Chapter 4 gives conclusions and recommendations for increasing the diversion rate of C&D debris.

The research was funded by the Hinkley Center for Solid and Hazardous Waste Management located in Gainesville, Florida and is the result of a collaborative effort among multiple private industry professionals, government employees, and other stakeholders with a vested interest in seeing that the 75 percent goal is achieved. Quarterly meetings between University of Central Florida researchers and stakeholders were held to discuss the topics found within this report.

CHAPTER 2: C&D DEBRIS INVENTORY

2.1 Literature Review

2.1.1 Waste Characterization Techniques

Waste characterization is a fundamental first step in constructing a debris inventory because it provides researchers information on the components of a debris stream. From waste characterization studies, information such as the typical mass per unit area of construction or volume of waste stream components can be determined which are crucial for many debris generation models. This section discusses the techniques frequently used for waste characterization.

2.1.1.1 Mass Sorting

Mass sorting is the process of estimating the composition of C&D waste by measuring the weight of components in the waste stream. Loads are chosen randomly at a landfill and are separated into different components which are then weighed (Reinart et al., 2002). Mass sorts can potentially provide the highest level of accuracy for waste characterization because they gather hands-on information about the debris. Mass sorts are more time consuming, labor intensive, expensive, inconvenient and riskier than other waste characterization techniques discussed in this report and they are typically performed at operating landfills, material recovery facilities (MRFs), or transfer stations. Loads must be diverted to predetermined sorting areas creating an inconvenience for the driver. Workers are exposed to hazards such as dust particles, hypodermic needles, and tetanus. Scales, rakes, shovels, gloves, magnets, and knives must be used, increasing the cost of waste characterization versus some of the other techniques available (Carr, 2009).

In 2004, researchers used mass sorts to characterize the C&D waste stream in the greater Rustenburg municipal area of South Africa (Zitholele Consulting Group, 2007). Thirteen sorters, two supervisors, a truck driver, a municipal supervisor and three laborers collected 50 random samples of waste entering the local landfill. In 2008 researchers in California conducted a mass sort over the duration of 61 days categorizing more than 750 samples at 27 disposal facilities around the state; nearly 7,000 vehicles were also surveyed to determine the origin of waste (Cascadia Consulting Group, 2008).

2.1.1.2 Visual Characterization

Visual characterization is the process of estimating the volume composition of a C&D waste load by observing the load, often at a landfill, and estimating the percent volume distribution of components1 (Reinart et al., 2002). Multiple researchers visually estimate the composition of a waste load and the average is used as the volume distribution. With the knowledge of the specific weight of the components, the volume composition can be converted into composition by weight.

With enough data available, reliable composition estimates can be obtained for C&D waste streams using visual characterization more rapidly and economically than conducting a mass sort. Several studies have employed the visual characterization method for determining waste composition including a study conducted at seven Florida landfills by researchers from the University of Central Florida, the University of Florida, and the Florida Institute of Technology in 2002 (Reinart et al., 2002). In 2006, a study was conducted for the North Central Texas Council of Governments that involved waste characterization of C&D debris arriving at the North Texas Municipal Water District McKinney Landfill. Visual characterization was used during two one-week waste characterization events. More than 600 loads totaling over 4,300 tons were visually inspected and categorized (R.W. Beck, 2007). In September of 2008 and January of 2009 researchers in Chicago used visual characterization to estimate the composition of 351 sample loads from the C&D waste sector. The loads were observed at five disposal facilities over a period of sixteen days. Samples were sorted into ten material classes and 81 subclasses (CDM, 2010).

2.1.1.3 Photogrammetry

Photogrammetry is the science of making reliable measurements by the use of photographs (Heck, et al., 2002). It can be used to estimate size, mass, volumes and quantities of materials in C&D debris samples (Reinart et al., 2002). Photogrammetric techniques are best used for waste characterization when direct access to C&D samples is difficult or uneconomical.

Photogrammetry is especially useful for waste characterization in post-disaster scenarios. For example, the Federal Emergency Management Agency (FEMA) uses aerial and satellite photography to produce quick estimates of C&D debris after a disaster (FEMA, 2010). Later, these estimates are validated through ground measurements or computer models. FEMA recommends using photogrammetric techniques when a disaster has made an area difficult to access or in cases where it is difficult to obtain a good perspective on debris quantities from the ground, e.g. estimating the size of very large debris piles at debris management sites (FEMA, 2010).

C&D debris estimates are obtained through photogrammetry by first selecting an object of reference within the photo to obtain a dimensional scale (Reinart et al., 2002). Once the dimensional scale is obtained, it is used to determine the size of C&D debris objects in the photograph. Then, debris estimating formulas are applied to estimate debris mass quantities.

2.1.2 Estimating C&D Debris Generation Rates

Debris generation rate estimates are important for determining infrastructure needs for the handling of C&D debris. As Florida attempts to meet its 75 percent goal, C&D debris estimates will be more important than ever for solid waste managers seeking to determine the necessary capacity of their facilities and for companies seeking to offer processing and/or end markets for recovered items. Debris estimates inform solid waste managers of the appropriate size a facility should be and offer an estimate of the amount of raw material secondary processors can expect. Methods for establishing C&D debris estimates are discussed in this section.

2.1.2.1 Waste Facility Monitoring

Monitoring of incoming loads to waste management facilities can be accomplished to determine the mass of C&D debris by collecting scalehouse records for Class III Landfills, C&D Landfills, and MRFs because each truckload of debris is weighed upon arrival to most of these facilities. In Florida, waste facility managers are charged with reporting their scalehouse records to the FDEP which produces yearly C&D debris estimations based on these data. The solid waste reports available at the FDEP website (http://www.dep.state.fl.us/waste/categories/recycling/SWreportdata/08_data.htm) convey an estimation of total C&D debris generalized by county. However, the FDEP reports do not provide the composition of the debris stream.

C&D composition can be estimated by performing waste sorting and visual characterizations as employed in several studies (Reinhart et al, 2002; McCauley-Bell et al. 1997; Cascadia Consulting Group, 2008; R.W. Beck, 2007). The mass estimations obtained through waste facility monitoring can be paired with waste characterization information to produce debris estimates for individual C&D materials.

2.1.2.2 Materials Flow Analysis Approach

A materials flow approach to estimating C&D debris generation rates is an analytical method of quantifying flows and stocks of materials or substances in a well-defined geographic control boundary. Consumption of construction materials and typical waste factors used for construction materials purchasing were used to estimate the mass of solid waste generated as a result of construction activities for the United States (US) (Cochran et al., 2010). The United States Environmental Protection Agency (USEPA) has also used this approach since the late 1960s for estimating MSW generation; however it has not used the method for estimating C&D debris generation (USEPA, 2006).

2.1.2.3 Linking Estimation to Construction Metrics (Debris Generation Multipliers)

Debris generation rates normalized by area can be used to estimate the amount of C&D debris when the area of each construction, demolition, or renovation activity is known. Debris generation multipliers are obtained through case studies performed at job sites. Area information is obtained from metrics such as building permit information, census data, or the valuation of construction activity.

Numerous case studies have been completed to obtain debris generation multipliers. In 1993, a study conducted for the Portland Metro area produced debris generation multipliers for several types of single family homes (McGregor et al., 1993). The results were obtained by performing waste characterization audits on 34 residential projects. The solid waste division of the USEPA sponsored a study to determine debris generation multipliers for metal roof replacements and residential homes with wood construction (Palermini and Associates, 1995). A study by the National Association of Home Builders (NAHB) found debris generation multipliers for residential new construction in the cities of Grand Rapids, Michigan, Portland, Oregon, and

Bowie, Maryland (NAHB, 1995). The study explored both wood and concrete construction. A study was performed by Franklin Associates for the USEPA that characterized building-related C&D debris on a national level (Franklin Associates, 1998). The researchers sampled multiple construction, demolition, and renovation sites throughout the United States to obtain generation multipliers in each category.

Studies have been performed around the world linking estimation to building metrics using debris generation multipliers. The USEPA estimated national values for building related C&D debris by multiplying numbers of buildings being constructed or demolished, based on building permits issued by amounts of debris estimated to be generated area of the project (Sandler, 2003). Debris generation multipliers were used to estimate the C&D generation in the state of Florida. Building permits, census data, and valuations of construction activity were used to obtain area values. The areas were then multiplied by debris generation multipliers on a mass per area basis to obtain the mass of debris (Reinart et al., 2002).

Researchers in Greece used an approach similar to Reinhart et al (2002) to estimate the C&D debris generation for the entire country (Fatta, et al., 2003). Studies that linked C&D debris generation to building metrics were also conducted for Thailand (Kofoworola et al., 2009) and Northwest Spain (Lage, et al., 2009). Also, in 2011 a model for quantifying construction waste in projects according to the European waste list was developed based on similar methods (LLatas, 2011).

The advantage of using this method is that once debris generation multipliers have been established they can be linked to building metrics to create a debris generation estimate able to be updated without the need to frequently visit landfills, MRFs, or transfer stations; whereas with mass sort, photogrammetry, and visual characterization, the time-consuming and costly procedures must be re-executed to update the inventory.

2.1.2.4 Database Models

Database models for estimating C&D debris generation have also been developed. Hazards U.S. Multi-Hazard (Hazus-MH) is a software tool created by Federal Emergency Management Agency (FEMA, 2011). It utilizes Geographic Information Systems (GIS) software to map and display locations of hazardous sites after a disaster and also of damage and economic loss estimates for buildings and infrastructure. Additionally, it allows users to predict damage and economic loss of hypothetical earthquake, hurricane wind, and flood scenarios.

Engineers Link Interactive (ENGlink Interactive) is an estimation tool developed by the US Army Corps of Engineers (USACE, 2010). It was initially developed as the USACE primary emergency management system tool. ENGlink Interactive focuses primarily, although not exclusively, on hurricanes.

The USEPA has developed its Incident Waste Management Planning & Response Tool (IWMPRT) that aids in the handling, transporting, treating, and disposing of large volumes of waste generated by natural disasters such as chemical spills; biological, chemical or radiological terrorism and animal disease outbreaks (USEPA, 2011). The program is web-based and updated as new information becomes available (USEPA, 2011). The IWMPRT includes information on debris characteristics and contamination and provides databases of treatment disposal facilities to help officials make better disposal decisions. The software also provides a waste quantity estimator allowing researchers to estimate mass and volume of debris for single or multiple structures for a given incident (USEPA, 2011).

2.1.3 Prediction Using Economic Factors

Economic and other independent variables can be used to explain and predict future waste generation rates. Population (McBean et al., 1993) and gross domestic product (GDP) (Ali Khan M et al., 1989; Buenrostro et al., 2001; Chang et al., 1993; Hockett et al., 1995; Wang et al., 2001) can be two of the most influential variables. Several studies have employed this approach including one by Christiansen et al. (1999) which showed that construction waste generation was highly correlated with an increase in the European Currency Unit on a per capita basis for each Member State in the European Union. Another study in Thailand concluded that the country's construction waste generation was proportional to the development of the economy, urbanization, and population growth (Kofoworola et al., 2009).

A regression analysis can be performed between economic factors and debris generation which allows prediction of debris. This approach has been taken in several studies including a bivariate regression analysis linking GDP to concrete debris generation based on cement production in

China (Jianguang et al., 2006). An increase in concrete debris was forecasted with the projected increase in GDP through the year 2050. A study in Norway predicted increasing C&D generation until at least the year 2018 attributed to a projected increase in economic growth over this period (Bergsdal, et al. 2007). Using economic variables for prediction is a more sophisticated and intellectually sound approach than using time-series data alone because explanatory variables uncover possible causal relationships in addition to explaining and predicting waste occurrences (Shan, 2010).

2.1.4 Summary of Findings

Linking debris generation to building metrics using debris generation multipliers is best utilized when time, money and personnel are limiting factors. The approach offers the greatest amount of flexibility because it can easily be performed by one person. As long as the debris generation multipliers are applicable, this option has lower cost compared to direct measurments. Debris estimations based on this method have advantages because when new building metric data are obtained, the inventory can be easily updated. Future predictions can be made from construction or GDP forecasts or other economic factors.

2.2 Methodology

The method chosen to estimate C&D debris generation was to use building permit information and construction metrics (Section 2.1.2.3). The methodology outlined in this report is modeled after the approach used by Reinhart et al. (2002) to estimate a debris inventory for the state of

Florida in the year 2000. In this report, the methodology was used to estimate C&D debris generation for UOC for the years 2001-2010 in six sectors as seen in Table 2.1. This section presents the methodology for constructing the debris inventory. A composition analysis was also performed and the methodology is outlined in this section.

Table 2.1. Six Sectors of Job Activity Used in Debris Calculations (Reinart et al., 2002)

Job Activities	Description
Residential Construction	Single and multi-family new home construction
Nonresidential Construction	Commercial new construction (includes hotels, stores, restaurants, business complexes, skyscrapers etc.)
Residential Demolition	Single and multi-family home demolition
Nonresidential Demolition	Commercial demolition (includes hotels, stores, restaurants, business complexes, skyscrapers etc.)
Residential Renovation	Residential additions, alterations, re-roofs, and driveway replacements.
Nonresidential Renovation	Commercial additions, alterations, and re-roofs

The calculation used to determine debris generation multiplies the total area of construction, demolition, or renovation activity by a corresponding debris generation factor. These methods are described in the following sections.

The debris inventory for UOC was built using building permit information, which contains detailed information about building-related activities such as project type, area, date of project, and project valuations. UOC does not include project area in the data reports available on their website, so the areas used to construct the debris generation model were obtained from a report generated by UOC's Information Systems and Services (ISS) division (Appendix A). Once the areas were obtained for each of the six sectors, they were then multiplied by debris generation factors to produce a total mass for each job activity. Debris generation multipliers used are presented in Table 2.2 through Table 2.4.

Table 2.2. New Construction and Demolition Debris Generation Multipliers (Reinart et al., 2002)

Sector	Construction Type	Debris Generation Multiplier (lb/ft^2)
Residential New Construction	Wood	4.32
	Concrete	8.06
Nonresidential New Construction	Wood	2.47
	Concrete	9.67
Residential Demolition	Wood[1]	92.9
	Concrete[2]	193.6
	Multi-Family	127
Nonresidential Demolition	N/A	173

[1] Wood-Frame, single family home with concrete slab foundation
[2] Concrete Block Frame, single family home with concrete slab foundation

Table 2.3. Debris Generation Multipliers for the Residential Renovation Sector (Reinart et al., 2002)

Renovation Category	Construction Type	Debris Generation Multiplier (lb/ft^2)
Alterations	N/A	14.18
Roof Replacements	Asphalt	2.4
	Metal	0.64
Additions	Wood	4.32
	Concrete	8.95

Table 2.4. Debris Generation Multiplier for the Nonresidential Renovation Sector (Reinart et al., 2002)

Renovation Category	Construction Type	Debris Generation Multiplier (lb/ft^2)
Alterations	N/A	4.09
Roof Replacements	Built-Up Asphalt	6
	Asphalt Shingles	2.4
	EPDM Roofing	4.7
	SBS-Modified Bitumen	4.8
	APP-Modified Bitumen	5.2
	CSPE Roofing	4.7
	PVC Roofing	4.7
	Single-Pile Roofing	5
Additions	Wood	2.47
	Concrete	9.67

The composition of the C&D debris stream was estimated for concrete, wood, drywall, asphalt, carpet and padding, metal, cardboard, and miscellaneous fractions for the years 2001-2010. The composition data were obtained from the report by Reinhart et al. (2002) and applied for all years analyzed in this study. These values were originally determined by combining national census data with mass fractions determined from waste load characterizations and literature (Reinart et al., 2002). Waste load characterizations were validated with a mass sort and photogrammetric studies performed at Florida landfills (Reinart et al., 2002). Composition for all sectors was determined by weighted average using the mass fractions presented in Table 2.5 and Table 2.6.

Table 2.5. Mass Fractions for New Construction and Demolition Sectors (Reinart et al., 2002)

Sector	Material	Fraction	Sector	Material	Fraction
Residential New Construction	Wood	0.11	Residential Demolition	Wood	0.070
	Asphalt	0.080		Metal	0.0020
	Carpet & Padding	0.030		Concrete	0.76
	Metal	0.030		Drywall	0.050
	Concrete	0.39		Asphalt Roofing	0.020
	Drywall	0.31		Misc.	0.090
	Misc.	0.050	Nonresidential Demolition	Concrete	0.82
Nonresidential New Construction	Wood	0.16		Metal	0.050
	Metal	0.020		Wood	0.0020
	Concrete	0.58		Misc.	0.13
	Drywall	0.10			
	Cardboard	0.020			
	Misc.	0.12			

Table 2.6. Mass Fractions for Renovation Sectors (Reinart et al., 2002)

Sector	Sub-Category	Material	Fraction
Residential Renovation	Additions	Concrete	0.48
		Drywall	0.21
		Wood	0.19
		Misc.	0.040
		Asphalt Roofing Materials	0.030
		Cardboard	0.030
		Metal	0.020
	Re-Roofs	Metal	0.040
		Asphalt	0.96
	Alterations	Concrete	0.32
		Drywall	0.12
		Wood	0.33
		Misc.	0.21
		Asphalt Roofing Materials	0.0030
		Cardboard	0.010
		Metal	0.070
Nonresidential Renovation	Additions	Concrete	0.58
		Drywall	0.10
		Wood	0.16
		Misc.	0.12
		Cardboard	0.020
		Metal	0.020
	Re-Roofs	Asphalt	0.20
		Concrete	0.76
		Misc.	0.040
	Alterations	Drywall	0.63
		Wood	0.21
		Misc.	0.11
		Metal	0.050

2.2.1 Residential and Nonresidential New Construction

Equation 2.1 was used to determine the debris generation of residential new construction (RNC) and nonresidential new construction (NRNC). The method is similar to that described above. However for these sectors it was necessary to determine the fraction of construction types. Two main construction types exist in Florida, wood frame estimated at 20.4 percent and concrete block at 79.6 percent (Reinart et al., 2002). The construction type determination was assumed to apply to both residential and nonresidential new construction.

$$Q_N = A_N[(B_N)(1- \alpha_N)) + (C_N)(\alpha_N))] \quad (2.1)$$

Q_N = Amount of debris generated in either the RNC or NRNC sector (lb/yr)

A_N = Area of activity (ft^2/yr) (Appendix A)

B_N = Debris generation multiplier (lb/ft^2) from construction of wood frame houses

C_N = Debris generation multiplier (lb/ft^2) from construction of concrete block frame houses

α_N = Fraction of all houses built in OC that are concrete block frame houses, 0.796

2.2.2 Residential Demolition

To determine the debris generation from residential demolition (RD), Equation 2.2 was used in conjunction with the construction type fractions presented in Table 2.7.

$$Q_{RD} = A_{RD}[(B_{RD})(\alpha_{RD}) + (C_{RD})(\beta_{RD}) + (D_{RD})(\gamma_{RD})] \quad (2.2)$$

Q_{RD} = Amount of debris generated in the residential demolition sector (lb/yr)

A_{RD} = Area of activity (ft^2/yr) (Appendix A)

B_{RD} = Debris generation multiplier (lb/ft^2) for a single-family home with a wood-frame and concrete slab foundation

C_{RD} = Debris generation multiplier (lb/ft^2) for a single-family home with a concrete block frame and concrete slab foundation

D_{RD} = Debris generation multiplier (lb/ft^2) for multi-family buildings

α_{RD} = Fraction of units demolished that are wood-frame, single-family homes with a concrete slab foundation

β_{RD} = Fraction of units demolished that are concrete-frame, single-family homes with a concrete slab foundation

γ_{RD} = Fraction of units demolished that are multi-family homes

Table 2.7. Construction Type Fractions Used for Residential Demolition (Reinart et al., 2002)

Type	Type Description	Fraction
1	Wood-frame, single family home with concrete slab foundation.	0.13
2	Concrete block frame, single family home with concrete slab foundation	0.75
3	Multi-family buildings	0.12

Equation 2.2 multiplies the appropriate debris generation factors from Table 2.2 by the area of residential demolition activity to obtain a mass of debris for this sector.

2.2.3 Nonresidential Demolition

To determine the debris generation from nonresidential demolition (NRD), Equation 2.3 was used. The generation multiplier was determined by averaging results from weight-based composition studies and multiplied by the average size of buildings between 1920 and 1969 and by the total number of buildings demolished during 1995 (Reinart et al., 2002).

$$Q_{NRD} = (A_{NRD})(B_{NRD}) \quad (2.3)$$

Q_{NRD} = Amount of debris generated in the nonresidential demolition sector (lb/yr)

A_{NRD} = Area of activity (ft^2/yr) (Appendix A)

B_{NRD} = Debris generation multiplier (lb/ft^2)

2.2.4 Residential Renovation

2.2.4.1 Residential Renovation Categories

Residential renovations (RR) consist of three categories: alterations, roof replacements, and additions. Equation 2.4 was used to determine the amount of debris generated in the residential renovations sector.

$$Q_{RR} = Q_{RA} + Q_{RRep} + Q_{Add} \quad (2.4)$$

Q_{RR} = Amount of debris generated in the residential renovations sector (lb/yr)

Q_{RA} = Amount of debris generated from residential alterations (lb/yr)

Q_{RRep} = Amount of debris generated from residential roof replacements (lb/yr)

Q_{Add} = Amount of debris generated from residential additions (lb/yr)

2.2.4.2 Residential Alterations

The debris generation multiplier for residential alterations (RA) was determined by case studies performed on three residential alteration projects performed by O'Brien & Associates and

Palermini & Associates (Reinart et al., 2002). The debris generation multiplier was determined for each alteration scenario based on the mass of nine construction materials and the area of each project. The generation rates for each material in the three projects were averaged and the averages were summed to obtain a final debris generation rate. This final multiplier value, 14.18 lb/ft^2, is used in this study. Equation 2.5 was used to determine the mass of debris generated from residential alteration activity.

$$Q_{RA} = (A_{RA})(B_{RA}) \quad (2.5)$$

Q_{RA} = Amount of debris generated for residential alterations (lb/yr).

A_{RA} = Area of activity (ft^2/yr) (Appendix A)

B_{RA} = Debris generation multiplier (lb/ft^2)

2.2.4.3 Residential Roof Replacements

Equation 2.6 was used to determine the mass of debris generated from roofing materials.

$$Q_{RRep} = A_{RRep}[(B_{RRep})(\alpha_{RRep}) + (C_{RRep})(\beta_{RRep})] \quad (2.6)$$

Q_{RRep} = Amount of debris generated for roof replacements (lb/yr)

A_{RRep} = Area of activity (ft^2/yr) (from Appendix A)

B_{RRep} = Debris generation multiplier for asphalt roofing material (lb/ft^2)

C_{RRep} = Debris generation multiplier for metal roofing material (lb/ft^2)

α_{RRep} = Fraction of reroofing projects that utilize asphalt shingles

β_{RRep} = Fraction of reroofing projects that utilize metal shingles

The debris generation multipliers used for roof replacements depend on the type of roofing material used. Two roofing material types were analyzed in this report: asphalt and metal. Asphalt shingles comprise 71 percent of reroofing projects whereas metal roofs comprise 10 percent (Reinart et al., 2002). The percentage included materials such as concrete tile but was not quantified in this study.

2.2.4.4 Residential Additions

The calculation for residential additions (Equation 2.7) is similar to the calculation that was made in Section 2.2.1 for residential new construction. The debris generation multipliers used here are the same as those for residential new construction because additions are essentially new construction projects.

$$Q_{Add} = A_{Add}[(B_{Add})(1-\alpha_{Add})) + (C_{Add})(\alpha_{Add}))] \tag{2.7}$$

Q_{Add} = Amount of debris generated from additions (lb/yr)

A_{Add} = Area of activity (ft^2/yr) (Appendix A)

B_{Add} = Debris generation multiplier (lb/ft^2) from construction of wood frame houses

C_{Add} = Debris generation multiplier (lb/ft^2) from construction of concrete block frame houses

α_{Add} = Fraction of all houses built in OC that are concrete block frame houses, 0.796

2.2.5 Nonresidential Renovations

2.2.5.1 Nonresidential Renovation Categories

Similar to RR, nonresidential renovations (NRR) consist of three categories: alterations, roof replacements, and additions. Equation 2.8 was used to determine the amount of debris generated in the residential renovations sector.

$$Q_{NRR} = Q_{NRA} + Q_{NRRepl} + Q_{NRAdd} \quad (2.8)$$

Q_{NRR} = Amount of debris generated in the nonresidential renovations sector (lb/yr)

Q_{NRA} = Amount of debris generated from nonresidential alterations (lb/yr)

Q_{NRRepl} = Amount of debris generated from nonresidential roof replacements (lb/yr)

Q_{NRAdd} = Amount of debris generated from nonresidential additions (lb/yr)

2.2.5.2 Nonresidential Alterations

The debris generation multiplier for nonresidential alterations (NRA) was determined by averaging debris generation multipliers on a mass per area basis for three nonresidential alteration projects ranging from 1,500 to 4,895 ft^2 (McGregor et al., 1993). The average debris generation multiplier from these three projects was 4.09 lb/ft^2 (Reinart et al., 2002). Equation 2.9 was used to estimate the amount of debris generated from nonresidential alterations.

$$Q_{NRA} = (A_{NRA})(B_{NRA}) \qquad (2.9)$$

Q_{NRA} = Amount of debris generated for nonresidential alterations (lb/yr)

A_{NRA} = Area of activity (ft^2/yr) (from Appendix A)

B_{NRA} = Debris generation multiplier (lb/ft^2)

2.2.5.3 Nonresidential Roof Replacements

Eight different roofing types were analyzed for nonresidential roof replacements. Percentages for each type of material were determined on a regional basis via information supplied in 1993 by the NARC (Reinart et al., 2002). This information was assumed to apply to UOC. The material fractions can be seen in Table 2.8. The debris generation multipliers for this category were also calculated using the NARC information (Reinart et al., 2002) and are presented in Table 2.4.

Table 2.8. Material Fractions for Nonresidential Roof Replacements

Type of Material Used in Reroof	Fraction of Total
Built-Up Asphalt	0.37
Asphalt Shingles	0.15
Ethylene Propylene Diene Monomer (EPDM) Roofing	0.17
Styrene-Butadiene-Styrene (SBS) Modified Bitumen	0.20
Atactic Polypropylene (APP) Modified Bitumen	0.06
Chloro Sulfonated Polyethylene (CSPE) Roofing	0.01
Poly Vinyl Chloride (PVC) Roofing	0.02
Single-Pile Roofing	0.02

$$Q_{NRRepl} = A_i[(B_i)(\alpha_i)+(C_i)(\beta_i)+(D_i)(\gamma_i)+(E_i)(\delta_i)+(F_i)(\varepsilon_i)+(G_i)(\zeta_i)+(H_i)(\eta_i)+(I_i)(\Theta_i)] \quad (2.10)$$

Q_{NRRepl} = Amount of debris generated from nonresidential additions (lb/yr)

A_i = Area of activity (ft^2/yr) (from Appendix A)

B_i = Debris generation multiplier for built-up asphalt roofing material (lb/ft^2)

α_i = Fraction of reroofing projects that utilize built-up asphalt shingles

C_i = Debris generation multiplier for asphalt shingles (lb/ft^2)

β_i = Fraction of reroofing projects that utilize asphalt shingles

D_i = Debris generation multiplier for EPDM roofing (lb/ft^2)

γ_i = Fraction of reroofing projects that utilize EPDM roofing

E_i = Debris generation multiplier for SBS roofing (lb/ft^2)

δ_i = Fraction of reroofing projects that utilize SBS roofing

F_i = Debris generation multiplier for APP roofing (lb/ft^2)

ε_i = Fraction of reroofing projects that utilize APP roofing

G_i = Debris generation multiplier for CSPE roofing (lb/ft^2)

ζ_i = Fraction of reroofing projects that utilize CSPE roofing

H_i = Debris generation multiplier for PVC roofing (lb/ft^2)

η_i = Fraction of reroofing projects that utilize PVC roofing

I_i = Debris generation multiplier for single-pile roofing (lb/ft^2)

Θ_i = Fraction of reroofing projects that utilize single-pile roofing

2.2.5.4 Nonresidential Additions

The calculation for nonresidential additions (NR_{Add}) is similar to the calculation that was made in Section 2.2.1 for nonresidential new construction. The debris generation multipliers used here are the same as those for nonresidential new construction because additions are essentially new construction projects.

$$Q_{NRAdd} = A_{NRAdd}[(B_{NRAdd})(1- \alpha_{NRAdd})) + (C_{NRAdd})(\alpha_{NRAdd}))))] \qquad (2.11)$$

Q_{NRAdd} = Amount of debris generated from nonresidential additions (lb/yr)

A_{NRAdd} = Area of activity (ft^2/yr) (Appendix A)

B_{NRAdd} = Debris generation multiplier (lb/ft^2) from construction of wood frame additions

C_{NRAdd} = Debris generation multiplier (lb/ft^2) from construction of concrete block frame additions

α_{NRAdd}= Fraction of all additions built in OC that are concrete block frame houses, 0.796

2.3 Results and Discussion

2.3.1 Debris Generation

Table 2.9 presents the UOC debris generation rates for each of the six sectors for the years 2001-2010 and shows the relative amount of debris for each sector of the total. An analysis of the information presented in Table 2.9 is found in Sections 2.3.1.1 – 2.3.1.7.

Table 2.9. Debris Generation in Each Construction Sector

Year	Debris Generation by Sector												
	RNC[1]		NRNC[2]		RD[3]		NRD[4]		RR[5]		NRR[6]		Total (Tons x 1000)
	Tons x 1000	Percent of Total	Tons x 1000	Percent of Total	Tons x 1000	Percent of Total	Tons x 1000	Percent of Total	Tons x 1000	Percent of Total	Tons x 1000	Percent of Total	
2001	60	37	47	28	30	18	2.0	1.0	9.0	5.0	18	11	160
2002	64	27	30	13	120	51	0.0	0.0	8.0	3.0	16	7.0	240
2003	68	43	31	20	37	23	0.0	0.0	9.0	6.0	13	8.0	160
2004	74	50	38	26	6.0	4.0	0.0	0.0	10	7.0	20	14	150
2005	67	39	54	32	19	11	7.0	4.0	10	6.0	14	8.0	170
2006	66	42	47	30	21	13	0.2	0.1	5.0	3.0	19	12	160
2007	28	20	43	31	45	33	0.0	0.0	3.0	2.0	17	12	140
2008	13	19	28	40	10	14	0.0	0.0	3.0	4.0	16	23	70
2009	10	17	9.0	15	31	52	0.0	0.0	2.0	3.0	8.0	13	60
2010	13	17	10	13	42	55	0.0	0.0	2.0	3.0	10	13	76

[1]RNC = Residential New Construction
[2]NRNC = Nonresidential New Construction
[3]RD = Residential Demolition
[4]NRD = Nonresidential Demolition
[5]RR = Residential Renovations
[6]NRR = Nonresidential Renovations

2.3.1.1 Residential New Construction

The debris inventory for RNC between the years of 2001-2010 is presented in Figure 2.1. The peak generation rate occurs in 2004 at just over 73,000 tons of debris. A downward trend begins in 2005 and continues until 2009 with a sharp decline occurring between 2006 and 2007.

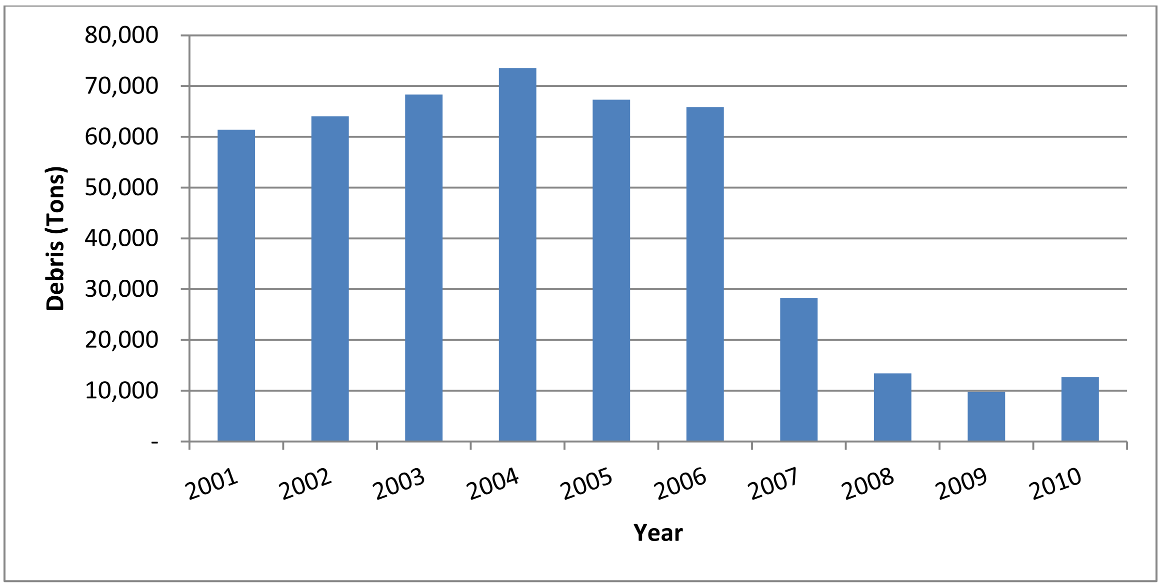


Figure 2.1. Debris Estimate (Tons) for Residential New Construction from 2001-2010

The RNC contribution ranges from 17.0 to 50.0 percent of the total with a mean of 31.0 $\pm$ 12 percent. The RNC debris contribution was highest during the years of 2001-2006. These years coincide with a strong period of economic growth in the US From 2006-2007; when a national economic recession began (Isidore, 2008), residential new construction contributed much less, an averaging 18 percent between the years 2007-2010.

2.3.1.2 Nonresidential New Construction

The result of the debris inventory for nonresidential new construction between the years of 2001-2010 is presented in Figure 2.2. The peak generation occurred in 2005 at just over 54,000 tons of debris. An upward trend is observed between the years 2002-2005 followed by a downward trend beginning in 2006 and lasting until 2009; the sharpest declines occurred in 2008 and 2009. The NRNC contribution ranged from 13.0 to 40.0 percent with a mean of 25.0 $\pm$ 9 percent.

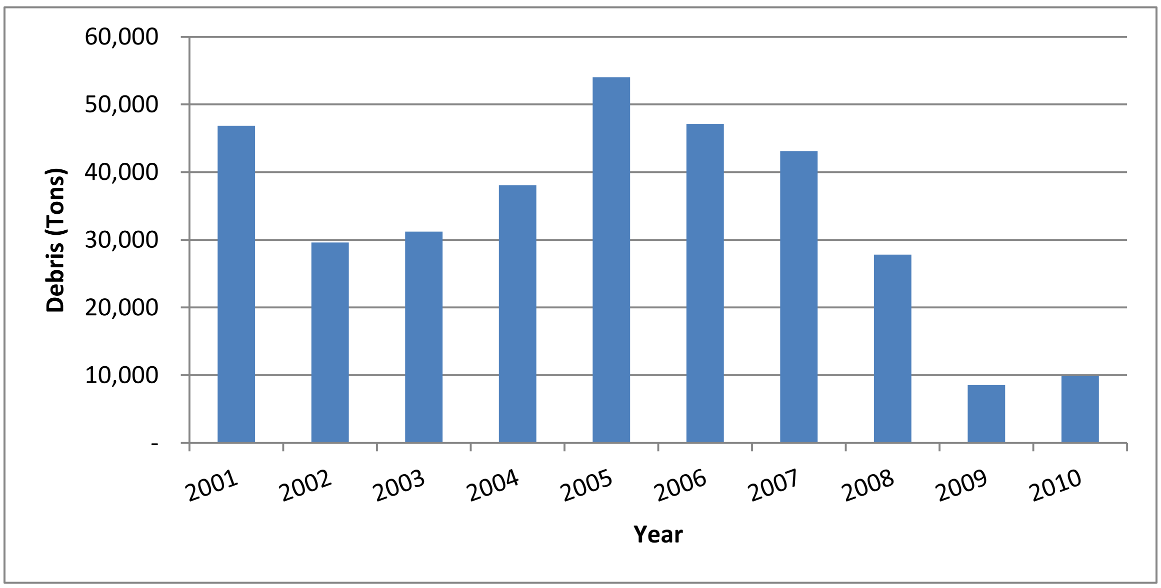


Figure 2.2. Debris Estimate (Tons) for Nonresidential New Construction from 2001-2010

Between the years of 2001-2010, the average combined contribution for both new construction sectors to the total was 56 percent. During the national economic downturn, the combined contribution for both new construction sectors was 43 percent. The data suggest that new construction in UOC generated a significant portion of the UOC debris stream regardless of economic strength or the decline in new construction debris quantities. This occurrence is contrary to the national data observed in the 2001 USEPA study showing that new construction constituted the smallest portion of the C&D waste stream (Sandler, 2003).

2.3.1.3 Residential Demolition

The result of the debris inventory for residential demolition between the years of 2001-2010 is presented in Figure 2.3. The peak generation occurred in 2002 at just over 120,000 tons of debris, much higher than the other years analyzed due to the demolition of a multi-family unit in this year. The RD contribution ranged from 4.00 to 55.0 percent with a mean of 27.0 $\pm$ 19 percent. The contribution of this sector to the total debris generation was low and may be related to high local availability of land without structures for construction in UOC; therefore limited demolition was needed.

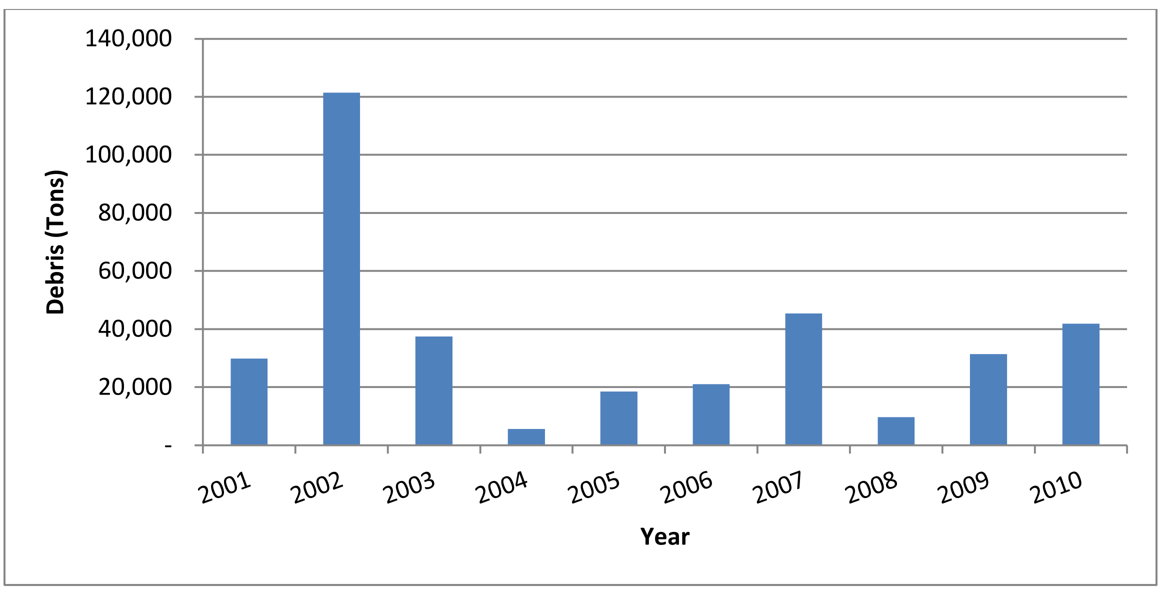


Figure 2.3. Debris Estimate (Tons) for Residential Demolition from 2001-2010

2.3.1.4 Nonresidential Demolition

The result of the debris inventory for residential demolition between the years of 2001-2010 is presented in Figure 2.4. A high point occurred in 2005 with seven of the ten years showing no activity. The NRD contribution ranged from 0.10 to 4.00 percent with a mean of 0.51 $\pm$ 1 percent.

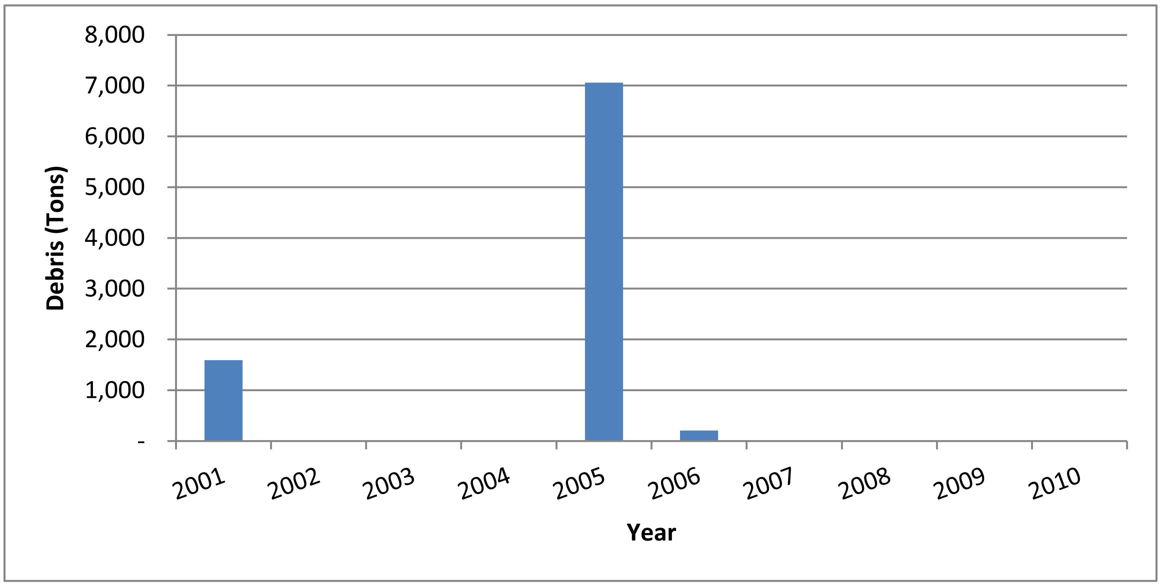


Figure 2.4. Debris Estimate (Tons) for Nonresidential Demolition from 2001-2010

2.3.1.5 Residential Renovations

The result of the debris inventory for residential renovations between the years of 2001-2010 is presented in Figure 2.5. The maximum debris generation occurred in 2004 at just over 10,000 tons with a minimum in 2010 of less than 2,000 tons. Fairly consistent generation between the years of 2001-2005 was seen, followed by a downward trend for the remaining years which corresponds to the economic downturn that began in late 2006. The RR contribution ranged from 2.00 to 7.00 percent with an average of 4.00 $\pm$ 2 percent. The data show the amount that residential renovation debris contributed to the total varies only minimally during the years analyzed.

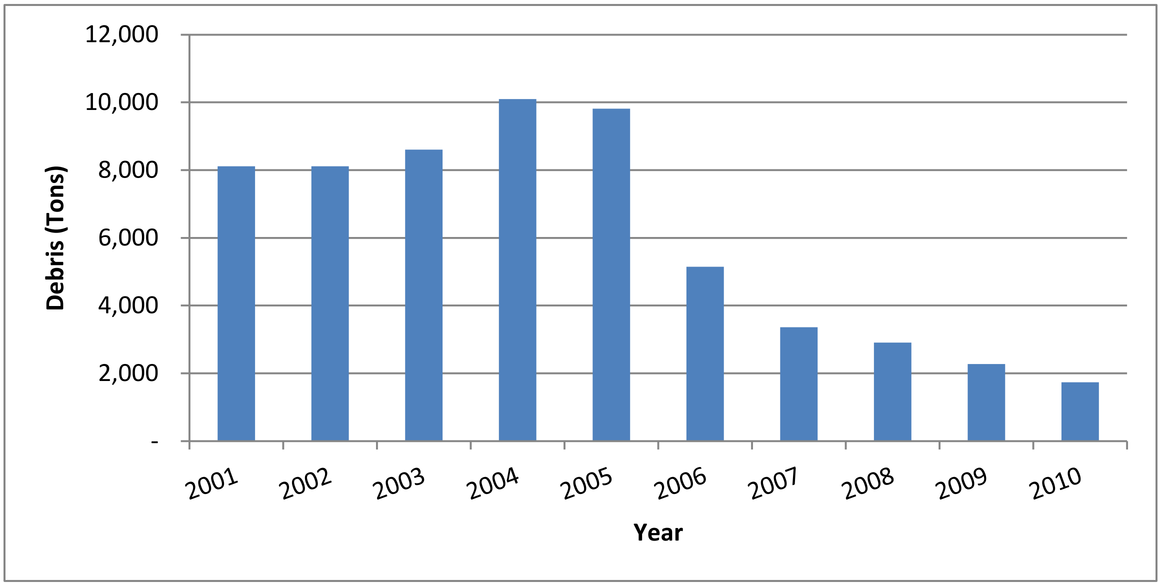


Figure 2.5. Debris Estimate (Tons) for Residential Renovations from 2001-2010

2.3.1.6 Nonresidential Renovations

The result of the debris inventory for nonresidential renovations between the years of 2001-2010 is presented in Figure 2.6. The maximum occurred in 2004 at just over 20,000 tons with a minimum in 2009 of just below 7,500 tons. The most noteworthy trend was downward beginning in 2006. The NRR contribution ranged from 7.00 to 23.0 percent with an average of 12.0 $\pm$ 4.5 percent.

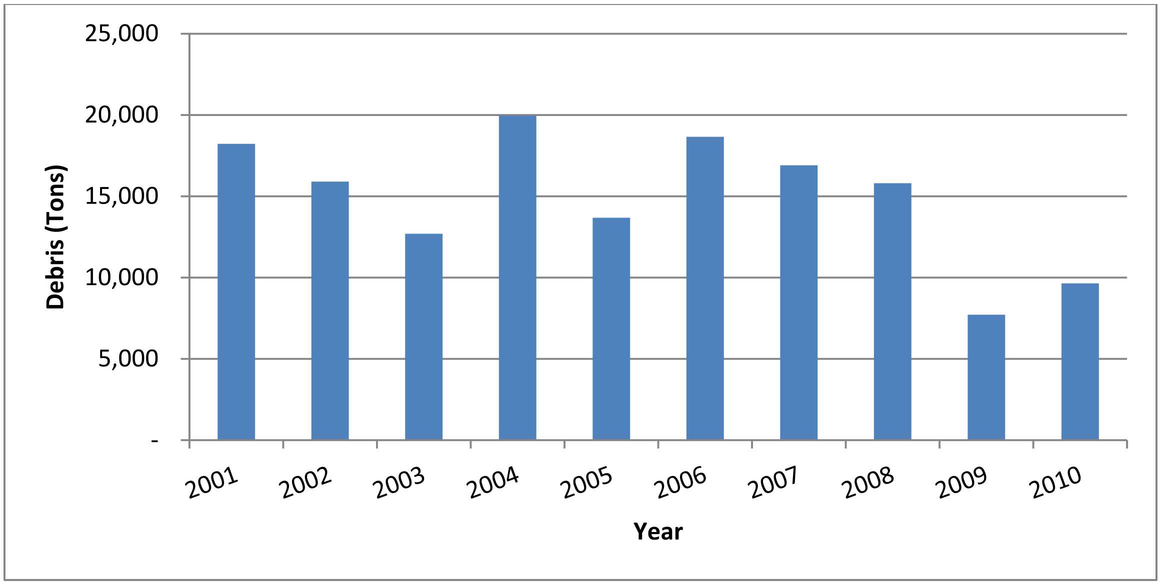


Figure 2.6. Debris Estimate (Tons) for Nonresidential Renovations from 2001-2010

2.3.1.7 Generation for All Sectors

The result of the debris inventory for all sectors between the years of 2001-2010 is presented in Figure 2.7. The maximum generation occurred in 2002 at approximately 239,000 tons with a minimum of approximately 60,000 tons in 2009. The mean and standard deviation for the data are 138,000 $\pm$ 55,000. A downward trend began in 2005 and continued until 2009.

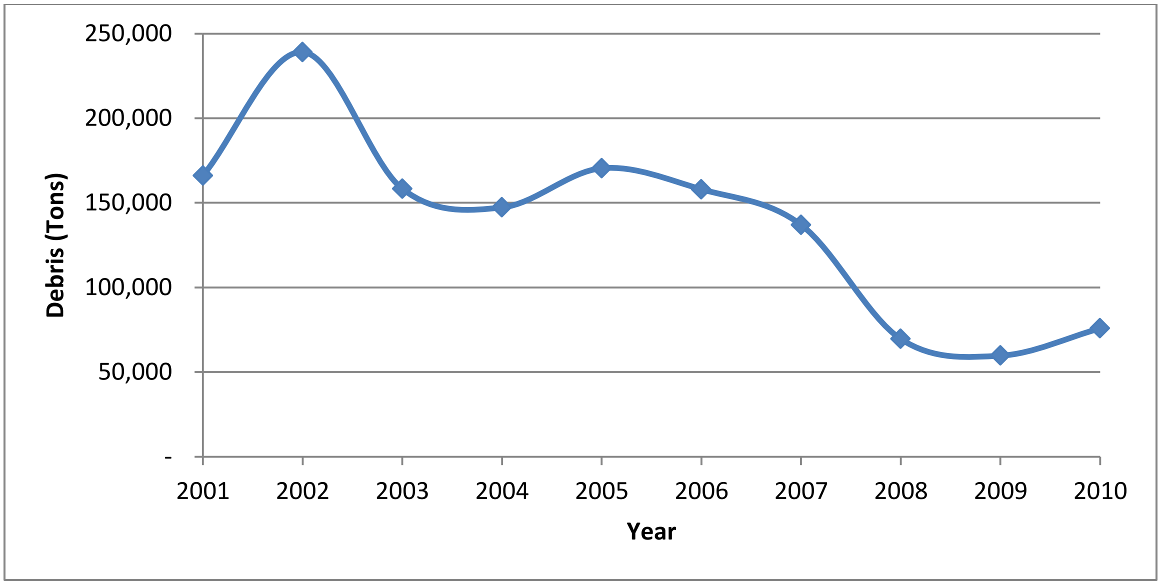


Figure 2.7. Debris Estimate (Tons) for All Sectors from 2001-2010

Peaks are observed in the year 2002 and 2005. Permit records suggest that high debris generation in 2002 was attributed to a large number of residential renovation projects, including the wet demolition of six multi-family apartment housing units and one clubhouse totaling 329,175 square feet. Wet demolitions add more mass to the waste stream than traditional demolition projects. This project alone contributed over 20,000 tons of debris to the total for that year. A second peak occurred in 2005 and is attributed to Hurricane Charley which struck the northern tip of Captiva Island, located in Southwest Florida, in August of 2004 at 150 miles per hour. Although Southwest Florida was most affected by the disaster, Central Florida also incurred considerable damage with roof damage being the most common. Figure 2.8 shows the marked increase in roofing permits against building permits issued in late 2004 and 2005 in response to hurricane effects with a decline in permit issuance since that time.

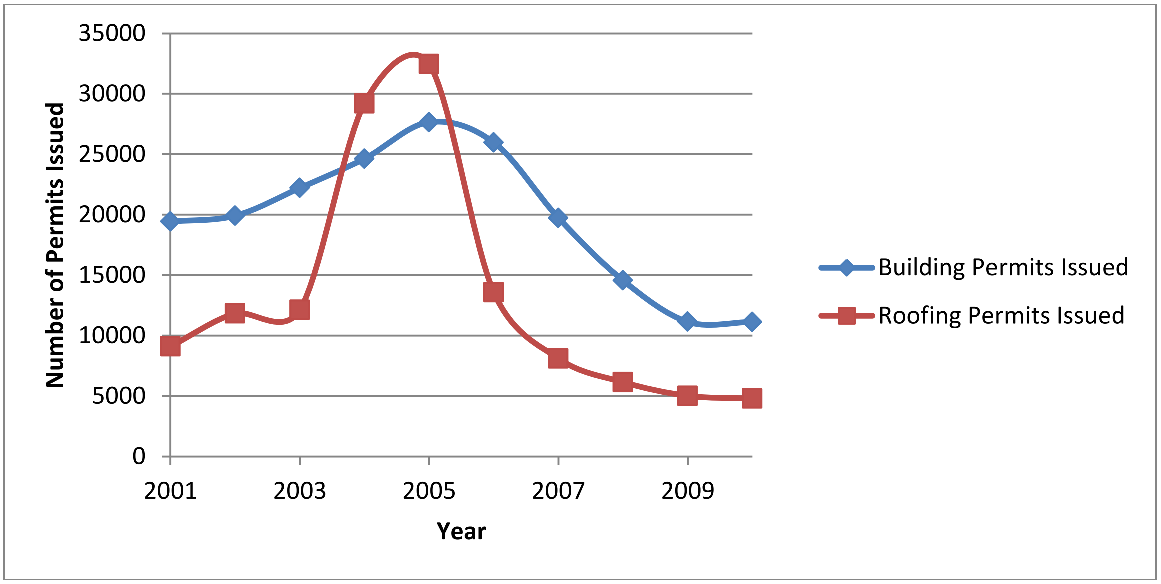


Figure 2.8. Building and Roofing Permits Issued 2001-2010

2.3.2 Composition

A composition study was performed on the UOC debris generation. Equation 2.12 was used to determine the weighted composition of each material in each sector. The weight fraction of each material was applied to the generation rate of C&D debris in each sector to obtain the quantity of each material in tons/year. The waste composition of the C&D debris was determined considering concrete, wood, drywall, asphalt, carpet and padding, metal, cardboard, and a miscellaneous fraction. The composition percentages of these eight materials were obtained from Reinhart et al. in 2002. These values were determined from multiple case studies performed on C&D debris in the six sectors. Figure 2.9 – 2.18 present the composition percentages for each sector. After material generation rates were determined, they were then summed across all sectors to obtain a total for all sectors which was used to determine an average material composition from for 2001-2010, presented in Figure 2.19.

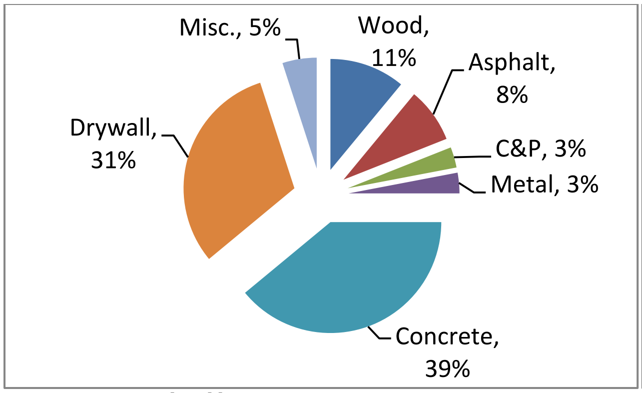
$$Q_{C,i} = (A_{CO})(\phi_i) \tag{2.12}$$

Q_C = Generation of a material of interest (Tons/year)

i = Material of interest

Q_{CO} = Debris stream generation in a given sector (Tons/year)

ϕ = Composition fraction for the material of interest



*C&P is Carpet and Padding

Figure 2.9. Composition Percentages for Residential New Construction (Reinart et al., 2002)

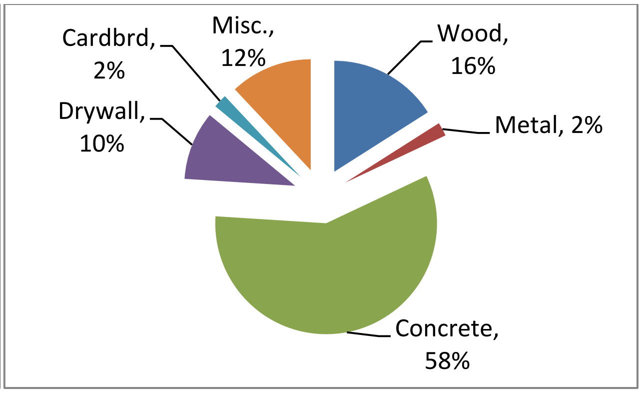


Figure 2.10. Composition Percentages for Nonresidential New Construction (Reinart et al., 2002)

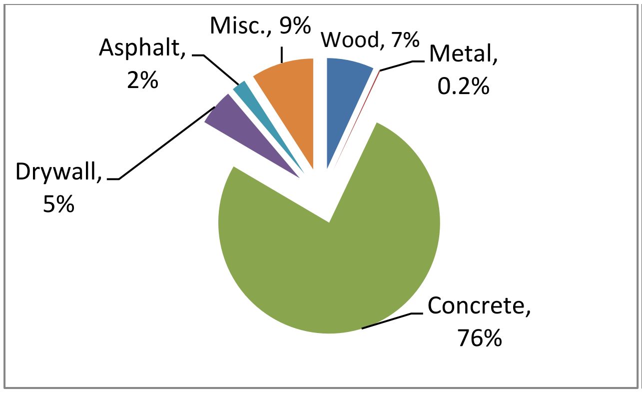


Figure 2.11. Composition Percentages for Residential Demolition (Reinart et al., 2002)

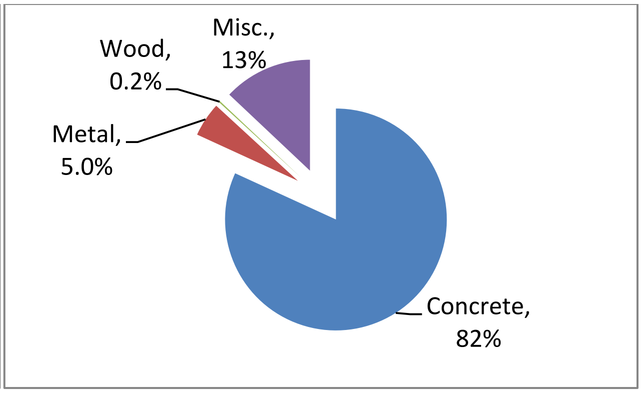


Figure 2.12. Composition Percentages for Nonresidential Demolition (Reinart et al., 2002)

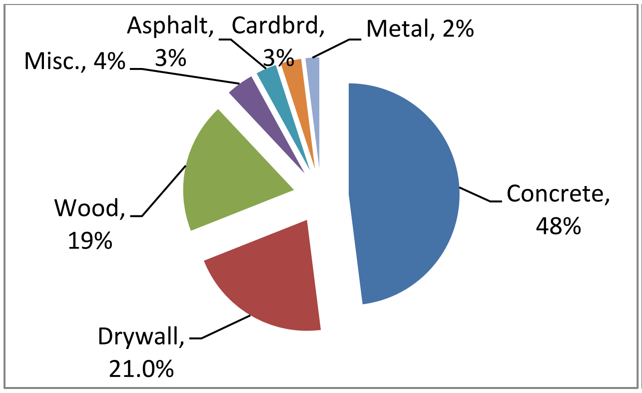


Figure 2.13. Composition Percentages for Residential Additions (Reinart et al., 2002)

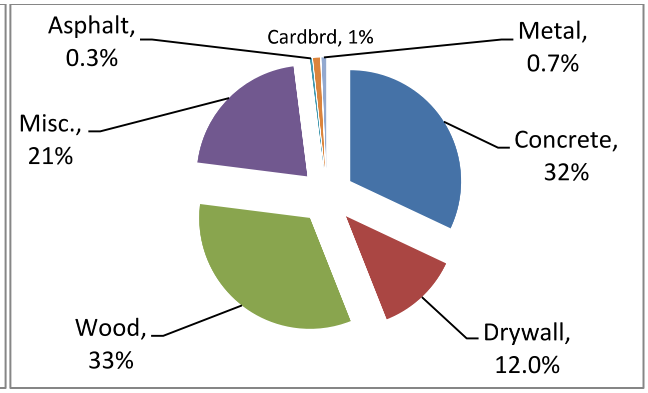


Figure 2.14. Composition Percentages for Residential Alterations (Reinart et al., 2002)

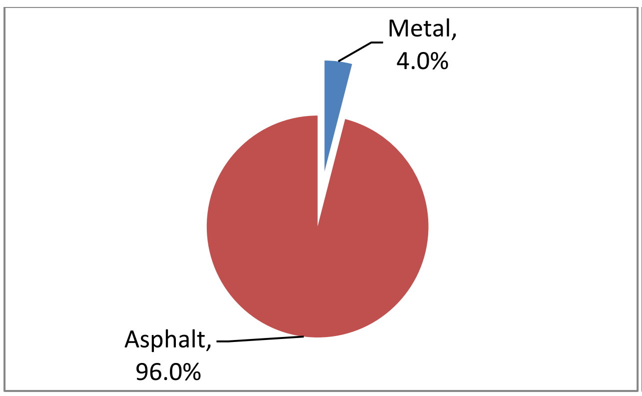


Figure 2.15. Composition Percentages for Residential Roof Replacements (Reinart et al., 2002)

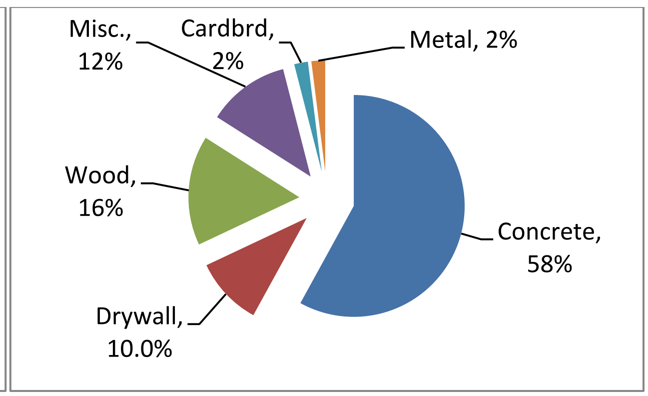


Figure 2.16. Composition Percentages for Nonresidential Additions (Reinart et al., 2002)

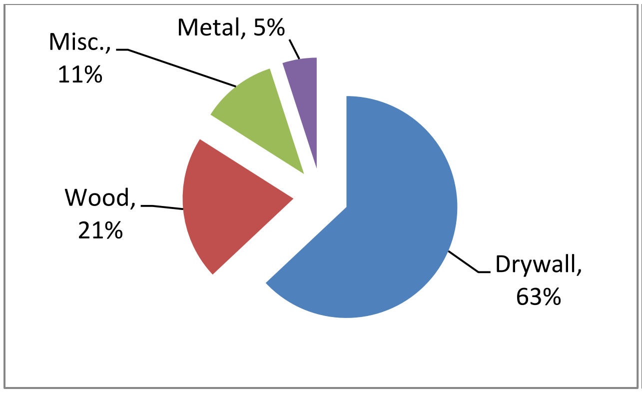


Figure 2.17. Composition Percentages for Nonresidential Alterations (Reinart et al., 2002)

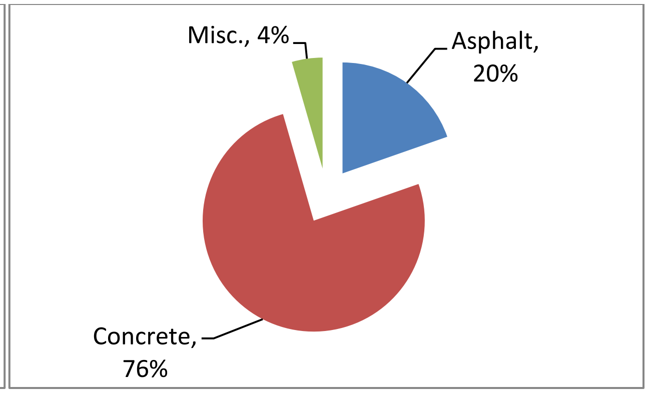


Figure 2.18. Composition Percentages for Nonresidential Roof Replacements (Reinart et al., 2002)

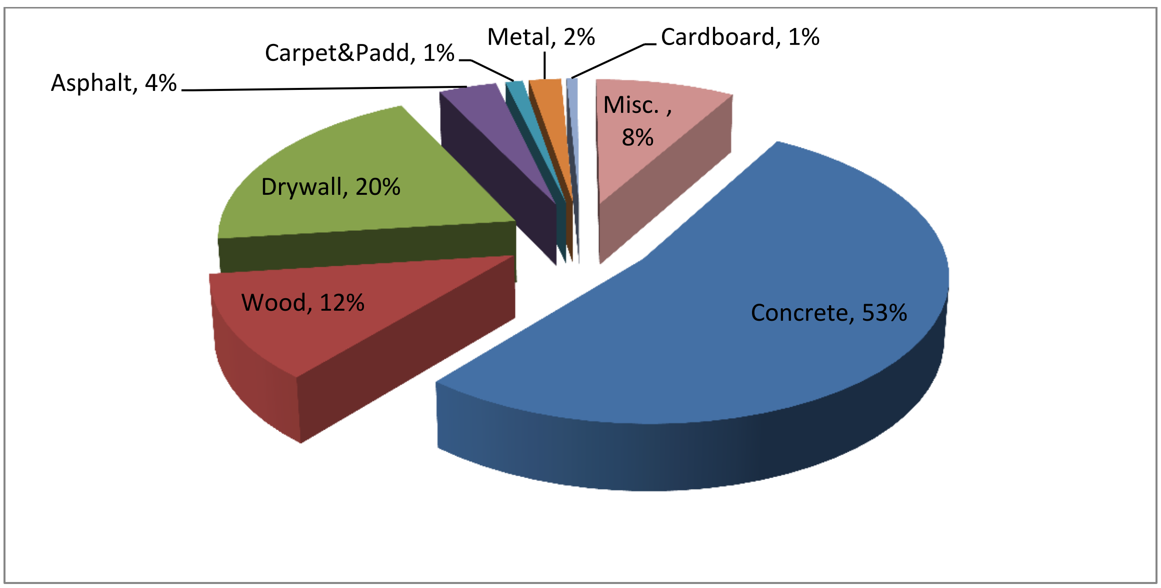


Figure 2.19. Average UOC Material Composition for All Sectors over 2001-2010

The yearly generations for each material are presented in Figure 2.20 and Figure 2.21. Concrete, at 53 percent, represents a large mass fraction of total building-related activity because every sector of building-related activity generates a significant amount of concrete debris in Florida, with the demolition sectors contributing the most. Concrete also has the highest density of any material. Drywall, at 20 percent, represents a large mass fraction because it is prevalent in the new construction and renovations categories which are very active sectors. Wood, which has been estimated to represent as much as 30 percent of the C&D stream in some national estimates (Sandler, 2003), represents a smaller fraction in UOC, 12 percent, because structures in UOC generally use more concrete than wood to meet hurricane codes and because readily available supply of concrete in Florida (discussed in Section 3.3.2.1) . Asphalt material, at 4 percent, also represents a significant portion of the waste stream, reaching nearly 7,000 tons in 2002, because most of the residential roofs in UOC are built with asphalt shingles.

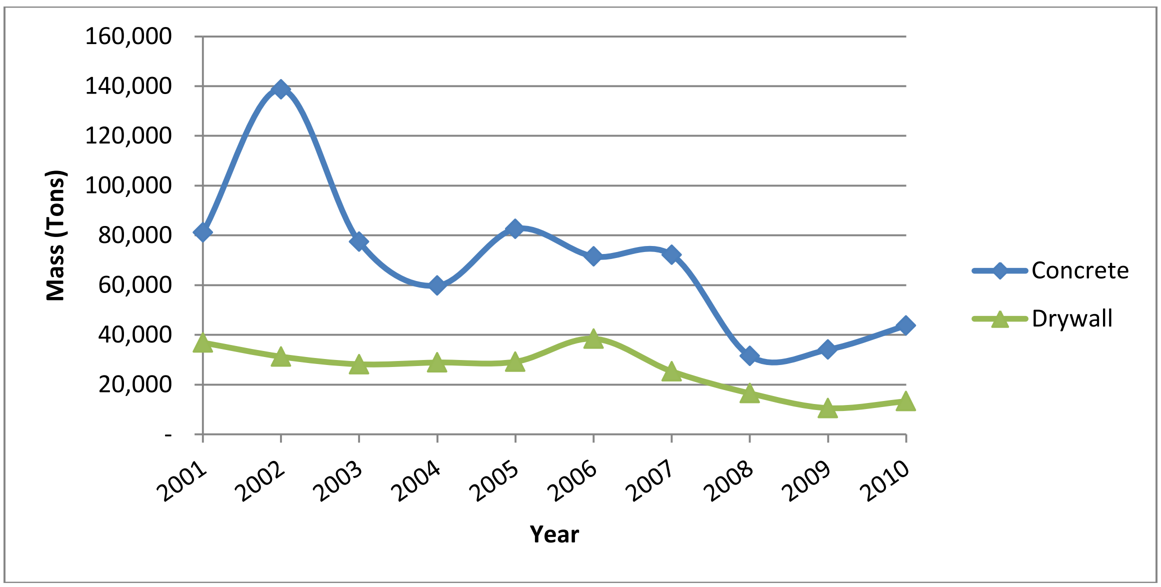


Figure 2.20. Annual Generation of Concrete and Drywall

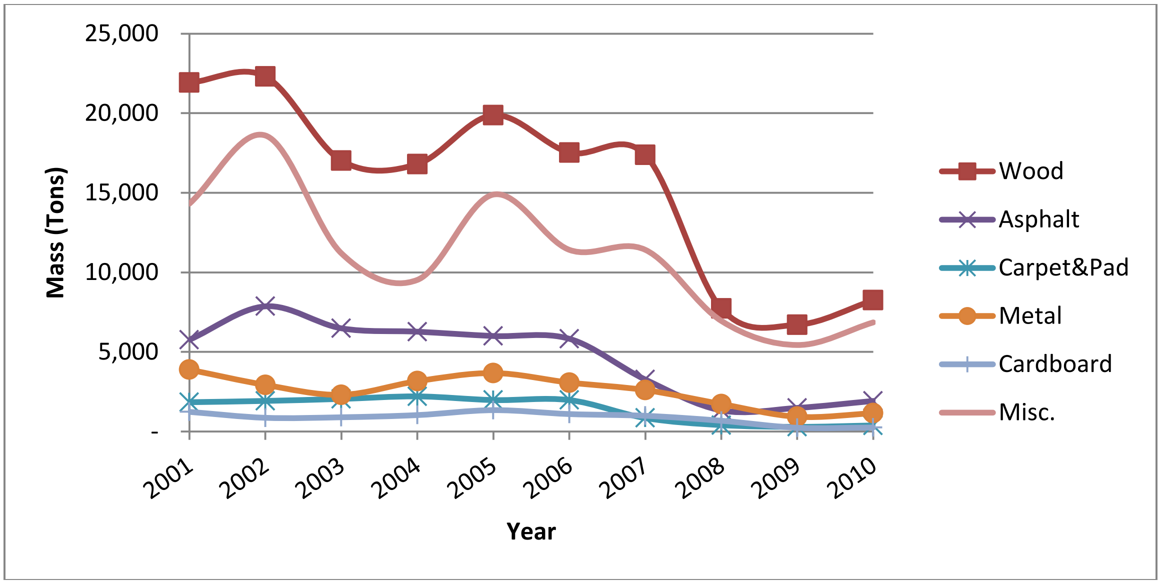


Figure 2.21. Annual Generation of Wood, Asphalt, Carpet & Padding, Metal, Cardboard, and Miscellaneous Materials

2.4 Data Comparisons

Table 2.10 presents the results of this study along with literature values. Data were normalized by population to allow a comparison between UOC data and historically reported data.

Table 2.10. Comparisons of per Capita C&D Debris Generation Rates

Study Number	Location	Year	C&D Per Capita Debris Generation Rate (pcd)
1	UOC (This Study)	2001-2009	0.45-1.99
2	U.S. National Average Range[1]	1977	0.12-3.52
3	Florida Average[1]	1995	2.01
4	U.S. National Avg.[1]	1996	2.80
5	South Carolina[1]	1997	1.40
6	Australia[2]	1997	0.88-2.19
7	Ireland[3]	1997	0.96
8	Florida Average[4]	2000	1.50
9	WA/DE/NH/VT/WI[5]	2008	1.70
10	California[6]	2008	0.82

[1] Franklin Associates, 1998. Land clearing debris (LCD) and road/bridge construction debris not considered
[2]Yuan et al., 2010. LCD and road/bridge construction debris consideration not stated
[3]Lage et al., 2009
[4]Reinhart et al., 2002. LCD and road/bridge construction debris not considered
[5]DSM Environmental Services, 2008. Multi-state study.
[6] California State, 2010. LCD and road/bridge construction debris consideration not stated

The results of this study were also compared to annual data reported to the FDEP, including data for Orange County (FDEP-OC) and Florida Statewide (FDEP-FL), presented in Table 2.11. The FDEP data include values reported by Class III Landfills, C&D Landfills MRF operators.

Table 2.11. FDEP Per Capita C&D Debris Generation Rates

Location	Year	C&D Per Capita Debris Generation Rate (pcd)
UOC- This Study (9-Year Average)	2001-2009	1.17
FDEP-FL[1] (9-Year Average)	2001-2009	2.45
FDEP- OC[2] (9-Year Average)	2001-2009	3.91

[1]FDEP-FL data generated by FDEP reports for the entire state of Florida
[2]FDEP-OC data generated by FDEP for the entire County of Orange

The FDEP-OC value in Table 2.11 is significantly larger than both the data from this study and the FDEP-FL value. One would expect that the FDEP-OC and FDEP-FL values would be much closer as they both represent similar populations, geographic areas, and debris categories. Figure 2.22 presents the trends for each of the three evaluations for the years 2001-2009

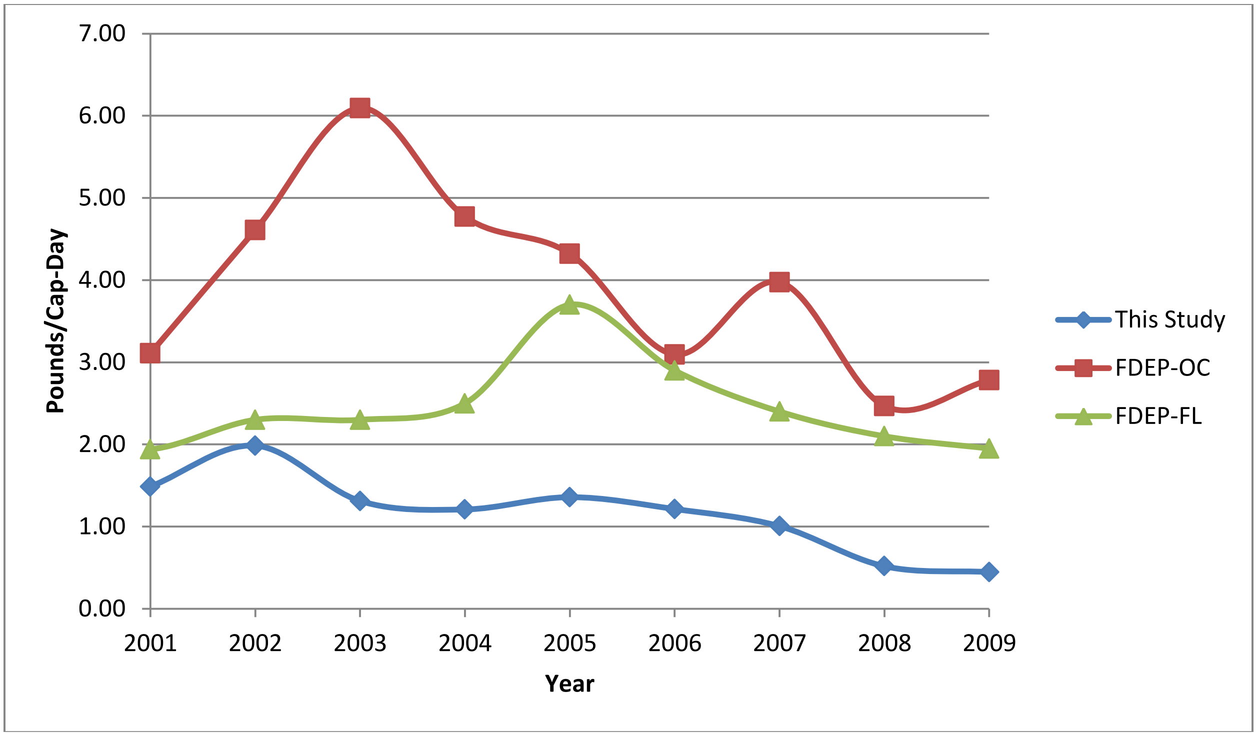


Figure 2.22. Per Capita C&D Debris Generation over Time

The higher per capita generation rates and outliers in the FDEP-OC data may be attributed to the inclusion of LCD, which is not present in this study, but may also be attributed to errors in reporting and work performed without permits. Reporting errors can occur because inefficient tracking procedures at disposal facilities and MRFs. When a C&D load enters a disposal facility or MRF in OC, the hauler should be asked for the county of origin of the load. According to county officials it is suspected that this question is not always asked and unknown values are attributed to OC or the information is unintentionally misreported. Misreporting can be a significant problem for debris tracking because it can falsely inflate or deflate the mass of debris reported to be flowing into a county. This phenomenon would cause inaccurate per capita generation values on the county level but would not affect the state values.

One form of misreporting occurs when a C&D load coming into an OC facility originates from another county but is reported as originating in OC, falsely inflating the mass estimate for C&D debris originating in OC. If this error were occurring in OC one would expect to find a compelling reason for C&D loads to be entering OC from surrounding counties, such as higher tipping fees in the surrounding counties, and that there is a higher generation rate on a per capita basis in OC versus surrounding counties. Table 2.12 shows that both conditions are true, suggesting that misreporting may be leading to a false inflation of the OC C&D per capita generation values.

Table 2.12. Waste Fee Schedules and Debris Generation for OC and Surrounding Counties

County	C&D Waste Fee Schedules ($/Ton)	C&D Per Capita Debris Generation Rate (pcd, 9-Year Average)
Orange	25.60	3.91
Lake	40.00	2.36
Seminole	33.17	1.42
Osceola	Unknown	2.93
Polk	37.95	0.86

Another form of misreporting can occur when C&D debris from non-MSW sources, such as road and bridge construction, is reported as coming from MSW sources. Similar to the way in which the drivers of incoming loads are supposed to disclose the county of origin of a load, they are supposed to state whether or not the load comes from an MSW or non-MSW source. In talks with county officials, it is suspected that this information is sometimes not sought causing some loads to be wrongly classified as MSW C&D, falsely inflating the amount of MSW C&D debris later reported by the FDEP. One other possible reason for the observed discrepancies may be the fact that home and business owners perform C&D activities without a permit. Although the number of cases where this happens is assumed to be low because the consequences are generally not worth the risk, the possibility still exists. Debris generated from non-permitted work is not accounted for in this study but would be included in FDEP inventories.

2.4.1 Debris Generation and Explanatory Variables

As discussed in Section 2.1.3 variables such as population and GDP can be used to explain and predict debris generation. Several bivariate and multivariate regression analyses were performed, presented in Table 2.13, in an attempt to identify the driving forces behind debris generation in UOC. Bivariate analyses between debris generation and chosen explanatory variables were first performed for 2001-2009 because data could be gathered for each variable within this timeframe. Most correlations were found to be weak for this timeframe so the analysis was separated into periods of economic growth (2001-2006) and periods of economic decline (2007-2009). Lastly, multivariate analyses were performed which improved the model further.

Table 2.13. Bivariate and Multivariate Regression Analyses: Economic Variable vs. UOC Debris Generation (Pounds per Capita-Year)

Economic Variables	Correlation Coefficient, R^2		
	2001-2009	2001-2006	2007-2009
Bivariate Analysis			
UOC Population	0.53	0.36	0.21
Percent Change in UOC Population	0.59	0.25	0.56
National GDP per Capita	0.37	0.39	0.52
Percent Change in National GDP per Capita	0.34	0.29	0.74
Florida GDP (FGDP) per Capita	0.53	0.37	0.79
Percent Change FGDP per Capita	0.53	0.56	0.99
Florida Construction GDP (FCGDP) per Capita	0.01	0.33	0.79
Percent Change in FCGDP per Capita	0.59	0.17	0.90
Consumer Confidence Index (CCI)	0.52	0.00	0.98
Multivariate Analysis			
Percent Change in FCGDP per Capita + CCI	0.63	0.18	1.0
Percent Change in FCGDP per Capita + % Change in UOC Population + CCI	0.67	0.29	1.0

Correlations between debris generation and the variables tested tended to be higher during periods of economic decline than they were during periods of economic growth. For example, Florida GDP increased from 2001-2006, however debris generation exhibited a weak correlation (R^2 = .37) with GDP. When the Florida GDP decreased during 2007-2009, debris generation was strongly correlated with GDP (R^2 = .79). The same is true for most other variables. This phenomenon may be attributed to the fact that during periods of economic growth, people have more disposable income and are somewhat likely to choose to spend their money on C&D activities, but have many other choices as well whereas in periods of economic decline people will very likely spend less on C&D activities and buy more necessary items. It is also possible that the correlations for the 2007-2009 timeframe are higher than the 2001-2006 timeframe because fewer data points area available.

The variables exhibiting high correlations in the bivariate analyses were analyzed together in an attempt to construct more robust models for predicting C&D debris generation, also seen in Table 2.13. Adding variables to the models yielded larger correlation coefficients, allowing for better prediction of C&D debris. For example, the strongest model constructed for this study analyzed over the 2001-2009 timeframe used percent change in FCGDP per capita, percent change in UOC population, and the consumer confidence index (CCI) and yielded a correlation coefficient of 0.67. The equation for the analysis is given in Equation 2.13 and can be used to predict UOC debris generation for estimated values for each independent variable. Further investigation into more robust models is a worthy exercise but is beyond the scope of this work.

$$\text{UOC Debris Generation} = 6.0(\%\ \text{Change in FCGDP}) + 0.57(\text{CCI}) + 2{,}600(\%\ \text{Change in UOC Population}) \tag{2.13}$$

CHAPTER 3: C&D MATERIALS MARKET IN OC

3.1 Introduction

For OC to do its part in helping Florida meet a 75 percent recycling goal, it must devise a plan for increasing C&D recycling rates based on an understanding of the historic recycling within its boundaries and the existing facilities that can handle recycling operations. It is also necessary to find end markets for each material in the C&D waste stream. This section analyzes factors that affect the material markets in OC and determines the potential demand for C&D waste stream components.

3.2 Historic Recycling Rates and Facilities

According to the FDEP Solid Waste Reports (FDEP, 2009), estimated C&D recycling rates from 2001 to 2009 for OC have been as low as 14 percent and as high as 49 percent as presented in Table 3.1. Figure 3.1illustrates the difference in the original and remaining debris inventory when the FDEP recycling rates are assumed and Figure 3.2 illustrates the difference in the original and remaining debris inventory when the 75 percent recycling goal is applied. When the FDEP recycling rates are assumed from 2001to 2009, an estimated 310,000 tons of debris would be recycled from building related activity alone. At a 75 percent diversion rate, as the State of Florida hopes to achieve, the result would have been one million tons of debris diverted from landfills from construction related activity alone.

Table 3.1. Historic C&D Recycling Rates in OC

Year	C&D Recycled (%)
2001	15
2002	14
2003	27
2004	16
2005	19
2006	24
2007	49
2008	33
2009	32

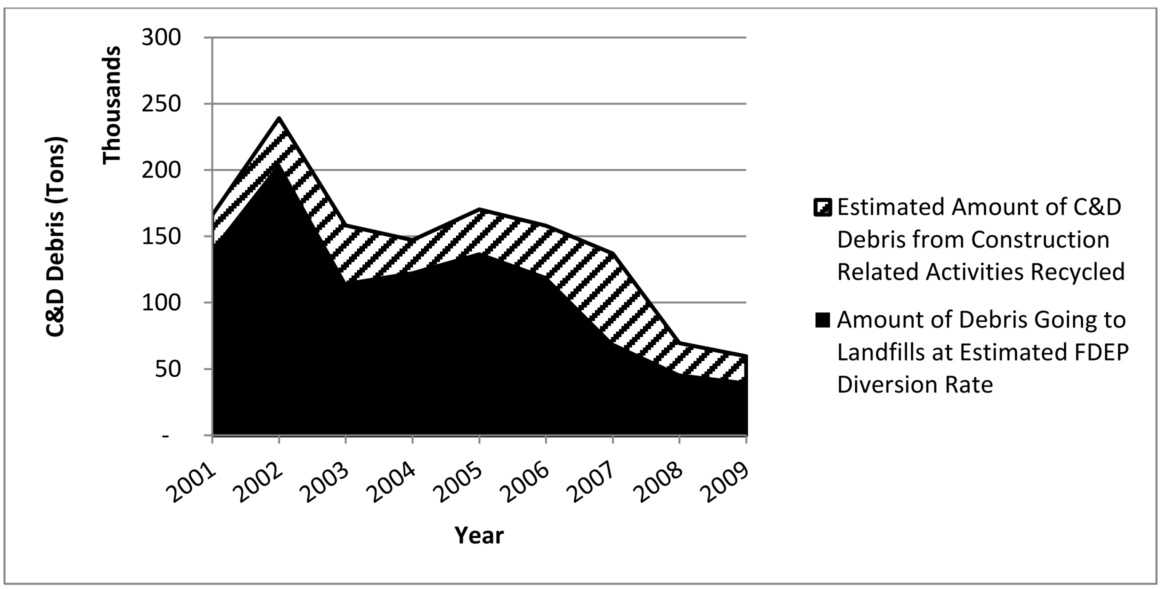


Figure 3.1. C&D Debris Generation with FDEP Reported Diversion Rates

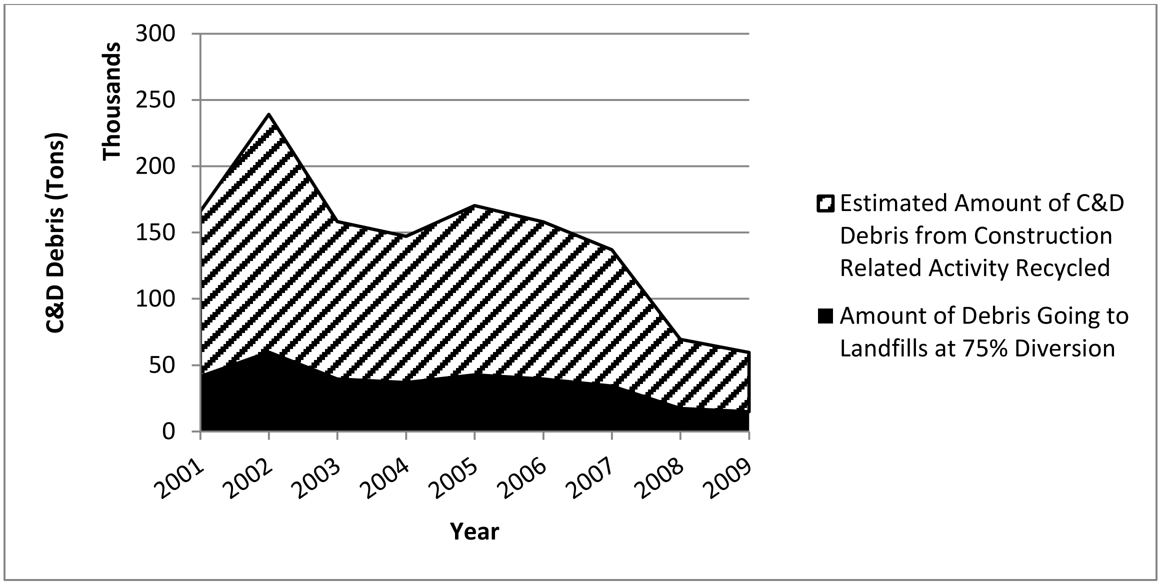


Figure 3.2. C&D Debris Generation with 75% Diversion Rates

For elements of the C&D debris stream to be recycled, they must be taken to a MRF that receives, separates and prepares recyclable materials for marketing to end-user manufacturers. Many MRFs in the Central Florida area accept recyclable materials from the C&D debris stream. However most operations are specialized, capable of processing only one or two materials, with concrete and metal being the most common, as seen in Table 3.2. Facilities that are able to accept three or more materials are termed multiple MRFs (MMRFs) in this report and are presented in Table 3.3. MMRFs offer OC the best chance to meet its 75 percent recycling goal because they are a central location for haulers to bring multiple materials which reduces the cost of transporting loads. MMRFs also take advantage of economies of scale which allow for a lower average operating cost per unit of recyclable material processed. Seven such facilities were found in Orange County as shown on the map in Figure 3.3, but as seen in Table 3.3, no single facility accepts all of the materials which could be recycled in the C&D debris stream.

Table 3.2. List of Known C&D Material Recovery Facilities (MRFs) in the Central Florida Area[*]

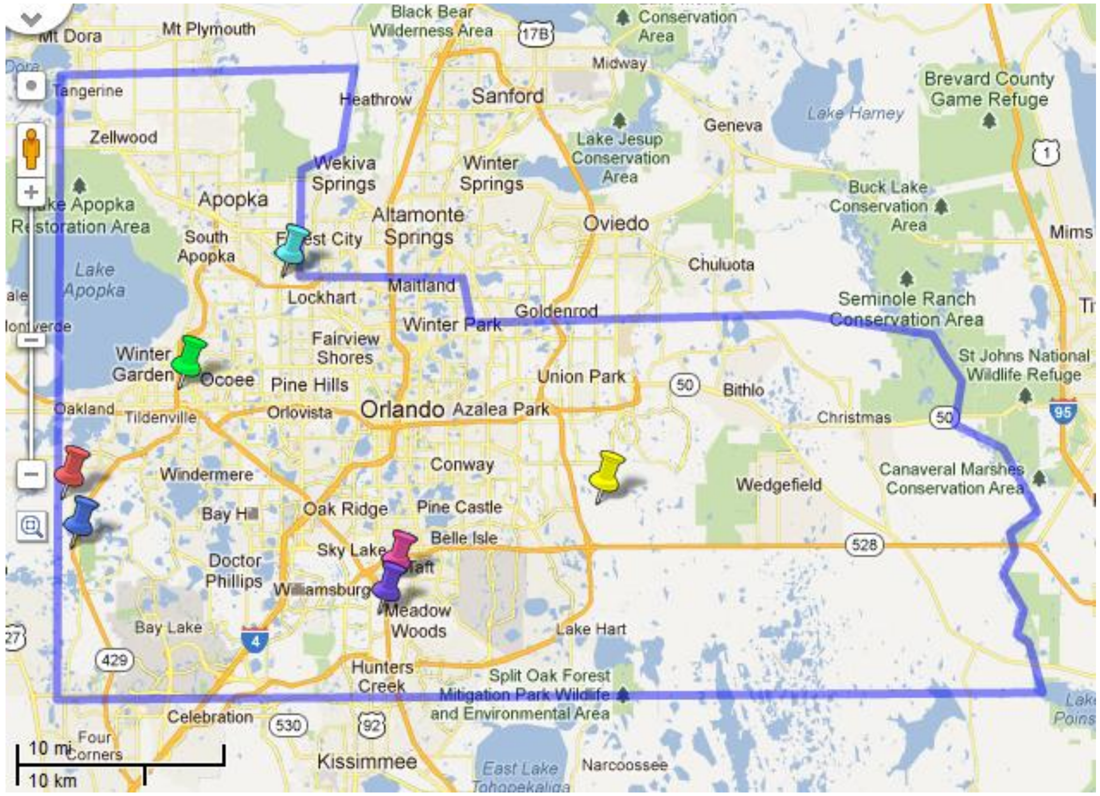
Facility	City	C&D Materials Recycled
MRFs		
Commercial Metals Company	Apopka	Metals (Ferrous and non-ferrous)
Whisper Winds Landscaping, Inc.	Ocoee	Land Clearing Debris
E&H Car Crushing Co., Inc.	Orlando	Metals (all)
Honey Bee Ranch	Orlando	Land Clearing Debris
Orlando Recycling	Orlando	Paper and Cardboard
Orlando Scrap Metal Recycling	Orlando	Metals (Aluminum, copper, brass, stainless, lead)
Promax Recycling, Inc[a]	Apopka	Concrete
Double D Crushers[a]	Winter Garden	Concrete
Independence Recycling[a]	Orlando	Concrete
American Demolition (Douglas Transport and Recycling Co.)[a]	Orlando	Concrete
BG Group- Portable Crusher[a]	Pompano	Concrete
BPH Rock[a]	Orlando	Concrete
Calleja, Joe E.[a]	Orlando	Concrete
CEM Enterprises[a]	Winter Garden	Concrete
Central Hauling and Excavating[a]	Orlando	Concrete
Crushing, Inc. Portable Crushing Unit[a]	Lakeland	Concrete
D.L. Rees[a]	Orlando	Concrete
Eagle Crusher (Eco-Rock Resource)[a]	Orlando	Concrete
Orlando Recycled Materials, Inc.[a]	Orlando	Concrete
Middlesex Asphalt LLC; Orange County Asphalt Plant #1[a]	Orlando	Concrete
Brothers Scrap Metals, Inc.[a]	Orlando	Metal
Trademark Metals (3 Locations)[a]	Orlando	Metal

[*]Contact information for each MRF and MMRF is given in Appendix B
[a]Source: HDR Engineering, 2011

Table 3.3. List of Known C&D Multiple Material Recovery Facilities (MMRFs) in the Central Florida Area[*]

MMRFs		
Angelo's Recycled Materials, Inc.	Apopka	Concrete, Asphalt
American Recycling Group (Waste Works)	Ocoee	Fiber, Metals, Plastics, Cardboard, scrap paper products. C&D specific: concrete, brick, stone, wood, drywall, glass, tiles, carpet, insulation, and shingles.
Orange County Landfill	Orlando	Concrete, Soils, Wood, Cardboard, Metal and other C&D Materials
Pine Ridge Landfill (Waste Management)	Winter Garden	Wood, Drywall, Plastic, Paper, Glass, Metal, and Concrete
Rocket Blvd. Materials Recovery Facility (Republic Services)	Orlando	Plastics 1-7, aluminum, tin and steel cans, cardboard, papers (office, junk mail, etc.) glass bottles, boxboard.
Taft Recycling (Waste Services)	Taft	Cardboard, Aluminum Cans, Metal, Plastics, and Wood Pallets
West Orange Environmental Resources, LLC	Winter Garden	Cardboard, All Metals, Concrete, Lumber, Composite Wood, Wood Pallets, All Plastics, Plastic Pipe (HDPE and PVC)

[*]Contact information for each MRF and MMRF is given in Appendix B
[a]Source: HDR Engineering, 2011



Map: ©Google, 2012

Legend:

#	Facility	Address
	West Orange Environmental Resources, LLC	7902 Avalon Road, Winter Garden, FL 34787
	Pine Ridge Landfill (Waste Management)	5400 Rex Drive, Winter Garden, FL 34787
	American Recycling Group, LLC (Waste Works)	320 Enterprise Street, Ocoee, FL 34761
	Angelo's Recycled Materials	2105 Vulcan Road, Apopka, FL 32703
	Orange County Landfill	5901 Young Pine Road, Orlando, FL 32825
	Rocket Blvd. MRF	11273 Rocket Blvd., Orlando, FL 32824
	Taft Recycling (Waste Services)	375 West 7th Street, Orlando, FL 32824

Figure 3.3. Location of MMRFs in OC.

Surveys of each of the known MMRFs were conducted in an attempt to understand the current operations and challenges of these facilities. Information sought included types of materials handled, fate of each material, amount of material each facility handles, the way in which materials are tracked, the challenges faced in managing the materials entering the facility, and the desire of each facility to expand its operation to accept more types of materials for recycling. Survey results can be found in Appendix C of this report. The surveys revealed that most facility operators desire to expand their operations but are held back by a lack of end markets for C&D materials. Some facility operators stated that the cost and skill required to process single stream recycling is also prohibitive.

3.3 Potential Markets

The objective of this section is to determine whether substantial markets exist in the Central Florida area for the major recyclable materials in the C&D debris stream: concrete, wood, drywall, asphalt shingles, and residual screened materials (RSM). Market consumption of materials was used to determine total potential demand for recycled materials and the potential supply for recycled materials was assessed. Concrete, drywall, wood, and asphalt roofing shingles represent the largest fractions (estimated at a combined 89%) of C&D debris (by weight) generated in UOC. The miscellaneous fraction (estimated at 8%) includes RSM and therefore should also be targeted for recycling programs.

3.3.1 Methodology

This study estimated potential demand for recycling C&D debris materials by examining markets that could use recycled materials but generally use natural resources. It assumes that natural resources or other waste sources could be replaced with recycled C&D debris. In some instances the entire state of Florida was considered as the control boundary for the potential recycling of OC's C&D materials; however the Central Florida area was used where local data were available. The consumption rate of materials was estimated and compared to the amount of recyclable waste material that was generated. Competitive materials were also analyzed to determine what impact they may have on the ability to recycle C&D debris materials. Five C&D debris materials were investigated with four, concrete, wood, drywall, and asphalt shingles undergoing a quantitative analysis and RSM undergoing a qualitative analysis due to a lack of quantitative data. These materials were chosen based on their high potential for recyclability and significant representation within the C&D waste stream. Data were obtained from literature, government agencies, and industry associations.

3.3.2 Materials

3.3.2.1 Concrete

According to the Construction Materials Recycling Association 140 million tons of concrete are recycled each year in the US (CMRA, 2012). Contractors can recycle concrete as a supplement to natural aggregates such as crushed stone, sand and gravel and in the past decade both the American Society for Testing and Materials (ASTM) and American Association of State

Highway and Transportation Officials (AASHTO) have accepted recycled concrete as a source of aggregate into new concrete. Recycled concrete has multiple end markets that include aggregate road base, ready mix concrete, soil stabilization, pipe bedding, and landscape materials. Aggregate road base is used as foundation for roadway pavement and parking lots, forming a structural foundation for paving, and is the major market for crushed concrete on the national level. Ready-mix concrete normally consists of a blend of cement, sand and water but crushed concrete can be used as an alternative ingredient. Concrete aggregate can be used as a soil stabilizer for sub-grade soils of marginal quality because it decreases the infiltration rate of water into the sub-grade. Recycled concrete serves as a stable pipe bed for laying underground utilities and as a landscape material, crushed concrete can be an attractive feature in various settings. For the purposes of quantifying a potential demand for recycled concrete it will be assumed that the concrete collected from C&D debris streams is crushed and the remaining product competes for the same applications as virgin crushed stone.

The United States Geological Survey (USGS) collects data from crushed stone producers around the country and for 2010 it was estimated that 1.3 billion tons of crushed stone were consumed in the US. Of all the uses for crushed stone (including construction, agricultural, chemical, and metallurgical) the most likely uses for recycled concrete are those in the construction industry. Forty four percent was reported to USGS for specified purposes, 26% was reported for unspecified uses, and 30% of the total consumed was estimated for nonrespondents to the U.S. Geological Survey canvasses (Willett, 2010). Of the 560 million tons reported by use, 82% was used as construction material (460 million tons), mostly for road construction and maintenance; 10%, for cement manufacturing (56 million tons); 2% each for lime manufacturing and for agricultural uses; and 4%, for special and miscellaneous uses and products (Willett, 2010). That leaves approximately 760 million tons used for unspecified purposes of which some is likely attributed to construction. 28 million tons (2.6% of total reported by use) of salient crushed stone was reported recycled in the US in 2010 along with 14 million tons of recycled concrete (Willett, 2010).

Florida sold and used 47 million tons of crushed stone in 2010, placing it among the top ten consumers. Assuming that the national numbers can be applied to Florida, then the demand for crushed stone in Florida can be estimated at 18 million tons. Approximately 330,000 (2% of the crushed stone total) tons of recycled concrete were sold and used in Florida in 2010. From Section 2 it is estimated that approximately 40,000 tons of concrete debris was generated in UOC in 2010. Extending this number to the entire county suggests that 62,000 thousand tons were generated, less than one percent of the demand for crushed stone in Florida showing that all recycled concrete generated in OC has the potential to be recycled right here in Florida.

According to the USGS, the crushed stone industry has a need to look beyond mining virgin materials for supplying demand because mining operations continue to be concerned with environmental, health, and safety regulations. Shortages of crushed stone in some urban and industrialized areas have also occurred because local zoning regulations have pushed manufacturers away in favor of more publically favorable land-development alternatives. These issues are expected to continue and to cause new crushed stone quarries to locate away from large population centers creating which will further incentivize the recycled crushed stone market.

3.3.2.2 Drywall

The U.S. produces approximately 15 million tons of new drywall per year (California State, 2012). The USGS estimates that approximately 12 percent of new construction and renovation drywall is wasted during installation (California State, 2012). Nationally, most drywall waste is generated from new construction (64 percent), followed by demolition (14 percent), manufacturing (12 percent), and renovation (10 percent) (California State, 2012). In 2009, the United States ranked fourth worldwide in the production of crude gypsum, with 11 million tons of production (Crangle, 2009). In 2009, U.S. apparent domestic gypsum consumption was more than 25 million tons with imports totaling 5 million tons, which included gypsum that was calcined for wallboard and other plaster products (Crangle, 2009). Uncalcined gypsum is most often used for cement production or agricultural applications. Approximately 1.4 million tons of uncalcined gypsum products were produced in 2009, of which approximately 1.1 million tons (79%) was for Portland cement production. Gypsum is added to cement to retard its setting time and makes up about 2% to 4% by weight of cement output (Roskill Informaton Services, 2009). The remaining 385,000 tons was used primarily for agricultural purposes. Finely ground gypsum rock was used in agriculture and other industries to neutralize acidic soils, to improve soil permeability, to add nutrients, to stabilize slopes, and to provide catalytic support for maximum fertilizer benefits. Small amounts of high-purity gypsum are also used in a wide range of industrial applications, including the production of foods, glass, paper, and pharmaceuticals. Other potential markets for recycled gypsum include cement production, as a stucco additive, sludge drying, water treatment, grease absorption, and for marking athletic fields. Until costs and legislation associated with landfilling scrap gypsum become more restrictive, recycling will likely continue to remain a low priority within the industry (Crangle, 2009). The majority of the calcined portion went to drywall manufacture. If 12% of the wallboard used in new construction and renovation is discarded as scrap as estimated, then up to 3 million tons was discarded as scrap in 2009 in the US.

Scrap drywall can be recycled into most markets that consume gypsum such as new drywall manufacture, Portland cement manufacture and agriculture. No estimates exist for drywall recycling amounts (Crangle, 2009). Drywall is usually processed for recycling by removing the paper and other contaminants, although some agricultural application may not require this as the paper decomposes. So, comparisons will be made for the gypsum in drywall only.

In Chapter 2, the amount of drywall estimated in the UOC debris stream was approximately 10,000 tons. Extending these numbers to the entire county gives an estimate of 17,000 tons of debris. The most likely use for recycled gypsum in Central Florida is in concrete production because Florida produces a significant portion of the nation’s Portland Cement and crop use as a soil amendment in Florida is low compared to most other states (Reinart et al., 2002). In 2005 the USEPA estimated that Florida was the third largest producer of ready-mixed concrete and in 2009 the USGS estimated that 3.4 million tons of cement were produced in Florida. Generally the maximum amount of gypsum from drywall that can go into Portland Cement is 4%, or 140,000 thousand tons in 2009, 88% greater than the amount of drywall debris generated in OC that year. However, competition for this market does exist from mined and synthetic gypsum (USEPA, 2008).

3.3.2.3 Wood

Markets for wood waste include reusing it to make new products, feedstock for engineered woods, landscape mulch, soil conditioner, animal bedding, compost additive, sewage sludge bulking medium, boiler fuel, and more (USDA, 2002). The United States Department of Agriculture (USDA) states that the most profitable uses for wood debris are direct reuse and grinding for use in engineered wood products yielding 20 to 32 times and four times the revenue as selling the same amount of wood for fuel or mulch, respectively. Estimations for wood waste are not commonly performed on a national level and of those that have been performed, few include estimations for wood waste derived from C&D activities (Biomass Research and Development Board, 2008). Unlike feedstock from forest logging and the primary wood products industry, for which data are regularly collected by USDA's Forest Service, no data are collected at a national or Federal level for C&D wood waste (Biomass Research and

Development Board, 2008). Information for estimations usually comes from surveys and assessments.

National estimates for wood waste in C&D debris include 39 million tons in 1999 (Biomass Research and Development Board, 2008), 33 million tons of usable waste wood nationwide in 2002 (NESCAUM, 2006), 28 million tons in 2003 (Sandler, 2003), and 36 million tons in 2003 (McKeever, 2003), with more recent studies not available. Reinhart et al. estimated 550,000 tons of wood waste generated in the state of Florida for the year 2000. The 2000 estimate is the most recent available for wood waste generation from C&D activities in the State of Florida and will be used to help estimate demand. Because the UOC data does not begin until 2001, the 2000 data are assumed to apply to 2001 so that a comparison can be made. In Section 2 of this report, it was estimated that in 2001, 22,000 tons of wood waste were generated from building related C&D activities in UOC. Approximately 6,600 tons were from demolition and renovation activities while 15,000 tons were from construction related activity. Extending these numbers to the entire county gives approximately 34,000 tons, 10,000 from demolition and renovation activity and 24,000 from construction related activity. The entire supply of wood debris has the potential to be recycled in Florida through three markets: engineered wood products, mulch, and waste to energy (WTE) conversion. The mulch and WTE conversion markets will be discussed quantitatively while the engineered wood products market will be discussed qualitatively due to a lack of quantitative data.

3.3.2.3.1 Mulch

Recycled wood products include mulches and mulch film covers. One study shows that Osage Orange wood, often used in heavy construction, was combined with polylactic acid to form a polymer composite designed for agricultural purposes (Finkenstadt et al., 2010). The resulting product was comparable to existing mulch film products and had the advantage of being completely biodegradable through a single growing season (Finkenstadt et al., 2010). Reinhart et al. estimated the total mulch demand in Florida to be 200,000 tons in the year 2000 based on the number of homes in Florida and the estimated bags of mulch used per home in that year as given by the Mulch and Soil Council and all mulch can be made completely from recycled wood. Because it is more profitable to use the scrap from new construction activities for reuse applications only the demolition and renovation portion of the debris stream, 10,000 tons, will be considered for use as mulch, which is 5% of the statewide demand.

3.3.2.3.2 Waste to Energy Technologies

WTE technologies are of two types, thermal and non-thermal. Combustion, pyrolysis, torrefaction, gasification, and plasma arc gasification are the thermal technologies and anaerobic digestion, fermentation and mechanical biological treatment are the non-thermal technologies. Currently the most common type of WTE technology is combustion used to convert the organics in MSW waste into heat and electricity. Approximately 87 waste to energy plants exist in the US for the purposed of MSW combustion (EIA, 2011). In 2010, these plants burned 12% of the nation’s MSW and generated 14 million kilowatt-hours of electricity (EIA, 2011). The combustion of waste in Florida is generally used to produce electricity which represents the largest segment of the WTE market. As of 2010, 14 such WTE plants existed in Florida processing nearly 20,000 tons per day of municipal solid waste while producing over 500 MW of electricity (City of Tampa, 2012). There are seven facilities in the Central Florida area, shown in Table 3.4, all within 113 miles from the center of OC and three within 60 miles.

Table 3.4. Waste to Energy (WTE) Facilities in Central Florida

WTE Facilities in Central Florida	Distance from Center of OC (mi)	MSW Acceptance Design Capacity (tons per day)[a]	Approximate Energy Production from Recovered Materials (MW)[b]
Lake County Resource Recovery Facility	58	529	15
Ridge Generating Station	59	906	24
McIntosh Power Plant	60	300	8
Hillsborough County SW Energy Recovery Facility	86	1,198	32
McKay Bay Refuse to Energy Project	91	998	26
Pinellas County Resource Recovery Facility	108	3,143	77
Pasco County Solid Waste Resource Facility	109	1,047	28
Total		8,121	210

[a]FDEP, 2001.
[b]Industcards, 2012. Lake County Resource and Pinellas County Resource numbers given, and the rest extrapolated.

The total amount of MSW combusted in the counties where Central Florida WTE combustion facilities are located (Lake, Polk, Pinellas, Hillsborough, and Pasco) is 3,700 tons per day according to the FDEP. Table 3.4 gives the design capacity of these facilities at 8,100 tons for a difference of 4,400 tons of remaining capacity. So, if all of the wood waste estimated to be generated in OC in 2001 (94 tons per day) were sent to WTE plants for combustion, it would only absorb 2% of the remaining available capacity of the plants in Central Florida. Even assuming that the remaining capacity is halved because of waste acceptance from neighboring counties and efficiency losses, all the estimated wood waste generated in OC in 2001 only occupies 4 % of the remaining available capacity. Since 2001, wood generation levels have decreased but the potential to recycle the entire waste wood debris stream has remained steady and even increased because the design capacity of WTE plants producing electricity has not changed and the popularity of the other aforementioned WTE technologies has increased.

3.3.2.3.3 Engineered Wood Products

Engineered wood is a term given to material derived from smaller pieces of wood that are bound together through a variety of glues, resins, and other chemicals to make a wood-like product. Engineered wood products include oriented strand-board, particleboard, glued-laminated timber, laminated lumber, wood I-joists, and finger-jointed studs (USDA, 2002). According to the Engineered Wood Products Association, there are 20 manufacturers of engineered wood products in Florida with eight located in the Central Florida area. Numbers could not be found for the amount of engineered wood products manufactured in Florida or OC, but the USDA states that scraps from new construction are the most widely accepted types for engineered wood products (USDA, 2002).

3.3.2.4 Asphalt Roofing Materials

An estimated 11 million tons of waste shingles are generated every year in the US (USEPA, 2005) of which ten million tons are from installations and tear-offs from re-roofing (NERC, 2011). The Polk County Waste Resource Management Division estimates that about 7% of the total C&D debris stream in Florida is comprised of asphalt shingles (FDEP, 2010b) which compares well with the estimated amount for OC, 4%, from Section 2 of this report.

Several potential markets exist for asphalt shingles including hot mix asphalt (HMA), cold patch, dust control on rural roads, temporary roads or driveways, aggregate road base, new shingles, and fuel. The most likely avenue for recycling asphalt shingles in Florida is HMA because it is the largest current market for recycled asphalt shingles (RAS) (CMRA, 2012b). Shingle recycling is increasing in popularity as states such as Alabama, North Carolina, Texas, Wisconsin, Pennsylvania, Des Moines, Maine, Massachusettes, and New Hampshire have all authorized the use of shingles in paving mixes in recent years. Because the use of recycled asphalt shingles in HMA is the largest market, the demand for this market will be quantified in this section while the other markets applicable to Florida will be qualitatively discussed.

3.3.2.4.1 Recycled Shingles in Hot Mix Asphalt

Post-maufacture shingles are currently being used in HMA production in Florida in limited amounts, likely for applications such as paving jobs that include neighborhoods, driveways, parking lots, and other private road uses (FDEP, 2010b). There are several benefits which can be derived from using recycled asphalt shingles (RAS) in HMA including reduced demand on virgin asphalt cement, producing an economic benefit for HMA producers, reduced demand on aggregate, and improved properties of HMA pavement (e.g. better rutting and cracking resistance).

Florida currently does not have a specification for the use of tear-off shingles in HMA for use in the statewide highway system (SHS). Traditionally the major hurdles to using RAS in HMA have been the potential presence of asbestos and economic considerations associated with integrating the use of recycled tear-off shingles into the HMA process. However, a large-scale pilot study conducted by the Polk County Waste Resources Management Division concluded that these concerns can be overcome and Polk County is now working with the Florida Department of Transportation (FDOT) and other agencies to assess potential research or informational needs to develop a specification that allows the inclusion of tear-off shingles (FDEP, 2010b). The Polk County study produced an HMA that was 5.5% ground asphalt shingle by weight, saved the HMA facility approximately $5 per ton in production costs, and showed no issues at the time of the installation of the asphalt.

If Florida adopts a standard for use in the SHS the demand for recycled asphalt shingles will far outweigh the supply increasing the likelihood of 100% recycling. In 2010, the FDOT was successful in beginning construction on 307 lane miles of additional roadway to the SHS and contracted 2,522 lane miles of roadway to be resurfaced on the SHS (FDOT, 2011). Each lane has an asphalt thickness of about 0.30 feet and a width of about ten feet (Reinart et al., 2002) giving a total of 45 cubic feet of HMA concrete used in 2010 in Florida. The Asphalt Institute gives a typical density of 145 lb/ft^3 at a 93% compaction, or 7% air void allowance, yielding a total weight of 3.3 million tons of HMA concrete used for these projects. Applying the percentage of recycled asphalt from shingles to other ingredients in HMA used in the Polk County study gives a demand of 182,000 tons of shingles in Florida. The analysis excludes demand from sources other than the SHS such as private roads, parking lots and more, producing a conservative estimate. The estimated amount of asphalt shingle debris from Chapter 2 for UOC is 1,920 tons, extended to the entire county yields 2,954 tons which is 2 % of the estimated statewide demand for recycled asphalt shingles for the use of HMA concrete, showing that 100% of OC asphalt from roofing shingles has the potential to be recycled as an alternative ingredient in HMA .

3.3.2.4.2 Additional Uses for Recycled Asphalt Shingles

Recycled asphalt shingles may be ground and mixed into the gravel used to cover rural, unpaved roads. The mixture leads to several improvements in these rural roads including the minimization of dust, reduced loss of gravel into side ditches, vehicle noise reduction, and a longer road life with less maintenance required (IDOT, 1997). RAS has also been used in temporary roads, driveways, and parking lot surfaces after typically being ground to ¼ inch and passed under a magnetic separator in order to sufficiently remove all nails. The processed shingles are spread and compacted for an easily installed surface. Lastly RAS can be used as an ingredient in new roofing shingles.

3.3.2.5 Residual Screened Materials

The most recent definition of RSM was promulgated in January 2010 in Rule 62-701.200(73) F.A.C. to mean “the fines fraction, consisting of soil and other small materials, derived from the processing or recycling of construction and demolition debris which passes through a final screen size no greater than three quarters of an inch (FDEP, 2011).” Constituents found in RSM can include wood, rocks, drywall, and concrete (Clark, et al., 2006). The idea of recycling RSM has increased in popularity because it represents a sizable portion of the miscellaneous fraction of the C&D debris stream; however this category could not be quantified due to a lack of data because the market is still emerging.

RSM can be used with written approval from FDEP as a subsurface construction material at Class I or Class III landfills, as an initial and intermediate cover for landfills, in conjunction with encapsulation technologies such as part of the aggregate feed in the production of concrete or asphalt, or in residential applications as long as it meets all the safety criteria set forth by the FDEP (FDEP, 2011). Additional beneficial use proposals for processed RSM are evaluated by FDEP staff scientists and engineers on a case-by-case basis and are subject to the sampling and analysis procedures set forth by the FDEP. Potential contaminants include arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver, volatile organic compounds, semi-volatile organic compounds, and pesticides (FDEP, 2010a). RSM can only be used in a residential setting if the concentration of each regulated chemical constituent is below the most protective human health exposure levels and leaching tests do not indicate any likelihood for adverse impacts to ground water (FDEP, 2010a). RSM was successfully used in a residential application, on lots in Miramar, Florida to elevate low areas (excluding building pads) (Clark, et al., 2006).

3.3.3 Summary

Table 3.5 summarizes the supply and demand for each material quantified in the study and shows that when the state of Florida is used as the control boundary, 100 percent of the supply has the potential to be recycled. However, the introduction of more local markets is vital to the success of OC's high diversion goal because of the cost and time necessary for the transportation of recyclables. It is expected that asphalt shingles have a particularly high potential for use in a locally created end market as an alternative ingredient material in hot mix asphalt (HMA) because roadwork involving the need for HMA is pervasive throughout OC.

Table 3.5. Supply and Demand Summary for C&D Recyclables

Material	OC Supply (Tons)(Year)	Demand (Tons)(Year)
Concrete	62,000 (2010)	18×10^6 (2010)[1]
Drywall	17,000 (2009)	140,000 (2009)[1]
Wood		
Mulch	10,000 (2001)	200,000 (2001)[1]
WTE	34,000 (2010)	1.6×10^6 (2001)[2]
Asphalt Shingles	3,000 (2010)	182,000 (2010)[1]

[1]Statewide Demand
[2]Local Demand (within 110 miles from the center of OC)

CHAPTER 4: CONCLUSIONS AND RECOMMENDATIONS

With the State of Florida's 75 percent by the year 2020 recycling goal in place, Orange County must keep the development and implementation of a more efficient strategy for the handling of its solid waste a top priority. Economic, societal, and political factors are but some of the influences at play that will determine the success of the high diversion goal. As the county develops its SWIRP, it is necessary for decision makers to have access to the best available data in order to make informed decisions. Reliable data regarding current and historic debris generation and recycling rates and end markets for recyclable materials are crucial for rulemaking.

4.1 Comments on the Debris Generation Model

At the second OC SWIRP project workshop held on February 28th, 2012 officials discussed ways in which to measure the program's success and it was suggested that future debris diversion be measured against a previously established baseline. The baseline would require historic debris generation estimates while the ability to analyze generation in the future against the baseline would require a method for updating debris generation estimates in a timely fashion. Due to the current issues with inefficiencies in tracking as discussed in Section 2.4, a debris generation baseline based on information from the FDEP reports might be artificially high. The method for determining debris generation based on building permit information and debris generation multipliers outlined in this thesis is a sound alternative method for establishing a baseline as well as an updateable database which can be used for determining the success of the SWIRP at a later date.

It is important to note that a debris generation model based exclusively on building permit information excludes debris generation as a result of land clearing, road and bridge construction, and disasters. While debris from road and bridge construction is not considered MSW C&D debris, LCD is and disaster debris contains many of the same constituents as the more routine C&D debris stream. In most studies that link debris generation to building permit information, the quantification of LCD is normally omitted from the analysis (Bergsdal et al., 2007; Buenrostro et. al, 2001; Christiansen et. al, 1999; Cochran et al., 2010; Fatta et al., 2003; Franklin Associates, 1998; Kofoworola et al., 2009; Lage et al. , 2009; Llatas, 2011; Reinhart et al., 2002) because its generation is highly variable and a debris generation multiplier is therefore difficult to estimate. The limited data found in this study suggest that LCD constitutes a small fraction of total C&D debris generation. It is recommended that disaster debris be tracked separately from traditional C&D loads at the time of disaster using one of the database tools discussed in Section 2.1.2.4 in order to distinguish the contribution from disasters.

Lastly it is important to note that the debris generation multipliers used in this thesis come from literature values (Reinhart et al. 2002) which were based on composition studies performed in the Central Florida area in or about the year 2000. The multipliers were compared with multipliers from other studies, some more recent, from other parts of the world (Lage et al., 2009); (Franklin Associates, 1998); (Kofoworola et al., 2009) and were found to be reasonable but it is recommended that waste characterization studies be conducted to update the debris generation multipliers for future studies.

4.2 Asphalt Shingles as an Alternative Ingredient Material

In Chapter 3 the case was made that over 90 percent of OC's C&D materials can potentially be recycled using end markets that currently exist in the state, however it is vital for more local end markets to be established in order for OC to realize its maximum diversion rate. One of the best opportunities that OC has for establishing a new local end market quickly exists with the use of asphalt roofing shingles in HMA. Roadwork involving the need for HMA is pervasive throughout OC and the asphalt from shingle debris generated in OC could be used in the HMA. Testing should be conducted to determine the appropriate ratio of asphalt from shingles in HMA for near-term use in private projects such as parking lots, driveways, and private roads. HMA with recycled asphalt shingle content can be used for public road projects once the State of Florida adopts a standard. Successful testing will help to convince Florida to adopt such a standard which will create a long-term and steady local demand for recycled asphalt shingles.

APPENDIX A: AREA REPORT FROM ORANGE COUNTY'S ISS DIVISION

ORANGE COUNTY BUILDING DEPARTMENT
SQUARE FOOTAGE BY WORK TYPE

YEAR:2001 WORK TYPE[a]	RESIDENTIAL SQUARE FOOTAGE	COMMERCIAL SQUARE FOOTAGE
001	16,823,409	11,420,016
002	39,577	13,975
003	206,835	7,366,227
004	2,079,879	760,606
005	22,308	0
007	346,465	18,432
036	0	0

ORANGE COUNTY BUILDING DEPARTMENT
SQUARE FOOTAGE BY WORK TYPE

YEAR:2002 WORK TYPE[a]	RESIDENTIAL SQUARE FOOTAGE	COMMERCIAL SQUARE FOOTAGE
001	17,550,784	7,224,699
002	57,501	154,259
003	74,626	6,523,184
004	2,070,543	692,452
005	23,098	0
007	1,407,663	0
036	490	0

ORANGE COUNTY BUILDING DEPARTMENT
SQUARE FOOTAGE BY WORK TYPE

YEAR:2003 WORK TYPE[a]	RESIDENTIAL SQUARE FOOTAGE	COMMERCIAL SQUARE FOOTAGE
001	18,718,969	7,616,229
002	32,791	36,334
003	62,792	5,551,906
004	2,288,816	389,282
005	7,320	0
007	434,727	0
036	1,698	0

ORANGE COUNTY BUILDING DEPARTMENT
SQUARE FOOTAGE BY WORK TYPE

YEAR:2004 WORK TYPE[a]	RESIDENTIAL SQUARE FOOTAGE	COMMERCIAL SQUARE FOOTAGE
001	20,152,396	9,276,784
002	155,609	363,583
003	113,648	9,217,365
004	2,360,673	107,925
005	32,473	0
007	65,507	0
036	576	0

ORANGE COUNTY BUILDING DEPARTMENT
SQUARE FOOTAGE BY WORK TYPE

YEAR:2005 WORK TYPE[a]	RESIDENTIAL SQUARE FOOTAGE	COMMERCIAL SQUARE FOOTAGE
001	18,451,778	13,174,281
002	103,458	122,116
003	338,030	5,777,567
004	1,927,046	453,094
005	7,373	51,957
007	214,908	81,570
036	5,640	0

ORANGE COUNTY BUILDING DEPARTMENT
SQUARE FOOTAGE BY WORK TYPE

YEAR:2006 WORK TYPE[a]	RESIDENTIAL SQUARE FOOTAGE	COMMERCIAL SQUARE FOOTAGE
001	18,045,910	11,493,541
002	61,517	90,429
003	96,575	8,522,767
004	1,154,531	318,179
005	1,150	0
007	243,675	2,371
036	10,248	0

ORANGE COUNTY BUILDING DEPARTMENT
SQUARE FOOTAGE BY WORK TYPE

YEAR:2007 WORK TYPE[a]	RESIDENTIAL SQUARE FOOTAGE	COMMERCIAL SQUARE FOOTAGE
001	7,730,750	10,512,507
002	104,283	405,370
003	91,009	6,571,489
004	564,747	807,873
005	7,110	0
007	526,596	0
036	4,914	0

ORANGE COUNTY BUILDING DEPARTMENT
SQUARE FOOTAGE BY WORK TYPE

YEAR:2008 WORK TYPE[a]	RESIDENTIAL SQUARE FOOTAGE	COMMERCIAL SQUARE FOOTAGE
001	3,666,016	6,785,752
002	87,819	104,303
003	62,521	6,294,227
004	532,649	835,942
005	0	0
007	111,685	0
036	0	0

ORANGE COUNTY BUILDING DEPARTMENT
SQUARE FOOTAGE BY WORK TYPE

YEAR:2009 WORK TYPE[a]	RESIDENTIAL SQUARE FOOTAGE	COMMERCIAL SQUARE FOOTAGE
001	2,678,116	2,078,612
002	48,696	81,781
003	44,642	3,412,405
004	467,008	171,941
005	3,768	0
007	363,928	0
036	0	0

ORANGE COUNTY BUILDING DEPARTMENT
SQUARE FOOTAGE BY WORK TYPE

YEAR:2010 WORK TYPE[a]	RESIDENTIAL SQUARE FOOTAGE	COMMERCIAL SQUARE FOOTAGE
001	3,465,040	2,404,364
002	36,204	210,690
003	29,270	4,253,659
004	367,823	158,280
005	5,721	0
007	485,740	0
036	0	0

[a]Work Type Legend
001 ERECT
002 REPAIR/RENOVATE
003 ALTER
004 MAKE ADDITION TO
005 RE-ROOF
007 DEMOLISH
036 DETACHED GARAGE ERECT. AFTERHOME BUILT
* All other available work types did not pertain to this study.
** To determine the debris inventory the following table was used:

Work Type(s)		Sector of Activity
001	=	New Construction
007	=	Demolition
Renovations[b]		
002 + 003	=	Alterations
005	=	Roof Repairs
004 + 036	=	Additions

[b]The Renovations sector is the sum of alterations, roof repairs, and additions.

APPENDIX B: MRF AND MMRF LIST AND CONTACT INFORMATION

Facility	City	C&D Materials Recycled	Address	Contact	Additional Details
MRFs					
AARDX- Wolf, Inc.	Apopka	(Recycling Center)			
Commercial Metals Company	Apopka	Metals (Ferrous and non-ferrous)	3000 Gamson Rd. Apopka, FL 32703 Orange County	407-293-6584	Buys & Sells Ferrous Metals Buys & Sells Nonferrous Metals Buys junked, wrecked or running autos, trucks & buses Car crushing & hauling Industrial scrap container service New & usable steel products Scrap Processing Yards

Whisper Winds Landscaping, Inc.	Ocoee	Land Clearing Debris	441 Ocoee Apopka Road Ocoee, FL 34761-2147	407-877-0116	N/A
E&H Car Crushing Co., Inc.	Orlando	Metals (all)	106 Gloucester St. Orlando, FL 32833	(407) 568-5865	
Honey Bee Ranch	Orlando	Land Clearing Debris	19543 E Colonial Drive Orlando, FL 32709	407/568-6003	Take material at $7/yard, sell final product (mulch and top soil) for $8/yard
Orlando Recycling	Orlando	Paper and Cardboard	1625 W. Princeton St., #7 Orlando, FL 32804	(407) 872-1595	
Orlando Scrap Metal Recycling	Orlando	Metals (Aluminum, copper, brass, stainless steel, lead)	18778 E. Colonial Dr. Orlando, FL 32820	(407) 568-3666	
Promax Recycling, Inc[a]	Apopka	Concrete	3070 Apopka BlvdApopka, FL 32703	(407) 299-0001	
Double D Crushers[a]	Winter Garden	Concrete	12608 State Road 545Winter Garden, FL 34787	(407) 238-2328	
Independence Recycling[a]	Orlando	Concrete	9800 Recycle Center Rd. Orlando, FL 32824	(407) 240-1664	
American Demolition (Douglas Transport and Recycling Co.)[a]	Orlando	Concrete	118 W Grant St Orlando, FL 32806		

BG Group- Portable Crusher[a]	Pompano	Concrete	3851 NW 65th Drive Boca Raton, FL 33496	561/999-5962	
BPH Rock[a]	Orlando	Concrete	13037 Mulberry Park Dr, Orlando, FL 32821	(407) 827-7424	
Calleja, Joe E.[a]	Orlando	Concrete	4000 Forsyth Rd Orlando, FL 32792		
CEM Enterprises[a]	Winter Garden	Concrete	12608 Avalon Rd. Winter Garden, FL 34787	(407) 509-3409	
Central Hauling and Excavating[a]	Orlando	Concrete	11041 Rocket Blvd. Orlando, FL 32824	(407) 438-3830	
Crushing, Inc. Portable Crushing Unit[a]	Lakeland	Concrete	3350 Reynolds Rd. Lakeland, FL 33803		
D.L. Rees[a]	Orlando	Concrete	11281 Rocket Blvd. Orlando, FL 32824	(407) 859-3533	
Eagle Crusher (Eco-Rock Resource)[a]	Orlando	Concrete	2930 Eunice Ave. Orlando, FL. 32808		
Orlando Recycled Materials, Inc.[a]	Orlando	Concrete	2300 Mercator Dr. Orlando, FL 32807	(407) 699-0052	
Middlesex Asphalt LLC; Orange County Asphalt Plant #1[a]	Orlando	Concrete	10705 Cosmonaut Blvd. Orlando, FL 32824	(407) 206-0078	
Brothers Scrap Metals, Inc.[a]	Orlando	Metal	420 S Norton Ave. Orlando, FL 32805	407-872-3622	
Trademark Metals (3 Locations)[a]	Orlando	Metal	51 East Landstreet Rd. Orlando, FL 32824	407-855-2990	
MMRFs					
Angelo's Recycled Materials, Inc.	Apopka	Concrete, Asphalt	2105 Vulcan Rd Apopka, FL 32703	(407) 290-8010	

American Recycling Group (Waste Works)	Ocoee	Fiber, Metals, Plastics, Cardboard, scrap paper products. C&D specific: concrete, brick, stone, wood, drywall, glass, tiles, carpet, insulation, and shingles.	320 Enterprise Street, Ocoee, FL	(407) 447-0047	
Orange County Landfill	Orlando	Concrete, Soils, Wood, Cardboard, Metal and other C&D Materials	5901 Young Pine Road, Orlando, FL 32829	(407) 836-6600	
Pine Ridge Landfill (Waste Management)	Winter Garden	Wood, Drywall, Plastic, Paper, Glass, Metal, and Concrete	5400 Rex Dr. Winter Garden, FL 34787	(407) 836-6601	
Rocket Blvd. Materials Recovery Facility (Republic Services)	Orlando	Plastics 1-7, aluminum, tin and steel cans, cardboard, papers (office, junk mail, etc.) glass bottles, boxboard.	11255 Rocket Blvd., Orlando, FL 32824	(407) 293-8000	
Taft Recycling (Waste Services)	Taft	Cardboard, Aluminum Cans, Metal, Plastics, and Wood Pallets	375 7th Street Taft, FL 32824	(321) 202-8426	
West Orange Environmental Resources, LLC	Winter Garden	Cardboard, All Metals, Concrete, Lumber, Composite Wood, Wood Pallets, All Plastics, Plastic Pipe (HDPE and PVC)	7706 Avalon Road Winter Garden, FL 34787	(407) 814-7000	

APPENDIX C: MMRF SURVEYS

Materials Recovery Facility Survey: American Recycling Group (Waste Works)

Facility Address: American Recycling Group, 320 Enterprise Street, Ocoee, FL OC
Facility Contact: (407) 447-0047, Spoke with: Debbi
Survey Date: Spoke with Debbi on 12/13/2011(email: debbiwasteworks@yahoo.com)
Notes: DBA Waste Works (garbage and roll-off company) and American Recycling Group. Only facility is in Ocoee.

Questions:

1. What materials do you recover and recycle?

   Fiber, Metals, Plastics, Cardboard, scrap paper products. C&D specific: concrete, brick, stone, wood, drywall, glass, tiles, carpet, insulation, and shingles.

Materials Recovery Facility Survey: Angelo's Recycled Materials

Facility: Angelo's Recycled Materials

Facility Contact: Jenny/Genie/Ginny? (407) 290-8010

Survey Date: 6/3/2011

Questions:

1. What materials do you handle?

   Mainly Concrete and Asphalt. They are a crushing service. Deal with small amounts of land clearing debris. They crush to different sizes of concrete with a popular size being #57 which is a golf-ball sized product

   a. What happens to each material that you handle/do you recover materials for the purpose of recycling them?

   They sell the concrete and asphalt that they acquire. Their crushed concrete products are used most often as a stabilizer. For example, 90% of home depots in Florida use the crushed concrete produced as a base for their parking lots to which asphalt is then applied. Also, their product has been used at the Rock Springs recreation park. They did not give pricing info.

   She mentioned that they have explored in the past creating a concrete product from their incoming feedstock that can be used in the making of new cements. But, because each load entering their facility is so highly variable, they found this option impractical. They would end up having to test each load and then purifying each load.

2. What amount of material comes through your facility in a year?

   She said it depends on the number of crushing companies in the area at any given time. But, in 2006-2007 she quoted 360,000 tons and in 2010 200,000 tons.

She noted that she sold all the crushed product in 2006-2007 and could have sold 400,000 tons or more. But, currently they have stockpiles waiting to be sold because of the lack of construction occurring in Florida. She said that every other crusher is in the same boat right now.

a. What percentage of material that comes in to your facility is recovered?

The spokesperson quoted nearly 100%. The only portion that is wasted is garbage that might come in with the loads.

3. How do you know from where the material streams entering your facility orginate?

Often, they partner with contractors on jobs they know to exist. For example, when the old OUC building was renovated, they knew about the job and partnered with the contractor to have the concrete and asphalt delivered to their facility as opposed to a competitor.

Loads are hauled to their facility, they do not provide hauling.

They do not currently charge for incoming loads. This means that as a contractor, you can save a lot of money by giving concrete and asphalt to this facility as opposed to paying tipping fees at landfills to dispose of it.

In 2006-2007 when the crushed concrete product was selling well, they would offer up to $3/ton to contractors for their concrete and asphalt.

a. What tracking procedures do you have in place?

They said their tracking consists of asking where the large loads come from when they enter the facility. But, she said most originate within OC. She did not offer information on if they ask about the type of job the loads come from. I think we should make this question part of the survey.

4. What challenges do you face in managing the materials entering your facility?

Making sure there are no contaminants in the stream before crushing occurs.

Hinkley Center for Solid and Hazardous Waste Management

University of Central Florida

5. Do you prefer a single stream or multiple stream collection scheme? What do you most often deal with?

   They usually don't have to deal with mixed loads. She said usually construction or demolition is done in stages where concrete and asphalt are not mixed in the same container. Or, a job will deal with only one material or the other but not both.

6. Why do you think it is so cheap to dispose of materials in Central Florida vs. Recycling them?

   For them, this is likely not a concern as they do not charge a tipping fee. They merely make their money by receiving the materials for free and charging for the end product.

7. Can I call back with other questions?

   Yes

Materials Recovery Facility Survey: Golden Gem Road Class III

Facility: Golden Gem Road Class III (Owned by OCE, LLC)

Facility Contact: Greg Fowler, (407) 814-7000

Survey Date: January 11th, 2012

Questions:

1. What materials do you handle?

   Cardboard, All Metals, Concrete, Lumber, Composite Wood, Wood Pallets, All Plastics, Plastic Pipe (HDPE and PVC)

Materials Recovery Facility Survey: Orange County Landfill

Facility: Orange County Landfill, 5901 Young Pine Road, Orlando, FL 32829
Facility Contact: Debbie Sponsler, OC Solid Waste Division, Section Manager
(407) 836-6600
Survey Date: 2 main interviews, both on 9/28/2011

Questions:

1. What is the permitted capacity of the landfill and when is the projected closure date?

   36,460,000 cubic yards, 2075

2. What materials do you currently handle?

   Class I waste – food, household and other putrescible waste, Class III waste – construction and demolition debris, furniture, carpet, cardboard, metals, also yard waste, asbestos, tires.

3. What materials do you recover?

   Concrete, soils, wood, cardboard and metals

   a. (Follow Up) You mentioned you currently recycle concrete, soils, wood, cardboard, and metal with the only other viable option being roofing in the future. You don't see the possibility of recycling drywall and plastics in the future? If not, why?

      They had an innovative grant from the FDEP in 2001 - 2003 that looked at the options for recycling drywall; however, there were a lot of challenges and barriers. Here is a link to the final report on the FDEP website - http://www.dep.state.fl.us/waste/quick_topics/publications/shw/recycling/InnovativeGrants/IGyear3/finalreports/OrangeFinalRpt.pdf

      They have not evaluated to the feasibility of recycling plastics other than what is currently accepted at the RMPF. They have been approached by a company that is setting up facilities in Florida to process commercial application plastics and will be meeting with them in November. Their website is www.rationalenergies.com.

b. (Follow Up) I did not realize that the recycling efforts at the OC Landfill had started only recently Can you give the start date?

They have been recycling metals for years but wasn't sure of the exact start date. The wood and cardboard has been within the last year.

c. Can you provide the data from the start date to the most current tracking period for each recovered material, including amount of material accepted and recovery efficiency percentage of each material accepted if possible?

The primary material other than the metals that we are getting is scrap wood that goes to the yard waste area for grinding. She is trying to get the tonnage information for these loads. She also has staff compiling data for the last two years of metal shipments. They don't receive a lot of concrete, but often those customers are directed to unload at the concrete pile so no separate weights are obtained. Cardboard is the most challenging as often those loads come in with trash and packing materials mixed in and we don't have the equipment or staff to separate it out to meet the quality requirements of the RMPF.

d. (Follow Up) You mentioned: The cardboard is taken to Waste Management's Recycle America Facility. The metals go to E&H for recycling. Are these companies paying you for the materials they take? Are you paying them?

They are paying the contract rates.

e. If they are paying you, are you able to give the price structure ($/ton, $/lb, etc)?

WMRA pays us $7.50/ton up to the first 30,000 tons per year and then $5.50/ton for additional tonnage. Here is a link to the E & H contract on the county website – http://apps.ocfl.net/OrangeBids/Termcontracts/listtermcontract.asp?ID=62321&CT=application/pdf&FN=Y11-199.pdf

4. What amount of material comes through your facility in a year?

Since they have just started this they are still on a learning curve and don't have a feel for the maximum capacity at this time.

(Follow Up about Yard Waste/LCD) At the Landfill they break out the yard waste according to the final disposition – Class III or Compost. Class III yard waste is likely the closest to land clearing debris as this is the bulky waste, such as tree stumps or it is yard waste mixed with Class III waste. The Compost waste is from our residential haulers and residential/commercial landscapers and is primarily grass clippings and small bundles of limbs. They don't break out the yard waste according to source (residential or commercial) as the tip fee is the same for all yard waste materials.

The last complete fiscal year of data she has is for 2009 – 2010. They received 23,216.59 tons of Class III Yardwaste and 76,940.04 tons of Compost Yardwaste. All of the tonnage they get is classified as MSW for purposes of the state report.

a. Is there a surplus of material at your site?

   The concrete and soils are stockpiled for use as needed on-site. The wood is taken to yard waste for grinding and then used for road and slope stabilization. The cardboard is taken to Waste Management Recycle America. The metals go to E&H for recycling.

b. What amounts of each material are recovered per year (information for the years 2001-2010 is preferred but if that is too much, 2007-2010 is great)?

   They just started a few months ago. Let me know if you want that short timeframe of data.

5. What is done with recyclable materials once they are recovered at the OC landfill?

   They are placed in 40 cubic yard containers for processing. Soils and concrete are directed to stockpile areas

6. Do you prefer a single stream or multiple stream collection scheme? What do you most often deal with?

   Prefer multi-stream but we receive most material as single-stream.

7. What opportunities still exist for recycling at your facility (i.e. what materials do you think could be recycled at your facility that are not currently recycled)?

The only other items that might be a viable option would be roofing. This would only work if construction picked up or a major storm event occurred.

a. What is the projected date that the infrastructure will be in place to handle these materials?

Not known at this time. It would depend on the amount brought in.

8. What challenges do you face in managing the recovery of recyclable materials at your facility?

The C&D comes in at a slower frequency than the other Class III material and requires constant repositioning of equipment and containers.

9. In your opinion, what are the impediments to recycling C&D materials?

The manpower, equipment and space needed to separate the materials. If the separation was done at the generation site it would allow us to be more efficient.

10. Can I contact you again with other questions?

Yes

Materials Recovery Facility Survey: Rocket Blvd. MRF

Facility: Rocket Blvd. Materials Recovery Facility (Republic Services), 11255 Rocket Blvd., Orlando, FL 32824

Facility Contact:

Republic Services in Orlando FL (MRF)
11255 Rocket Boulevard, Orlando FL 32824
(407) 293-8000

Survey Date: 12/13/2011

Questions:

1. What materials do you recover/recycle?

   Plastics 1-7, aluminum, tin and steel cans, cardboard, papers (office, junk mail) glass bottles, boxboard.

Materials Recovery Facility Survey: Taft Recycling

Facility: Taft Recycling (aka South Orlando MRF), 375 West 7th Street, Orlando, FL 32824-8145

Facility Contact: Wilson Estevez, (407) 851-0074

Survey Date: 9/23/2011

Questions:

2. What materials do you handle?

   They are mainly a transfer station. They transfer anything that cannot be used on-site to Omniwaste landfill in St. Cloud (their affiliate landfill). They accept construction & demolition debris, landscaping, class III materials (furniture, carpet)

   a. What happens to each material that you handle/do you recover materials for the purpose of recycling them?

      Recycle cardboard, aluminum cans, metal, plastics, and wood pallets

      Materials come in with commercial contracts from roll off trucks.

      Pay for 100% recyclable recyclable materials (such as cardboard). Charge to take class III and unusable C&D materials (anything not from the list that can be recycled above. Also, anything that cannot be easily sorted into recyclable/nonrecyclable), and yard waste.

      Don't foresee recycling drywall or RSM because they are hard to sort and their operation is not set up for that now.

3. What amount of material comes through your facility in a year?

   Estimated 50- 60 tons a day just C&D in 2011, call back when Mr. Wilson Estevez is available for historic data.

4. What tracking procedures do you have in place?

   Question about origin of load is not usually asked about unless a company requires it.

5. Do you prefer a single stream or multiple stream collection scheme? What do you most often deal with?

   Prefer a multiple stream collection scheme because it improves the quality of recyclable materials and expedites sorting and processing.

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