CHARACTERIZATION OF BUILDING-RELATED CONSTRUCTION AND DEMOLITION DEBRIS IN THE UNITED STATES

Prepared for

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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

CHARACTERIZATION OF BUILDING-RELATED CONSTRUCTION AND DEMOLITION DEBRIS IN THE UNITED STATES

Executive Summary

INTRODUCTION

The purpose of this report is to characterize the quantity and composition of building-related construction and demolition (C&D) debris generated in the United States, and to summarize the waste management practices for this waste stream. C&D debris is produced when new structures are built and when existing structures are renovated or demolished. Structures include all residential and nonresidential buildings as well as public works projects, such as streets and highways, bridges, piers, and dams. Many state definitions of C&D debris also include trees, stumps, earth, and rock from the clearing of construction sites.

The focus of this report is on building-related wastes, including construction, demolition, and renovation of residential and nonresidential buildings. Road and bridge debris, land clearing debris, etc. are not covered in detail in this report. They are, however, discussed briefly.

METHODOLOGY

The methodology used for this study combines national Census Bureau data on construction industry activities with point source waste assessment data (i.e., waste sampling and weighing at a variety of construction and demolition sites) to estimate the amount of building-related C&D debris produced nationally.

It is important to recognize that this is a first attempt to use this methodology. It is expected that as the trend towards better characterization of C&D sites continues and more communities record their C&D debris quantities and compositions, the national estimates as developed in this report can be tested and modified accordingly. Currently, the limited point source waste assessment data may be a source of considerable uncertainty in the analysis.

Since the method developed here makes use of readily available Census Bureau data on national C&D activity, (e.g., construction and demolition permits and construction value) the methodology should be well suited for periodic updating. Waste assessment results should change very slowly over time because construction materials used and building construction practices remain relatively constant from year to year. Composition of waste from demolished buildings, which have been built over a range of years, should change even more slowly.

DEFINITIONS

(For purposes of this report, following is a working set of definitions)

Construction and Demolition (C&D) Debris is waste material that is produced in the process of construction, renovation, or demolition of structures. Structures include buildings of all types (both residential and nonresidential) as well as roads and bridges. Components of C&D debris typically include concrete, asphalt, wood, metals, gypsum wallboard, and roofing. Land clearing debris, such as stumps, rocks, and dirt, are also included in some state definitions of C&D debris.

Generation of C&D debris, as used in this report, refers to the weight of materials and products as they enter the waste management system from the construction, renovation, or demolition of structures, and before materials recovery or combustion takes place. Source reduction activities (e.g., on-site usage of waste wood mulch or the on-site use of drywall as a soil amendment) take place *ahead* of generation, i.e., they reduce the amount of waste generated.

Recovery of materials, as estimated in this report, includes the removal of products or materials from the waste stream for the purpose of **recycling** the materials in the manufacture of new products.

Source reduction activities reduce the amount or toxicity of wastes before they enter the waste management system. **Reuse** is a source reduction activity involving the recovery or reapplication of a product or material in a manner that retains its original form and identity. Reuse of products such as light fixtures, doors, or used brick is considered source reduction, not recycling.

Discards include the C&D debris remaining after recovery for recycling (including composting). These discards would presumably be combusted or landfilled, although some debris is littered, stored or disposed on-site, or burned on-site.

REPORT HIGHLIGHTS

Building-Related C&D Debris Generation Estimates

- An estimated 136 million tons of building-related C&D debris were generated in 1996 (Table ES-1).
- The estimated per capita generation rate in 1996 was 2.8 pounds per person per day.
- Forty-three percent of the waste (58 million tons per year) is generated from residential sources and 57 percent (78 million tons per year) is from nonresidential sources.
- Building demolitions account for 48 percent of the waste stream, or 65 million tons per year; renovations account for 44 percent, or 60 million tons per year; and 8 percent, or 11 million tons per year, is generated at construction sites.

Table ES-1

SUMMARY OF ESTIMATED BUILDING-RELATED C&D DEBRIS GENERATION, 1996*
(Roadway, Bridge, and Land Clearing Debris not included)
(Thousand Tons)

Source	Residential		Nonresidential		Totals	
	Thou tons	Percent	Thou tons	Percent	Thou tons	Percent
Construction	6,560	11	4,270	6	**10,830**	**8**
Renovation	31,900	55	28,000	36	**59,900**	**44**
Demolition	19,700	34	45,100	58	**64,800**	**48**
Totals	**58,160**	100	**77,370**	100	**135,530**	**100**
Percent	**43**		**57**		**100**	

* C&D debris managed on-site should, in theory, be deducted from generation. Quantities managed on-site are unknown.

Source: Franklin Associates

Composition of C&D Debris from Buildings

The composition of C&D debris is highly variable and depends critically on the type of activity where sampling is done. Whereas wood is typically the largest component of waste material generated at construction and renovation sites, concrete is commonly the largest component of building demolition debris.

Road, Bridge, and Land Clearing Debris

Road, bridge, and land clearing wastes represent a major portion of total C&D debris, and some of the materials produced are managed by the same processors and landfills that manage building-related wastes. A methodology was not developed in the scope of this project to estimate these wastes. Point source waste assessment data were not available for these projects.

Management Practices for C&D Debris

- The most common management practice for C&D debris is landfilling, including C&D landfills, MSW landfills, and unpermitted sites. An estimated 35 to 45 percent was discarded in C&D landfills in 1996. An estimated 30 to 40 percent of C&D debris is managed on-site, at MSW landfills, or at unpermitted landfills.

- A 1994 survey done for the EPA identified about 1,900 active C&D landfills in the United States.

- An estimated 20 - 30 percent of building-related C&D debris was recovered for processing and recycling in 1996. The materials most frequently recovered and recycled are concrete, asphalt, metals, and wood.

- There is an trend toward increasing recovery of C&D debris in the United States. ***C&D Recycling*** estimates there are about 3,500 operating facilities that process C&D debris materials in the United States.

- Recent deconstruction demonstration projects show that high diversion rates may be achieved. Deconstruction minimizes contamination of demolition debris; however, it is labor intensive, and generally requires more time than traditional demolition.

- Metals have the highest recycling rates among the materials recovered from C&D sites. The Steel Recycling Institute estimates that the recycling rate for C&D steel is about 85 percent (18.2 million tons out of 21.4 million tons generated). These numbers include not only scrap steel from buildings but also from roads and bridges.

- We estimate there are about 500 wood processing facilities in the United States that derive wood from C&D debris. The leading states for these wood processing plants are North Carolina, Oregon, and California.

Peer Review and Data Sources

This first edition report underwent extensive internal and external peer review of methodology and data sources. Major contributors of data sources and peer review include the National Association of Home Builders Research Center; Gershman, Brickner & Bratton, Inc.; EPA Region 5, and the U.S. Department of Commerce, Bureau of the Census.

As part of an ongoing effort to better characterize non-hazardous wastes subject to regulation under Subtitle D of RCRA, USEPA encourages public comment on this report, including additional methodological considerations and data sources.

Chapter 1

INTRODUCTION AND METHODOLOGY

BACKGROUND

The purpose of this report is to characterize building-related construction and demolition (C&D) debris generated in the United States. Construction and demolition debris is produced when new structures are built and when existing structures are renovated or demolished. Structures include all residential and nonresidential buildings as well as public works projects, such as streets and highways, bridges, piers, and dams. Many state definitions of C&D debris also include trees, stumps, earth, and rock from the clearing of construction sites.

National estimates of construction and demolition debris generation have been limited in the past to extrapolation of local data, using population or construction employment to make the extrapolations. Values for generation rates reported in various locations across the country have ranged from 0.12 to 3.52 pounds per capita per day (Wilson 1977), a range too large for meaningful extrapolations.

At least three studies in the past 30 years have made national generation rate estimates. The first was a 1969 Public Health Service study, which reported a national average of 0.66 pounds per person per day (ppd) (PHS 1969). The same study reported an urban average generation rate of 0.72 ppd, a number which was also reported in the 1986 EPA municipal solid waste characterization report as an estimate for the national average (EPA 1986). Based on the U.S. population in 1986 (240 million), the EPA report estimated 31.5 million tons per year of C&D debris generation.

In a draft report prepared for the National Renewable Energy Laboratory in 1994 (Franklin 1994), Franklin Associates identified 22 cities, counties, or states for which C&D debris data were reported. There was a weak but positive correlation between C&D debris generation and per capita construction employment in each area. The national extrapolated estimate for C&D debris generation using that methodology was 64.4 million tons per year.

The previous C&D debris estimates for the United States now appear to be low, based on the results of this study. As discussed in the sections that follow, we estimate that C&D debris generation for building-related wastes only (i.e., excluding wastes from roadways, bridges, land clearing, and excavation), was about 136 million tons in 1996.

METHODOLOGY

The initial objective of this study was to develop a methodology somewhat parallel to EPA's material flows methodology used for MSW characterization that would use readily available national data, which would be suitable for periodic updates. The material flows methodology starts with national production data by material and product, adjusts for imports, exports, average lifetimes, and consumption, and then calculates national generation by summing up all the materials and products that make up MSW. Because of the long and extremely variable lifetimes of buildings, roads, and other structures, the material flows method was determined to be infeasible for C&D debris.

Another approach—sampling and weighing at landfills—is often used for determining local waste management system needs and would be the preferred method for this study if sufficient time and funds were available. However, even on the local level there may be significant barriers to this method. Sampling from a mixed waste stream with statistical confidence is very difficult, time consuming, and costly. Locating all the places where C&D debris is placed is not a trivial matter in some localities, and obtaining permission to sample at private landfills can be a major challenge. For a national study of this type, this method would be both cost and time prohibitive.

The methodology used for this study combines national Census Bureau data on construction industry project activity with point source waste assessment data (i.e., waste sampling and weighing at a variety of construction and demolition sites) to estimate the amount of C&D debris produced nationally. Because of the lack of point source waste assessment data from roadway, bridge, and landclearing projects, this study was limited to building-related wastes.

It is important to recognize that this is a first attempt to use this methodology. We expect that as the trend towards better characterization of C&D sites continues where more communities record their C&D debris quantities and compositions, the national estimates as developed in this report can be tested and modified accordingly. Currently, the limited point source waste assessment data may be a source of considerable uncertainty in the analysis.

Since the methodology developed here makes use of readily available Census Bureau data on national C&D activity, (e.g., construction and demolition permits and construction value) the methodology should be well suited for periodic updating. Waste assessment results should change very slowly over time because construction materials used and building construction practices remain relatively constant from year to year. Composition of waste from demolished buildings, which were built over a range of years, should change even more slowly.

PEER REVIEW AND DATA SOURCES

This first edition report underwent extensive internal and external peer review of methodology and data sources. Major contributors of data sources and peer review include the National Association of Home Builders Research Center, Gershman, Brickner & Bratton, Inc., EPA Region 5, and the U.S. Department of Commerce, Bureau of the Census.

During the peer review process, a consensus was reached that this report represents a credible attempt at estimating national generation of building-related construction and demolition debris. However, the report could benefit from additional waste sampling studies to strengthen the source category (construction, demolition, and renovation) estimates. Further, future editions will need to address roadway, bridge, and land clearing debris in order to present a more complete picture of the national construction and demolition waste stream. As part of an ongoing effort to better characterize non-hazardous wastes subject to regulation under Subtitle D of RCRA, USEPA encourages public comment on this report, including additional methodological considerations and data sources.

DEFINING C&D DEBRIS

A broad definition of the representative projects and sources of C&D debris is shown below (Table 1). This table shows that the generation sources of C&D debris cover a broad segment of the U.S. economy. The sources range from homebuilders and homeowners to general commercial developers, general building contractors, highway and street contractors, bridge erectors/constructors, bituminous pavement contractors, small home remodelers, site grading contractors, demolition contractors, roofing contractors and drywallers, and excavation specialists.

The amount of C&D debris generated and reported to regulatory agencies around the country varies considerably from one community to another. This variation is created, in part, by the difference in state regulations on the subject material, and also by the historical demographics and current growth and development activity of the community.

Excerpts from a number of state definitions of C&D debris are presented in this chapter, with more complete citations in Appendix B. This is a representative sample of how states are defining C&D debris. It illustrates the diversity of C&D debris terminology. Several states include land-clearing debris as C&D; however, Massachusetts, New York, and North Carolina specifically exclude these materials. Oregon excludes clean fill materials when separated from other C&D wastes and used as fill materials or otherwise land disposed. New York, Kansas, and Rhode Island's definitions specifically exclude some materials, even

Table 1

REPRESENTATIVE GENERATION SOURCES OF C&D SECTOR MATERIALS*

Site clearance materials
(Brush, tree, and stumpage materials)

Excavated materials
(Earth, fill, and other excavated rock and granular materials)

Roadwork materials
Concrete slabs and chunks from concrete road construction
Asphalt chunks and millings from asphalt pavement
Bridge/overpass construction/renovation materials

New construction materials
(Residential, commercial, and industrial project sources)

Renovation, remodeling or repair materials
(Residential, commercial, and industrial project sources)

Demolition materials . . . including wrecking, implosion, dismantling, and deconstruction
(Residential, commercial, and industrial project sources)

Disaster debris

* Note that estimates for site clearance, excavated materials, and roadwork materials are not included in this report.

Source: Gershman, Brickner & Bratton, Inc. Fairfax, Virginia

if resulting from C&D activities. Examples of exclusions include garbage, carpeting, furniture, corrugated containerboard, and other containers.

The variance in state definitions affects the interpretation of the results of this report. Corrections or adjustments may be required when comparing the results of this report with state data, depending on the definition the state used. Corrections may also be required when comparing data from any two states.

The amount of C&D debris available for discard in any region also depends on the general economic conditions of the region, the weather, major disasters, special projects, and local regulations. In fast growing areas, the C&D waste stream from buildings consists primarily of construction debris, with much smaller quantities of demolition debris. Demolition debris is produced when older buildings are demolished to make way for the new developments. By contrast, in many urban areas demolition debris dominates the C&D waste stream.

STATE DEFINITIONS FOR CONSTRUCTION AND DEMOLITION DEBRIS
(A representative sample of definitions that points out the variability of definitions used)

California. Construction and demolition (C&D) debris includes concrete, asphalt, wood, drywall, metals, and many miscellaneous and composite materials. C&D debris is generated by demolition and new construction of structures such as residential and commercial buildings and roadways.

Florida. "Construction and demolition debris" means 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 or 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 . . . unpainted, non-treated wood scraps from facilities manufacturing materials used for construction of structures or their components and unpainted, non-treated wood pallets provided the wood scraps and pallets are separated from other solid waste; and the commingling of wood scraps or pallets with other solid waste; and *de minimis* amounts of other non-hazardous wastes that are generated at construction or demolition projects . . . .

Hawaii. "Construction and demolition waste" means solid waste, largely inert waste, resulting from the demolition or razing of buildings, of roads, or other structures, such as concrete, rock, brick, bituminous concrete, wood, and masonry, composition roofing and roofing paper, steel, plaster, and minor amounts of other metals, such as copper. Construction and demolition waste does not include cleanup materials contaminated with hazardous substances, friable asbestos, waste paints, solvents, sealers, adhesives, or similar materials.

Kansas. "Construction and demolition waste" means solid waste resulting from the construction, remodeling, repair and demolition of structures, roads, sidewalks and utilities; and solid waste consisting of vegetation from land clearing and grubbing, utility maintenance, and seasonal or storm-related cleanup. Such wastes include, but are not limited to, bricks, concrete and other masonry materials, roofing materials, soil, rock, wood, wood products, wall covering, plaster, drywall, plumbing fixtures, electrical wiring, electrical components containing no hazardous materials and non asbestos insulation. It shall not include asbestos waste, garbage, cardboard, furniture, appliances, electrical equipment containing hazardous materials, tires, drums and containers even though such wastes resulted from construction and demolition activities. Clean rubble that is mixed with other construction and demolition waste during demolition or transportation shall be considered to be construction and demolition waste.

Kentucky. . . . Construction/demolition debris . . . results from the construction, remodeling, repair, and demolition of structures and roads and . . . uncontaminated solid waste consisting of vegetation resulting from land clearing and grubbing, utility line maintenance, and seasonal and storm-related cleanup. Such waste includes, but is not limited to bricks, shredded or segmented tires, concrete and other masonry materials, soil, rock, wood, wall coverings, plaster, drywall, plumbing fixtures, tree stumps, limbs, saw dust, leaves, yard waste, paper, paper products, metals, furniture, insulation, roofing shingles, asphalt pavement, glass, plastics that are not sealed in a manner that conceals other wastes, electrical wiring and components containing no liquids or hazardous metals that are incidental to any of the above . . . . Asbestos . . . only if approved by the division . . . .

STATE DEFINITIONS FOR CONSTRUCTION AND DEMOLITION DEBRIS (Continued)

Maricopa County, Arizona. Construction debris is a general term used to describe a large class of solid wastes usually generated as a byproduct of the construction, demolition, or maintenance of residences, commercial or industrial facilities and infrastructure. Construction debris includes such materials as: broken concrete, asphalt, steel, aluminum, glass, brick, tile, paper, plastics, wood products, sheet rock, street sweepings and canal dredgings.

Massachusetts. C&D waste is comprised of debris generated from construction, renovation, repair, and demolition of roads, bridges, and buildings and includes wood, steel, concrete, masonry, plaster, metal, and asphalt, but not wood from land-clearing, i.e. stumps, logs, brush, and soil, nor rock from excavations.

Minnesota. Construction Wastes—Building materials, packaging, and rubble resulting from construction, remodeling, repair, and demolition of buildings and roads.
Demolition Debris—Solid waste resulting from the demolition of buildings, roads, and other man-made structures, including concrete, brick, bituminous concrete, untreated wood, masonry, glass, trees, rock, and plastic building parts. Demolition debris does not include asbestos.

North Carolina. "Construction" or "demolition" when used in connection with "waste" or "debris" means solid waste resulting solely from construction, remodeling, repair, or demolition operations on pavement, buildings, or other structures, but does not include inert debris, land-clearing debris or yard debris.

Nebraska. "Construction and demolition waste" shall mean waste which typically results from construction or demolition projects and includes all materials which are the by-products of construction work or which result from demolition of buildings and other structures, including, but not limited to brick, concrete rubble, masonry materials, paper, gypsum board, wood, rubber and plastics. Construction and demolition waste does not include friable asbestos-containing materials, liquid waste, hazardous waste, putrescible waste or furnishings from demolished structures.

New York. Construction and demolition (C&D) debris means uncontaminated solid waste resulting from the construction, remodeling, repair and demolition of utilities, structures and roads; and uncontaminated solid waste resulting from land clearing. Such waste includes, but is not limited to bricks, concrete and other masonry materials, soil, rock, wood (including painted, treated and coated wood and wood products), land clearing debris, wall coverings, plaster, drywall, plumbing fixtures, non asbestos insulation, roofing shingles and other roof coverings, asphalt pavement, glass, plastics that are not sealed in a manner that conceals other wastes, empty buckets ten gallons or less in size and having no more than one inch of residue remaining on the bottom, electrical wiring and components containing no hazardous liquids, and pipe and metals that are incidental to any of the above. Solid waste that is not C&D debris (even if resulting from the construction, remodeling, repair and demolition of utilities, structures and roads and land clearing) includes, but is not limited to asbestos waste, garbage, corrugated container board, electrical fixtures containing hazardous liquids such as fluorescent light ballasts or transformers, fluorescent lights, carpeting, furniture, appliances, tires, drums, containers greater than ten gallons in size, any containers having more than one inch of residue remaining on the bottom and fuel tanks. . . .

STATE DEFINITIONS FOR CONSTRUCTION AND DEMOLITION DEBRIS (Continued)

Oregon. "Construction and Demolition Waste" means solid waste resulting from the construction, repair or demolition of buildings, roads and other structures, and debris from the clearing of land, but does not include clean fill when separated from other construction and demolition wastes and used as fill materials or otherwise land disposed. Such waste typically consists of materials including concrete, bricks, bituminous concrete, asphalt paving, untreated or chemically treated wood, glass, masonry, roofing, siding, plaster; and soils, rock, stumps, boulders, brush and other similar material. This term does not include industrial solid waste and municipal solid waste generated in residential or commercial activities associated with construction and demolition activities.

Portland, Oregon Metropolitan Service District. Construction Waste - Waste materials resulting from the construction, remodeling and repair of buildings and other structures.
Demolition Waste - Solid waste, largely inert, resulting from the demolition or razing of buildings, roads, and other man-made structures. Demolition waste consists of, but is not limited to, concrete, brick, bituminous concrete, wood, masonry, composition, roofing and roofing paper, steel, and amounts of other metals like copper. Plaster (i.e., sheet rock or plasterboard), any other non-wood material that is likely to produce gases or leachate during the decomposition process, and asbestos wastes are not considered to be demolition wastes.

Rhode Island. "Construction and Demolition (C&D) Debris" shall mean non-hazardous solid waste resulting from the construction, remodeling, repair, and demolition of utilities and structures; and uncontaminated solid waste resulting from land clearing. Such waste includes, but is not limited to wood (including painted, treated and coated wood and wood products), land clearing debris, wall coverings, plaster, drywall, plumbing fixtures, non-asbestos insulation, roofing shingles and other roofing coverings, glass, plastics that are not sealed in a manner that conceals other wastes, empty buckets ten gallons or less in size and having no more than one inch of residue remaining on the bottom, electrical wiring and components containing no hazardous liquids, and pipe and metals that are incidental to any of the above. Solid waste that is not C&D debris (even if resulting from the construction, remodeling, repair, and demolition of utilities, structures, and roads and land clearing) includes, but is not limited to, asbestos waste, garbage, corrugated container board, electrical fixtures containing hazardous liquids such as fluorescent light ballasts or transformers, fluorescent lights, carpeting, furniture, appliances, tires, drums, containers greater than ten gallons in size, any containers having more than one inch of residue remaining on the bottom, and fuel tanks. . . .

South Carolina. "Construction and demolition debris" means discarded solid wastes resulting from construction, remodeling, repair and demolition of structures, road building, and land-clearing. The wastes include, but are not limited to, bricks, concrete, and other masonry materials, soil, rock, lumber, road spoils, paving material, and tree and brush stumps, but does not include solid waste from agricultural or silvicultural operations.

Washington. "Demolition waste" means solid waste, largely inert waste, resulting from the demolition or razing of buildings, roads and other man-made structures. Demolition waste consists of, but is not limited to, concrete, brick, bituminous concrete, wood and masonry, composition roofing and roofing paper, steel, and minor amounts of other metals like copper. Plaster (i.e., sheet rock or plaster board) or any other material, other than wood, that is likely to produce gases or a leachate during the decomposition process and asbestos wastes are not considered to be demolition waste . . . .

See Appendix B for complete texts and citations.

The components that make up C&D debris also vary a great deal depending on the type of construction and the methods used by the construction industry. Table 2 shows typical contents of C&D debris by broad material types. Table C-1 in Appendix C shows a more detailed list of C&D debris components.

Construction debris from building sites typically consists of trim scraps of construction materials, such as wood, sheetrock, masonry, and roofing materials. There is typically much less concrete in construction debris than demolition debris, although some construction projects produce considerable quantities of concrete, depending on the technology used to build the concrete walls. Scrap from residential construction sites typically represents between 6 and 8 percent of the total weight of the building materials delivered to the site, excluding the foundation, concrete floors, driveways, patios, etc. There is typically very little waste concrete to dispose of from residential construction projects.

Table 2

TYPICAL COMPONENTS OF CONSTRUCTION AND DEMOLITION DEBRIS

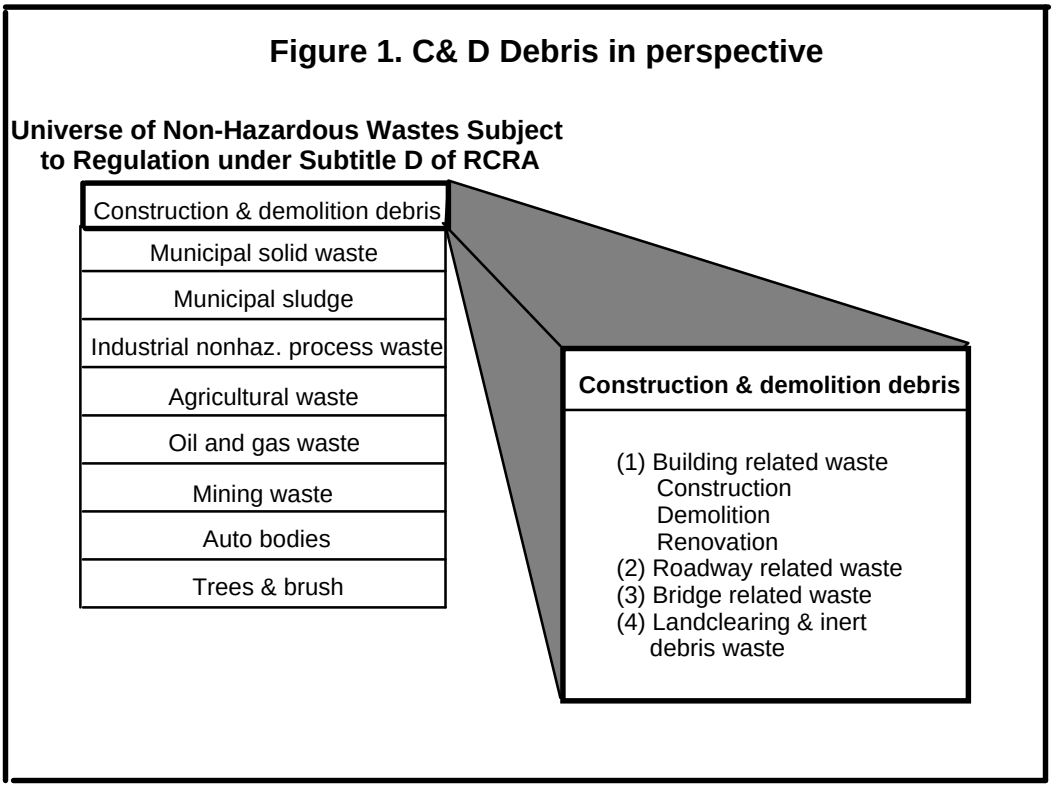
Material Components	**Content Examples**
Wood	Forming and framing lumber, stumps, plywood, laminates, scraps
Drywall	Sheetrock, gypsum, plaster
Metals	Pipes, rebar, flashing, steel, aluminum, copper, brass, stainless steel
Plastics	Vinyl siding, doors, windows, floor tile, pipes
Roofing	Asphalt & wood shingles, slate, tile, roofing felt
Rubble	Asphalt, concrete, cinder blocks, rock, earth
Brick	Bricks and decorative blocks
Glass	Windows, mirrors, lights
Miscellaneous	Carpeting, fixtures, insulation, ceramic tile

When buildings are demolished, large quantities of waste may be produced in a relatively short period of time, depending on the demolition technique used. The demolition project duration can vary depending on the technique used—implode a structure with explosives, use a crane and wrecking ball technique, or deconstruct the structure. In actual practice, the vast majority of demolition projects use a combination of the last two basic techniques depending on the materials used in the original project, the physical size of the structure, the surrounding buildings that cannot be disturbed or impacted, and the time allocated for the project. One hundred percent of the weight of a building, including the concrete foundations, driveways, patios, etc., may be generated as C&D debris when a building is demolished. On a per building basis, demolition waste quantities may be 20 to 30 times as much as construction debris.

CONSTRUCTION AND DEMOLITION DEBRIS IN PERSPECTIVE

C&D debris is generally a non-hazardous waste subject to regulation under Subtitle D, as shown in Figure 1. Other non-hazardous wastes include municipal solid waste (MSW), sludges from water and wastewater treatment plants, nonhazardous wastes from industrial processes, agricultural wastes, oil and gas wastes, mining wastes, spent automobiles, and trees and brush. MSW, which is primarily the waste from residential and commercial sources, has been characterized in more detail and for a longer period of time by the EPA than the other non-hazardous wastes. A material flows methodology was developed for MSW characterization in the late 1960s and early 1970s, and has been modified and updated periodically since then. The latest of the EPA reports was published in May of 1998 (EPA 1998).

Figure 1. C& D Debris in perspective



Although the C&D debris stream is usually described based on its origin as outlined in Table 1 above, there are some potential overlaps with other waste streams, in particular, MSW. For example, the MSW characterization includes all postconsumer corrugated boxes, even though significant quantities of these boxes enter the waste stream from building construction sites. (See Appendix A, Table A-11.) To simply sum up the national quantities of MSW and C&D debris could result in double counting. Other examples of MSW sometimes collected at C&D sites include wood pallets, food and beverage containers, caulking tubes, and paint containers. On the other hand, building material wastes are frequently collected by MSW waste management systems. However, EPA's material flows

methodology does not include them. Examples include pipes, plumbing fixtures, and building materials that are replaced by residents and discarded with their household trash. The overlap issues are discussed further in Chapter 4 of this report.

The six activities that generate C&D debris from buildings include the construction, demolition, and renovation (improvements and repair) of both residential and nonresidential buildings. Residential buildings include single-family houses and duplexes, up to and including high rise multi-family housing. Nonresidential buildings include commercial, institutional, and industrial buildings.

Construction activities generally produce cleaner materials than demolition. Demolitions may produce several types of materials bonded together or contaminated with hazardous materials, such as asbestos or lead paint. Renovation projects can produce both construction and demolition type wastes.

DEFINITIONS
(For purposes of this report, following is a working set of definitions)

Construction and Demolition (C&D) Debris is waste material that is produced in the process of construction, renovation, or demolition of structures. Structures include buildings of all types (both residential and nonresidential) as well as roads and bridges. Components of C&D debris typically include concrete, asphalt, wood, metals, gypsum wallboard, floor tile, and roofing. Land clearing debris, such as stumps, rocks, and dirt, are also included in some state definitions of C&D debris.

Generation of C&D debris, as used in this report, refers to the weight of materials and products as they enter the waste management system from the construction, renovation, or demolition of structures, and before materials recovery or combustion takes place. Source reduction activities (e.g., on-site usage of waste wood mulch or the on-site use of drywall as a soil amendment) take place *ahead* of generation, i.e., they reduce the amount of waste generated.

Recovery of materials, as estimated in this report, includes the removal of products or materials from the waste stream for the purpose of **recycling** the materials in the manufacture of new products.

Source reduction activities reduce the amount or toxicity of wastes before they enter the waste management system. **Reuse** is a source reduction activity involving the recovery or reapplication of a product or material in a manner that retains its original form and identity. Reuse of products such as light fixtures, doors, or used brick is considered source reduction, not recycling.

Discards include the C&D debris remaining after recovery for recycling (including composting). These discards would presumably be combusted or landfilled, although some debris is littered, stored or disposed on-site, or burned on-site.

OVERVIEW OF THIS REPORT

Chapter 1 contains background information on the methodology used for this report, examples of state definitions for C&D debris, and perspectives on the components of C&D and its relationship to other non-hazardous wastes. Chapter 2 contains estimates of the national generation of the building fraction of C&D debris from each of six major building C&D activities, i.e., residential construction, demolition, and renovation, and nonresidential construction, demolition, and renovation. Examples of locally generated data for the other C&D related generating sectors, e.g., roadway, bridge, and land clearing debris are presented for illustrative purposes. Also included in Chapter 2 are some data showing the composition of C&D debris from the various C&D activities.

Chapter 3 of the report discusses the options for management of C&D debris in the United States, including landfilling and recovery for recycling.

Chapter 4, Perspectives, discusses the overlap of the C&D debris waste stream and the MSW waste stream.

Chapter 1

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Chapter 2

GENERATION OF CONSTRUCTION AND DEMOLITION DEBRIS

INTRODUCTION

For the purposes of this initial national report, emphasis has been placed on the generation of construction and demolition (C&D) debris from building construction, demolition, and renovation activities. Examples of locally generated data for the other C&D-related generating sectors, e.g., roadway, bridge, and land clearing debris, are presented.

BUILDING-RELATED CONSTRUCTION AND DEMOLITION DEBRIS GENERATION

For analysis purposes, building C&D debris is divided into six categories: residential construction, demolition, and renovation and nonresidential construction, demolition, and renovation. These categories were selected based on the relationship between available Census data and empirical composition factors.

The following sections describe the data used and the methods for estimating the amount of building-related C&D debris generated, on a weight basis. Tables A-1 through A-6 in Appendix A are worksheets that provide details of the calculations used to arrive at generation for each component of the C&D debris stream.

Construction Debris

Residential. Empirical data for new residential construction have been identified from five sources: The NAHB Research Center; METRO in Portland, Oregon; Woodbin 2 in Cary, North Carolina; McHenry County, Illinois; and Cornell University. Each of these groups has conducted waste assessments at new construction sites.

The National Association of Homebuilders (NAHB) Research Center has developed a detailed methodology for conducting waste assessments at construction sites. Assessment data have been analyzed for single-family residential construction debris at four sites, including Largo, Maryland; Anne Arundel County, Maryland; Portland, Oregon; and Grand Rapids, Michigan. The NAHB Research Center also conducted a waste assessment at a 36-unit condominium construction project in Odenton, Maryland.

The Metropolitan Service District in Portland, Oregon (METRO) conducted a series of sampling projects at a large number of residential construction sites in Oregon over the last 5 or more years.

Wake County, North Carolina and the North Carolina Division of Pollution Prevention and Environmental Assistance conducted five residential construction waste assessments in the Raleigh, North Carolina area. Woodbin 2, a non-profit organization of the County, organized the assessments.

McHenry County, Illinois conducted waste audits at a single-family construction site and a 6-unit apartment building, and Cornell University conducted a waste audit at a single-family residence in New York.

The data from the five sources are summarized in Table 3. A total of 93 dwelling units are represented on this table. Generation rates ranged from 2.41 to 11.3 pounds per square foot of floor space. Geography does not appear to be the reason for the spread in data; it is more likely the types of houses, the specific practices of the builders, and the lack of uniform standards for the collection and storage of the sampled materials. The weighted average value from the five sources is 4.38 pounds per square foot.

Extrapolation factors are Census Bureau data that record the number of construction permits and the total square feet of new construction. According to the Department of Commerce Current Construction Reports (C-30), in 1996 the value of new private and public residential construction put in place totaled $181.795 billion. Data from areas where permits are required were used to calculate an average dollars per square foot. Total value in areas where permits are required was $127.9 billion for a total of 2,172 million square feet of floor space (1995). This amounts to $58.89 per square foot. Applying this factor to the total C-30 value and correcting 3 percent for inflation results in a total of 2,997 million square feet of new residential construction in 1996. At 4.38 pounds per square foot (Table 3), total generation is **6.56** million tons per year.

Nonresidential. The methodology for nonresidential construction debris is similar to that for residential construction debris. However, nonresidential buildings are much more varied than residential buildings and fewer waste assessments have been done, making the quantity estimates more uncertain.

Nonresidential buildings include private industrial, office, hotels/motels, other commercial, religious, educational, hospital and institutional, and miscellaneous buildings plus public industrial, educational, hospital, and other categories.

Table 3
ESTIMATED GENERATION OF RESIDENTIAL CONSTRUCTION DEBRIS

EMPIRICAL WASTE ASSESSMENTS

Date	Research Group	Type of data	Location	No. of Units	Building Size (Sq ft)	Total Waste (Pounds)	Generation rate (Lb/sq ft)	Average generation (Lb/sq ft)
1992	NAHB	Single-family	Portland, OR	1	3,000	13,684	4.56	
1994	NAHB	Single-family	Grand Rapids, MI	1	2,600	12,182	4.69	
1994	NAHB	Single-family	Largo, MD	1	2,200	10,210	4.64	
1995	NAHB	Single-family	Ann Arundel Cty, MD	1	2,450	9,436	3.85	
		Totals			10,250	45,512		**4.44**
1993	METRO	Single-family	Portland, OR	1	2,800	13,800	4.93	
1994	METRO	Single-family	Portland, OR	1	1,290	8,600	6.67	
1994	METRO	Single-family	Portland, OR	1	1,290	10,600	8.22	
		Totals			5,380	33,000		**6.13**
<1994	METRO (1)	Single family	Portland, OR	37	2,080	7,720	3.71	**3.71**
1996-97	Woodbin 2 (2)	Single-family	North Carolina	1	3,250	19,382	5.96	
1996-97	Woodbin 2	Single-family	North Carolina	1	3,250	36,722	11.30	
1996-97	Woodbin 2	Single-family	North Carolina	1	3,250	25,296	7.78	
1996-97	Woodbin 2	Single-family	North Carolina	1	3,250	28,805	8.86	
1996-97	Woodbin 2	Single-family	North Carolina	1	3,250	23,122	7.11	
					16,250	133,326		**8.20**
1993	County (3)	Single-family	McHenry Co. IL	1	2,000	14,880	7.44	
	Cornell U.	Single-family	Highland Mills, NY	1	1,890	4,556	2.41	
1996	NAHB	Multi-family (4)	Odenton, MD	36	50,400	204,000	4.05	
1993	County (3)	Multi-family (5)	McHenry Co. IL	6	9,000	33,580	3.73	
					59,400	237,580		**4.00**
Totals for 93 dwelling units				**93**	**172,130**	**754,494**		**4.38**

EXTRAPOLATION

Value of new private and public construction put in place (6)	181,795	million
Average cost of construction (7)	$60.66	per square foot
Total square feet of new construction	2,997	million square feet
Average C&D debris generation rate	4.38	pounds per square foot
Total Generation of Residential Construction Debris	**6.56**	**million tons**

(1) Average of 37 residential construction sites. Metro Report, 1994.
(2) Wake County SWM & NC Div of Pollution Prevention. Coordinated by Woodbin 2, a non-profit organization. Five sites were between 3000 and 3500 square feet each.
(3) Audit by McHenry County, assisted by Cornerstone Material Recovery.
(4) 36-unit condominium, average 1400 square feet.
(5) 6-unit apartment building.
(6) Department of Commerce, Current Construction Reports.
(7) Based on 1995 construction permits, 3% adjustment to 1996 for inflation.

Source: Franklin Associates

Table 4 shows the results of six nonresidential waste assessments. Ranging from 1.61 to 4.21 pounds per square foot, the average generation rate of the individual sampling studies is 3.89 pounds per square foot. These buildings include a retail store, restaurant, institutional building, and two office buildings.

Table 4
ESTIMATED GENERATION OF NONRESIDENTIAL CONSTRUCTION DEBRIS

EMPIRICAL WASTE ASSESSMENTS

Date	Research Group	Type of data	Location	Building Size (Sq ft)	Total Waste (Pounds)	Generation Rate (Lb/sq ft)
1995	Turner Construction	Retail Store Construction	Seattle, WA	37,000	148,000	4.00
1995	METRO	County Justice Center	Portland, OR	41,850	176,000	4.21
1992	METRO	Restaurant	Portland, OR	5,000	10,940	2.19
1994	METRO	Office construction (1)	Portland, OR	7,452	12,000	1.61
1997	Sellen Construction	Office construction	Seattle, WA	297,115	1,163,560	3.92
			Totals	388,417	1,510,500	
			Average			**3.89**

EXTRAPOLATION

Value of new private and public construction put in place (2)	198,700	million dollars
Average cost of construction (3)	$90.40	per square foot
Total square feet of new construction	2,198	million square feet
Average C&D debris generation rate	3.89	pounds per square foot
Total Generation of Nonresidential Construction Debris	**4.27**	**million tons**

(1) Two office buildings.
(2) Department of Commerce Current Construction Reports.
(3) Based on 1995 construction permits, with 3% adjustment to 1996 for inflation.

Source: Franklin Associates

The 1996 value of nonresidential buildings, as reported in Current Construction Reports, is $198.7 billion. Average construction costs in 1995 were $87.77 per square foot, resulting in an estimated 2,197.7 million square feet of new construction, after making a 3 percent correction for inflation. Multiplying by 3.89 pounds per square foot results in a total estimated generation of **4.27** million tons per year.

Demolition Debris

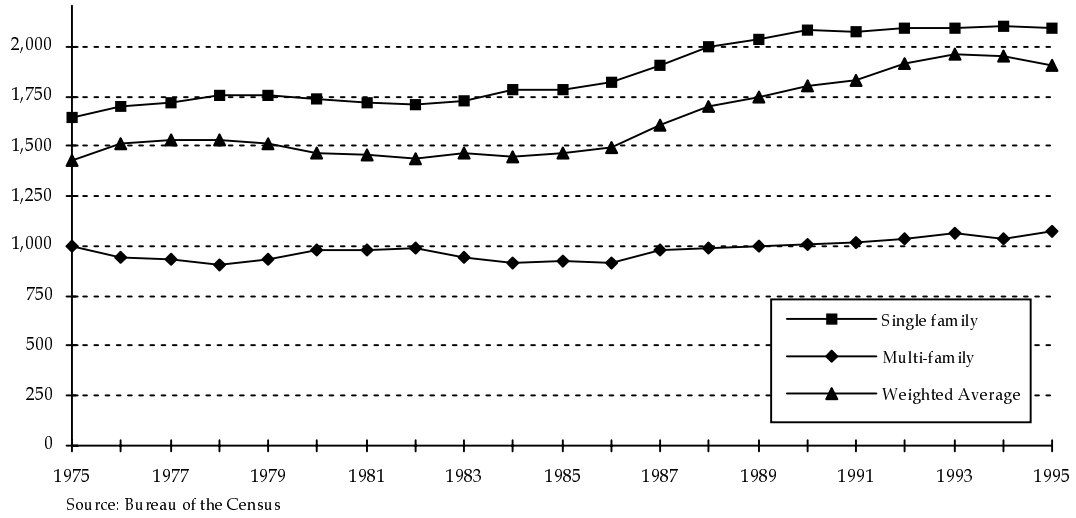
Residential. Demolition debris is estimated, starting with the number of residential demolitions per year, estimating the average house size when demolished, and then multiplying by the waste material per square foot, from empirical demolition waste assessments.

The NAHB economists have estimated the number of demolitions per year, based on Component of Inventory Change (CINCH) data (Carliner 1996). They estimate that the units actually destroyed through intentional demolitions or disasters such as fires or weather-related incidents between 1980 and 1993 averaged 245,000 per year. This is about three times the number reported by the Census Bureau based on permit data. Reasons for the higher number include unpermitted demolitions, municipalities that do not require permits, and

demolition permits that are handled by municipal offices other than building departments. Although CINCH data have been discontinued in 1995 due to federal budget cuts, these data are expected to be available through the American Housing Survey (AHS).

Houses of all ages and sizes may be demolished, but on average it is recognized that older houses are demolished more frequently, and older houses are on average smaller than new ones. New single-family housing units and multi-family housing units (including apartments and condominiums) built in 1995 averaged 2,100 square feet and 1,050 square feet, respectively. Figure 2 shows how average new house sizes have increased over the last 20 years. Multi-family houses have remained nearly the same, while new single-family houses grew from 1,600 square feet to 2,100 square feet. For this analysis, we assumed the average single-family and multi-family house sizes are 1,600 and 1,000 square feet, respectively, when demolished.

Figure 2. Average size of new house constructio



Source: Bureau of the Census

Table 5 shows three single-family house demolition assessments and one multi-family deconstruction assessment. The weight of houses when demolished depends critically on whether the houses have concrete foundations and basement walls or not. The use of masonry in exterior cladding also affects the house weight significantly. None of the three single-family houses in Table 5 had full basements. Therefore, we made adjustments to the sampling data to develop an estimate of residential demolition debris which reflects the likely impact of some of the demolished houses having basements.

Table 5

ESTIMATED GENERATION OF RESIDENTIAL DEMOLITION DEBRIS

EMPIRICAL WASTE ASSESSMENTS

Date	Research Group	Type of data	Location	Building Size (Square feet)	C&D Debris (Pounds)	Generation rate (Lb/sq ft)
1992	METRO	SF Demolition (1)	Portland, OR	1,280	66,000	52
1994	METRO	SF Demolition (2)	Portland, OR	1,200	63,000	53
1994	METRO	SF Demolition (3)	Portland, OR	750	31,000	41
	Total Single-family, without foundations			3,230	160,000	50
	Adjustment for concrete (4)				197,000	61
	Total Single-family, including concrete			3,230	357,000	111
1997	NAHB	4 unit MF Deconstruction	Maryland	2,000	254,400	127
	Weighted average for single-family and multi-family (Appendix A-3)					**115**

EXTRAPOLATION

Estimated number of residential demolitions per year	245,000
Estimated average size of residences demolished (sq ft)	1,396
Average C&D debris generation rate (pounds per square foot)	115
Total Generation of Residential Demolition Debris (tons/yr)	**19,700,000**

(1) 1920s house. Concrete rubble not included.
(2) Concrete rubble not included.
(3) Small house without basement.
(4) Franklin Associates estimate. See Table A-3 for calculation of amount of concrete, in lb/sq ft. (Assumes a composite house, i.e., partial basement, garage, etc.)

Source: Franklin Associates

The Census Bureau provides data on the types of foundations in existing houses in *Current Housing Reports*. Forty-five percent of single-family houses have basements, 26 percent are on concrete slabs, and the remainder have crawl spaces. Table A-3 in the appendix describes an analysis using these percentages to estimate that on average the amount of concrete in a 1,600 square foot single family house is 61 pounds per square foot. The amount can range from zero for houses without basements, garages, or driveways to more than 150 pounds per square foot.

We estimate the total C&D debris generated when single-family houses are demolished is 111 pounds per square foot. For multi-family housing, NAHB Research Center's value of 127 pounds per square foot (Table 5) was used, resulting in an average for all residences of 115 pounds per square foot. Applying this rate to the 245,000 housing units demolished per year results in a waste generation estimate of **19.7** million tons per year, as shown in Table 5.

Nonresidential. The method used to estimate the generation of nonresidential demolition debris is to first determine the number of demolitions per year, then estimate the average size (in square feet) of buildings being demolished. The number of square feet is then multiplied by the generation per square foot, as determined by empirical waste assessments.

The Census Bureau has, until 1995, monitored the number of demolitions, based on permits issued by permit issuing entities. This data series is now discontinued because of federal budget cuts. In 1995, a total of 43,795 nonresidential demolition permits were issued. That number is used in this study as an estimate for 1996. In 1994 there were 45,061 permits issued, which suggests that using the 1995 number for 1996 is a reasonable estimate. Data were not found indicating that the number of demolitions is actually larger than the permits would indicate. Therefore, no correction was made, as was done for residential demolitions. It is less likely that nonresidential demolitions escape the permitting requirements than residential demolitions, because nonresidential demolition is more closely regulated.

We estimated the average nonresidential building size at 13,300 square feet by the following method. The 1996 ***Statistical Abstract*** characterizes existing commercial buildings by type, including the number of buildings, and total square feet based on the time period (decade) when the buildings were built (EIA 1992). Based on those data, we determined that buildings now standing that were built between 1920 and 1969 average 13,300 square feet per building.

Table 6 shows the results of waste assessments at 23 nonresidential buildings over the last several years. The average generation rate is 155 pounds per square foot. Multiplying by the square feet per building and the total number of demolition permits results in a nonresidential demolition debris generation of **45.1** million tons per year.

Renovation Debris

Renovation (or remodeling) includes improvements and repairs to existing buildings. Renovation debris consists of both construction and demolition materials. Remodeling waste quantities are even more variable than construction or demolition waste. Renovation debris ranges from single materials being generated, such as when driveways or roofs are replaced, to multiple material generation, such as when buildings are modified or enlarged. For this analysis, we made estimates for wastes generated when major improvements are made.

Table 6
ESTIMATED GENERATION OF NONRESIDENTIAL DEMOLITION DEBRIS

EMPIRICAL WASTE ASSESSMENTS

Date	Research Group	Type of Building	Location	Building Size Square feet	Total Waste Tons	Generation rate Lb/sq ft
1991	NAHB	Prison shop	Oakalla, BC	12,000	1,301	217
1994-1995	METRO	Warehouse	Portland, OR	86,400	1,566	36
1992	METRO	Department store	Portland, OR	44,000	3,639	165
1994	METRO	Institutional building	Portland, OR	60,000	5,454	182
1997	Argonne	Office building	Chicago, IL	5700	289	101
1997	W. County	Cold storage building	Washington Co., OR	73,600	13,163	358
1995-1996	R.W. Rhine	17 Industrial buildings	Northwestern U.S.	2,204,000	167,200	152
		Totals		2,485,700	192,612	
		Average				**155**

EXTRAPOLATION

Total demolitions (1)	43,795	
Average building size (2)	13,300	sq ft
Average C&D debris generation rate	155	pounds per square foot
Total nonresidential demolition debris	**45,100,000**	**tons/year**

(1) U.S. Census Bureau, Manufacturing and Construction Division, 1995.
(2) U.S. Energy Information Administration, 1992. From 1996 Statistical Abstract.

Source: Franklin Associates

Residential. In 1996, the value of residential improvements and repairs amounted to $114.3 billion (Census 1997). Of this, 68 percent (or $77.7 billion) was for improvements and 32 percent (or $36.6 billion) was for repairs. Improvements are defined by the Census Bureau to include additions, alterations, and major replacements which add to the value or useful life of a property, or adapt a property to a new or different use. Repairs include incidental maintenance and repairs to keep a property in ordinary operating condition (C-Series Reports).

Because of the wide variation in remodeling projects, waste assessments to determine generation per square foot are not very useful for estimating total generation. More important is the amount of material produced per job, e.g., per kitchen addition or bath remodeling or roof replacement. Table 7 shows the results of five waste assessments that have been made at residential sites, showing a wide variation in generation rates on a square foot basis. Remodeling typically generates more waste per square foot than new construction, largely because of the demolition that accompanies remodeling. However, some remodeling jobs, like roof replacement, produce relatively low amounts of material on a square foot basis.

Table 7
EMPIRICAL WASTE ASSESSMENTS FOR RESIDENTIAL RENOVATION DEBRIS

Date	Research Group	Type of data	Location	Size of Project (Sq ft)	Total Waste (Pounds)	Generation rate (Lb/sq ft)	Average generation (Lb/sq ft)
1997	NAHB	SF Remodel (Kit & rm add.)	Maryland	560	11,020	19.68	
1997	NAHB	SF Remodel (bathroom)	Chapel Hill, NC	40	2,883	72.10	
		Totals		600	13,903		**23.17**
1993	METRO	Kitchen remodel	Portland, OR	150	9,600	64.00	
1993-1994	METRO	House remodel	Portland, OR	1,330	26,000	19.55	
		Totals		1,480	35,600		**24.05**
1997	NAHB	SF Remodel (New roof)	Maryland	1,400	4,640	3.31	**3.31**

Source: Franklin Associates

We estimated renovation debris generation for this analysis by reviewing the number of major home improvements, then estimating the amount of material produced by each type of improvement. Although all home improvement projects cannot be included in a study of this type, selection of the major projects can be useful for making first estimates.

Appendix A Tables A-7, A-8, A-9, and A-10 show some of the assumptions made and the results of estimating the amount of material produced when driveways are replaced, when asphalt and wood roofs from residences having one to four units per structure are replaced, and when residential heating and cooling equipment is replaced. Based on the assumptions made, replacement of these categories produces 13 million tons of concrete from driveways, 6.4 million tons of asphalt roofs, 1.4 million tons of wood roofing, and 1.6 million tons of heating, ventilating, and air conditioning (HVAC) equipment.

The analysis above assumes that 60 percent of residential driveways are made of concrete and are on average 45 feet long (NAHB 1995). Asphalt driveways are also very common, but replacement generates much less waste than concrete, since asphalt driveways are usually overlaid with new asphalt rather than being replaced.

Approximately 67 percent of residences have asphalt roofs (NAHB 1997a). For this analysis, 25 percent were assumed to have wood roofs. Other residential roofing materials include slate, tile, metal, and concrete. These materials are used much less than asphalt and wood, and generally are used over long periods before being replaced.

The NAHB Research Center has compiled estimates of waste generation rates by type of remodeling projects (Yost 1998). The major waste generation remodeling activities involve kitchens, bathrooms, and room additions. Generation from these job types are shown in Table A-5 in Appendix A.

Annually there are approximately 1.25 million major kitchen remodeling jobs (complete tear-out), with an average generation of 4.5 tons per job, and 1.25 million minor kitchen remodeling jobs (facelift, e.g., cabinet replacement) at 0.75 tons per job. Major bath remodelings (1.2 million per year) produce on average one ton of waste material each, and 1.8 million minor bath remodeling jobs produce on average 0.25 tons of waste each. Room additions, estimated at 1.25 million per year, produce on average 0.75 tons apiece. On this basis, we estimated total residential renovation generation, from the improvement or replacement projects itemized above, to be **31.9** million tons per year.

Nonresidential. Based on Census Bureau data, total dollars spent for nonresidential renovation projects in 1996 was $100.4 billion. We calculated this number by assuming the ratio of residential to nonresidential dollars is the same in 1996 as in 1992. We could not find any information on total renovation dollars for 1996.

Very few waste assessments are available for nonresidential renovation. Therefore, the previous methodology cannot be used to estimate this amount. Lacking specific assessment data, we compared total dollars spent on nonresidential and residential renovation and assumed that the amount of waste generated is proportional to dollars spent in these two sectors. (See Table A-6 for more details of this analysis.)

Based on the assumption that waste generation per dollar is equal to the residential rate, total nonresidential renovation is equal to **28.04** million tons per year, less than residential generation by the ratio of dollars spent.

Summary of Building-Related C&D Generation

Table 8 summarizes the estimates for C&D debris generation from the construction, demolition, and renovation of residential and nonresidential buildings in the United States. The estimated total for 1996 is almost 136 million tons, with 43 percent coming from residential and 57 percent from nonresidential sources. Forty-eight percent of the C&D debris generated is from building demolitions, 44 percent is from renovation, and 8 percent is from building construction.

Figure 3 provides a breakdown, in percent of total, of the six building sectors that generate C&D debris. The largest sector is nonresidential demolition at 33 percent. Residential and nonresidential renovation debris make up 23 and 21 percent, respectively, followed by residential demolition at 15 percent. New construction represents 8 percent of total C&D debris, with residential at 3.4 percent and nonresidential at 4.8 percent.

Table 8

SUMMARY OF ESTIMATED BUILDING-RELATED C&D DEBRIS GENERATION, 1996*
(Roadway, Bridge, and Land Clearing Debris not included)
(Thousand Tons)

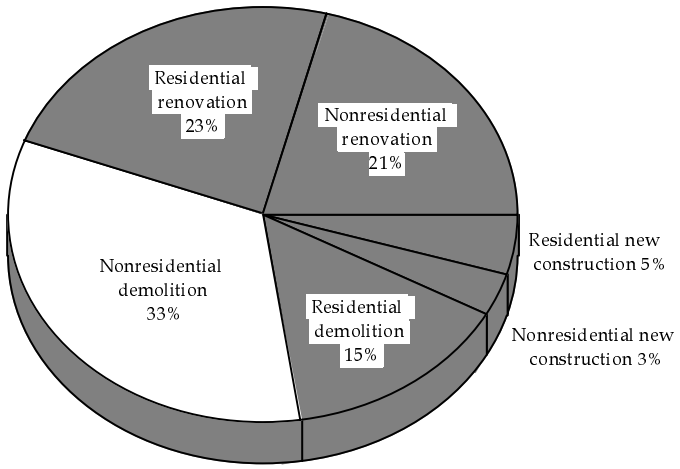
Source	Residential		Nonresidential		Totals	
	Thou tons	Percent	Thou tons	Percent	Thou tons	Percent
Construction	6,560	11	4,270	6	**10,830**	**8**
Renovation	31,900	55	28,000	36	**59,900**	**44**
Demolition	19,700	34	45,100	58	**64,800**	**48**
Totals	**58,160**	100	**77,370**	100	**135,530**	**100**
Percent	**43**		**57**		**100**	

* C&D debris managed on-site should, in theory, be deducted from generation. Quantities managed on-site are unknown.

Source: Franklin Associates

The estimate of 136 million tons per year is equal to 2.8 pounds per capita per day (pcd). This compares to 4.3 pcd of MSW generation. Note that the 2.8 pcd does not include C&D debris from roadway and bridge construction and demolition or from land clearing projects. These wastes are discussed briefly in the following section.

Figure 3. Generation of construction and demolition debris from buildings



CONSTRUCTION AND DEMOLITION DEBRIS GENERATION FROM ROAD, BRIDGE, AND OTHER NON-BUILDING ACTIVITIES

In this initial characterization study, we developed a methodology to estimate C&D debris generation from building construction, demolition, and renovation. However, because point source data were not available, we did not estimate the generation of site clearance materials, excavated materials, and roadwork materials. These are waste streams that will require further investigation in future editions of EPA's C&D work. These other wastes are typically managed by many of the same processors and landfills that manage building-related wastes.

We have made attempts, however, to provide certain cameo examples of locally generated data on most of these other generating sectors within the context of this report. Most communities and states that report C&D debris include the total C&D debris stream, which of course varies according to applicable regulations and definitions.

In 1995, a report was completed for Anne Arundel County, Maryland (part of the Metro Washington, DC area) that attempted to quantify total C&D debris generated and/or disposed in that County (GBB 1995). The report concluded that 138,000 tons per year of in-County generated C&D waste was being disposed at area C&D landfills (called "rubblefills" in the State of Maryland), while 435,000 tons per year of C&D debris materials were processed/recycled. This latter figure was reported to be about 12 percent wood waste and 88 percent concrete, asphalt, brick, block and porcelain waste generated in the County. This particular report is significant in the sense that it represents an example of total C&D generation in a large developing community.

STATE CONSTRUCTION AND DEMOLITION DEBRIS GENERATION RATES

We identified six states that have C&D debris generation records available. They are California, Florida, Massachusetts, Oregon (Portland metropolitan area), South Carolina, and Vermont. Generation of C&D debris from these states ranged from 1.43 pcd in South Carolina to 3.41 pcd for Massachusetts.

All of these states except Massachusetts report rates lower than 2.8 pcd, which is our estimate for building-related debris alone. The state data may include road debris as well. There are several reasons some of the states' estimates may be low. The six states' data reflect reports from facilities receiving C&D debris. Some of the many locations typically accepting C&D debris—ranging from established landfills to processors to sites with temporary permits (or no permits)—may be missed when C&D debris quantities are reported. Also, C&D debris mixed with MSW may be missed. In some states, road debris (asphalt and concrete) is mostly reused or recycled; it either remains on site or is incorporated into other roads. Thus, very little road debris would be expected in the states' quantities.

It is important to note that the methodology used in this report includes all building-related C&D debris, whether managed in C&D or MSW landfills, processing centers, land clearing landfills, or unpermitted landfills. It also includes on-site managed waste, if any, e.g., concrete or asphalt that is used as fill material, since no method was determined for making a correction. An important feature of the methodology used for residential demolition debris estimation, i.e., changes in housing inventory, is that residential buildings destroyed by natural disasters are included in this estimate.

We contacted two of the states by phone to discuss their C&D debris generation estimates. Florida reported a generation rate in 1995 of 2.01 pounds per capita per day. This rate was determined from reports to the state by each of the counties. The waste reported consists primarily of building waste, and is thought by the official contacted to be under-reported by many of the counties (Moreau 1997).

South Carolina has a reported generation rate of 1.43 pcd. The person contacted thinks that number is also grossly under-reported (Pitt 1997). C&D debris landfills for utilities and manufacturing and short term landfills are not required to report their quantities in South Carolina, and are not monitored by the State.

COMPOSITION OF CONSTRUCTION AND DEMOLITION DEBRIS

Six sets of C&D sorting data that provide some empirical measurements of the composition of C&D debris were identified. Each of the sampling studies was conducted with the specific goal of developing composition data for C&D debris. Probably the most rigorous assessments have been conducted at residential construction sites. These waste assessment projects are:

1. The National Association of Homebuilders (NAHB) Research Center conducted waste assessments at four residential construction sites: Largo, Maryland; Anne Arundel County, Maryland; Portland, Oregon; and Grand Rapids, Michigan. The Research Center also conducted a waste assessment at a four-unit multi-family demolition (or deconstruction) site (NAHB 1997b).

2. The Metropolitan Service District in Portland, Oregon (METRO) conducted a series of sampling projects at a number of residential and nonresidential construction, demolition, and renovation sites in Oregon.

3. Cunningham Environmental Consulting and the Cascadia Consulting Group sampled loads of C&D debris at disposal sites and transfer stations. Loads of residential and commercial construction, demolition, and remodeling debris from the Seattle area were selected (Cunningham 1996). Detailed sorting of these loads was done.

4. Gershman, Brickner & Bratton, Inc. (GBB) conducted a C&D sorting study for the Town of Babylon, New York that was funded by the New York State Energy Research and Development Authority (NYSERDA). The three-week study included C&D samples from waste loads from all or parts of 16 residential and nonresidential construction, demolition, and renovation projects (Brickner 1993). A total of 161.5 tons were sorted.

5. GBB, in association with the Metro Waste Authority, also sampled C&D debris from residential and commercial construction, demolition, and remodeling projects in Des Moines, Iowa for a one-week period (Brickner 1995).

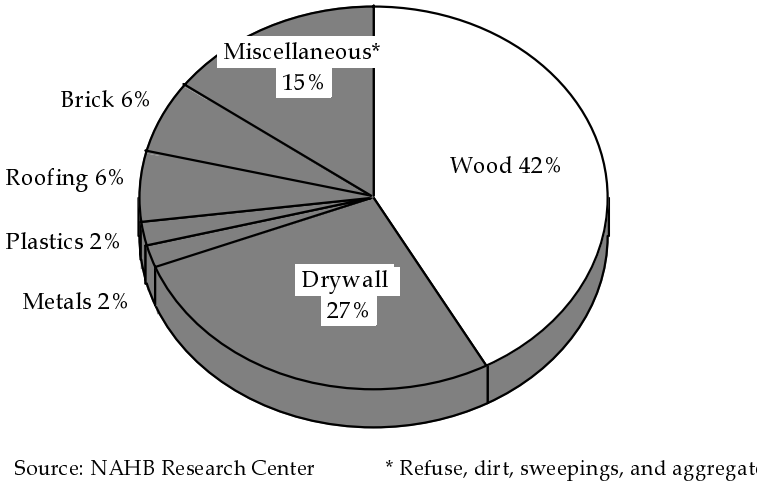
6. R.W. Rhine, Inc. of Tacoma, Washington, a demolition contractor, provided waste assessment data from the demolition of 19 nonresidential (industrial/commercial) buildings in the greater Northwest area.

In addition to the analyses listed above, the University of Florida is conducting waste audits at Florida residential construction sites. Data from these studies are expected to be available soon.

The detailed composition data from the sampling studies are shown in Tables A-11 through A-18 in Appendix A of this report. A review of these tables demonstrates that the composition of C&D debris is highly variable, as may be expected because of the many different types of buildings and construction practices in existence. The data collections were done under many different conditions and levels of detail. Therefore, we made no attempt to average all the compositions. Although different, there are some observations that can be made.

The first two (Tables A-11 and A-12) and sixth (Table A-16) sets of data characterize waste at the source, i.e., at specific construction or demolition sites. The other three data sets (Cunningham in the Seattle area and GBB in Babylon, New York and Des Moines, Iowa) characterize debris as disposed at the landfills. The sectors (or sources) for each load of C&D debris that was sorted are identified, but the specific phase of construction or demolition is not identified.

Figure 4. Sample composition of residential new construction debris (Average of assessments in four locations)



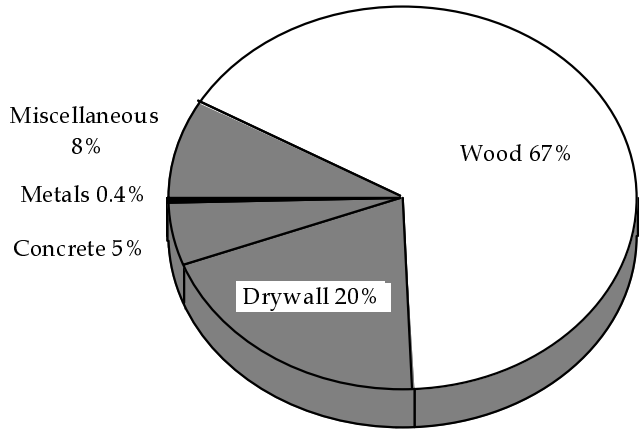
Source: NAHB Research Center * Refuse, dirt, sweepings, and aggregat

NAHB and Metro examined both composition and quantity per square foot of floor space for single-family housing. Both of these groups developed data from well-defined construction projects, i.e., the materials consist of trim scraps from beginning to end of the residential construction process, without serious contamination from other sources. Figures 4 and 5 show these data in percent by weight. Figure 4 shows the average composition for four single-family houses, two in the East, one in the Midwest, and one in the Northwest. Wood is the largest component, followed by drywall.

Figure 5 shows the composition from three new residential construction sites in the Portland, Oregon area. The percentage of wood in the Northwest samples is considerably higher, as may be expected, because a large fraction of homes in the Northwest have wood roofs. Residential construction debris in the Southwest and southern United States is expected to contain a lower percentage of wood than in the East and Midwest, and more brick and cinder blocks. As waste assessment data become available in other regions of the country, it will be possible to develop an overall composition for residential construction debris and to relate composition to total generation, i.e., estimate total C&D debris generation by material type.

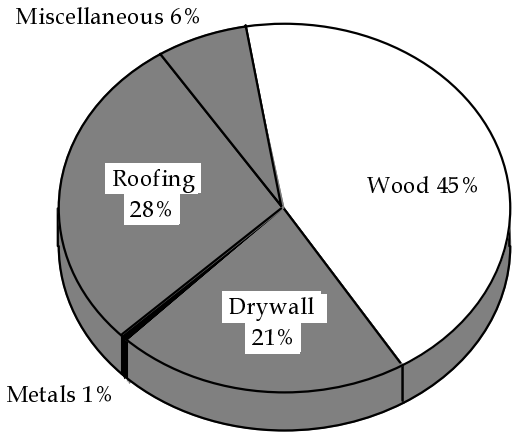
Figure 6 shows the composition of residential renovation debris in the Northwest. This stream is similar to the construction debris stream, but with an obvious difference, an increase in the amount of roofing materials. Only trim pieces of roofing are included in new construction debris.

Figure 5. Sample composition of residential new construction debris (Average of three sites, Portland, Oregon)



Source: METRO Portland, Oregon

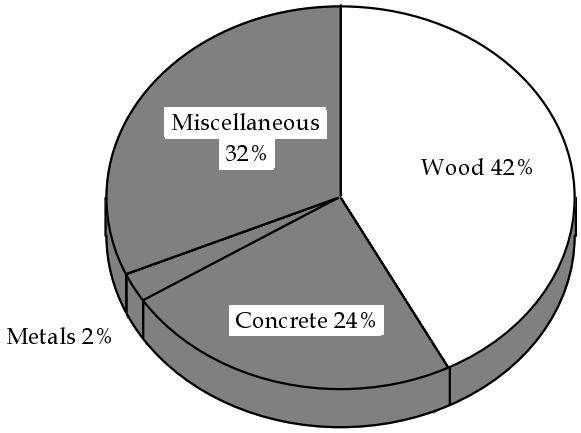
Figure 6. Sample composition of residential renovation debris (Average of two sites, Portland, Oregon)



Source: METRO Portland, Oregon

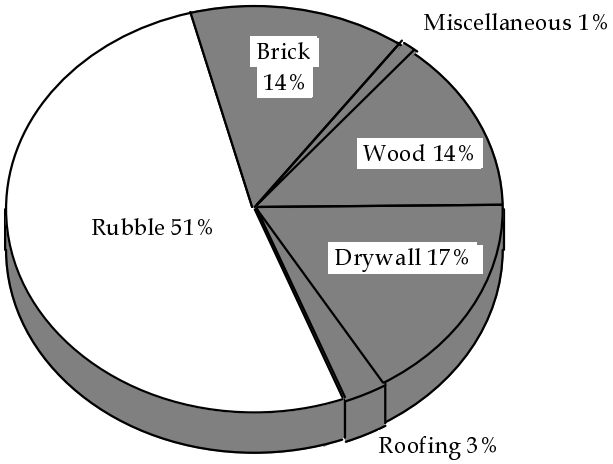
Concrete is missing from the renovation stream of Figure 6. Obviously these two projects did not include projects like driveway replacement. This demonstrates that many samples are required before we can report an overall composition that represents the U.S. average with confidence.

Figure 7. Sample composition of residential demolition debris (Average of three sites, Portland, Oregon)



Source: METRO Portland, Oregon.

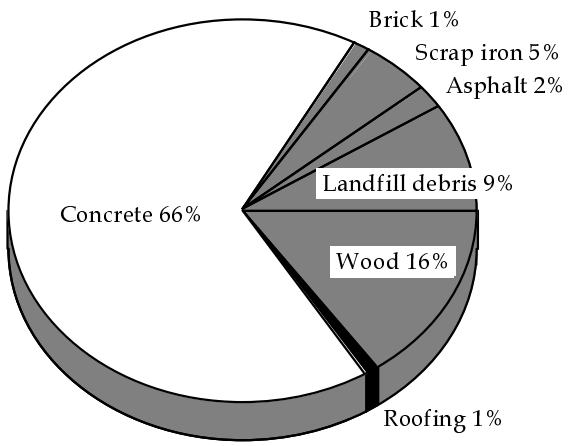
Figure 8. Sample composition of multi-family demolition debri



Source: NAHB Research Center, Inc.

Figure 7 displays the composition of residential demolition debris. Concrete is an obvious component of this stream, as it is in Figure 8, which shows the composition of a 2,000 square foot two story four-plex that was disassembled by NAHB in a demonstration project for the USEPA.

Figure 9. Sample composition of demolition debris (19 nonresidential projects in the Pacific Northwest)



Source: R.W. Rhine, Inc., Tacoma, WA

Figure 9 shows the average composition of 19 nonresidential buildings that were demolished in the Northwest area. These were large industrial/ commercial type buildings that ranged in weight from 891 tons to 37,500 tons. While this figure represents the average composition, the percentage of wood ranged from 0.03 percent to 88 percent in the 19 buildings. This demonstrates the huge variability of building types.

Some general observations can be made from these figures. Residential construction and renovation projects tend to yield significant quantities of wood and drywall, whereas demolition sites are heavily weighted toward concrete and rubble. The debris from 19 nonresidential demolition projects of Figure 9 averaged 66 percent concrete.

Chapter 2

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Chapter 3

MANAGEMENT OF CONSTRUCTION AND DEMOLITION DEBRIS IN THE UNITED STATES

INTRODUCTION

Construction and demolition (C&D) debris is managed in a variety of ways, ranging from reuse to recycling to disposal in landfills or combustion facilities. The most common management method is landfilling, including specially permitted C&D landfills and municipal solid waste (MSW) landfills, as well as unpermitted inert debris sites.

In most states there is no formal reporting mechanism that documents C&D debris disposal, recovery, or recycling activities. The information collected by many state agencies is largely anecdotal. In addition, information from private companies is generally considered to be proprietary and not available for public dissemination.

LANDFILLING

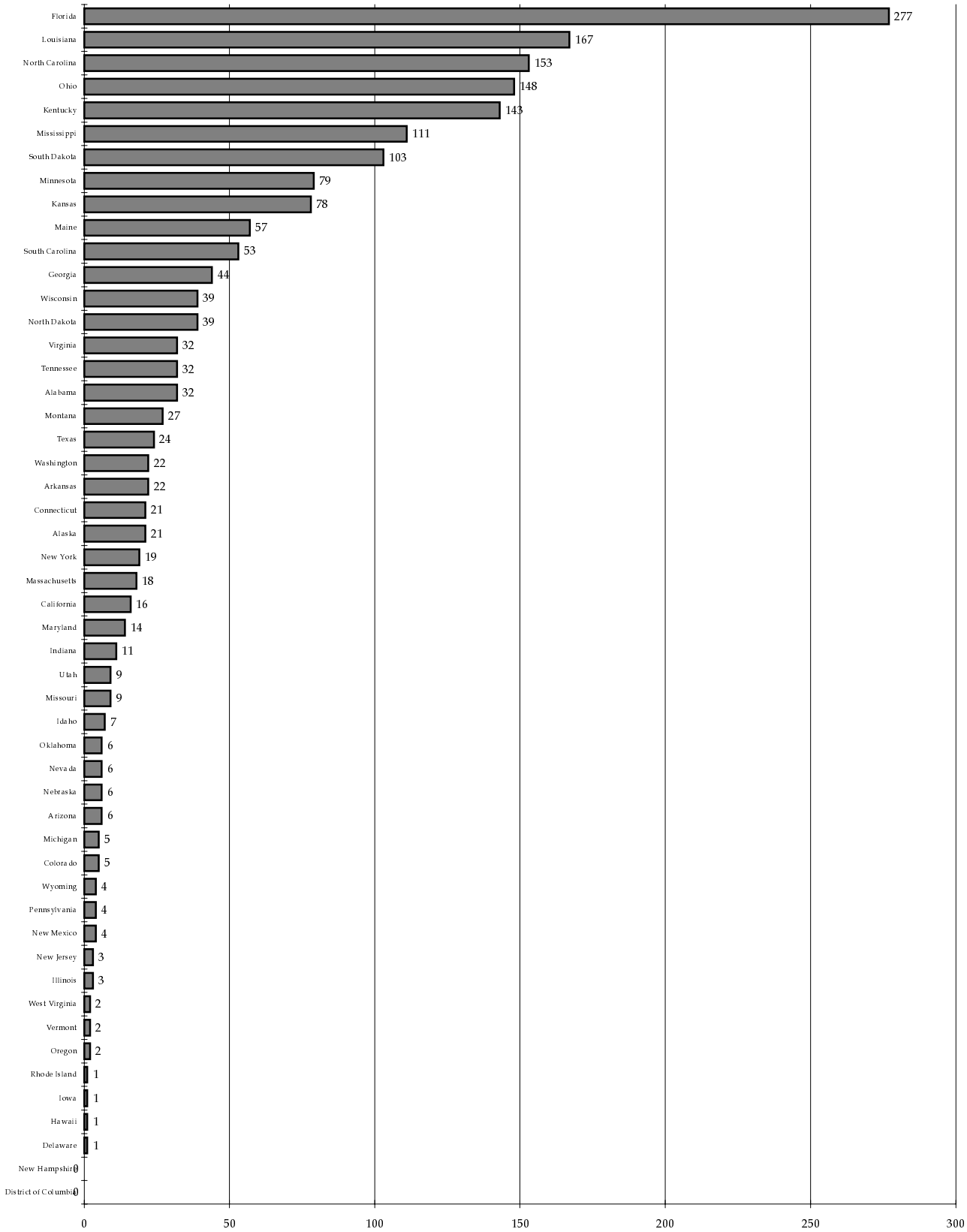
A large fraction of C&D debris generated in the United States ends up in C&D landfills. Since much of this waste stream is inert, solid waste rules in most states do not require the landfills to provide the same level of environmental protection (liners, leachate collection, etc.) as landfills licensed to receive MSW. Therefore, C&D landfills generally have lower tipping fees, and handle a large fraction of the C&D debris.

A 1994 survey done for the EPA identified about 1,900 active C&D landfills in the United States (ERG 1994). Florida had the largest number (280), followed by six other states (Louisiana, North Carolina, Ohio, Kentucky, Mississippi, and South Dakota) with over 100 C&D landfills apiece. (See Appendix A, Table A-19 and Figure 10.)

A recent survey of 850 randomly selected C&D landfills in the United States (40 percent response rate) found that on average, C&D landfills received 29,300 tons of material in 1995 (Bush 1997). Assuming that average holds true for the 1,900 active landfills, 55.6 million tons per year are disposed of in permitted C&D landfills. This amount is equal to about 41 percent of the estimated 136 million tons of building related C&D debris, as estimated in the previous chapter. However, this 55.6 million tons is likely to contain significant amounts of non-building C&D debris.

The amount of C&D debris disposed of in MSW landfills is not known. It is significant, however, because in many areas, particularly where landfill tipping fees are low, disposal in MSW landfills is the most common management method for C&D debris.

Figure 10. Number of C&D debris landfills in the United States



Source: ERG List prepared for USEPA, September 30, 1994.

A significant fraction of residential renovation debris is discarded by homeowners into the household trash and disposed of in MSW landfills. Discarded items include replacement plumbing and electrical fixtures, lumber, and other building materials used in home repair or improvement projects.

Unpermitted landfills for C&D debris are also very common in many states. These are fill areas for inert materials, with little or no control or record keeping by the state or local governments. Some of these are on-site facilities that are used only for the disposal of C&D debris generated at a specific site and may be closed following completion of the activity. Little data exists on the number of unpermitted C&D landfills nationwide. Georgia, the only state known to count them, has about 900 such sites (ICF 1995).

Open burning of C&D debris at construction sites is practiced in many rural areas as well as in many small to medium size cities. The amount of material burned is unknown.

Regulatory schemes used by states for C&D landfills have been divided into four categories as summarized in Table 9. Eleven states require C&D landfills to meet state MSW landfill requirements or requirements similar to these. Twenty-four states regulate C&D landfills separately from MSW landfills. In addition to the 24 states that regulate all C&D landfills as a landfill unit separate from sanitary landfills, eight states have defined further separate requirements for on-site and off-site C&D landfills. Of those eight states, Maine requires both off-site and on-site landfills to meet MSW landfill rules if they are greater than six acres. Seven states exempt all on-site landfills from regulatory requirements. Of these seven, sanitary landfill regulations apply to all off-site landfills in Colorado and New Mexico.

In summary, disposal in landfills is the major waste management option for C&D debris from buildings. We estimate that C&D, MSW, and other landfills account for roughly 65 to 85 percent of that waste stream.

RECOVERY OF C&D DEBRIS FOR RECYCLING

The six major constituents of C&D debris, if not too severely contaminated, have all been recovered and processed into recycled-content products that have been marketed somewhere in the United States. The materials most frequently recovered and recycled are concrete, asphalt, metals, and wood. To a much lesser degree, gypsum wallboard and asphalt shingles have been processed and recycled. The technologies to recover and process these materials for reuse are available. The major barriers to increased recovery rates at this time are:

Table 9

STATE REGULATORY SCHEMES FOR C&D LANDFILLS

State	Must meet MSW Landfill Requirements	Separate C&D Debris Regulations	Separate Requirements for On-Site and Off-Site Landfills	Exempt On-Site C&D Debris Landfills from Regulation
Alabama		Yes		
Alaska	Yes			
Arizona	Yes			
Arkansas		Yes		
California		Yes		
Colorado				Yes
Connecticut	Yes			
Delaware		Yes		
Florida		Yes		
Georgia		Yes		
Hawaii				Yes
Idaho	Yes			
Illinois			Yes	
Indiana		Yes		
Iowa	Yes			
Kansas		Yes		
Kentucky			Yes	
Louisana				Yes
Maine			Yes	
Maryland		Yes		
Massachusetts	Yes			
Michigan			Yes	
Minnesota		Yes		
Mississippi				Yes
Missouri		Yes		
Montana		Yes		
Nebraska	Yes			
Nevada	Yes			
New Hampshire		Yes		
New Jersey			Yes	
New York		Yes		
New Mexico				Yes
North Carolina		Yes		
North Dakota	Yes			
Ohio		Yes		
Oklahoma	Yes			
Oregon				Yes
Pennsylvania			Yes	
Rhode Island	Yes			
South Carolina		Yes		
South Dakota		Yes		
Tennessee			Yes	
Texas		Yes		
Utah				Yes
Vermont		Yes		
Virginia		Yes		
Washington		Yes		
West Virginia			Yes	
Wisconsin		Yes		
Wyoming		Yes		
Total Number	**11**	**24**	**8**	**7**

Source: ICF Incorporated. "Construction and Demolition Waste Landfills." February 1995.

- the cost of collecting, sorting, and processing;
- the low value of the recycled-content material in relation to the cost of virgin-based materials, and
- the low cost of C&D debris landfill disposal.

Responses to a survey of North American aggregate producers indicated that plant permitting issues, as well as product specifications that favor the use of virgin materials, were also problems facing recyclers (Deal 1997).

The number of recycling facilities for C&D debris has been growing rapidly in the last few years. In 1996, it was estimated there were at least 1,800 operating C&D recycling facilities (Brickner 1997). That number includes more than 1,000 asphalt and concrete crushing facilities, 500 wood waste processing plants, and 300 mixed-waste C&D facilities. No information is available on the average throughput of these facilities.

The estimate of 1,800 C&D facilities does not include quarry rock crushing plants, brush/tree tub grinding plants, or pallet grinding operations. The asphalt and concrete crushing plants handle large quantities of road debris, but also concrete recovered from building construction, renovation, and demolition.

The largest number of C&D recycling facilities were reported to be in the Western States (28 percent) and the Mid-Atlantic states (27 percent). The Southwestern and Rocky Mountain States each have only three percent of the total, and the Southeastern, Upper Midwestern, and New England states have 12, 13, and 14 percent of the facilities, respectively.

Because of the effort being exerted to develop markets for recovered materials, the number of C&D recycling facilities is continuing to grow. A July 1997 status update lists 37 new recycling plants or equipment additions in the United States, including planned projects for the rest of 1997 (Leiter 1997). The editor of **C&D Debris Recycling** estimates there are now more than 3,500 C&D debris recycling facilities in operation (Turley 1998).

Deconstruction

Deconstruction is a new expression to describing the process of selective dismantling or removal of materials from buildings before or instead of demolition (NAHB 1996a). A common practice in the United States is to remove materials of value from buildings prior to and during demolition for recycling or reuse. Reuse and recycling examples include electrical and plumbing fixtures that are reused, steel, copper, and lumber that are reused or recycled, wood flooring that is remilled, and doors and windows that are refinished for use in new construction.

Demolition contractors have been practicing deconstruction in varying degrees for a number of years to remove some of the more valuable materials prior to demolition by conventional methods. This activity, along with recovery of demolition materials after the building has been knocked down, has increased significantly since the 1970s and 1980 (Taylor 1997). Deconstruction minimizes contamination of demolition debris, thus increasing the potential for marketing the recovered materials. It is, however, labor intensive, and may require more time than traditional demolition.

Several deconstruction demonstration projects have been completed recently, showing that high diversion rates may be achieved. The NAHB Research Center completed the deconstruction of a two-story, four-unit apartment building in Maryland (NAHB 1997). The Research Center measured the volume and the weight of all materials on site, whether salvaged, recycled, or landfilled. The diversion rate was 76 percent by weight and 70 percent by volume.

In another recent demonstration project, three buildings were deconstructed at the recently closed Fort Ord Army Base, located in Monterey County, California (Schneider 1997). The buildings included a one-story clinic, a single-story administration building, and a two-story barracks. Goals of this project include the evaluation of costs and potential recovery.

Asphalt and Concrete Recycling

Concrete is made up of cement, water, and aggregate, such as crushed stone, sand, or grit. Concrete can be recycled by first crushing it to remove any metals. The primary use of crushed concrete is as a replacement for road-base gravel. Other applications include use as an aggregate in asphalt or concrete. Concrete recycling is practiced in most areas of the country. The practice is most prevalent in areas where landfill tipping fees are high or aggregate is in short supply.

Asphalt pavements are made of asphalt concrete (AC), which consists of asphalt (the bituminous binder) and aggregate. The aggregate makes up the bulk of the asphalt concrete, while the asphalt binder comprises about 5 to 7 percent CIWMB 1997).

While no reports have been identified showing the amount of asphalt and concrete recycled, some datapoints that provide indications of the amounts recycled are discussed below (Brickner 1997).

As stated above, it is estimated there are more than 1,000 asphalt and concrete crushing facilities in the United States. GBB estimates that potentially 50 million tons per year of milled pavement in the United States is reused. Twenty to 50 percent goes back into pavement as Reclaimed Asphalt Pavement (RAP), with the remainder finding its way into aggregate base or subbase. GBB research in the Pacific Northwest, for example, has estimated that for the State of Washington alone, the use of RAP is between 650,000 and 1,000,000 tons per year.

Based on data collected for the State of Washington from waste concrete processors/recyclers, GBB has estimated that 1.4 to 1.5 million tons of waste concrete in that state are recovered, crushed, and recycled on an annual basis.

In Anne Arundel County, Maryland, an area between Washington, DC and Baltimore, Maryland, GBB field work in 1995 indicated that the concrete and asphalt processors in that County alone were receiving, crushing and recycling over 850,000 tons per year of these two types of materials (includes out-of-county generation).

In California, asphalt pavement and concrete are not reported separately. The state estimated generation of "inert solid waste," which consists of concrete, asphalt, dirt, brick and other rubble, at 8.2 million tons per year. The estimated recycling rate for inert solid wastes is 57 percent; the remainder is disposed of (CIWMB 1997).

Waste Wood Recycling

Wood waste produced at construction sites generally has a better potential for reuse than wood from demolition sites due to the ease of separating the materials. Demolition wood is often less desirable because of contamination and because of the difficulty in separating the wood from other building materials.

Wood processing facilities have sprung up in many areas of the United States in recent years, particularly in areas with high landfill costs. Many of these facilities accept wood from C&D debris as well as other wood. Processed (chipped) wood is used as mulch, composting bulking agent, animal bedding, and fuel. Wood waste from construction or demolition is attractive as a fuel because of its low moisture content. Depending on the wood waste boiler system design and the state/regional air pollution permit requirements for the facility, a level of quality control may be necessary at the wood processing plant to reduce and/or avoid the processing of treated and/or painted wood if used as a fuel source in a combustion process.

The American Forest & Paper Association (AF&PA) has located 315 wood processing facilities in the United States that process C&D debris, as shown in Table A-20 of the Appendix. These facilities were included in the estimate of 500 wood processing plants as discussed above. The leading states for these wood processing plants are North Carolina (44), Oregon (35), and California (34). Quantities of wood processed are not given in the AF&PA report.

Metals Recycling

Metals have the highest recycling rates among the materials recovered from C&D sites. Good markets for ferrous metals, as well as copper and brass, have existed for many years. The Steel Recycling Institute estimates the recycling rate for C&D steel is about 85 percent (18.2 million tons out of 21.4 million tons generated). These numbers include not only scrap steel from buildings but also from streets, bridges, and highways (Heenan 1996). The percentage of metals coming from roads and bridges is unknown.

A 1997 survey of North American aggregate producers by Vanderbilt University and C&D Recycling Magazine found that the markets for waste rebar removed from the concrete rubble appear to have increased from 1994 to 1997 (Deal 1997). Twenty-one percent of the 1994 recyclers depended on disposal for their rebar compared to 4 percent in 1997.

Asphalt Shingles

Asphalt shingles are most commonly used on slanted residential roofs. Built-up roofing, which consists of roofing felt between layers of tar and gravel, is traditionally used on flat commercial roofs. These two materials represent the majority of the waste coming from roof replacement or repair. About two-thirds of the residential roofing market is made up of asphalt shingles (NAHB 1996b). Other roofing materials include wood, tile, and concrete.

The common uses for recycled roofing asphalt include hot mix asphalt for paving, cold mix asphalt paving product, and new roofing materials. Meeting the specifications for paving and roofing materials is still limiting the growth of these applications. Preconsumer manufacturing scrap (approximately one million tons per year) is currently being used in hot mix asphalt; however, postconsumer scrap (estimated at 8 to 10 million tons per year), which is less uniform in composition, is not nearly as widely used or recommended for use in hot mix asphalt (Button 1997).

Drywall (Sheetrock, Gypsum)

Drywall is being recycled in several locations by first separating the paper backing, which is recycled into new paper backing, and then remixing the gypsum and using it in the manufacture of new drywall. Recovered drywall has also been used as animal bedding, cat litter, and as a soil amendment.

Estimated Recovery Rate

Because of the relatively benign nature of C&D debris (i.e., much of it is inert), there has been no concerted effort in the past to track and quantify the generation or recovery rate from a national perspective. Therefore, only general estimates can be made based on data from those local communities and states that monitor the waste stream.

A total survey of states was not feasible for this project, but several states were contacted in an attempt to estimate of the national recovery rate for C&D debris. States representing more than 50 percent of the U.S. population were contacted. Most states contacted have no statewide records available on the quantity of C&D debris generated or recovered for recycling. We identified five states that report recycling rate data for C&D debris. The recovery rates in the five states range from 37 percent to 77 percent. The five states and their reported recovery rates are:

Massachusetts	77 percent
Florida	46 percent
Vermont	37 percent
Oregon (Metro)	42 percent
South Carolina	40 percent
Average	48 percent

These data confirm that there is significant recovery of C&D debris for recycling in these locations. However, it is not likely that these five states are representative of the United States as a whole. We expect that the states that keep records have higher recovery rates than the national average.

The definitions of what constitutes C&D debris and what constitutes recycling among the states are not standardized, as was discussed earlier, although most C&D debris definitions include both building-related wastes and as road and bridge debris. Massachusetts includes asphalt and concrete from roads in both the numerator and denominator of the recovery rate calculation, but does not include land clearing debris, (i.e., stumps, soil, rock, etc.). Florida's recovery numbers include primarily building debris and land clearing debris. Road debris is generally not counted (Moreau 1997).

Several methods were explored for estimating a national recovery rate for C&D debris. The first is to look at the relationship of recovery rate and landfill tipping fees. It might be expected that states with low C&D landfill tipping fees have lower recovery rates.

Lowest C&D landfill tipping fees are generally in the lower population density states, such as the Midwest, where the average has been reported at $19.70 per ton, compared to $46 and $42.60 per ton in the Northeast and West, respectively (Bush 1997). A large number of states in the Midwest do not have recovery rate records. In the South, the average is $27.10 per ton. Using tipping fees as a guide, a conservative estimate would be that the average recovery rate might be about half of the average of the five states reporting recovery rates, or 20 to 30 percent of generation.

To test how reasonable the 20 to 30 percent estimate is, consider the 1,800 C&D debris recovery facilities referred to above. Assuming the 1,000 concrete and asphalt plants handle primarily road debris, there are 800 or more wood and mixed waste processors that are thought to handle primarily building debris. Recycling rates of 20 to 30 percent (27 to 41 million tons per year) would result in an average throughput of 90 to 140 tons per day, which appears to be a reasonable average size.

SUMMARY OF C&D DEBRIS MANAGEMENT PRACTICES

Over the past 10 years a significant amount of data has been collected on the amount of C&D debris disposed of at C&D and MSW landfills and the amount processed at recycling facilities. The studies were conducted at the municipal, county, or state levels. Research has also been conducted on the number of C&D landfills and processing facilities in operation on the national level. This foundation of new research was used to estimate how C&D debris is managed on a national level.

Table 10 summarizes our estimated C&D debris management practices in the United States in 1996. These quantity estimates apply to building-related wastes, as estimated in Chapter 2. An estimated 35 to 45 percent of the waste generated is managed in C&D landfills, 20 to 30 percent is recovered for recycling, and 30 to 40 percent is disposed of in MSW landfills and other disposal sites, such as unpermitted landfills or combustion facilities.

Table 10
ESTIMATED MANAGEMENT OF BUILDING-RELATED C&D DEBRIS IN THE UNITED STATES, 1996

Management Option	Million tons/year	Percent of Total
Recovered for recycling	25-40	20-30
C&D landfills	45-60	35-45
MSW landfills and other*	40-55	30-40
Totals	136	100

* Includes combustion and disposal in unpermitted sites.
Source: Franklin Associates

Chapter 3

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Chapter 4

ADDITIONAL PERSPECTIVES ON CONSTRUCTION AND DEMOLITION DEBRIS

INTRODUCTION

The solid waste industry usually identifies wastes according to the source and predominant method of solid waste management. Waste materials defined as municipal solid waste (MSW) are normally discarded from residences or commercial establishments and managed in municipally controlled landfills or processing facilities. Construction and demolition (C&D) debris is generated at construction and demolition sites, and managed in C&D landfills or processing facilities.

However, the lines separating the various sectors of solid waste are sometimes blurred. Data sources for the production of some components of MSW (e.g., paper products) are developed from trade association data. These sources tabulate the entire production, without regard to the final discard point; i.e., some paper products are not discarded from residences or commercial establishments, but are collected from construction sites. Conversely, some wastes that are classified as C&D debris by the methods developed in this report, because they are building materials, are placed into the household trash and end up in MSW landfills.

While this blurring of lines may not be an issue of great importance because of the relatively small amounts of crossover, it could potentially result in double counting of some fractions when estimating the national generation.

MSW COLLECTED WITH C&D DEBRIS

Definitions for some components that make up MSW are affected by the data that are available. For example, postconsumer old corrugated containers (OCC) are included in EPA's MSW characterization, even though some of them are discarded from construction sites. Light fixtures, major appliances, vinyl siding, and other items are often delivered to construction sites in corrugated boxes. As a result, nearly all construction site waste assessments include OCC as a waste category. On a volume basis, up to 20 percent of wastes collected at residential construction sites may be OCC. By weight, OCC ranged from 2 percent to 10 percent in the waste audits performed by NAHB.

An extensive year-long demonstration project conducted by CornerStone of Wisconsin, Inc. was monitored on a quarterly basis by GBB (Brickner 1997). GBB reported that through the use of specialized collection vehicles serving new residential construction in Southeast Wisconsin, the amount of collected and marketed OCC averaged about 25 percent of the total collected volume of material. Since the loose corrugated containers were estimated to occupy about 30 cubic yards per ton, the actual weight recovered was estimated to be 7 percent of the total average weight of material generated from each of the residential units serviced by the unique CornerStone system.

Additional data on several other C&D debris sorts that also quantified OCC are presented in Appendix A of this report.

Although the amount of OCC collected at C&D sites can be a significant fraction of residential construction wastes, it is a small fraction of the total OCC discarded, and on a weight basis it represents a very small fraction of the total C&D debris stream.

Other common MSW items typically collected at C&D sites include food and beverage containers, appliances, and carpeting. Containers discarded by workers at construction and demolition sites typically show up in C&D debris. Major appliances and carpeting also frequently remain in houses that are demolished, and are included with mixed C&D debris.

C&D DEBRIS COLLECTED WITH MSW

Significant quantities of building materials, particularly renovation scraps, are also discarded in the municipal waste stream. Examples include pipes, plumbing fixtures, and building materials that are replaced by the residents and discarded with their household trash. The amount of these types of wastes in MSW is not known. However, this "overlap" of MSW and C&D may account for some of the discrepancies that have been experienced between expected MSW quantities and actual weights.

At the current level of refinement of C&D generation and recovery data, the overlap of MSW and C&D debris is not expected to be a cause for concern at the national level in the near future.

Chapter 4

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Appendix A

CALCULATIONS

Table A-1
Residential Construction Debris Worksheet

Method to Use

(1) Start with total dollars of new construction, from Census Bureau. Current Constr Reports, C-30.
(2) Calculate sq ft of new construction from total dollars and $/sq ft construction cost.
(3) From empirical waste assessment, estimate lb/sq ft of new construction.
(4) Calculate total generation.

Calculation

(1) C-30, Residential Construction (1996) = $181,795,000,000
(Includes private new housing units and public housing & redevelopment)

(2) 1995 Census data, Table 1175 of 1996 Stat Abs. (Note: whole industry not included)

Residential Construction	$127,900,000,000	
Residential sq ft of new constr	2,172,000,000	sq ft
Cost of new construction	$58.89	per sq ft

Total sq ft of new constr = 181,795,000,000/58.89/1.03 2,997,326,036 sq ft
(Includes 3 percent inflation factor)

(3) See sampling waste assessment results:

Average Generation = 4.38 lb/sq ft

(4) Total new residential construction debris = 6,564,000 tons/year

Table A-2
Nonresidential Construction Debris Worksheet

Method to Use

(1) Start with total dollars of new construction, from Census Bureau. Current Constr Reports, C-30.
(2) Calculate sq ft of new construction from total dollars and $/sq ft construction cost.
(3) From empirical waste assessment, estimate lb/sq ft of new construction.
(4) Calculate total generation.

Calculation

(1) C-30, Nonresidential Construction (1996) $198,694,000,000
(Includes all private nonres and public industrial, educ, hosp & other)

(2) 1995 Census data, Table 1175 of 1996 Stat Abs. (Note: whole industry not included)

Nonresidential Construction	$112,000,000,000	
Nonresidential sq ft of new construction	1,276,000,000	Sq ft
Cost of new construction	$87.77	per sq ft

Total sq ft of new construction = 198,694,000,000/87.77/1.03
(Includes 3 percent inflation factor) 2,197,759,570 sq ft

(3) See sampling waste assessment results:

Generation = 4.02 lb/sq ft

(4) Total new residential construction debris = 4,417,000 tons/year

Table A-3
Residential Demolition Worksheet

Method to Use

(1) Start with the number of residences demolished per year.
(2) Estimate the average size of residences that are demolished (single-family (SF) and multi-family (MF)).
(3) Estimate pounds of waste generated per sq ft, from sampling studies.
(4) Calculate total generation.

Calculation

(1) Estimate: 245,000 residential demolitions per year, per NAHB Economics Dept.

(2) Smaller than the average size of new residences, because it is older.
See graph of sizes of houses built, in Figure 2:
New houses built in 1995 are 2,100 sq ft (SF), and 1,050 sq ft (MF)
New MF house sizes are unchanged since 1975, while new SF houses grew from 1,600 sq ft to 2,100 sq ft
Ave size is 1,396 sq ft from 1975 to 1986, then climbs to 1,900 sq ft/house
Demolitions: use 1600 sq ft for SF houses and 1000 sq feet for MF houses

(3) METRO sampling of three SF houses = 49.5 lb/sq ft without concrete	39.6 tons		31%
Estimated wt of foundation, 30' X 30' house w/8" thick basement walls			
30'X8'X0.67'X4X150 lb/cu ft/2000 = est. tons of foundation	48.2 tons		38%
(assumes 8 in. wall thickness and concrete density of 150 lb/cu ft)			
Basement floor			
30'X30'/3X150 lb/cu ft/2000 = tons of floor	22.5 tons		18%
Garage floor & driveway 10X(20+45)/3X150/2000	16.3 tons		13%
Total for 1600 sq ft single family with full basement & garage	126.6 tons		100%
Total in lb/sq ft	158.2 lb/sq ft		
Concrete only	108.7 lb/sq ft		
For house on slab (basic house)	39.6 tons		51%
Concrete slab (same as basement floor)	22.5		29%
Garage floor & driveway (same as above)	16.3		21%
Total for SF on slab	78.35 tons		100%
Total in lb/sq ft	97.9 lb/sq ft		
Concrete only	48.4 lb/sq ft		
For house with crawl space (no bsmt, garage, or driveway)	39.6 tons		
Total for SF with crawl sp	49.5 lb/sq ft		
Concrete only	0.0 lb/sq ft		
For MF housing (per NAHB MF (Table 5))	127 lb/sq ft		

(4) Fraction of total units in U.S. from 1996 Statistical Abstract, Table 1194, Existing housing (1993)

Single family residences:

Foundation type	Fraction of total units	C&D debris (lb/sq ft)	Sq ft/unit	Est. units demol-ished	Total Sq ft	Generation (tons)	Percent of waste
Basement	0.30	158.2	1,600	72,426	115,882,000	9,200,000	47%
Concrete slab	0.17	97.9	1,600	42,406	67,850,000	3,300,000	17%
Crawl sp & other	0.19	49.5	1,600	46,865	74,983,000	1,900,000	10%
	0.66			161,697	258,715,000	14,400,000	73%
Weighted ave. SF residence		111.3	1,600				
Multi-family (>1)	0.34	127.0	1,000	83,303	83,303,000	5,300,000	27%
Totals	1.00			245,000	342,018,000		100%

Total residential demolition generation =	**19,700,000**	tons
Average pounds per sq ft of house demolished =	**115**	lb/sq ft
Average tons per dwelling unit demolished =	**80.4**	tons/unit

Source: Franklin Associates

Table A-4
Nonresidential Demolition Worksheet

Method to Use

(1) Start with the number of demolitions per year.
(2) Estimate the average size of nonresidential buildings demolished, assuming buildings demolished were built between 1920 and 1969.
(3) Estimate pounds of waste generated per sq ft, from sampling studies.
(4) Calculate total generation.

Calculation

(1) Use demolition permits data from the U.S. Bureau of the Census.
Note: Census permits data are discontinued as of 1995.

Census no. for 1994 = 45,061 buildings
Census no. for 1995 = 43,795 buildings

(2) Calculation of the average size of nonresidential buildings built between 1920 and 1969

Construction period		No. of yrs in period	Bldgs built in period (thou)	Million sq ft	Average bldg size Sq ft/bldg
1990	1992	3	128	2,502	19,547
1980	1989	10	884	14,287	16,162
1970	1979	10	982	14,014	14,271
1960	1969	10	783	12,612	16,107
1946	1959	14	880	10,421	11,842
1920	1945	26	724	8,712	12,033
1900	1919	20	255	3,608	14,149
Before	1989		169	1,721	10,183
1920	1969	50	2,387	31,745	13,299

The average size of buildings built between 1920 and 1969 = 13,299

Source: U.S. Energy Information Administration, "Commercial Buildings Characteristics,1992". From 1996 Statistical Abstract, Table 1206. (Excludes buildings 1,000 square feet or smaller).

(3) Average generation from sampling (Table 6) 173 lb/sq ft

(4) Total nonresidential generation 50,400,000 Tons

Source: Franklin Associates

Table A-5
Residential Renovation Worksheet

Method to Use

(1) Start with total dollars of improvements and repairs, from Census Bureau. Current Constr Reports, C-30.
(2) Estimate the number of replacements of roofs, driveways, HVAC, kitchens, etc. and the amount of waste materials generated from each.
(3) Calculate total generation.

Calculation

(1)	1996 Expenditures for improvements and repairs of residential properties		114,300	million dollars
	Census data, released 8/4/97			
	Improvements	68 percent	77,724	
	Repairs	32 percent	36,576	
			114,300	million dollars

(2)	**Estimates for remodeling ***	**Million jobs**	**Tons/job**	**Tons**
	Kitchens (minor)	1.25	0.75	937,500
	Kitchens (major)	1.25	4.5	5,625,000
	Baths (minor)	1.8	0.25	450,000
	Baths (major)	1.2	1.00	1,200,000
	Additions	1.25	0.75	937,500

(3) Replacements (see FAL estimates, on following Tables A-7 through A-10)

Concrete from driveway replacements	13,000,000	tons/year
Asphalt roofs	6,800,000	
Wood roofs	1,400,000	
Heating & A/C replacements	1,574,000	
Kitchen remodeling	6,562,500	
Bathroom remodeling	1,650,000	
Additions	937,500	
Total residential renovation debris	31,924,000	tons/year

* NAHB Research Center

Source: Franklin Associates

Table A-6
Nonresidential Renovation Worksheet

Method to Use

(1) Start with total dollars of improvements and repairs, from U.S. Census.
(2) Calculate average $/sq ft of renovation from nonresidential renovation waste assessments.
(3) Generation (tons)=[Total Dollars / (Dollars/sq ft)] X (lb/sq ft) / (lb/ton).

Alternative method: Simply multiply quantity of residential renovation debris (Table A-5) by the ratio of dollars spent nonresidential to residential.

Calculation

(1) Total nonres improvements in 1996 * 100,400 million dollars
This compares to 1996 residential improvements of 114,300 million dollars
Total res + nonres 214,700 million dollars
*Assume same ratio of res/nonres as in 1992.
Bureau of the Census, Expenditures for Nonresidential Improvements and Repairs: 1992
From Table E: Comparison of Resid & Nonres Improvements & Repairs: 1992

	Tot. Dollars	Sq ft	$/sq ft		
(2) Renovation assessments	$8,578,000	72,000	$119	/sq ft	28.49 lb/sq ft
	$12,305,422	180,000	$68	/sq ft	6.85
	$2,100,000	24,000	$88		20.63
	$22,983,422	276,000	$83	/sq ft	17.67 lb/sq ft

(3) Total estimated square feet of renovation = 100,400 million / ($83/sq ft) 1,206 million sq ft

Estimated generation (method one) = 1,206 million X 17.67lb/sq ft/2,000 lb/ton = 10,652,000 tons/yr
Note: Total floorspace of nonresidential buildings in 1992 is 67.876 billion sq ft
Therefore 1,206 million represents 1.7 percent of total.
This seems to be unreasonably low. It implies an average of more than 50 years between renovations.
Therefore, use the alternative methodology.

Alternative methodology: Estimated generation = 31,924,000 / 114,300X100,400 = 28,042,000 tons/yr

Source: Franklin Associates

Table A-7
Estimated Weight of Concrete Driveways Replaced
Each Year from Residences With Less than Five Units/Structure

Total Housing units with < 5 units/structure, 1993*				81,094,000
Median age of housing = 28 years				
Estimated dimensions of ave driveway, LxWxT (ft)	8 X	45 X	0.333	
Calculated average driveway volume (cu ft)				119.9
Estimated percent of driveways replaced each year	3%			
Est. percent of homes with concrete driveways	60%			
Replacements/yr (total units times % replaced)				1,445,900
Total concrete removed (cu ft)				173,334,500
Density of concrete (lb/cu ft)	150			
Total tons of concrete				**13,000,000**

* 1996 Statistical Abstract, Table 1189.

Source: Franklin Associates

Table A-8
Estimated Weight of Asphalt Roofs Replaced
Each Year from Residences with Less than Five Units/Structure

Total Housing units with < 5 units/structure, 1993*		81,094,000
Median age of housing = 28 years		
Assume average roof area (sq ft)	1,400	
Assume weight of asphalt roof (lb/100 sq ft)	240	
Average wt of asphalt roof (lb/roof)		3,360
Estimated percent of homes with asphalt roofs**	67%	
Estimated percent of roofs replaced each year**	7%	
Replacements/yr (total no. times percent replaced)		3,803,300
Total tons of asphalt roofing removed		**6,400,000**

* 1996 Statistical Abstract, Table 1189.
** NAHB Research Center Waste Management Update 2, October 1996.

Source: Franklin Associates

Table A-9
Estimated Weight of Wood Roofs Replaced
Each Year from Residences with Less than Five Units/Structure

Total Housing units with < 5 units/structure, 1993*		81,094,000
Median age of housing = 28 years		
Assume average roof area (sq ft)	1,400	
Assume weight of wood roof (lb/100 sq ft)	200	
Calculated weight of wood roof (lb/roof)		2,800
Estimated percent of homes with wood roofs	25%	
Estimated percent of roofs replaced each year	5%	
Replacements/yr (total times percent replaced)		1,000,000
Total tons of wood roofing removed		**1,400,000**

* 1996 Statistical Abstract, Table 1189.

Source: Franklin Associates

Table A-10
Estimated Weight of Heating, Ventilating, and Air Conditioning Equipment Replaced Each Year

Total Housing units, 1993 (1) 106,610,000

Median age of housing = 28 years

	Estimated lb/unit*	Number in use (1)	Est. % replaced per year	Total TPY
Warm air furnaces	300	55,763,000	5	418,200
Electric heat pump	600	9,697,000	5	145,500
Steam or hot water systems	1,000	14,898,000	3	186,200
Floor, wall, or pipeless furnace	200	5,625,000	5	28,100
Built-in electric units	200	8,084,000	7	56,600
Room heaters	200	4,056,000	7	28,400
Stoves	200	3,477,000	3	10,400
Fireplaces	300	1,076,000	4	6,500
Central air	600	46,277,000	5	694,200
Total Replacement Products in the U.S. (1993)				**1,574,100**

(1) 1996 Statistical Abstract, Table 1189.
(2) Estimated by Franklin Associates.

Note: Equipment that remains in building unused will eventually become demolition debris.
Source: Franklin Associates

Table A-11
Construction Waste From Single Family Residential Construction (1)

	Largo, MD (2)			Anne Arundel County, MD (3)			Portland, OR (4)			Grand Rapids, MI (5)			Average
	Pounds	Tons	% of C/D	Pounds	Tons	% of C/D	Pounds	Tons	% of C/D	Pounds	Tons	% of C/D	% of C/D
Wood	4,305	2.15	42.2	3,319	1.66	35.2	6,676	3.34	48.8	5,310	2.66	43.6	42.4
Concrete													
Brick			0	1,240	0.62	13.1			0			0	3.3
Shingles													
Other Roofing													
Asphalt			0	544	0.27	5.8			0			0	1.4
Fiberglass													
Glass													
Metals	200	0.10	2.0	316	0.16	3.3	73	0.04	0.5	183	0.09	1.5	1.8
Plastics & foam	135	0.07	1.3	67	0.03	0.7	51	0.03	0.4	409	0.20	3.4	1.4
Mixed													
Textiles				51	0.03	0.5	10	0.01	0.1	85	0.04	0.7	0.4
OCC	420	0.21	4.1	478	0.24	5.1	280	0.14	2.0	1,240	0.62	10.2	5.4
Other Packaging	50	0.03	0.5	58	0.03	0.6	20	0.01	0.1	147	0.07	1.2	0.6
Other mixed C&D	2,420	1.21	23.7	423	0.21	4.5	2,768	1.38	20.2	1,908	0.95	15.7	16.0
Drywall	2,680	1.34	26.2	2,940	1.47	31.2	3,806	1.90	27.8	2,900	1.45	23.8	27.3
Masonry & Tile													
Inerts													
Totals	**10,210**	**5.11**	**100**	**9,436**	**4.72**	**100**	**13,684**	**6.84**	**100**	**12,182**	**6.09**	**100**	**100**
Square feet	2,200			2,450			3,000			2,600			
Pounds/sq ft	4.6			3.9			4.6			4.7	Average lb/sq ft =		4.4

(1) Source: NAHB Research Center, 1995.
(2) 2 story -2200 sq ft, W/O bsmt, vinyl sided w/brick front, 4 bdrm, 2 1/2 ba, 2 car gar, no deck, 11/94.
(3) 2 story -2450 sq ft, full bsmt, 2 car gar, brick facade, 4 bdrm, 2 1/2 ba, 3/95.
(4) Custom 2 story -3000 sq ft, full bsmt, tile roof, 4 bdrm, 3 ba, 2 car gar, tile roof, 7/92
(5) 2 story -2600 sq ft, W/O bsmt, vinyl siding, 4 bdrm, 2 1/2 ba, 3 car gar w/deck, 10/94
(5) OCC, approx. 380 containers - largest contributors to volume: cabinets, appliances, vinyl siding, windows, doors, and electrical fixtures.

Table A-12
Riverdale Case Study
Multi-Family (4-Plex) Building Deconstruction

Material	Tons	Percent
Wood	17.6	14
Drywall	21.6	17
Roofing	3.5	3
Rubble	66.5	52
Brick	17.9	14
Miscellaneous	1.4	1
	128.5	101

Total building floor area = 2,000 square ft

Generation rate = 129 pounds/square foot

Source: NAHB Research Center, Inc. June 1997

Table A-13

Residential C&D Debris Composition

METRO, Portland Oregon (As generated) (1)

	New Construction		New Construction		New Construction		Kitchen Renovation		House Renovation	
	Pounds	**Percent**	**Pounds**	**Percent**	**Pounds**	**Percent**	**Pounds**	**Percent**	**Pounds**	**Percent**
Wood	6,945	50.4	6,000	71.5	8,400	79.3	1,526	15.2	14,500	55.1
Drywall	3,806	27.6	1,450	17.3	1,210	11.4	7,620 (2)	76.1		
Concrete	1,698	12.3								
Metal	138	1.0					186	1.9		
Cardboard	280	2.0			135	1.3				
Roofing									10,200	38.8
Miscellaneous	909	6.6	936	11.2	850	8.0	675	6.7	1,600	6.1
	13,776	100.0	8,386	100.0	10,595	100.0	10,007	100.0	26,300	100.0
Total square feet	2,800		1,290		1,290		150.0		1,330.0	
Pounds/sq ft	4.9		6.5		8.2		66.7		19.8	

	Demolition		Demolition		Demolition	
	Pounds	**Percent**	**Pounds**	**Percent**	**Pounds**	**Percent**
Wood	19,000	25.7	34,000	54.0	18,000	58.0
Drywall						
Concrete	30,000	40.5			10,000	32.2
Metal	4,000	5.4				
Cardboard						
Roofing						
Miscellaneous	21,000	28.4	29,000	46.0	3,020	9.7
	74,000	100.0	63,000	100.0	31,020	100.0
Total square feet	1,280.0		1,200.0		750.0	
Pounds/sq ft	57.8		52.5		41.4	

(1) Includes recycled and disposed materials.

(2) Plaster and brick

Source: METRO Data Sheets, Portland, OR 1992-1995.

Table A-14

Nonresidential C&D Debris Composition

METRO, Portland Oregon (As generated) (1)

	Institutional New Construction		2 Office Buildings New Construction		Hospital Lab & Office Renovation		Office Building Renovation		Department Store Renovation	
	Pounds	Percent	Pounds	Percent	Pounds	Percent	Pounds	Percent	Pounds	Percent
Wood	36,000	20.5	4,400	37.0			7,200	40.2	406,000	20.4
Drywall			4,800	40.3			10,000 (2)	55.9	222,000	11.2
Concrete										
Metal					11,600	22.1	300	1.7	812,000	40.8
Cardboard	34,000	19.3							10,000	0.5
Roofing									10,200	0.5
Miscellaneous	106,000	60.2	2,700	22.7	40,800	77.9	400	2.2	530,000	26.6
	176,000	100.0	11,900	100.0	52,400	100.0	17,900	100.0	1,990,200	100.0
Total square feet	41,850		7,452		10,560		6,000.0		198,500.0	
Pounds/sq ft	4.2		1.6		5.0		3.0		10.0	

	Warehouse Demolition		Department Store Demolition		Institutional Demolition	
	Pounds	Percent	Pounds	Percent	Pounds	Percent
Wood	2,496,000	79.7	84,000	1.2	142,000	1.3
Drywall						
Concrete	176,000	5.6	6,534,000	89.5	7,210,000	66.1
Metal	402,000	12.8	646,000	8.9	256,000	2.3
Cardboard						
Roofing						
Miscellaneous	58,800	1.9	34,000	0.5	3,300,000	30.3
	3,132,800	100.0	7,298,000	100.0	10,908,000	100.0
Total square feet	86,400.0		44,000.0		60,000.0	
Pounds/sq ft	36.3		165.9		181.8	

(1) Includes recycled and disposed materials.

Source: METRO Data Sheets, Portland, OR 1992-1995.

Table A-15

Construction & Demolition Debris Composition

City of Seattle (As Disposed)

	Residential New Construction		Commercial New Construction		Residential Remodeling (1)		Commercial Remodeling(1)		Residential Demolition		Commercial Demolition	
	Tons	Percent	Tons	Percent	Tons	Percent	Tons	Percent	Tons	Percent	Tons	Percent
Wood waste	1,569	52.6	2,583	34.6	7,257	55.5	3,834	51.1	6,509	49.5	12,791	31.0
Mineral Aggregates (2)	870	29.2	2,740	36.8	4,076	31.2	1,641	21.9	3,989	30.4	11,734	28.4
Glass	1	0.0	3	0.0	136	1.0	2	0.0	204	1.6	349	0.8
Metals	82	2.7	759	10.2	674	5.2	957	12.8	694	5.3	7,391	17.9
Paper	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Yard wastes	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Plastics	160	5.3	241	3.2	397	3.0	598	8.0	317	2.4	1,891	4.6
Other materials	242	8.1	965	12.9	424	3.2	278	3.7	416	3.2	5,663	13.7
Other Organics	45	1.5	31	0.4	107	0.8	127	1.7	972	7.4	1,110	2.7
Hazardous Waste	15	0.5	133	1.8	15	0.1	65	0.9	41	0.3	362	0.9
	2,984	100.0	7,455	100.0	13,086	100.0	7,502	100.0	13,143	100.0	41,292	100.0

(1) Roofing materials hauled separately not included.

(2) Mineral aggregates include roofing materials (composition, built-up, tarpaper, clay roofing tile, slate), concrete, bricks, masonry, tile, mortar, fiberglass insulation, and gypsum scrap.

Source: Construction and Demolition Debris Study for the City of Seattle, by Cunningham Environmental Consulting and Cascadia Consulting Group. Draft Report, March 1996

Table A-16
Composition of Building Construction & Demolition Debris

Component	Residential Renovation		Residential New Construction		Residential Demolition		Commercial Renovation		Commercial Demolition		Total Composition	
	Pounds	Percent	Pounds	Percent	Pounds	Percent	Pounds	Percent	Pounds	Percent	Pounds	Percent
Asphalt	0.0	0.00	0.0	0.00	0.0	0.00	12.9	0.01	0.0	0.00	12.9	0.00
Brick	1,474.3	3.66	520.6	1.87	1,648.6	2.13	545.3	0.40	0.0	0.00	4,188.8	1.30
Corrugated	339.9	0.84	891.5	3.21	141.3	0.18	316.1	0.23	125.3	0.31	1,814.1	0.56
Carpeting	154.5	0.38	326.6	1.18	9.9	0.01	51.5	0.04	109.0	0.27	651.5	0.20
Cinder Block	10.7	0.03	169.1	0.61	13,641.0	17.61	26,206.6	19.03	0.0	0.00	40,027.4	12.39
Concrete with Rebar	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Concrete without Rebar	77.3	0.19	2,177.9	7.84	11,820.3	15.26	30,201.1	21.93	816.5	2.05	45,093.1	13.96
Dirt/Earth	0.0	0.00	119.0	0.43	0.0	0.00	144.2	0.10	0.0	0.00	263.2	0.08
Drywall	4,759.6	11.83	3,939.8	14.18	1,045.2	1.35	5,220.2	3.79	25.4	0.06	14,990.2	4.64
Electric Fixtures	79.9	0.20	10.5	0.04	3.3	0.00	639.8	0.46	40.0	0.10	773.5	0.24
Electrical Wiring	36.0	0.09	4.2	0.02	68.2	0.09	929.0	0.67	81.5	0.20	1,118.9	0.35
Furniture	13.0	0.03	0.0	0.00	0.0	0.00	63.0	0.05	421.5	1.06	497.5	0.15
Glass	85.8	0.21	58.7	0.21	57.2	0.07	63.9	0.05	18.8	0.05	284.4	0.09
Insulation-Foam	190.8	0.47	31.6	0.11	61.9	0.08	333.8	0.24	2.2	0.01	620.3	0.19
Insulation-Sheathing	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Masonite/Slate	468.3	1.16	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	468.3	0.14
Metal Drums	0.0	0.00	0.0	0.00	8.4	0.01	29.8	0.02	440.0	1.10	478.2	0.15
Metal-Ferrous	875.6	2.18	214.7	0.77	1,454.4	1.88	6,729.8	4.89	2,577.3	6.47	11,851.8	3.67
Metal-Nonferrous	75.9	0.19	91.0	0.33	28.1	0.04	165.6	0.12	4.0	0.01	364.6	0.11
Misc. Fines	10,921.7	27.14	9,904.6	35.65	26,308.9	33.97	24,901.4	18.08	21,785.6	54.67	93,822.2	29.04
Other Paper	239.1	0.59	40.1	0.14	38.2	0.05	173.9	0.13	167.1	0.42	658.4	0.20
Pallets	17.8	0.04	123.6	0.44	0.0	0.00	160.6	0.12	195.0	0.49	497.0	0.15
Plastic film	123.5	0.31	52.5	0.19	33.4	0.04	143.7	0.10	51.8	0.13	404.9	0.13
Plastic-PVC Pipe, Rigid, etc.	20.5	0.05	194.5	0.70	32.1	0.04	295.0	0.21	830.2	2.08	1,372.3	0.42
Porcelain/Bathroom Fixtures	72.1	0.18	19.1	0.07	144.5	0.19	138.7	0.10	75.3	0.19	449.7	0.14
Pressboard/Chipboard	941.6	2.34	1,511.7	5.44	593.1	0.77	1,855.7	1.35	4,937.1	12.39	9,839.2	3.05
Roofing Material-Felt	10.8	0.03	36.2	0.13	148.3	0.19	0.0	0.00	0.0	0.00	195.3	0.06
Roofing Material-Shingles	4,328.8	10.76	272.0	0.98	933.6	1.21	18,209.5	13.22	0.0	0.00	23,743.9	7.35
Rubber	11.2	0.03	82.4	0.30	0.0	0.00	21.6	0.02	0.0	0.00	115.2	0.04
Siding-Aluminum	0.0	0.00	0.0	0.00	87.3	0.11	0.0	0.00	0.0	0.00	87.3	0.03
Siding-Vinyl	439.7	1.09	119.2	0.43	80.9	0.10	0.0	0.00	45.1	0.11	684.9	0.21
Textiles	5.8	0.01	4.8	0.02	3.2	0.00	36.9	0.03	0.0	0.00	50.7	0.02
Tile-Ceiling	206.5	0.51	153.3	0.55	198.8	0.26	573.6	0.42	31.5	0.08	1,163.7	0.36
Tile/Ceramics	921.6	2.29	344.8	1.24	48.5	0.06	1,156.4	0.84	14.2	0.04	2,485.5	0.77
Tires	26.7	0.07	0.0	0.00	0.0	0.00	15.3	0.01	0.0	0.00	42.0	0.01
Treated Wood	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	168.9	0.42	168.9	0.05
Tree Limbs/Stumps	782.1	1.94	1,952.2	7.03	298.7	0.39	810.7	0.59	104.6	0.26	3,948.3	1.22
Untreated Wd.-Plywood	723.1	1.80	1,082.0	3.89	652.5	0.84	5,724.8	4.16	1,811.4	4.55	9,993.8	3.09
Untreat. Wd.-Dimen. Wd.(not paint.)	10,214.7	25.38	3,319.6	11.95	17,252.5	22.28	7,245.5	5.26	4,727.1	11.86	42,759.4	13.24
Untreat. Wd.-Dimen. Wd.(Paint.)	1,348.6	3.35	18.8	0.07	607.0	0.78	4,512.8	3.28	101.1	0.25	6,588.3	2.04
White Goods/Appliances	249.0	0.62	0.0	0.00	0.0	0.00	91.1	0.07	144.6	0.36	484.7	0.15
TOTAL	**40,246.5**	**100.0**	**27,786.6**	**100.0**	**77,449.3**	**100.00**	**137,719.8**	**100.0**	**39,852.1**	**100.00**	**323,054.3**	**100.00**

Source: Gershman, Brickner & Bratton, Inc., for Town of Babylon, NY; Demolition Age, September 1993.

Table A-17
Composition of C&D Debris in Des Moines, Iowa (1)

Componer	Residential New Construction		Residential Renovation		Residential Demolition	
	Tons	Percent	Tons	Percent	Tons	Percent
Asphalt	0.0	0.0	0.0	0.0	0.0	0.0
Brick	11.3	5.2	5.3	3.8	0.9	3.9
Cardboard	9.7	4.5	2.7	2.0	0.1	0.4
Concrete	26.4	12.1	12.5	9.1	5.0	21.8
Drywall	35.4	16.3	7.4	5.4	2.4	10.5
Metal	3.4	1.6	13.1	9.5	1.1	4.8
Plastic	1.9	0.9	0.9	0.7	0.1	0.4
Roofing	12.2	5.6	39.3	28.5	3.8	16.6
Wood	96.5	44.3	41.1	29.8	7.4	32.3
Other	20.8	9.6	15.4	11.2	2.1	9.2
	217.6	**100.0**	**137.7**	**100.0**	**22.9**	**100.0**

Componer	Commercial Construction		Commercial Renovation		Commercial Demolition		Total Composition	
	Tons	Percent	Tons	Percent	Tons	Percent	Tons	Percent
Asphalt	0.4	0.6	0.0	0.0	0.0	0.0	0.4	0.0
Brick	4.4	6.7	17.1	4.6	2.0	7.4	41.0	4.8
Cardboard	4.9	7.5	5.4	1.4	0.4	1.5	23.2	2.7
Concrete	21.6	32.9	81.7	21.8	8.5	31.6	155.7	18.4
Drywall	4.3	6.6	58.6	15.6	5.3	19.7	113.4	13.4
Metal	5.8	8.8	48.1	12.8	3.2	11.9	74.7	8.8
Plastic	0.3	0.5	0.8	0.2	0.0	0.0	4.0	0.5
Roofing	6.3	9.6	39.3	10.5	0.8	3.0	101.7	12.0
Wood	12.3	18.8	67.9	18.1	6.7	24.9	231.9	27.4
Other	5.3	8.1	56.5	15.1	0.0	0.0	100.1	11.8
	65.6	**100.0**	**375.4**	**100.0**	**26.9**	**100.0**	**846.1**	**100.0**

(1) C&D debris generated in one week of July 1994 in Des Moines, Iowa

Source: Brickner, Robert, Gershman, Brickner & Bratton, Inc. "Identifying C&D Debris Markets." Scrap Processing, March/April 1995.

Table A-18
Average Composition of Waste from 19 Industrial/Commercial Demolition Projects in the Northwest Area

Material	Totals Tons	Average Percent
Wood	28,000	15.5
Roofing	1,400	0.8
Concrete	120,300	66.8
Brick	2,200	1.2
Scrap Iron	8,700	4.8
Asphalt	3,200	1.8
Landfill debris	16,400	9.1
Total tons	180,200	100.0
Total tons (17 buildings)	167,200	
Building size (square fee	2,204,000	
Average generation rate*	151.7 lb/sq ft	

* Building sizes available for 17 of the 19 projects.
Source: R.W. Rhine Inc., Tacoma, Washington

Table A-19
Number of Active Construction & Demolition (C&D) Landfills in the United States

State	Number of C&D Landfills	Rank from high	Rank from low
Alabama	32	17	35
Alaska	21	23	29
Arizona	6	35	17
Arkansas	22	21	31
California	16	26	26
Colorado	5	37	15
Connecticut	21	22	30
Delaware	1	49	3
District of Columbia	0	51	1
Florida	277	1	51
Georgia	44	12	40
Hawaii	1	48	4
Idaho	7	31	21
Illinois	3	42	10
Indiana	11	28	24
Iowa	1	47	5
Kansas	78	9	43
Kentucky	143	5	47
Louisiana	167	2	50
Maine	57	10	42
Maryland	14	27	25
Massachusetts	18	25	27
Michigan	5	36	16
Minnesota	79	8	44
Mississippi	111	6	46
Missouri	9	30	22
Montana	27	18	34
Nebraska	6	34	18
Nevada	6	33	19
New Hampshire	0	50	2
New Jersey	3	41	11
New Mexico	4	40	12
New York	19	24	28
North Carolina	153	3	49
North Dakota	39	14	38
Ohio	148	4	48
Oklahoma	6	32	20
Oregon	2	45	7
Pennsylvania	4	39	13
Rhode Island	1	46	6
South Carolina	53	11	41
South Dakota	103	7	45
Tennessee	32	16	36
Texas	24	19	33
Utah	9	29	23
Vermont	2	44	8
Virginia	32	15	37
Washington	22	20	32
West Virginia	2	43	9
Wisconsin	39	13	39
Wyoming	4	38	14
Total	**1889**		

Source: "List of Industrial Waste Landfills and Construction and Demolition Waste Landfills, prepared for U.S. Environmental Protection Agency by Eastern Research Group, Inc., September 30, 1994.

Table A-20
Number of Active Wood Processing Facilities that also Accept C&D Waste by State

State	Construction	Demolition	Construction & Demolition	Total Number of Facilities
North Carolina	12	0	32	44
Oregon	5	2	28	35
California	11	1	22	34
Maryland	15	0	9	24
New Jersey	5	1	14	20
Washington	9	0	8	17
Ohio	5	0	8	13
New York	7	0	5	12
Florida	1	2	7	10
Georgia	7	0	3	10
Massachusetts	5	3	0	8
Virginia	2	1	5	8
Alabama	0	0	6	6
Michigan	6	0	0	6
Minnesota	5	1	0	6
Illinois	2	1	2	5
Oklahoma	2	0	3	5
Texas	3	1	1	5
Wisconsin	3	2	0	5
Connecticut	1	0	3	4
New Hampshire	1	0	3	4
Pennsylvania	2	0	2	4
Rhode Island	1	0	3	4
Colorado	1	0	2	3
Idaho	0	0	3	3
Maine	0	0	3	3
Delaware	1	0	1	2
Indiana	2	0	0	2
Vermont	1	0	1	2
Alaska	0	0	1	1
Arizona	1	0	0	1
Hawaii	1	0	0	1
Iowa	1	0	0	1
Kansas	1	0	0	1
Louisiana	0	1	0	1
Mississippi	0	0	1	1
New Mexico	0	0	1	1
South Carolina	0	0	1	1
South Dakota	1	0	0	1
Tennessee	1	0	0	1
Arkansas	0	0	0	0
District of Columbia	0	0	0	0
Kentucky	0	0	0	0
Missouri	0	0	0	0
Montana	0	0	0	0
Nebraska	0	0	0	0
Nevada	0	0	0	0
North Dakota	0	0	0	0
Utah	0	0	0	0
West Virginia	0	0	0	0
Wyoming	0	0	0	0
Total	**121**	**16**	**178**	**315**

Source: "National Wood Recycling Directory", (First Edition). American Forest & Paper Association, January 1996.

Appendix B

STATE DEFINITIONS FOR CONSTRUCTION AND DEMOLITION DEBRIS

Appendix B

STATE DEFINITIONS FOR CONSTRUCTION AND DEMOLITION DEBRIS

This appendix includes a representative sample of definitions of construction and demolition (C&D) debris used by states and other jurisdictions. The definitions are the most recent available from the states.

STATE OF CALIFORNIA

Construction and demolition (C&D) debris includes concrete, asphalt, wood, drywall, metals, and many miscellaneous and composite materials. C&D debris is generated by demolition and new construction of structures such as residential and commercial buildings and roadways.

STATE OF FLORIDA

"Construction and demolition debris" means 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 or 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 or their components and unpainted, non-treated wood pallets provided the wood scraps and pallets are separated from other solid waste; and the commingling of wood scraps or pallets with other solid waste; and *de minimis* amounts of other non-hazardous wastes that are generated at construction or 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.
(Florida Department of Environmental Protection, Bureau of Solid and Hazardous Waste, Division of Waste Management. Solid Waste Management in Florida. Classification of Landfills. Rule 62-701.200 (19). June 1997)

STATE OF HAWAII

"Construction and demolition waste" means solid waste, largely inert waste, resulting from the demolition or razing of buildings, of roads, or other structures, such as concrete, rock, brick, bituminous concrete, wood, and masonry, composition roofing and roofing paper, steel, plaster, and minor amounts of other metals, such as copper.

Construction and demolition waste does not include cleanup materials contaminated with hazardous substances, friable asbestos, waste paints, solvents, sealers, adhesives, or similar materials.
(Hawaii Department of Health. Hawaii Administrative Rules, Title 11, Chapter 58.1, Solid Waste Management Control)

STATE OF KANSAS

"Construction and demolition waste" means solid waste resulting from the construction, remodeling, repair and demolition of structures, roads, sidewalks and utilities; and solid waste consisting of vegetation from land clearing and grubbing, utility maintenance, and seasonal or storm-related cleanup. Such wastes include, but are not limited to, bricks, concrete and other masonry materials, roofing materials, soil, rock, wood, wood products, wall covering, plaster, drywall, plumbing fixtures, electrical wiring, electrical components containing no hazardous materials and non asbestos insulation. It shall not include asbestos waste, garbage, cardboard, furniture, appliances, electrical equipment containing hazardous materials, tires, drums and containers even though such wastes resulted from construction and demolition activities. Clean rubble that is mixed with other construction and demolition waste during demolition or transportation shall be considered to be construction and demolition waste.
(Kansas Department of Health and Environment. Kansas Statutes Annotated Chapter 65—Public Health, Article 34—Solid Waste and Administrative Regulations Article 29—Solid Waste Management, Part 1. Administrative Procedures; Part 2. Standards. May 1994)

STATE OF KENTUCKY

Construction/Demolition Debris Landfill - Construction/demolition debris landfill is the category of solid waste site or facility for the disposal of solid waste that results from the construction, remodeling, repair, and demolition of structures and roads and for the disposal of uncontaminated solid waste consisting of vegetation resulting from land clearing and grubbing, utility line maintenance, and seasonal and storm-related cleanup. Such waste includes, but is not limited to bricks, shredded or segmented tires, concrete and other masonry materials, soil, rock, wood, wall coverings, plaster, drywall, plumbing fixtures, tree stumps, limbs, saw dust, leaves, yard waste, paper, paper products, metals, furniture, insulation, roofing shingles, asphalt pavement, glass, plastics that are not sealed in a manner that conceals other wastes, electrical wiring and components containing no liquids or hazardous metals that are incidental to any of the above and other inert waste as approved by the division. Asbestos-containing materials may be accepted only if the permit application includes procedures approved by the division to handle these materials.
(Kentucky Natural Resources and Environmental Pollution Control, Division of Waste Management. Permits Issued by the Division of Waste Management, I. Solid Waste Landfill Permits (Construction and Operation), Landfill Classifications: Construction/Demolition Debris Landfill)

MARICOPA COUNTY, ARIZONA

Construction debris is a general term used to describe a large class of solid wastes usually generated as a byproduct of the construction, demolition, or maintenance of residences, commercial or industrial facilities and infrastructure. Construction debris includes such materials as: broken concrete, asphalt, steel, aluminum, glass, brick, tile, paper, plastics, wood products, sheet rock, street sweepings and canal dredgings.
(Maricopa County, Arizona. Construction Wastes: Classification)

THE COMMONWEALTH OF MASSACHUSETTS

C&D waste is comprised of debris generated from construction, renovation, repair, and demolition of roads, bridges, and buildings and includes wood, steel, concrete, masonry, plaster, metal, and asphalt, but not wood from land-clearing, i.e. stumps, logs, brush, and soil, nor rock from excavations.
(The Commonwealth of Massachusetts Department of Environmental Protection. 310 CMR 16.00, Site Assignment Regulations for Solid Waste Facilities. 16.02: Definitions; Also 1997 Master Plan Update Draft, Non Municipal Solid Waste)

STATE OF MINNESOTA

Construction Wastes

"Building materials, packaging, and rubble resulting from construction, remodeling, repair, and demolition of buildings and roads."

Demolition Debris

"Solid waste resulting from the demolition of buildings, roads, and other man-made structures, including concrete, brick, bituminous concrete, untreated wood, masonry, glass, trees, rock, and plastic building parts. Demolition debris does not include asbestos."
(Minnesota Office of Environmental Assessment. Metropolitan Solid Waste Planning Policy. Draft 11/25/96)

STATE OF NORTH CAROLINA

"Construction" or "demolition" when used in connection with "waste" or "debris" means solid waste resulting solely from construction, remodeling, repair, or demolition operations on pavement, buildings, or other structures, but does not include inert debris, land-clearing debris or yard debris.
(North Carolina Division of Waste Management. GS 130A-290. DEFINITIONS (1) (4))

STATE OF NEBRASKA

"Construction and demolition waste" shall mean waste which typically results from construction or demolition projects and includes all materials which are the by-products of construction work or which result from demolition of buildings and other structures, including, but not limited to brick, concrete rubble, masonry materials, paper,

gypsum board, wood, rubber and plastics. Construction and demolition waste does not include friable asbestos-containing materials, liquid waste, hazardous waste, putrescible waste or furnishings from demolished structures.
(Nebraska Department of Environmental Quality. Title 132 - Integrated Solid Waste Management Regulations, Chapter 1 011. Effective date: May 14, 1994)

STATE OF NEW YORK

Construction and demolition (C&D) debris means uncontaminated solid waste resulting from the construction, remodeling, repair and demolition of utilities, structures and roads; and uncontaminated solid waste resulting from land clearing. Such waste includes, but is not limited to bricks, concrete and other masonry materials, soil, rock, wood (including painted, treated and coated wood and wood products), land clearing debris, wall coverings, plaster, drywall, plumbing fixtures, non asbestos insulation, roofing shingles and other roof coverings, asphalt pavement, glass, plastics that are not sealed in a manner that conceals other wastes, empty buckets ten gallons or less in size and having no more than one inch of residue remaining on the bottom, electrical wiring and components containing no hazardous liquids, and pipe and metals that are incidental to any of the above. Solid waste that is not C&D debris (even if resulting from the construction, remodeling, repair and demolition of utilities, structures and roads and land clearing) includes, but is not limited to asbestos waste, garbage, corrugated container board, electrical fixtures containing hazardous liquids such as fluorescent light ballasts or transformers, fluorescent lights, carpeting, furniture, appliances, tires, drums, containers greater than ten gallons in size, any containers having more than one inch of residue remaining on the bottom and fuel tanks. Specifically excluded from the definition of construction and demolition debris is solid waste (including what otherwise would be construction and demolition debris) resulting from any processing technique, other than that employed at a department-approved C&D debris processing facility, that renders individual waste components unrecognizable, such as pulverizing or shredding. Also, waste contained in an illegal disposal site may be considered C&D debris if the department determines that such waste is similar in nature and content to C&D debris.
(New York State Department of Environmental Conservation, Division of Solid & Hazardous Materials. 6 NYCRR Park 360 Solid Waste Management Facilities. Title 6 of the Official Compilation of Codes, Rules and Regulations. 360-1.2(b)(38). Effective November 26, 1996. Reprinted January 1997)

STATE OF OREGON

"Construction and Demolition Waste" means solid waste resulting from the construction, repair or demolition of buildings, roads and other structures, and debris from the clearing of land, but does not include clean fill when separated from other construction and demolition wastes and used as fill materials or otherwise land disposed. Such waste typically consists of materials including concrete, bricks, bituminous concrete, asphalt paving, untreated or chemically treated wood, glass, masonry, roofing, siding, plaster; and

soils, rock, stumps, boulders, brush and other similar material. This term does not include industrial solid waste and municipal solid waste generated in residential or commercial activities associated with construction and demolition activities.
(Oregon Department of Environmental Quality. Disposal Site Definitions)

PORTLAND, OREGON METROPOLITAN SERVICE DISTRICT
Construction Waste - Waste materials resulting from the construction, remodeling and repair of buildings and other structures.
Demolition Waste - Solid waste, largely inert, resulting from the demolition or razing of buildings, roads, and other man-made structures. Demolition waste consists of, but is not limited to, concrete, brick, bituminous concrete, wood, masonry, composition, roofing and roofing paper, steel, and amounts of other metals like copper. Plaster (i.e., sheet rock or plasterboard), any other non-wood material that is likely to produce gases or leachate during the decomposition process, and asbestos wastes are not considered to be demolition wastes.
(Portland, Oregon Metropolitan Service District, Solid Waste Department. Investigation of Alternative Markets for Recycled Wood. Prepared by International Resources Unlimited, Inc.)

STATE OF RHODE ISLAND
"Construction and Demolition (C&D) Debris" shall mean non-hazardous solid waste resulting from the construction, remodeling, repair, and demolition of utilities and structures; and uncontaminated solid waste resulting from land clearing. Such waste includes, but is not limited to wood (including painted, treated and coated wood and wood products), land clearing debris, wall coverings, plaster, drywall, plumbing fixtures, non-asbestos insulation, roofing shingles and other roofing coverings, glass, plastics that are not sealed in a manner that conceals other wastes, empty buckets ten gallons or less in size and having no more than one inch of residue remaining on the bottom, electrical wiring and components containing no hazardous liquids, and pipe and metals that are incidental to any of the above. Solid waste that is not C&D debris (even if resulting from the construction, remodeling, repair, and demolition of utilities, structures, and roads and land clearing) includes, but is not limited to, asbestos waste, garbage, corrugated container board, electrical fixtures containing hazardous liquids such as fluorescent light ballasts or transformers, fluorescent lights, carpeting, furniture, appliances, tires, drums, containers greater than ten gallons in size, any containers having more than one inch of residue remaining on the bottom, and fuel tanks. Also excluded from the definition of C&D debris is solid waste resulting from any processing technique that renders individual waste components unrecognizable, such as pulverizing or shredding, at a facility that processes C&D debris.
(State of Rhode Island Department of Environmental Management, Office of Waste Management. Rules and Regulations for Composting Facilities and Solid Waste Management Facilities Rule 1.3.47)

STATE OF SOUTH CAROLINA

"Construction and demolition debris" means discarded solid wastes resulting from construction, remodeling, repair and demolition of structures, road building, and land-clearing. The wastes include, but are not limited to, bricks, concrete, and other masonry materials, soil, rock, lumber, road spoils, paving material, and tree and brush stumps, but does not include solid waste from agricultural or silvicultural operations.
(South Carolina Department of Health and Environmental Control. Chapter 61. R. 61-107.11 Solid Waste Management: Construction, Demolition and Land-Clearing Debris Landfills. B. Definitions)

WASHINGTON STATE DEPARTMENT OF ECOLOGY

"Demolition waste" means solid waste, largely inert waste, resulting from the demolition or razing of buildings, roads and other man-made structures. Demolition waste consists of, but is not limited to, concrete, brick, bituminous concrete, wood and masonry, composition roofing and roofing paper, steel, and minor amounts of other metals like copper. Plaster (i.e., sheet rock or plaster board) or any other material, other than wood, that is likely to produce gases or a leachate during the decomposition process and asbestos wastes are not considered to be demolition waste for the purposes of this regulation.
(Washington State Department of Ecology Solid Waste and Financial Assistance Program, Chapter 173-304 WAC, Minimum Functional Standards for Solid Waste Handling)

Appendix C

TYPICAL CONSTRUCTION AND DEMOLITION DEBRIS CONSTITUENTS

Table C-1

TYPICAL CONSTRUCTION AND DEMOLITION DEBRIS CONSTITUENTS

Primary Inert Fractions
Asphalt
Brick
Cinder block
Concrete with rebar/wire mesh
Concrete without steel reinforcing
Masonite/slate
Tile-ceramic
Glass
Dirt/earth
Plastic sheet film
Plastic pipe
Porcelain, including bathroom fixtures
Metal-ferrous
Metal-nonferrous
Electrical wiring
Insulation-fiberglass
Plastic buckets/containers

High Organic Based Fractions
Ceiling tiles
Corrugated shipping containers
Insulation-treated cellulose
Insulation-sheathing
Pallets/spools/reels
Pressboard/chipboard
Roofing materials (e.g., roofing felt, asphalt shingles)
Dimensional lumber & shapes (clean)
Plywood, particleboard, oriented strandboard, etc.

Range of Composite Materials (may require special handling)
Carpeting
Carpet padding
Gypsum wallboard (mainly gypsum with paper backing)
Electrical fixtures (metal, light tubes/bulbs, ballasts)
Electrical switches
Rubber hosing/conduits
Tires (some with wheels)
Painted wood
Pressure treated wood
Wood composites

Source: Gershman, Brickner & Bratton, Inc. Fairfax, Virginia

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