Developing a Cost Effective Construction and Demolition Waste Management Plan

by

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(ABSTRACT)

Concern over construction and demolition (C&D) wastes is becoming a prevalent part of any construction project. Historically, landfilling waste materials was the standard solution for most contractors, but as tipping fees have risen dramatically over the past five to seven years, many contractors are looking for alternative methods, such as recycling or waste minimization, to reduce wastes.

This thesis investigates C&D wastes and proposes a methodology to address the problem of assessing waste disposal techniques efficiently and economically. A brief history of C&D wastes is provided to understand how and why costs associated with waste materials have risen over the last several years. Current waste management resources are

discussed to demonstrate the availability of alternative disposal methods. An overall waste management plan is developed to provide a contractor with a step by step flowchart for analyzing material wastes, quantitatively assessing all costs associated with waste disposal, and implementing and updating the chosen waste management techniques. A case study is provided to illustrate how the waste management plan is used in an actual project. The thesis concludes with a discussion of the potential for further research in the area of C&D waste management.

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Chapter 1

Introduction

Construction is a vital connection to the infrastructure and growth of industry in the United States. Buildings, roadways, bridges, airports, dams, and other constructed facilities play an important role in shaping society's functions. The construction industry pushes technological limits by constantly striving to build taller, longer, and deeper structures every year. One aspect of these projects, which also pushes forward with the same growing intensity, is the generation of 100 million tons of construction and demolition wastes annually (Brickner, 1994).

Construction and demolition (C&D) wastes are as much a part of construction as schedules, estimates, hammers, or nails. However, costs to dispose of C&D wastes have risen dramatically in recent years, forcing contractors to reevaluate waste disposal methods in some areas and choose whether to view C&D waste as a resource, or simply as rubbish. The research in this thesis examines the current plight of C&D wastes and presents a plan to address managing this aspect of construction.

1.1 Background

The visibility of construction in the United States is readily seen in the skylines of major cities, the roadways of any state, and the bridges across major waterways. The benefits from construction are products used by people every day. Society has grown to expect many standards from products that are sold and purchased. Many of these standards have gone beyond mere function or performance—they now encompass environmental issues that are of local, regional, and national concern (Kinlaw, 1993).

One major issue, not always addressed in construction projects is the management of C&D wastes. C&D wastes have been estimated to make up 15-20% of all municipal solid wastes (MSW) in the United States (Brickner, 1994). Table 1.1 illustrates the quantity of C&D wastes with respect to other municipal material waste streams.

Table 1.1: Constituents of material waste stream (source: Johnston and Mincks, 1992)

Constituents	Millions of tons	Percentage
Refuse	124,000,000	65%
C&D wastes	***36,000,000***	***19%***
Sewage sludge	11,000,000	6%
Glass	11,000,000	6%
Incinerator residue	5,000,000	2%
Rubber	5,000,000	2%
Total	192,000,000	100%

The 15-20% estimate is difficult to quantify precisely, as C&D wastes are nonhomogeneous, and are typically buried in landfills. Previously, low visibility allowed the construction industry to avoid many of the legislative and societal constraints placed on waste disposal. However, as landfills across the United States close and tipping fees rise, the types of wastes which are brought to disposal facilities are being scrutinized more closely.

In response to environmental pressure, the United States is moving heavily towards the concept of "greening" products and processes. While the term "green" encompasses a very wide range of meanings, the main idea is to minimize waste and/or environmental impact (Miller and Szekely, 1995). Other *desired* aspects of "greening" involve maintaining the specified performance throughout a complete product life cycle without increasing costs. Many industries, throughout the last twenty years, were reluctant to join this cause simply because "greening" anything meant increased costs. However, as government mandates and penalties for defying those mandates increased, many companies began to feel the financial effects of ignoring environmental issues (Moavenzadeh, 1994). C&D wastes have not been as visible as the leaking drums and billowing smokestacks of other industries, however, many of these visible industries have implemented programs to address environmental problems.

The construction industry has lagged behind other industries with respect to programs and plans to handle the waste generated by its activities. This has prompted some researchers and waste management consultants to develop and organize alternatives to landfilling C&D wastes with little regard to the effort and expense required to extract, transport, and handle these materials. Assuming that alternative disposal methods can be found and utilized, is not practical or economical for all construction projects. Therefore, a thorough waste management plan should incorporate four sections: assessment of the material wastes on a particular project; development of standard and alternative waste disposal methods; calculation of the economic impact of the disposal methods available; and finally, a section to summarize, implement and update waste management techniques chosen for a project.

The preceding discussion raises two crucial issues which must be addressed when analyzing C&D wastes. The first is, there must be an effective methods for a contractor to compare methods of environmental conservation of C&D wastes. The second is that a contractor must be able to address the environmental conservation of C&D wastes without losing any competitive advantages that might, at a minimum, discourage conservation and at a maximum, impact a company's overall economic performance.

The research effort in this thesis focuses on the problem of construction waste management and the alternatives for those directly impacted. Specific waste management techniques are discussed in chapter 3. The following sections state the objectives, scope, and limitations of this thesis.

1.2 Objectives

This thesis concentrates on the ability of the construction industry to economically assess waste disposal techniques in order to voluntarily decrease C&D wastes. Specifically, the objective of this thesis is to develop a method to investigate waste disposal resources which provides both environmental and economic benefits. The thesis presents a waste management plan as a guide to choosing alternatives based on various economic factors, such as transportation, labor, and disposal costs. The waste management plan differs from regulations or guidelines which many municipalities or districts require to address construction issues such as erosion control, spill containment, and hazardous waste (asbestos) movement on site. The waste management plan specifically addresses waste with respect to how the contractor plans to recycle (if possible) excess materials and minimize or dispose of materials which can not be recycled. The objective of the waste management plan is to guide a contractor through the steps required to assess, quantify, implement, and monitor waste management techniques.

1.3 Scope and Limitations

The scope of this research is limited by two main parameters. One parameter, pertains to the ability of the contractor to have a positive environmental impact on the constructed facility. The life cycle is composed of five parts: designing, constructing, operating, retrofitting, and decommissioning. Although all of these phases are important to the overall function of a facility, emphasis is placed on the phases which the contractor/builder can provide the most environmental impact. The three which are emphasized the most are constructing, retrofitting, and decommissioning (demolition). The life cycle analysis is limited, but focuses on the immediate resources of the contractor (i.e., the immediate life cycle). The main objective is to only focus on resources, such as equipment and materials, that the contractor can control.

The second parameter for this research is the analysis of waste management strategies with respect to a broad range of recycling markets—from limited recycling, as in a rural setting, to very active recycling, as in a large city. This is an area which will provide a practical basis for developing an overall waste management plan. When analyzing recycling markets, it would be relatively straightforward to develop a plan only for a locality which had very strong markets for C&D wastes. In contrast, a waste management plan for a range of recycling markets raises many questions and challenges for contractors. The research will focus on these questions and challenges by analyzing the minimization and material management techniques to make the plan applicable and successful for any type of construction project.

1.4 Outline

The presentation of this thesis is divided into six sections. The approach is to: first, introduce the problem and some terminology for the research; second, assess the current status of C&D wastes in the construction industry; third, identify some resources which are available to manage various types of wastes; fourth, present a waste management plan which establishes a procedure for assessing and comparing C&D waste management techniques; fifth, introduce a case study demonstrating how to use the waste management plan; and finally, conclude with a discussion on the future direction of waste management in the construction industry.

The preceding portions of chapter 1 have provided background for this thesis, stated the objectives of the research, and outlined the scope and limitations. The following sections in chapter 1 identify terms and meanings for this thesis and the applicability of each in construction.

Chapter 2 of this thesis presents the current status of C&D wastes in the construction industry. A brief history is given to demonstrate how the philosophy of material usage has changed in construction. The generation of C&D wastes is discussed and data is provided showing the quantification of specific wastes. A brief section describing regulations for construction wastes is included. Finally, the chapter concludes with a discussion on the recyclability of C&D materials and how material recycling markets are impacted. The main purpose of chapter 2 is to provide an understanding of the quantities of C&D wastes generated and how these wastes are currently addressed by the construction industry.

The third chapter of this thesis discusses how the wastes are classified and various management resources that are applied to each classification. Waste management techniques and the advantages/disadvantages of each are described. The techniques are chosen based on costs and ease of implementation from a contractor's perspective.

Chapter 4 outlines the waste management plan (WMP) and begins to demonstrate the steps required for analyzing the economic impact of utilizing specific waste management techniques. A flowchart is presented to describe the entire waste management process. Also, equations are given to provide the background for the quantitative analysis of various waste disposal alternatives. Finally, a presentation method and template are given to provide not only waste management data, but to show which areas of waste management require more emphasis.

Chapter 5 presents a case study to demonstrate how the waste management plan developed in chapter 4 is implemented on an actual project. The data provided is for the demolition phase of a renovation project performed between June 1993 and July 1994. Materials are analyzed based on the waste management plan and alternative disposal resources are investigated to assess options which may have been available to the contractor during the project.

Chapter 6 gives a conclusion and provides insight into possible future research opportunities for C&D waste management.

1.5 Terms for the Thesis

One of the many dilemmas facing the current environmental movement with respect to C&D wastes, is terminology. Different industries use terms or phrases to imply various meanings. The meanings are not extremely different, but the variations are enough to cause confusion when the words or phrases are used. This section clarifies these environmental terms for the purposes of this thesis.

1.5.1 Sustainable Development

Sustainable development is a term which has a long term impact on environmental practices. A social definition, given by Margaret Thatcher to the U.N. General Assembly in November 1989, stated that "it must be growth which does not plunder the planet today and leave our children with the consequences tomorrow". A more technical meaning is provided by Dr. Karl-Henrik Robert, a Swedish oncologist, who states that," substances from the Earth's crust must not be allowed to systematically increase in the ecosphere" (Harris, 1996). In essence, sustainable development is growth with direction. Within this concept, there are many methods to grow and a variety of directions, but for the purposes of this thesis, growth refers to economic diversity and direction refers to reducing C&D wastes. Economic diversity is a term which implies economic growth, but more importantly, also demonstrates new, economic waste disposal options for a construction company—which is discussed later in more detail.

1.5.2 "Green"

"Green" is a more elusive term than sustainability, because it encompasses many other issues which go beyond technical and economical solutions to environmental problems. Companies are forced to look beyond economics, to issues such as moral and ethical impacts on the environment. The ASCE Construction Congress writes that "the idea of "green building" centers around constructing facilities in such a manner that less burden is placed on the natural environment than if not constructed "green" (Bashford and Robson, 1995). For the purposes of this thesis this definition will provide the overall concept of the term "green". Within the concept of "greening", there are some fundamental ideas which come from environmental organizations such as the Environmental Protection Agency (EPA) and Greenpeace. Green initiatives for these groups, although not exactly the same, are composed of three ideals (Miller and Szekely, 1995):

1. Integrating environmental considerations into management and business practices
2. Establishing environmental goals to be met or surpassed
3. Evaluating environmental performance or impact of actions

These ideals do not establish the outcome of becoming "green", but rather they provide a framework to implement, analyze, and improve environmental programs-programs which are constantly changing based on ethical, technological, and financial demands. The term "green" becomes difficult to quantify because it does not start from the same baseline for every organization nor does it follow the same path of implementation or improvement. Put simply, "greening" is not an end product, but rather, it is an evolving process.

1.5.3 Life Cycle Analysis

When applied in the environmental arena, "Life Cycle Analysis (LCA) is a holistic environmental accounting procedure which quantifies and evaluates all wastes discharged to the environment and energy and raw materials consumed throughout the entire life-cycle, beginning with sourcing raw materials from the earth through manufacturing and distribution to consumer use and disposal" (Jackson, 1993). LCA is a common tool which is used to evaluate the environmental impact of a specific product or material. It does not provide a yes or no answer as to whether one product should be chosen over another, rather, it provides a baseline to compare the environmental impact of different alternatives. The environmental impact can be assessed with respect to air emissions, water effluents, solid waste generation, other environmental releases, or a combination of the preceding.

When utilizing the LCA, one portion which must always be defined is the 'life' aspect. The 'life' of a product is composed of several major stages (Jackson, 1993):

Raw material acquisition—energies and processes utilized to extract the principle materials from the earth

Manufacturing, processing, distribution, and transporting—the systems of processes required to transform the raw material into a final product and transport it to a customer

Use and maintenance—energy utilized or released by the final product and the processes required to maintain it at an operational state

Waste management—the processes needed to achieve the final disposal method, recycle, reuse, incineration, or landfilling

With respect to this thesis, the emphasis focuses on the waste management portion of the LCA. Costs and environmental impacts related to waste management are analyzed to provide solutions to C&D waste problems. The justification for focusing the analysis is that a contractor typically orders a material based on cost when all other contract specifications are the same. To date, there is little standardized information which allows a contractor to easily compare the energy required to produce one cubic yard of concrete from various concrete plants. This eliminates the emphasis on raw material acquisition and the manufacturing of the product. Although these two stages of the product life cycle analysis are important, they are inputs which are not easily quantified or standardized throughout the construction industry and are not the focus for this thesis—the focus for this thesis centers around the management of C&D wastes ***on*** the construction site. One of the major inputs into a LCA are the limits or the boundaries of the analysis. Drawing boundaries for a LCA is important because this defines or limits the number of external factors which are used to determine the environmental impact of a material.

Figure 1.1 summarizes the life cycle for steel framing and fastenings (AIA, 1993). Defining boundaries for steel framing and fastenings, in this example, is necessary because the life cycle is extensive and complicated. This thesis utilizes the boundary conditions that allow a contractor to have information and control over the C&D wastes which are generated. A contractor has little control over how construction materials are manufactured because there is limited standardized information pertaining to the energy required to manufacture and process raw materials. A contractor does have the information to identify the raw materials which are in products, and can use that data to insure that hazardous materials are not being introduced into the constructed facility. Because of the lack of manufacturing information, the emphasis for this thesis pertains mostly to the economics of recycling C&D wastes, while also limiting the amount of waste generated during these processes. Figure 1.2 illustrates the boundary conditions pertaining to this thesis with respect to steel framing and fastenings.

Life cycles for constructed facilities are similar to each other, but do have some variations, due to the overall integration of material systems. A life cycle for a constructed facility consists of the following stages:

Design—decisions for types of materials, facility dimensions, and environmental climate controls are made with respect to cost and overall environmental impact

Construction—materials are transported and incorporated into a design plan with most emphasis placed on minimizing cost, providing quality, and finishing in a timely manner

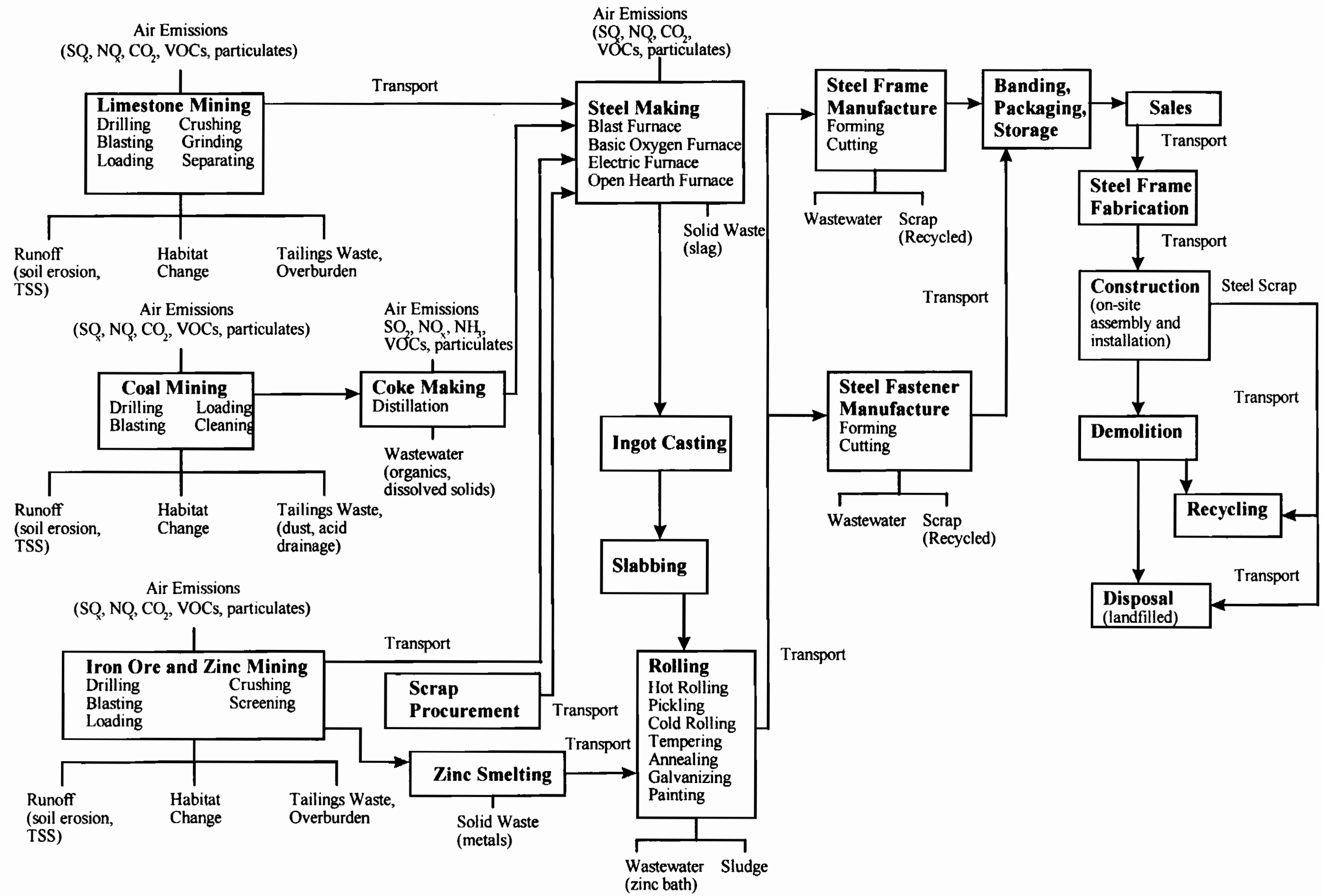

Figure 1.1 Life cycle summary of steel framing and fastenings (AIA, 1994)

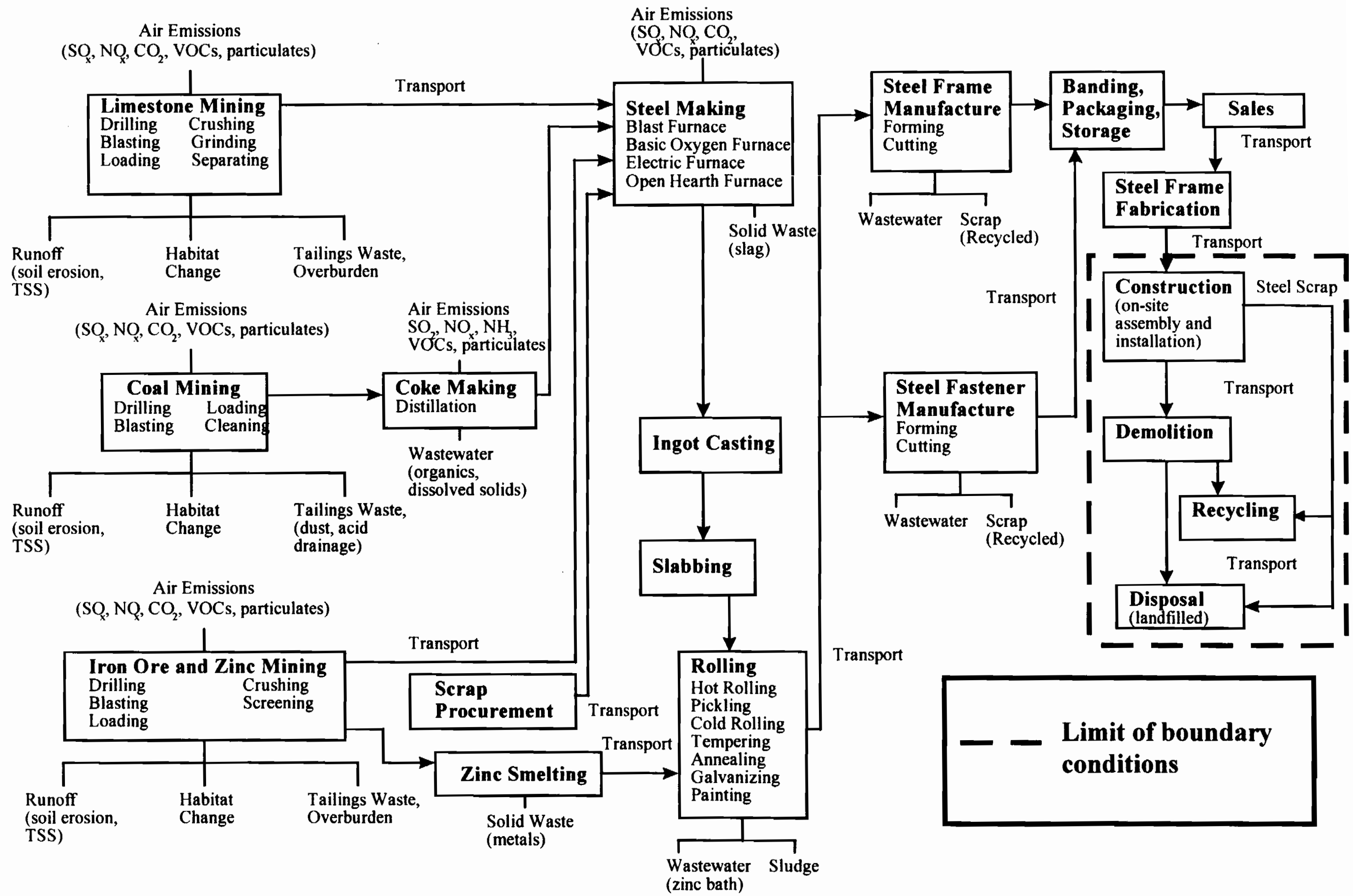

Figure 1.2 Limiting boundary conditions, according to this thesis, for steel framing and fastenings

Operation—systems in the facility are utilized and monitored for signs of deterioration from the design standards

Retrofitting—substandard systems are repaired or replaced with alternative systems based on cost and overall environmental impact/benefit

Decommissioning—the cost of replacing substandard systems outweighs the cost of constructing a new facility

C&D wastes are a very important aspect of the life cycle of a constructed facility. There are many points when decisions can be made to minimize these wastes. One example during design may be to dimension the facility to make use of standard material sizes to prevent excess materials from being cut as waste. The main limitation is that a contractor is typically not a part of the design phase. In most cases, the decisions have been made by an engineer—the contractor merely follows predetermined specifications and drawings. The ability of the contractor to manage construction wastes becomes limited to the materials which workers can physically move and utilize on site. When having a direct impact on materials is used as a criteria for managing C&D wastes, the 'life' of a facility is then based on three stages: construction, retrofitting, and decommissioning. These three stages are analyzed in this thesis to provide a more common assessment of problems and solutions for construction contractors.

This chapter has established the objectives and limitations for this thesis and has outlined the steps that will be used to achieve those goals. Background definitions were provided to clarify terms and meanings that will be used throughout the discussion.

Chapter 2

The Evolution of C&D Wastes

Chapter 2 of this thesis discusses the current status of C&D wastes in the construction industry. The chapter focuses on the quantities of wastes and how they are distributed with respect to various construction projects. A brief discussion addresses material recycling and alternatives available for recycling C&D wastes. One section of the chapter provides information on aspects of recycling markets for C&D wastes in the United States.

2.1 History of C&D Wastes

C&D wastes have been a quiet aspect of construction throughout the industry's history. However, the last hundred years have brought the most change in the waste philosophy of the construction industry. Throughout the early 1900's labor was inexpensive, so building materials accounted for most of construction costs. This meant that contractors could not afford to discard materials, but they could afford more labor to cut and trim leftover materials for later use. After World War II, many technologies began to change the way construction materials were manufactured. Products required less preparation time for installation, and many were produced in the controlled environment of factories. This did two things for construction materials: first, it provided consistent quality, and second, it allowed for mass production. The panelization of materials such as plywood and gypsum board were two such innovative improvements which helped change the focus of construction costs (Mincks, 1994). The effect was a higher quality product at a lower price. This transformed the construction industry by placing less emphasis on material wastes, and putting more efforts towards reducing labor costs. For example, before gypsum board was used, plaster was the material of choice for wall covering. Plaster was batched mixed, and the material cost was typically twice the cost of the installation labor. In the mid-1990's however, gypsum is an abundant resource and is relatively inexpensive compared to the labor required to install it, which runs almost three times as much as the gypsum board itself (Mincks, 1994). As labor costs have increased, due to rising insurance, health, and worker's compensation fees, there has been less emphasis on reducing material wastes and more focus on labor efficiency (Oglesby, Parker, and Howell, 1989).

The fundamental change in philosophy towards material wastes has led to the concept that the C&D waste stream is closely related to the material flow during construction—this can be best illustrated by figure 2.1 (Gavilan and Bernold, 1994). There are various consumable and non-consumable materials on a construction site. The consumables are those which are physically used and left in the constructed facility. Some materials can be reused on later projects, while others are leftover and must be returned to the supplier or kept for later use. One example of leftover materials are shingles. Many times unopened bundles of shingles can be returned to a supplier for compensation, but typically one or two bundles are left to provide a color reference and a source for repair material in the event that shingles on the structure are damaged. Non-consumables are materials that aid in the construction, but do not end up in the completed structure.

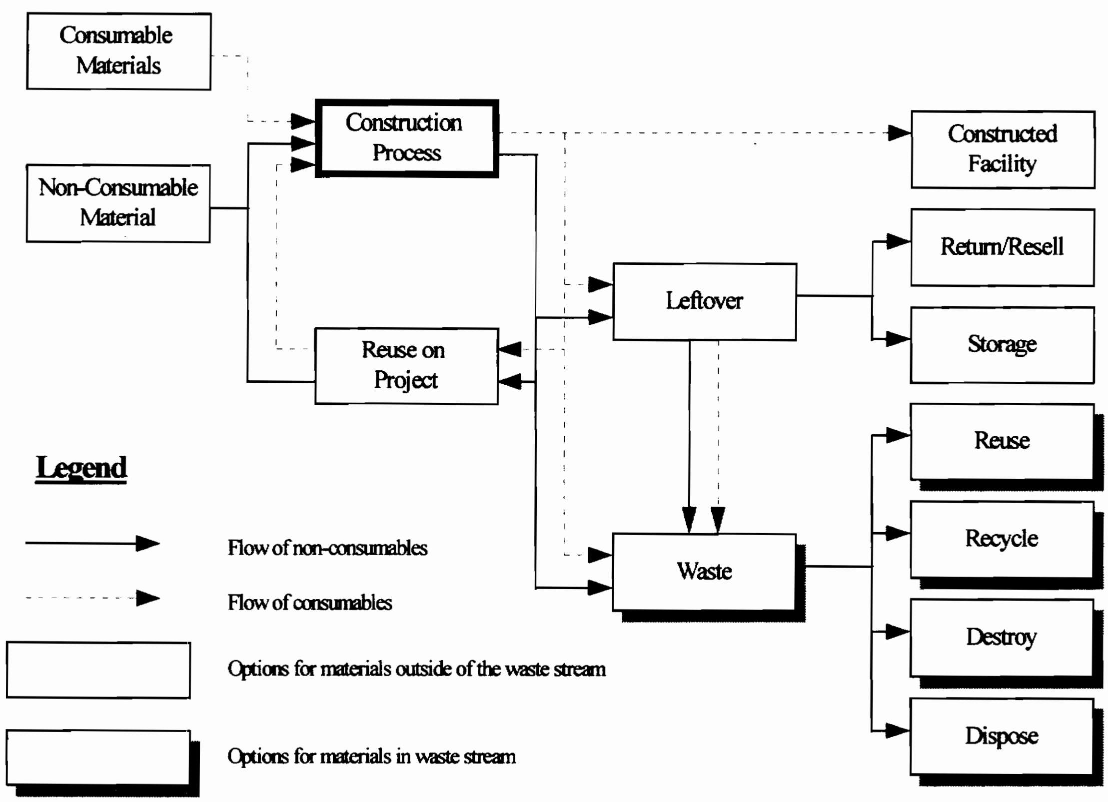

Figure 2.1 Generic flow pattern of construction materials on site

2.2 How C&D Wastes are Generated

C&D wastes are generated from a variety of sources on a construction site. Gavilan and Bernold (1994) provide a framework that organizes C&D wastes into six categories: design, procurement, handling of materials, operation, residual, and other sources. Table 2.1 provides details for the typical sources of waste for each category. These sources do vary depending on the materials utilized in each project.

Table 2.1: Identification of C&D waste sources (source: Gavilan and Bernold, 1994)

Waste	Cause of Waste
Design	Blueprint error Detail error Design changes
Procurement	Shipping error Ordering error
Handling of materials	Improper storage/deterioration Improper handling (on and off site)
Operation	Human error (by craftsmen or other laborers Equipment malfunctions Acts of God (catastrophes, accidents, weather)
Residual	Leftover scrap Unreclaimable nonconsumables
Other sources	

Many of the listed causes of waste are beyond the control of the contractor. Design errors with blueprints or change orders can cause waste for a builder. Improperly handled material off the construction site causes excess waste as materials are brought to the site already damaged. Communication problems also accounts for many sources of error in

C&D wastes. Ordering too much, too little, or wrong material can cause waste. Many times, human error is the cause of waste, as wrong dimensions or poor cuts are made on a material. Other sources of waste may come from losing, reordering, then discovering the misplaced material, or even nighttime dumping of wastes by local residents

2.3 Disposal Regulations

Regulations for disposal of C&D wastes have not been as stringent as those of municipal solid wastes (MSW). In many cases, C&D landfills, sometimes called cleanfills, demofills, or rubblefills, are separate from the MSW landfills and do not receive the same scrutiny as MSW wastes (Brickner, 1994). Without the ability to specifically identify C&D wastes going into landfills, government agencies such as the Environmental Protection Agency (EPA) are unable to track, monitor, and quantify the total amount of wastes accurately. Regulatory agencies can not track and quantify the wastes accurately, which then limits their ability to make adequate regulations and enforce them properly. A broad breakdown of environmental regulations from a national level to a local level is provided in figure 2.2. This diagram demonstrates the lack of regulations for C&D wastes as most emphasis is placed on municipal and overall solid wastes—there are very few regulations or departments set up to specifically address C&D wastes. RCRA, subtitle D, pertains to the disposal of MSW, but has no provisions specifically for C&D waste. The EPA has revised some regulations which may affect C&D waste disposal with respect to waste to energy (WTE) facilities. The Clean Air Act Amendment of 1990 required the

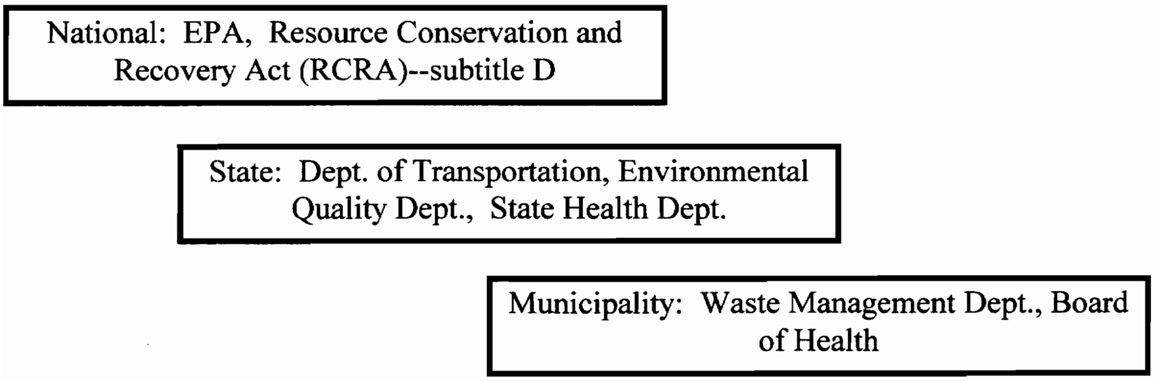

Figure 2.2 Breakdown of Environmental Regulations

EPA to devise better emission guidelines and operating requirements for WTE's, which may in turn limit the types of wastes which can be processed at these types of facilities (Fallon and Spumberg, 1994). Most regulations for C&D waste disposal, if developed, are instituted at the state level. A good example of state regulations for recycling involves the use of recycled asphalt pavement (RAP). By using RAP in new pavement projects, state Departments of Transportation give specifications on the quality of the material, installation criteria, and quantities. Requiring the use of RAP does, however, not provide specifications for disposal of waste materials for contractors, but it does show that some states are slowly beginning to monitor and regulate various forms of C&D wastes in projects. Overall, states are more regional and can institute regulations which are more effective and more enforceable than federal mandates or laws (Beaudoin, 1996). Some states, such as Florida and New Jersey, have implemented general guidelines for MSW, which focus on source reduction and waste minimization—this type of legislation will also aid in the reduction of C&D wastes (Fallon, and Spumberg, 1994). A survey by Gersham, Brickner, and Bratton (GBB), a waste consultant firm specializing in C&D recycling, identified approximately 5,600 traditional sanitary landfills and 1,807 C&D waste landfills in 1994. Figure 2.3 shows the estimated number of C&D landfills by region for the United States. Although this survey does not provide specific quantities of wastes, it demonstrates the unregulated presence of C&D wastes and disposal facilities (Brickner, 1994a).

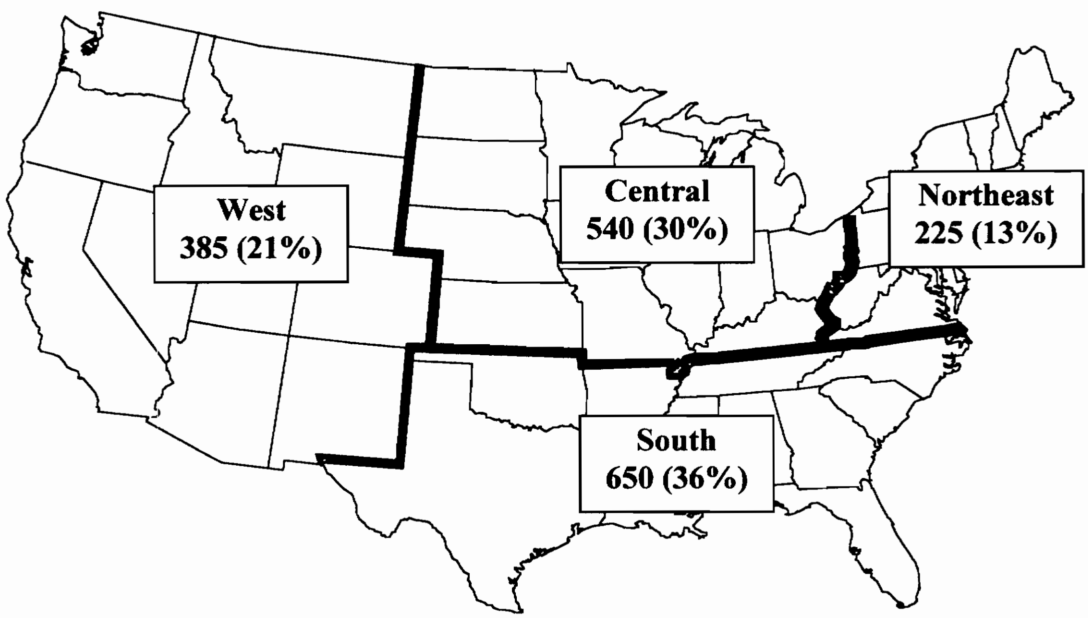

Figure 2.3: Estimated number of C&D landfills per region in the United States (source: Brickner, 1994a)

2.4 Current Disposal Rates

C&D disposal rates often vary across the country, due to the fact that most wastes are mixed and hauled off sites to landfills where they are buried. One report by the EPA estimates that C&D wastes make up around 23% of the total municipal solid waste stream in the United States (U.S. EPA, 1986). Most data on the subject places the figure at 15-20% of the local MSW, depending on the locality and the amount of construction or demolition being performed. According to GBB, there are 100 million tons of C&D waste generated annually in the United States (Brickner, 1994). Table 2.2 shows a common breakdown of material wastes on residential construction sites. Although this is not a standard breakdown of the wastes on a residential project, it is a typical snapshot of wastes in the order of volume produced. This breakdown is altered slightly when the densities of the materials are factored in. For example, in the case of masonry and tile, the density is much higher than that of dimensional lumber, even though the percent volume of dimensional lumber waste is 13% higher than masonry and tile. This demonstrates that the densities of waste materials are just as important as the volumes, due to the fact that waste disposal fees are based on the cost per unit of weight (tons). Table 2.3 also shows the typical breakdown of material wastes for a variety of construction projects. Densities are not included in this table, in order to place more emphasis on the different types of materials instead of the weights of the materials. This survey was taken in Hong Kong, but according to GBB, the waste stream is virtually identical to the waste stream of similar construction projects in the United States.

Table 2.3 provides very valuable data with respect to new construction, renovation, and demolition. In new construction, the materials are easier to quantify and identify. Roadwork is an example of this, because there are two or three main materials utilized on the project—this also holds true for earthwork projects. Data for new building construction was not available for the survey in Hong Kong, but based on the percent

Table 2.2: Waste stream in residential construction (modified from the Toronto Home Builders Association, 1990)

Material	Volume (%)	Density[1] (lb/ft^3)	Actual Wt. (lbs) based on 20 CY dumpster
Dimensional lumber	25	37.3	5036
Drywall	15	48	3888
Masonry and tile	12	82.5	5346
Manufactured wood	10	≈42	2268
Old corrugated containers	10	*	*
Asphalt	6	*	*
Fiberglass	5	*	*
Metal Waste	4	*	*
Plastic and foam	4	*	*
Other packaging	4	*	*
Other wastes	5	*	*
Total	**100**		*

* Materials are grouped together, making individual densities indeterminable

1 American Institute of Architects. (1994a).

volumes from table 2.2, there is a wider variety of material wastes compared to the roadwork and earthwork projects. Renovation projects also show a greater variety of C&D wastes. This can be attributed to the fact that quantities and types of materials are more difficult to estimate when they are hidden behind obstructions or within structures. Demolition waste is more difficult to estimate because there are so many unknown materials. This means that there are still a few main waste sources, but there will also be

Table 2.3: Composition of C&D wastes in Hong Kong (% volume) (source: Schlauder and Brickner, 1993)

Constituent	Roadwork Material	Excavated Material	Building Demo Waste	Renovation Waste	Mixed Site Clearance	Total
Asphalt	23.4	0.0	1.6	0.0	0.1	2.22
Concrete	46.4	3.2	20.0	0.8	9.2	14.67
Reinforced concrete	1.6	3.0	33.1	8.3	8.3	16.46
Dirt, soil, mud	16.8	48.9	11.8	16.1	30.6	23.84
Rock	7.1	31.1	6.8	7.8	9.7	11.53
Rubble	0.0	1.4	4.9	15.3	14.1	7.72
Wood	0.1	1.1	7.1	18.2	10.5	7.9
Sand	4.6	9.5	1.4	3.2	1.7	3.17
Metal (ferrous)	0.0	0.5	3.4	6.1	4.4	3.29
Block concrete	0.0	0.0	1.1	1.1	0.9	.08.
Brick	0.0	0.3	6.2	11.9	5.0	5.18
Glass	0.0	0.0	0.2	0.8	0.6	0.32
Other organics	0.0	0.3	1.3	2.6	3.1	1.71
Plastic pipe	0.0	0.0	0.6	0.4	1.1	0.60
Trees	0.0	0.7	0.0	0.0	0.1	0.15
Fixtures	0.0	0.0	0.1	0.0	0.1	0.02
Miscellaneous	0.0	0.0	0.1	0.1	0.2	0.11
Bamboo	0.0	0.0	0.3	0.1	0.2	0.21
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

more waste constituents overall. Although these examples do not constitute the entire construction industry, they are good indicators of the quantities and varieties of waste materials which are prevalent during construction and demolition projects.

C&D wastes are quantifiable when comparing various construction projects, but they are very inconsistent when comparisons are made between localities and regions. Many of the factors that affect C&D disposal rates are beyond the control of a builder. These include (Schlauder and Brickner, 1993):

- season and climate
- strength of national economy (growth of construction in the U.S.)
- decisions on repairs of municipal infrastructure (roads, bridges, utilities)
- development of urban renewal projects
- catastrophic events such as earthquakes, fires, floods, tornadoes, and hurricanes

The factors listed above dictate how much construction waste is generated and in what time frame. A disaster such as a hurricane can bring massive destruction to a heavily populated area in an extremely short period of time. A clear example was the total C&D waste accumulated from Hurricane Andrew which struck south Florida in 1992. The storm generated an estimated 2.25 million tons of demolition debris in a matter of hours. Also, additional debris totaling nearly 250,000 tons was accumulated due to the rebuilding of homes and business in that area (Schlauder and Brickner, 1993). A C&D

landfill facility can easily become overwhelmed with the incoming materials generated by a storm of this magnitude. Many materials which would otherwise be very valuable to salvage have to be landfilled because of the limited processing time.

2.5 Recycling Practices

As C&D wastes slowly become a focus of attention for reduction, more emphasis is placed on how to recycle the waste materials into reusable products. There are many uses of C&D waste materials, from incineration for energy to reuse as a raw material. Some of these materials are recycled into sustainable products, while others are recycled into products which can only be reused once. Although the emphasis for reuse should be placed on sustainable products (i.e. those which can be reused/recycled many times), table 2.4 lists alternatives to landfilling C&D debris.

There are obstacles to recycling C&D materials, such as those listed in table 2.4. Contaminants from other sources make recycling difficult and in some cases, impossible—one example is drywall. Most gypsum recycling facilities only take drywall waste from new construction. This is because gypsum manufacturers do not process drywall which has been painted. The paint changes the surface of the material and because gypsum is so abundant and cheap, the cost to strip the paper from the painted drywall does not justify recycling for manufacturers or contractors. Another aspect of painted drywall is the use of hazardous materials such as lead-based paints. Dealing with

Table 2.4: Alternatives to landfilling C&D wastes (source: Johnson and Mincks, 1995 and Brickner and Bixby, 1994)

Category	Source	Alternative
Wood	Framing lumber Forming lumber Trees, brush	Salvage, chip, mulch Incinerate (non-treated lumber) Compost
Concrete	Highways Buildings Sidewalks, curb & gutter,	Recycle--use as base material for roads, or aggregate for new concrete
Asphalt aggregate	Asphalt Roads	Recycle--use as base material for roads, or aggregate for new road construction
Masonry	Bricks, rubble, mortar	Reuse unbroken bricks Crush broken bricks for use as fill materials in road construction
Metals	Steel beams Metal studs Copper wiring Ductwork	Recycle to metals
Gypsum	Gypsum drywall Gypsum sheathing	Recycle to gypsum drywall Recycle to kitty litter Recycle to fertilizer
Cardboard & paper products	Packaging	Recycle to paper products
Dirt, spoils	Excavation	Fill material

hazardous materials such as lead open up new costs for insurance, equipment, and labor. These are costs which most manufacturers choose not to deal with and therefore do not accept drywall from renovation and demolition projects (Blancett, 1996). Other hazardous waste issues include treated wood, painted wood, wood treated with creosote, and contaminated fill. Typically, these materials are refused at recycling centers and at C&D landfills.

2.6 Potential for C&D Recycling

C&D wastes contain a high percentage of recyclables—in some cases, the recyclable content can exceed 50% (Perez, 1994). This recyclability is dependent on some aspects of the construction operation. One aspect is the season—as stated earlier, more construction is performed during the spring and summer than the fall and winter. Another aspect of C&D recyclability is the scheduling of a construction or demolition project. A contractor requires materials such as brick, masonry, and concrete wastes during the initial stages of a demolition project. Surges of wood, gypsum board, and metal follow later in the construction process. The overall type of project dictates the last aspect of recyclability. Demolition of suburban homes generates more wood wastes, while new industrial construction may present a variety of waste materials. The waste stream is only as consistent as the waste materials which are extracted from the facility (Perez, 1994).

Overall, with the C&D waste stream making up 15-20% of MSW, and 50% of that being conceivably recyclable, there is a great potential for these wastes to be recycled. An example of the recyclability of C&D wastes was demonstrated in Portland Oregon, where in 1993, 45% of the 380,000 tons of building industry wastes produced were diverted from local landfills. There were several factors which helped achieve this recyclability, such as waste markets and high tipping fees, but the ability to attain high recycling rates was evident. C&D waste recycling was also very successful through the Coastal Regional Solid Waste Authority (CRSWA) in North Carolina. In 1994, CRSWA, working with a private waste consultant, achieved a 26% recycling rate for C&D wastes in 12 months. As a result of the program, market opportunities were opened through public and private cooperation (Hilts, 1995).

2.7 Markets for C&D Recycling

One of the most important factors in the recycling of C&D wastes is the availability of markets for materials. Markets for recycled C&D wastes are based on geographic regions and are influenced by three main issues (Harler, 1995):

- legislation or regulation
- increased tipping fees at landfills
- costs for trucking materials to recycling facilities

Legislation and regulation are very instrumental in developing markets for C&D materials. Many recyclers believe that government mandates requiring the use of recycled materials will force new markets to develop. Recycled aggregate is one example of how increased mandates would help open up markets. In aggregate-poor states, recycling concrete or asphalt is widely accepted, however, in aggregate-rich states, quarries work together to lobby against the use of recycled aggregate (Harler, 1995).

Tipping fees at landfills are an instrumental method of forcing markets for C&D wastes to develop. Tipping fees across the United States average between $65-75/ton, with fees in the Northeast running over $100/ton (Mincks, 1994). The C&D market development in Portland, Oregon is an example of how increased tipping fees can force contractors to find markets for waste materials. Tipping fees in the Portland area rose from $17.50/ton in 1987 to $75.00/ton in 1993—an increase of over four times the original cost in six years (Goddard, 1995). This increase did not eliminate all of the C&D wastes, but it did force contractors to look for alternative methods and markets to dispose of major waste materials. Drywall became one of the major materials diverted from landfills. Figure 2.4 illustrates how recycling rates for two major components of the waste stream, drywall and wood, rose as tipping fees increased over a six year period. The amount of recovered drywall and wood wastes shown in figure 2.4 also demonstrates that when tipping fees in the Portland area reached and surpassed $50/ton, recycling became a more economical alternative. A guideline for recycling is that tipping fees around $50/ton allow processors to begin pricing recycling facilities competitively with landfills (Apotheker, 1992). This number varies, however, depending on other variables such as transportation, labor, and equipment costs. The amount of wood waste recovered in 1993 (90,000 tons) would, assuming that the wood wastes were southern yellow pine with a density of 37 lb/ft^3, equate to one studded wall on 16" centers, with a top and bottom plate, that stretched for 261 miles. Assuming that ½" thick drywall were used, 20,000 tons of recovered drywall would cover both sides of the wall for 236 miles.

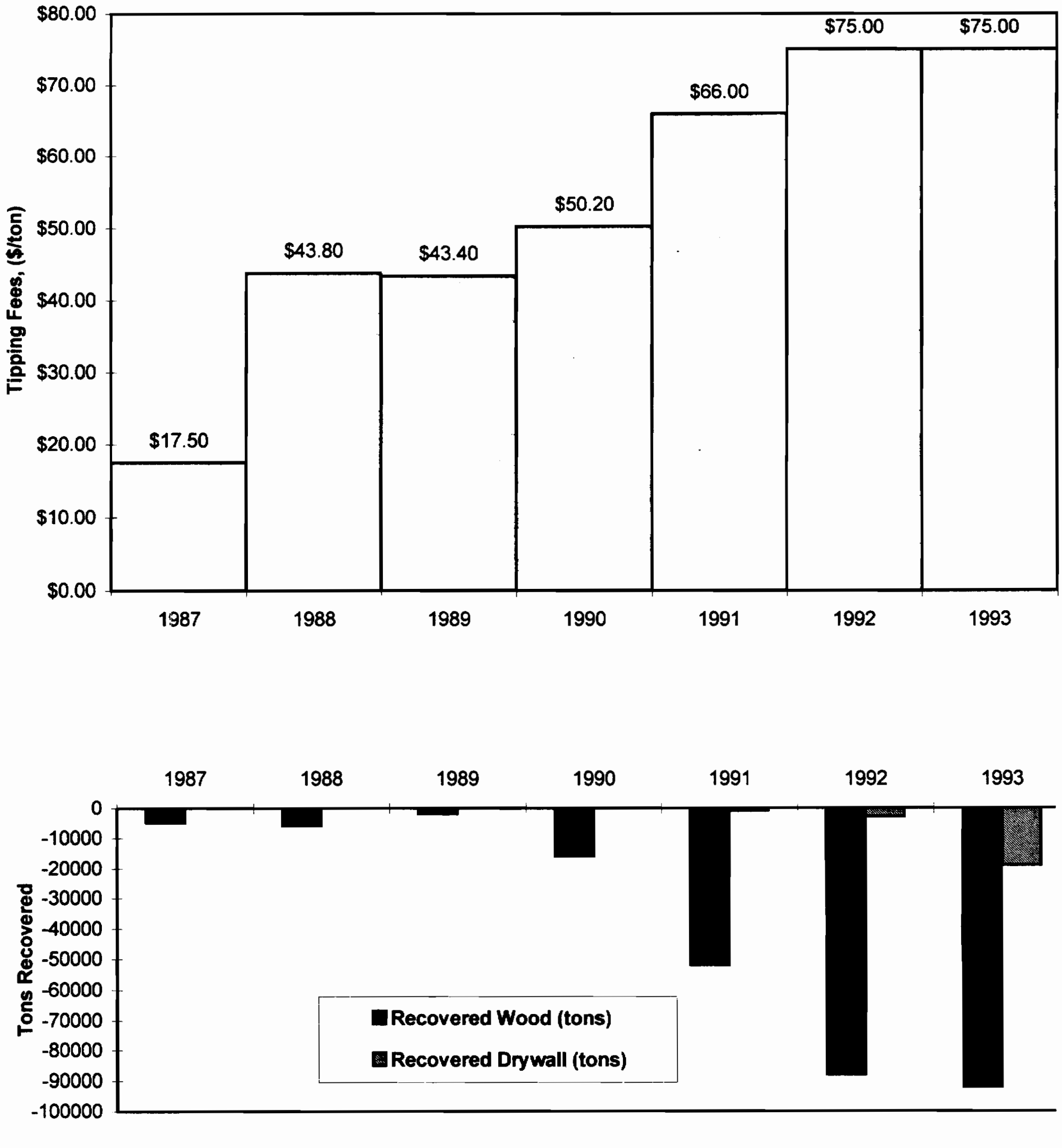

Figure 2.4: Tipping fees vs. recycling (wood and drywall) amounts (source: Goddard, 1995).

Transportation costs prove to be very instrumental in how markets for C&D waste material markets develop. The main factors involved with transporting wastes are costs for equipment, fuel, and drivers. These factors dictate an economical haul distance which can change based on the salvage or resale value of the waste materials. The haul distance is not constant as long as material values fluctuate. For transportation to be viable, the costs for tipping or processing at the market facility must be lower than the cost for tipping at a landfill. The difference between these two costs is typically the maximum cost a contractor can spend to economically transport wastes.

The discussion thus far has provided a background establishing the importance of addressing C&D wastes in a marketable as well as environmental manner. Further economical assessments of construction wastes will be made in chapter 4 of this research. The following section of this thesis describes various methods to manage C&D wastes and gives insight into the specific benefits and limitations of each method.

Chapter 3

Resources for Managing C&D Wastes

Chapter 3 of the thesis provides current resources and alternatives for disposal and minimization of C&D wastes. Alternatives are analyzed to demonstrate economic benefits and limitations, and to show how geographical factors may influence the validity of specific resources. This chapter serves as the basis for chapter 4, where the waste management plan will establish a method to analyze these types of alternative disposal resources.

As noted in chapter 1, section 1.3, the purpose of analyzing waste management techniques is to provide a plan from a contractor's perspective. An analysis of better design alternatives is not discussed due to its lack of input from a contractor once the project is at the construction stage. However, waste management issues that can be addressed at the time of bid preparation, such as ordering optimum quantities of materials, are discussed in this chapter. Another focal point of this chapter is that the waste management techniques are presented merely as independent options—comparisons between management techniques are not made due to the objectives of this research. Chapter 4 however, establishes a systematic approach for deciding which options are feasible and economically beneficial.

3.1 Types of Waste Management Resources

The main resources for managing C&D wastes are divided into four categories: first, recycling; second, reusing/salvaging; third, source reduction/waste minimization; and fourth, incineration. Recycling involves extracting, processing, and reincorporating waste materials back into original or new products. Reusing or salvaging is a similar process except that instead of reprocessing and reincorporating materials into products, the waste materials are extracted and reused with little or no processing. Source reduction or waste minimization deals mostly with using excess materials in new construction and preventing the flow of wastes into landfills (Jackson, 1993). Incineration, or waste to energy (WTE) technologies, provide waste disposal options as C&D wastes are simply burned with most other types of municipal solid wastes (MSW) to provide energy. A hierarchy of the waste management resources is provided in figure 3.1.

As shown in figure 3.1, waste minimization is the most desirable management technique because its main input is planning. Other resources have several inputs, such as energy, transportation, or raw material usage. These types of inputs deplete other supplies such as fuel or electricity. WTE resources are listed last in the hierarchy because they do not afford an opportunity to reuse or recycle waste—the sustainability of the waste materials is eliminated in the form of energy. Landfilling is included with WTE resources because the sustainability of the materials is also eliminated, but without expending energy.

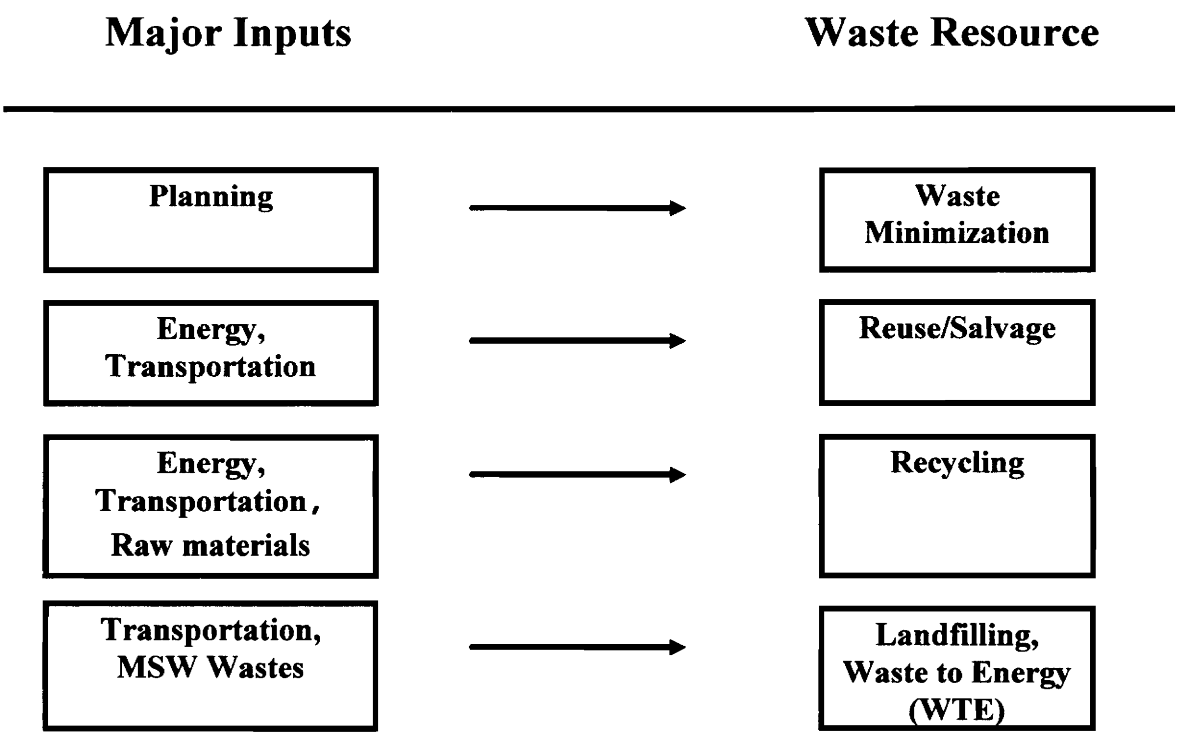

Figure 3.1: Hierarchy of waste management resources

The remaining sections of this chapter discuss waste management resources which are available to contractors in limited waste markets. The resources are grouped into two main categories: recycling/reuse resources, and waste minimization resources. WTE and landfilling resources are not addressed in this section because they are typically standard disposal methods that a contractor may typically choose.

Recycling/Reuse Resources

Although recycling and reuse are two slightly different operations, the combination allows a contractor to save material costs and to reduce overall wastes on a project. The two waste management techniques are grouped together to emphasize the importance of reincorporating material wastes back into new materials or reusable materials. The following sections describe various recycling/reuse resources for waste management.

3.2 Diverting Construction Wastes to Material Salvage Organizations

There are many types of waste building materials which are salvageable and reusable. Most of these materials come from demolition and renovation projects, but they can also come from new construction. Examples include, windows, doors, cabinets, plumbing fixtures (toilets, sinks, bathtubs, shower stalls), molding, lumber, and electrical fixtures (Triangle, 1993). These materials are very valuable because little processing is required for reuse after they are salvaged. Other materials such as masonry, concrete, and steel require more labor and equipment to salvage, but they may also be valuable.

Before deciding to salvage materials, salvage organizations must be identified. There are many such organizations across the United States, and even into Canada. Some of these organizations are nonprofit, while others are private companies. These organizations typically take materials which have been removed or salvaged by a contractor and organize them to be resold or reused in low cost construction.

One example of a nonprofit material salvage organization is The Loading Dock in Baltimore, Maryland. The Loading Dock has been established since 1985 and is dedicated to increasing decent, affordable housing for low income people through recycling (Riggie, 1992). The Loading Dock, in its first year of operation, diverted over 2000 tons of useable materials from area landfills; however, by 1991 that number grew to 7000 tons with a retail value of around $1 million. There are 200 to 250 companies which donate materials to the organization on a regular basis. The incentive is that a donor receives a tax deduction in place of the costs for disposal, and The Loading Dock gets stock for its warehouse which it sells to community groups, such as the YMCA or nonprofit housing organizations, for only the cost of handling the materials (Riggie, 1992).

An example of a private material salvage organization is Urban Ore, located in Berkeley, California. Urban Ore is a salvage broker that purchases some reusable goods and accepts other as donations. Customers who bring materials to Urban Ore pay less for disposal and can even earn money if salvaged materials are valuable enough. Urban Ore sells the materials at a reduced price to anyone who is interested. The company is established to allow residents and businesses to dispose and purchase salvaged materials in one place (Triangle, 1993).

3.2.1 Advantages/Disadvantages to Material Salvage Organizations

Material salvage organizations are a viable alternative for waste disposal. There are many types of materials which may be reused with minimal salvage efforts and minimal processing. Contractors can give away certain waste materials and even purchase quality salvaged materials. The main considerations that must be assessed are the labor and equipment costs to salvage each material and the costs to transport the material to the salvage organization's facility. One disadvantage with material salvaging is that these types of organizations are generally located near areas with continuous amounts of construction and demolition. Utilizing this resource may be very dependent upon transportation costs. Another disadvantage, especially for demolition contractors is that most demolition and removal must occur within a specified time frame which limits the time and incentive for contractors to remove salvageable materials (Triangle, 1993).

3.3 On-line Material Exchange Networks

A growing source of waste management resources are material exchange networks that have access to the World Wide Web (WWW). These exchanges are established as regional databases, and are maintained by local, state, or federal organizations. There are generally two forms of material exchange advertisement on the WWW: waste exchange information contacts and waste exchange resource listings. Waste exchange information contacts consist of an organization title, location, phone number, and contact person. A contact person can be accessed by phone or fax, and in some cases, electronic mail (e-mail). The unique aspect of on-line information contacts is that there is usually a person who is in charge of the exchange network. This person is responsible for coordinating material providers with material inquirers. The information contacts available are free and there are no passwords or usernames that must be registered. A current listing of contact information for material exchange networks is provided in Appendix A.

Waste exchange resource listings are another form of on-line information for waste management. These resources are regional and national material exchange networks with complete listings of materials wanted and materials available on-line. There is no contact person required to obtain this information. All of the initial correspondence is performed electronically, to match the needs of donors and inquirers. Figure 3.2 is a screen image of a materials exchange network with on-line resource listings. In this example, wood has been chosen as the material to view current listings. A contractor lists a description of the wood, quantities, and any costs which might be associated with the product. A response to the ad is made by clicking on the gray bar shown under each listing. Some exchanges charge a monthly fee to maintain listings, while others are free.

Some exchanges such as the National Materials Exchange Network (NMEN), are accessible by registering a name, address, phone number, email (if applicable), username, and password. The registration for the NMEN is free, but a username and password must be used to access the site every time. Most of the material exchange networks, on-line or

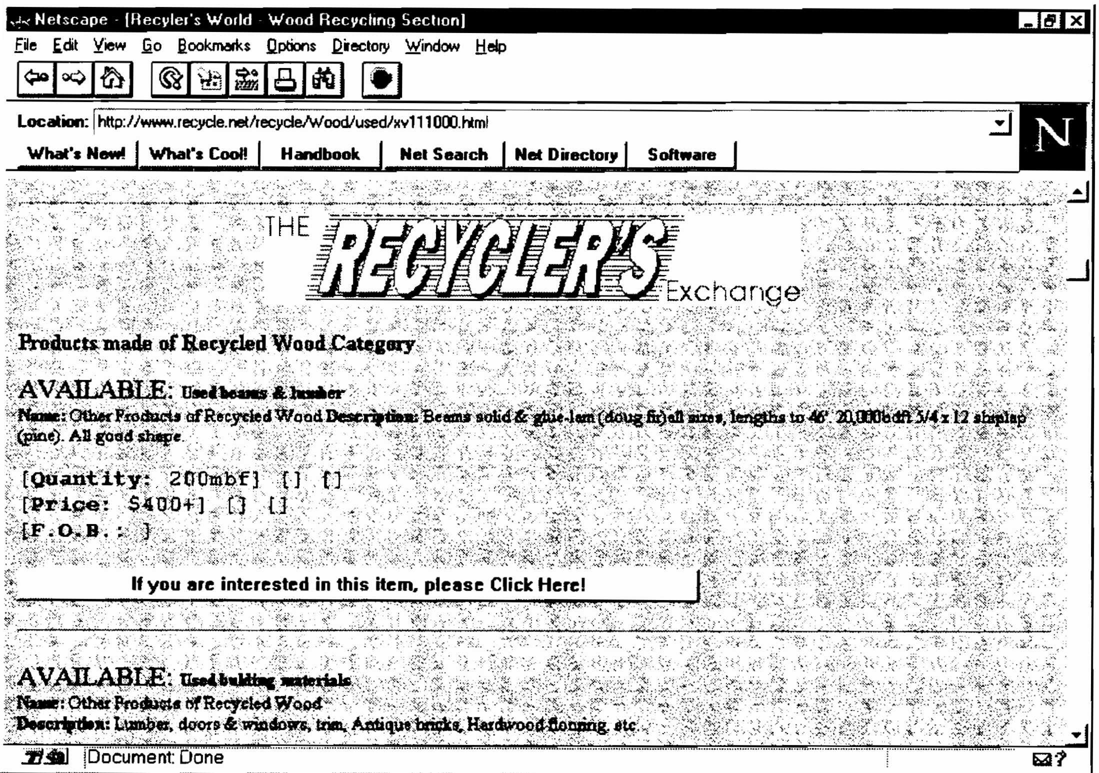

Figure 3.2: Example of materials network exchange with on-line listings (The Recycler's Exchange: http://www.recycle.net/recycle/RNet/RE_fp.html)

not, are not limited to construction materials. Many have listings for other materials such as industrial wastes, chemicals, plastics, glass, paper, and tires.

3.3.2 Advantages/Disadvantages of On-Line Resources

On-line material exchange networks and listings provide a source of options for waste management. Material exchange networks establish more regional connections that can be accessed beyond local resources available to most contractors. In some listings, suppliers or buyers of materials do express an interest in transporting the material on a regional basis. This can be beneficial to a contractor if transportation costs become a major factor. One of the disadvantages to on-line resources is that a construction company must have a computer with internet access. Another disadvantage of on-line resources is that there is no guarantee that materials or buyers will be available. Demand for specific materials may fluctuate with seasons, locations, and proximity to major construction projects.

Waste Minimization Resources

Waste minimization is a general material management technique used to limit or reduce the quantity of new waste materials that are left or used on site. The management technique may range from using materials more conservatively to reusing waste materials or scraps in the project. While recycled materials are generally finished products, minimized wastes must sometimes be cut or modified to be incorporated back in the project.

3.4 Just in Time Material Management

Just-in-time (JIT) management is a technique which originated in the Japanese auto industry to minimize excess supplies of materials on site and improve production efficiency. A basic definition of the process is: "producing the necessary units, in the necessary quantities, at the necessary time" (New and Clark, 1989). Most industries, including construction, have some amount of inventory stored to protect against fluctuations in material supplies. These fluctuations come from sources such as economics, labor, or transportation problems. The principle behind JIT is that inventory is only stored if necessary, and otherwise, excess is strictly eliminated. Critical materials are only moved when they are needed in the final product. JIT has been utilized in many manufacturing industries, including computers, tractors, automobiles, electronic components, washing machines, motorcycles, and photocopiers (New and Clark, 1989). The most common applications of JIT are in assembly line operations of mechanical or electrical products (New and Clark, 1989).

3.4.1 How Just-in-Time Works

The baseline for a successful JIT program is the relationship between the manufacturer and the supplier. It is essential for the two parties to agree on a consistent delivery system. The supplier is part of the key to guaranteeing that materials will be delivered on time, but not earlier than required by the manufacturer. This in turn reduces storage and inventory costs for the manufacturer. The supplier, in return for a consistent material flow, is rewarded by receiving long term commitments from the manufacturer for ordering materials. In many cases, suppliers are reduced, but those remaining receive much larger orders from manufacturers (Dion, Blenkhorn, and Banting, 1992).

3.4.2 Benefits of Just-In-Time

There are a number of benefits which arise from implementing just-in-time management. Many of the benefits are material related, but some deal with the layout of assembly lines, worker involvement (quality circles), and management (Bowman, 1991). The focus for this thesis however, remains on the benefits of using JIT with respect to material and waste minimization. These benefits are (Ajala, 1992):

- less stockpiles of excess materials
- less opportunity for damage to occur on site
- better use of available materials
- quality of materials delivered
- more emphasis on scheduling of material deliveries with suppliers

One of the main benefits that JIT encourages is the reduction of excess materials on the work site. For manufacturing, this is beneficial because excess stock costs money to store, move, and track (Ajala, 1992). The same is true for the construction industry, but only on the smaller scale of a construction site. Another problem which arises is that as materials remain on site and are not immediately used in the final product, there is always a chance that damage can occur. Inefficient material handling also occurs as a result of having stockpiles of extra materials. This is costly because the extra labor and time required to move materials does not add value to the final product (Ajala, 1992). On a construction site, damage to materials may occur due to inclement weather, vandalism, or theft. These damages could be avoided if excess materials were not left on site for extended periods of time.

The use of JIT also promotes more efficient use of materials on site. This benefit stems from the concept that materials are available only in limited quantities, and must be handled and installed properly to prevent damage or waste. Workers are responsible for finding better methods to move and install materials while maintaining the quality of the finished product. JIT forces workers to realize that inventories do not come from an "endless supply" and therefore must be conserved and installed with minimal waste (Ajala, 1992). Promoting the efficient use of materials is beneficial on construction projects because it encourages workers to take accurate measurements and be more conscientious about how materials are utilized.

JIT is also beneficial with respect to the quality of materials delivered to the manufacturer. A supplier involved in a JIT program is a very active participant in the process. Each driver or deliverer is responsible for not only arriving to the plant on time, but also for checking the quantities, models, and quality of the products before leaving for the supplier's facility. Problems or wrong orders are noted and immediately reported to the supplier who can make the necessary arrangements to insure that production is not interrupted at the manufacturing plant. This quality control measure insures that wrong or defective materials are not delivered to the plant where they can cause delays or other problems (Bradley, 1992).

Finally, JIT is very instrumental in making suppliers and manufacturers work together. The auto industry has provided some very good examples of how suppliers and manufacturers can form partnerships which benefit each other. The Diamond-Star assembly plant, a joint venture between Chrysler and Mitsubishi, opened in Normal, Illinois in 1988. Since then, Chrysler has sold its shares back to Mitsubishi, but Mitsubishi has remained successful by using JIT. A monthly production plan is established 60 days in advance of the car manufacture. At that time, parts and supplies are scheduled for arrival from Japan as well as in the United States. Orders are released 25 days ahead of manufacturing regarding options and colors of cars, while a production schedule is created 15 days in advance, establishing the manufacturing schedule for the day the car is to be built. The scheduling plan is released to the Japanese suppliers 60 days in advance, factoring in time for shipping at sea and trucking across the country. Domestic suppliers are given a 15 day advance notice of the production schedule. This type of cooperation is also found in other auto manufacturers such as Toyota, Honda, Mazada, Nissan, and Chrysler (Raia, 1992). In an example with nine Chrysler assembly plants that used JIT, a study by the Automotive Industry Action Group (AIAG) found that Chrysler was able to save more than 50$ per vehicle even with excess transportation costs (JIT, 1993).

3.4.3 Drawbacks of Just-In-Time

Just-in-time is not a flawless management technique and there are some reasons why this type of system may not work or may not be accepted—regardless of the type of industry.

Some drawbacks to Just-in-time are (Maddow, 1995):

- vulnerability of having only one or few suppliers
- suppliers willing to participate in a JIT program can not be found
- demand for the manufactured product fluctuates which does not allow regular deliveries of materials
- increased planning requirements (availability of materials)

The major drawback to JIT for many companies is the practice of working with a minimum number of suppliers. Many organizations feel that this does not make good business sense. For example, Honda had to shut down its JIT plant in Marysville, Ohio in 1995 because it ran out of plastic parts. The plant only had limited parts on site when a fire wiped out its only plastics supplier (Maddow, 1995). Material suppliers are not immune to disasters, but when problems occur, there is a trickle down effect which adversely impacts production at a manufacturing plant.

Another problem which may arise with the use of JIT, is the lack of suppliers willing to participate in this type of system. Partnering with a manufacturer does not make the delivery of materials easier. Supplies must be delivered on time with very small allotments for error. Many suppliers have to invest in electronic data equipment such as computers, or bar code readers to give accurate, real-time information to persons in charge of tracking deliveries (Dion, et al., 1992). This is an added expense which may not justify the rewards for some suppliers. However, an added benefit may stem from the ability to quickly order and reorder materials electronically.

One last drawback to JIT is the fluctuation in the demand for the manufactured product. This irregular demand disrupts the level resource flow that JIT is supposed to achieve. An irregular material flow causes problems for suppliers and does not encourage long term scheduling and planning. This does little to promote relations for both the supplier and the manufacturer (Maddow, 1995). Preplanning is essential to the success of this type of material management.

3.5 Educating Workers About Waste Management

An educated workforce is also very important when investigating waste management resources. Education about C&D wastes and alternatives to disposal is very important because the field workers need to be active participants for almost any type of waste management plan to be successful. The use of roll-off containers at many construction sites does not allow workers to actually view the types and quantities of wastes being thrown away, which in turn, makes defining waste problems very difficult (Malin, 1995). Many times, workers must know which materials can be salvaged or recycled, which methods of collection are used on a project (on-site or off-site), and which materials can be grouped together. Construction supervisors must keep track of subcontractors on site and perform inspections to make sure that proper disposal methods are being utilized.

One subcontractor improperly disposing of wastes can contaminate a recycling container, and negate the efforts of other subs on the project.

3.6 Local/Regional C&D Waste Management Resource Guides

There are many local resources available to aid contractors in C&D waste management. Some localities and cities such as Portland, Oregon, Los Angeles, California, and the Research Triangle in North Carolina have published waste management resource guides for contractors. A C&D waste management guide for Los Angeles is included in Appendix B. The guides contain listings of companies who take waste materials and other important information, such as:

- phone numbers/addresses
- types of material accepted
- any restrictions or limitations
- services offered or fees (some companies offer free pickup, or provide roll-off containers for pickup—other companies charge for picking up materials)

Local waste management guides offer very valuable information to a contractor. One disadvantage to these guides is that they are generally available only in larger cities or areas that have the resources or businesses to accept C&D wastes. This limits contractors who work in more rural areas or who can not afford to transport waste materials to a larger municipality.

The emphasis of the thesis thus far has focused on defining the problem and presenting resources which are available to address waste management. Chapter 4 addresses how a C&D waste management plan is initiated and analyzes the steps required to assess waste management methods economically.

Chapter 4

Developing the Waste Management Plan

The basis for initiating a waste management plan (WMP) is derived both from a concern for protecting the environment and a concern for economics. A conflict arises because environmental problems are difficult to quantify, while economic problems can be quantified to several decimal places. A contractor can develop a WMP for environmental reasons, but the plan in all likelihood, will be driven by economics. Thus the establishment of a waste management methodology may be motivated by preventing damage to the environment; ultimately, however, it must be based on economics.

4.1 Issues Addressed by Standard Waste Management Plans

As WMPs are currently developed, there are several issues which are addressed during the initial stages of the program. One of the first issues to analyze is the choice of alternatives for waste disposal or minimization. The choices are typically waste minimization, reuse/salvaging, recycling, landfilling, or waste to energy technologies (WTE). As noted in chapter 3, reuse/salvaging and recycling operations are grouped together as well as WTE and landfilling. This is because the two sets of alternatives are very similar with respect to functions and outcomes. Therefore, the choices are reduced to three general alternatives: waste minimization, reuse/recycling, and landfilling/WTE.

Standard WMPs also address the demographics of construction wastes on the project. Aspects of construction waste such as quantities, specific materials, and weights of materials are important because these factors allow for the calculation of approximate tonnages to determine the economic feasibility of using alternative waste disposal methods. Other external variables which are usually addressed include factors such as transportation costs, labor costs to assemble and process the waste materials, tipping or disposal fees, and miscellaneous equipment costs (Goddard and Palermini, 1992). Methods of separating and sorting wastes must also be analyzed when planning waste management.

4.1.1 Transportation Costs

Transportation costs are one of the main factors in deciding alternatives for a WMP. Other factors such as labor costs, tipping/disposal fees, and equipment costs will be briefly discussed later. The cost of transporting waste materials is composed of the hourly rate of a driver, the cost to rent or own a truck, fuel, the hourly cost of operation, maintenance on the truck, and any miscellaneous costs such as taxes, or storage fees (Peurifoy, Ledbetter, and Schexnayder, 1996). Converted to a rate per mile, these costs are multiplied by the number of miles to get to the landfill or the disposal facility.

4.1.2 Labor Costs

Labor costs for waste disposal are divided into two major categories. One category is the labor required to collect, separate, and load materials for recycling or reuse. This cost is driven by the hourly rate of each worker and the time required to perform the tasks. Another type of labor cost is the labor required to prepare specific materials for acceptance into recycling facilities. In some cases, such as removing reinforcing steel from concrete, extra labor is required to clean the material of excess debris to make it acceptable for reuse or recycling. Another example occurs when drywall and connectors must be removed from wood before it can be chipped or shredded. Generally, if the contractor does not provide the necessary preparation for the material, the facility will either charge higher tipping fees, or will not accept the material (Johnston and Mincks, 1995).

4.1.3 Tipping/Disposal Costs

As mentioned previously in chapter 2, tipping fees for C&D wastes vary depending on the method of disposal. Recycling facilities generally charge less than landfills to attract consistent supplies of waste materials. Many recycling facilities accept mixed wastes and provide labor and equipment to sort salvageable materials. Those facilities that do not accept mixed wastes require loads to be "clean" or they will not be accepted. A "clean" load means that the contents of the container or truck are homogeneous and no other materials have been inadvertently added to the container. Figure 4.1 shows the different dumping fees for "clean" wastes and mixed wastes at a landfill and a recycling yard. It may be necessary for a contractor to perform a cost comparison for on-site separation of wastes vs. separation at the recycling facility. Figure 4.1 demonstrates that the difference between dumping non-separated wastes (refuse and recyclables) vs.

separated wastes (clean rubble) at a recycling yard is $35/ton. If on-site separation costs are greater than $35/ton, there is little advantage to separating wastes before transporting to the recycling facility.

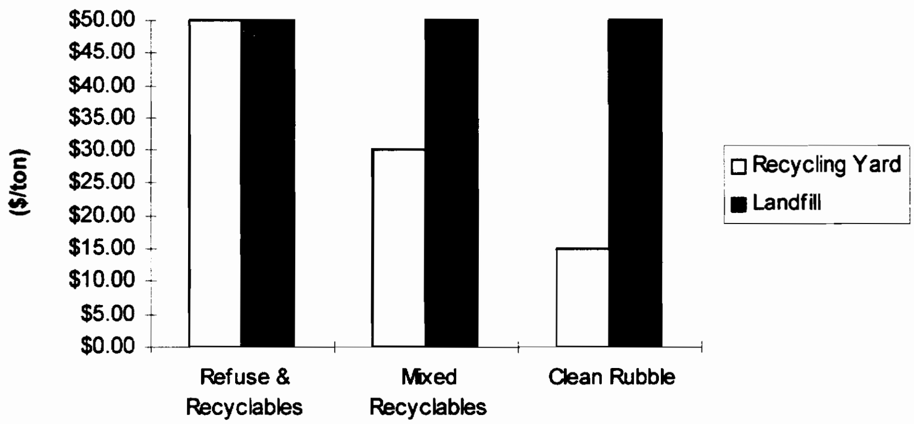

Figure 4.1: Dumping fees at a recycling yard vs. a landfill (source: Johnston and Mincks, 1995)

4.2 Separating and Sorting C&D Wastes

One economic decision that must be addressed when planning waste management is whether to separate materials on-site or to haul them to a recycling facility for off-site separation. On-site separation, or source separation, is performed on the project, so that when wastes leave the site, they have already been sorted based on the material. Off-site separation, or comingled separation, involves a single waste container which is transported and sorted at a recycling facility. Comingled wastes are all types of wastes on a project that are mixed and disposed of together. There are several advantages and disadvantages to each method which are discussed below.

4.2.1 Source Separation On-Site

On-site source separation utilizes multiple containers for each type of material with sufficient waste quantities. Quantities can range from roll-off containers (20 cubic yards) to pickup truck loads (Malin, 1995). The containers or trucks are then hauled to, or picked up by, the recycling facilities. One of the major concerns with on-site source separation is minimizing contamination of the containers. Eliminating contamination adds value to the waste material and insures that the recycling facility will accept the containers (Malin, 1995). Some advantages and disadvantages to on-site source separation include (Malin, 1995):

Advantages of on-site source separation:

- involves and educates workers and subcontractors about waste issues
- source-separation provides good public relations for visitors or customers
- more advantageous on large jobs where waste quantities are greater

Disadvantages of on-site source separation:

- long learning curve for crews to become familiar and comfortable with the process

Disadvantages of on-site source separation (cont.):

- waste containers take up space on small sites
- smaller jobs may not be suitable as the lack of waste quantities do not justify the costs of the containers or storage

4.2.2 Comingled Waste Delivered to Off-Site Separation

Off-site separation of mixed C&D wastes is another waste management process which can benefit a contractor. This process usually has a higher rate of recovery because recycling facilities have better equipment and more experience in separating various materials. This is particularly advantageous on smaller projects where waste quantities do not require large containers. According to researcher Peter Yost, at the National Association of Home Builders Research Center, "comingled processing is profitable when landfilling fees are at least fifty dollars per ton" (Malin, 1995). Other advantages and disadvantages to commingled waste processing include (Malin, 1995):

Advantages to commingled waste processing:

- higher diversion rates
- requires no additional space on the project site
- requires no added labor or education of crews and subcontractors

Disadvantages to commingled waste processing:

- crews and subcontractors remain ignorant of waste management issues
- earnings from separating wastes go to the recycling facility rather than to the contractor
- little benefit is gained with respect to public relations for both the owner or contractor

4.3 Limitations of Standard Waste Management Plans

Standard WMPs address the factors listed in the previous two sections and describe how these factors should be utilized with a great degree of accuracy. Equations, that are discussed in detail later in this chapter, are implemented to accurately quantify variables such as labor, transportation, disposal, and equipment costs for individual waste management operations. There are however, problems and limitations encountered with standard WMP practices which are analyzed from a contractor's viewpoint, in this thesis.

One of the major drawbacks to standard WMPs is that construction projects, whether they are new construction, demolition, or renovation are very diverse. There is always a variety of materials on site and therefore, many sources of possible waste. This means that a contractor may want to use different waste management techniques for different types of waste. Wastes generated in larger quantities, such as concrete, asphalt, steel, or drywall may be recycled more economically than wastes generated in smaller quantities

(Malin, 1995). After deciding the waste management method for larger quantities of waste, a plan must be developed to address the smaller quantities which are also generated. In some cases, waste minimization may prove more economical than landfilling.

Another problem encountered when developing a WMP is the organization and calculation of data used to make the economic comparisons of waste management options. Equations for calculating economic alternatives need to be presented in a manner to show how each variable interrelates. The data should be calculated in a spreadsheet format in order for a contractor to easily import it or use it during the estimating phase. The waste management approach should be clearly defined and displayed for each material and summarized to allow easy access and comprehension.

4.4 Waste Management Plan Overview

The waste management process is developed as a closed loop system in which there are many dynamic inputs. These inputs are never final, and must be periodically updated to insure accurate information. A flow chart depicting the layout of a WMP is shown in figure 4.2. The flow chart represents a summary of the overall process and is explained in greater detail later in this chapter.

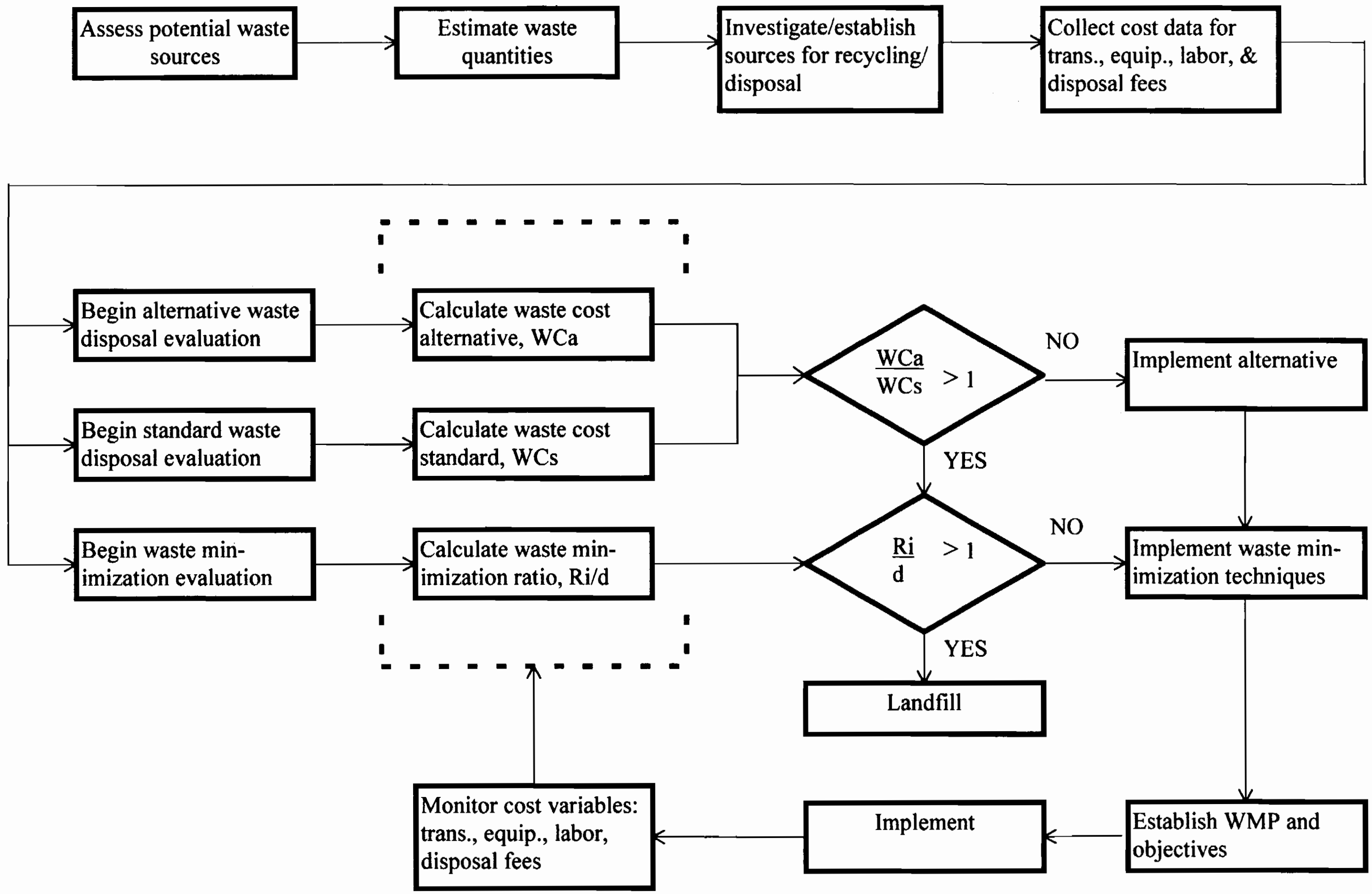

Figure 4.2: Flowchart for the WMP

4.4.1 Assessing Potential Waste Sources and Quantities

The WMP process is initiated when estimating is performed on the project in question. The first major portion of the WMP is the waste assessment phase. In this phase, material wastes are identified and potential waste quantities are estimated. In new construction, the process is much easier than for demolition or renovation (Goddard, 1995). Material quantities can be estimated with a high degree of accuracy, therefore wastes for various materials can be calculated based on historical data or experience. For demolition and renovation projects, estimating quantities of wasted materials is more difficult, and therefore requires updating costs to make accurate assessments of waste management techniques. Hazardous wastes may also be identified, but are addressed separately due to environmental disposal regulations. Some examples of hazardous wastes include, lead based paint, asbestos, wood coated with creosote, painted or treated wood, and painted drywall.

4.4.2 Sources for Waste Disposal/Recycling

Establishing sources for waste disposal is the next phase in the revised WMP—these sources are a very dynamic portion of the overall plan. As shown in chapter 3, waste disposal options originate from a variety of areas. Some larger municipalities provide manuals for alternative C&D waste disposal, but in other cases, sources may need to be identified by making phone calls. Because the listing of possible resources can change, updating is necessary to keep the WMP optimized.

4.4.3 Collecting Cost Data

Collecting data for transportation, equipment, labor, and disposal fees begins after investigating waste disposal options. This portion of the WMP is essential because it establishes the baseline costs that are used to evaluate alternatives to disposal. These costs can vary, especially for a factor such as labor, where there may be a learning curve for separating wastes or reusing waste materials.

4.4.4 Calculating the Waste Cost Standard (Landfill Option)

The waste cost standard, WCs, is an equation used to evaluate the cost of disposing of wastes in a usual manner—typically in a landfill or C&D landfill. The equation, adapted from Johnston and Mincks (1995) is:

$$WCs = \frac{Ls + Es + Ts + Fs\,(W)}{W} \qquad \text{(Equation 1)}$$

where,

WCs = the waste cost standard, per ton ($/ton)

Ls = labor cost for collecting, separating, and loading ($)

Es = equipment costs for collecting, separating and loading ($)

Ts = transportation costs, including labor and equipment ($)

Fs = tipping and disposal fees ($/ton)

W = weight of waste material (tons)

This equation was modified to include the cost of equipment necessary to collect, separate, and load material wastes. The costs for the equipment required to transport the wastes are included in the transportation costs. Another variable, Fs, (tipping and disposal fees) was modified so that the units ($/ton) would reflect the same units assessed by landfill operators.

4.4.5 Calculating the Waste Cost Alternative

The waste cost alternative, WCa, is a formula utilized to compile the waste disposal costs of a method other than the standard method (WCs). This equation (equation 2) was modified from Johnston and Mincks's (1995) original formula. The original formula, reflected the costs for the disposal of all material wastes using the alternative method. Equation 2 is based on the alternative method costs for each ***individual*** material.

The labor costs for preparation, Pa, are different from the typical labor costs, La, for collecting material wastes. Pa costs involve the cost for workers to sift through the wastes on site and remove any unnecessary portions to make the material acceptable at a recycling facility. One example of this is when rebar is removed from concrete prior to transporting it to a crushing facility. Another example occurs when connectors or drywall must be removed from wood before the wood will be accepted for chipping or reuse (Johnston and Mincks, 1995). The tipping fees associated with the alternative disposal

$$WCa = \frac{La + Ea + Pa + Ta + Da(Wd) + LFa\,(Wlf)}{W} \qquad \text{(Equation 2)}$$

where,

WCa = waste costs for the alternative method ($/ton)

La = labor costs for collecting, separating, and loading using alternative method ($)

Ea = equipment costs for collecting, separating, and loading using alternative method ($)

Pa = labor costs for preparation of material for acceptance into recycling, % of La ($)

Ta = transportation costs, including labor and equipment using alternative method ($)

Da = tipping or disposal fees using alternative method ($/ton)

Wd = weight of material going to the alternative disposal facility (tons)

LFa = tipping fees for any portion of the material that goes to the landfill ($/ton)

Wlf = weight of the material going to the landfill or demofill (tons)

W = total weight (Wd + Wlf) of the wasted material (tons)

method, Da, can also be entered as a credit if the contractor receives money for the WCa material. For example, if copper can be recycled on a particular project, a contractor may get money from a metal recycling facility. In this case, the credit will be entered into the equation as a negative number. Also, if all of the copper can be recycled, the landfill fees, LFa will equal zero and hence, will not be a factor.

4.4.6 Calculating the Cost Ratio

The cost ratio, CR, is a comparison made between the standard cost for disposal and the alternative cost for disposal. This ratio establishes the basis for utilizing one alternative method for disposal over another, or even over the standard disposal method. The equation for calculating CR is (Johnston and Mincks, 1995):

$$CR = \frac{WCa}{WCs} \qquad \text{(Equation 3)}$$

where,

CR = the ratio of costs; the alternative waste disposal costs compared to the standard disposal waste costs (dimensionless)

WCa = waste costs for the alternative method ($/ton)

WCs = the waste cost standard, per ton ($/ton)

If $CR > 1$, then the cost of the alternative disposal method exceeds traditional disposal methods. Conversely, if $CR < 1$, then the standard disposal costs exceed alternative disposal costs (Johnston and Mincks, 1995). This ratio is not the deciding factor, but it does allow for a quantitative comparison between disposal methods and also provides a starting point for assessing various disposal options

4.4.7 Calculating the Waste Minimization Ratio

Waste minimization is a waste management method used mostly with new construction wastes. A decision to implement waste minimization techniques is calculated using two equations. The first equation (equation 4) calculates Cd, or the cost of disposal of the waste material. The second equation (equation 5), establishes Ri/d, or the ratio of the cost to install the excess waste over the cost to dispose of the waste. The formula for calculating Cd, is (Johnston and Mincks, 1995):

$$Cd = \frac{((A \times WF)\,Wt) \times (TF) + (T)(m) + Cs + Es}{A} \qquad \text{(Equation 4)}$$

where,

Cd = the cost of disposal, including tipping fees, collection, and transportation ($/unit)

A = area or unit quantity of material to be installed (unit)

WF = waste factor, or percentage of waste anticipated for the material (% or decimal)

Wt = weight of the material per unit, converted to tons (tons/ 1 unit)

TF = tipping fees, taxes, and assessments for disposing in the landfill ($/ton)

T = transportation costs, including truck and driver, per mile ($/mile)

m = roundtrip distance to the point of disposal (miles)

Cs = labor cost of collecting and sorting material ($)

Es = equipment cost of collecting and sorting material ($)

This equation is modified to include a factor, Es, for the cost of the equipment necessary to collect and sort the waste material—this does not include the cost of the equipment required to transport the material as that cost is included in the transportation costs.

The second equation Ri/d, utilizes the cost of disposal from the above formula. Ri/d represents a ratio of the costs to install wasted materials into the project over the costs to dispose of that material. The formula to solve for Ri/d is (Johnston and Mincks, 1995):

$$Ri/d = \frac{(L + La) - M}{(Cd)(\%W)} \qquad \text{(Equation 5)}$$

where,

Ri/d = the ratio between waste installed and the cost of disposal for that waste (dimensionless)

L = unit cost of labor for the material installation ($/unit)

La = unit cost of the additional labor required to install the waste materials ($/unit)

M = unit cost of the material for the installation ($/unit)

Cd = cost of disposal including tipping fees, collection and transportation ($/unit)

%W = the percentage of waste that will be incorporated into the project (%)

In this equation, the unit cost of the material is subtracted from the expected labor cost because the material is already available on site, as waste. When the ratio, Ri/d >1, the cost of utilizing the waste material in the project is greater than its disposal. However, when Ri/d < 1, the cost of disposing a particular waste material is higher than incorporating the waste material into the project (Johnston and Mincks, 1995). An example using this type of analysis is the use of old brick in renovation projects. Unless an owner wants the old brick to be cleaned and reused, a quick analysis may be beneficial to determine the extra labor cost to carefully remove, clean, and prepare the old brick for reuse, compared to the cost for new brick.

4.5 Establishing a WMP Template for Spreadsheet Calculations

The calculations used to perform the WMP analysis can be organized in a spreadsheet format. The justification for using a simple spreadsheet, in this case Microsoft Excel© 7.0, is that a contractor can easily import the data into existing spreadsheets used to perform quantity takeoffs on a project. The standard waste disposal (WCs) template, demonstrated in table 4.1, is formatted so that each variable can be entered separately. This allows a contractor to track how each variable changes which can provide historical data and better insight into estimating unknown factors such as the learning curve associated with sorting wastes correctly. Table 4.2 is set up only as a template for alternative waste disposal. The factors that affect the decision to use one disposal method over another are subject to change—for example, equipment costs may not be necessary for collecting or sorting every type of waste. Table 4.3 is another template set up to calculate the costs associated with waste minimization.

Table 4.1: The waste management plan template for standard waste disposal

Waste Management Plan Worksheet						
Standard Waste Disposal (WCs)						
Material	**Qnty.**	**Ls**	**Es**	**Ts**	**Fs**	**WCs**
	(tons)	($)	($)	($)	($/ton)	($/ton)

Table 4.2: The waste management plan template for alternative waste disposal

Waste Management Plan Worksheet											
Alternative Waste Disposal (WCa)											Cost Ratio
Material	**Qnty.**	**La**	**Ea**	**Pa**	**Ta**	**Da**	**Lfa**	**Wd**	**Wlf**	**WCa**	**CR**
	(tons)	($)	($)	($)	($)	($/ ton)	($/ ton)	(tons)	(tons)	($/ ton)	

The waste minimization templates are established in the same manner as the standard and alternative waste disposal templates. Table 4.4 is a summary template that gives the status of the waste management techniques that are used for each material. In some cases, there can be multiple techniques that apply to one material. An example occurs

Table 4.3 The waste management plan template for waste minimization

Waste Management Plan Worksheet															
Waste Minimization															
Cost of Disposal										Disposal vs. Installation Cost Ratio					
Material	Quantity, A	WF	Wt	TF	T	m	Cs	Es	Cd	L	La	M	Cd	%W	Ri/d
	(units)	(%)	(tons/ 1 unit)	($/ ton)	($/ mile)	(miles)	($)	($)	($/ unit)	($/ unit)	($/ unit)	($/ unit)	($/ unit)	(%)	

when it is both economical to minimize waste, or reuse the waste materials in the project, and economical to recycle any wastes that are left over after minimization. The summary template serves as a simple table for a contractor to use as a quick reference for waste management on the project. An asterisk (*) indicates that the desired management technique is being used, while an (X) mark means that the chosen technique is the most economical, although not the best environmental solution.

Table 4.4 Waste management plan summary template

Waste Management Plan Summary Worksheet					
Material	**CR**	**Recycle/Reuse**	**Landfill**	**Ri/d**	**Minimization**
Masonry	0.92	*		.79	**YES**
Steel	0.56	*		4.51	**NO**
Drywall	1.89		**X**	.89	**YES**
Wood	5.6		**X**	1.43	**NO**

The cost ratio, CR, is listed before the recycling and landfill categories to give a numeric indication of the difference between disposal methods. The breakeven point for the costs occurs when CR equals one. Therefore if a contractor wants to advertise "green" business practices, it will be easier to choose materials or disposal methods which will provide the most benefit or least cost. This way, a contractor can use the CR ratio as a tool to aid in the overall waste management decision. The same incentive holds true for the waste minimization category listed in table 4.3.

Another advantage to using the spreadsheet format is that specific breakeven costs for variables such as transportation, labor, and disposal fees can be calculated. A contractor can quickly calculate the quantities of materials that are necessary to make a specific waste management method feasible by rearranging the equation to calculate WCa to solve for W. In this case, the equation becomes:

$$W = WCa\ (La + Ea + Pa + Ta + Da(Wd) + LFa\ (Wlf)) \qquad \text{(Equation 6)}$$

where the variables are defined earlier in this chapter. This can provide valuable information to a contractor during the construction phase of a project as costs can change for each variable.

4.6 Implementation of the Waste Management Plan

One of the main factors in implementing the WMP is defining the waste disposal responsibilities of all parties involved in the project (Goddard and Palermini, 1992). Owners may include explicit language in the proposal package that stipulates the major requirements for waste management, and also any waste reduction goals that will be established. An owner may also require the prime contractor to develop and implement a WMP to describe how the contractor plans to address waste management. A subcontractor may also be responsible for developing a WMP, or for adhering to the plan established by the prime contractor. If the subcontractor chooses not to follow the established WMP, the general contractor will have to charge the sub for collecting and transporting wastes to the appropriate facilities.

The contractors responsibilities for implementing a WMP were described earlier in figure 4.2. A contractor's main concerns are to insure that costs for the chosen waste management methods are monitored and updated as the project progresses. This will be discussed in greater detail later in this chapter. Depending on the waste management necessary on projects, one person may be designated to include waste management responsibilities in their duties (Goddard and Palermini, 1992).

4.7 Updating and Monitoring the Waste Management Plan

The WMP requires periodic updating to insure that alternative disposal technique costs do not exceed standard disposal costs. As figure 4.2 demonstrates, updating costs takes place at the quantification phase—this is the point where any change in tipping fees, transportation costs, equipment costs, or labor costs will be reassessed. Systematic updating of the WMP provides a contractor with data to confirm or discount the initial assumptions made regarding the chosen waste management technique. Because updating the economic analysis is so closely linked to estimating the initial costs, this portion of the WMP is best performed by those involved with estimating the project.

Monitoring the WMP is the last phase that requires a contractor's attention. Although monitoring and maintaining disposal records for C&D wastes are not required for every project, it is logical to assume that regulations will eventually mandate contractors to monitor and log the disposal method and location of all waste materials (Mincks, 1994). This procedure is already in place to track the movement of hazardous construction wastes such as lead-based paints and materials contaminated with asbestos. One major benefit recognized by monitoring the WMP is the collection of historical data specific waste management techniques. Monitoring the WMP requires the combined efforts of field engineers, who can monitor the actual waste movement on the project, and estimators who can use this information to improve future economic analyses. Establishing a historical database allows a contractor to track (Johnston and Mincks, 1995):

- costs and/or profits associated with different waste management techniques
- performance of waste management techniques in different geographical areas

Historical information allows a contractor to better estimate disposal costs for projects and provide accurate data to both owners and subcontractors.

Another benefit that stems from monitoring the WMP is that documentation can be used to improve a contractor's image. Documenting waste movement forces a contractor to quantify the amount of wastes that are recycled or disposed. This in turn allows a contractor to compare overall waste management methods with other contractors. The ability to market environmental waste management or a "green builder" may provide an economic edge over competing contractors (Johnston and Mincks, 1992).

This chapter has provided the framework for establishing the waste management plan. A flowchart was developed and explained to illustrate the steps necessary to evaluate waste management techniques. The following section of the thesis demonstrates how to use the waste management plan with a detailed case study analysis.

Chapter 5

Using the Waste Management Plan:

A Case Study of the Tyler Hall Renovation

The purpose of the following chapter of this thesis is to demonstrate how the concepts and objectives from chapter 4 might be implemented based on an actual project. A case study is presented using actual data in order to show how the waste management worksheet templates need to be modified or altered to adapt to specific project requirements. The sample project is assessed in retrospect, therefore all conditions are developed as though they occurred during the construction.

5.1 Background on the Project

The project chosen for the waste management case study is the interior demolition of Tyler Hall on the campus of Radford University in Radford, Virginia. The project, originally estimated at $3,183,030 by Branch & Associates, Inc. (B&A), in Roanoke, Virginia, began in June 1993 and was completed in July 1994 (Noonkester, 1996). Tyler Hall was an older dormitory which was originally constructed in the early 1940's and had been designated for renovation to provide more modern dorm rooms and administrative offices. The building consisted of four floors; one lower level, below ground, and three upper level floors. Figure 5.1 shows a general plan view of Tyler Hall. When the building renovation was completed, the number of rooms was increased to 84, with a capacity of 169-177 students and 2-4 advisors. Of the 84 new rooms, 6 were designated as HDCP (handicapped) rooms. New construction in the building totaled 18,240 cubic feet while renovation work totaled 611,040 cubic feet (Noonkester, 1996).

5.2 Description of the Demolition/Construction Plan

The overall approach to the Tyler Hall renovation was to totally "gut" the building, leaving only the exterior masonry work, interior structural columns, slabs, and the foundation. After the interior demolition, the contractor began installing completely new walls, electrical systems, and plumbing systems. Demolition work began on the top floor, and proceeded down to the lower level—the reason for doing this was to keep debris away from floors which had already been demolished and cleaned (Noonkester, 1996).

The contractor's original plan of construction was to begin the project by removing all the doors in the interior of the building, and then remove all asbestos containing materials located in tiles and flooring throughout the building. After the asbestos was removed on each floor, all electrical and plumbing systems were removed—this included all fire alarm hardware, plumbing fixtures, and electrical outlets. All air conditioning and convection heating units were also removed at the same time. After the building systems were taken out, the interior walls, consisting of steel framing with lath and plaster finishes, were cut into 4-5 foot sections that could be easily removed by two persons.

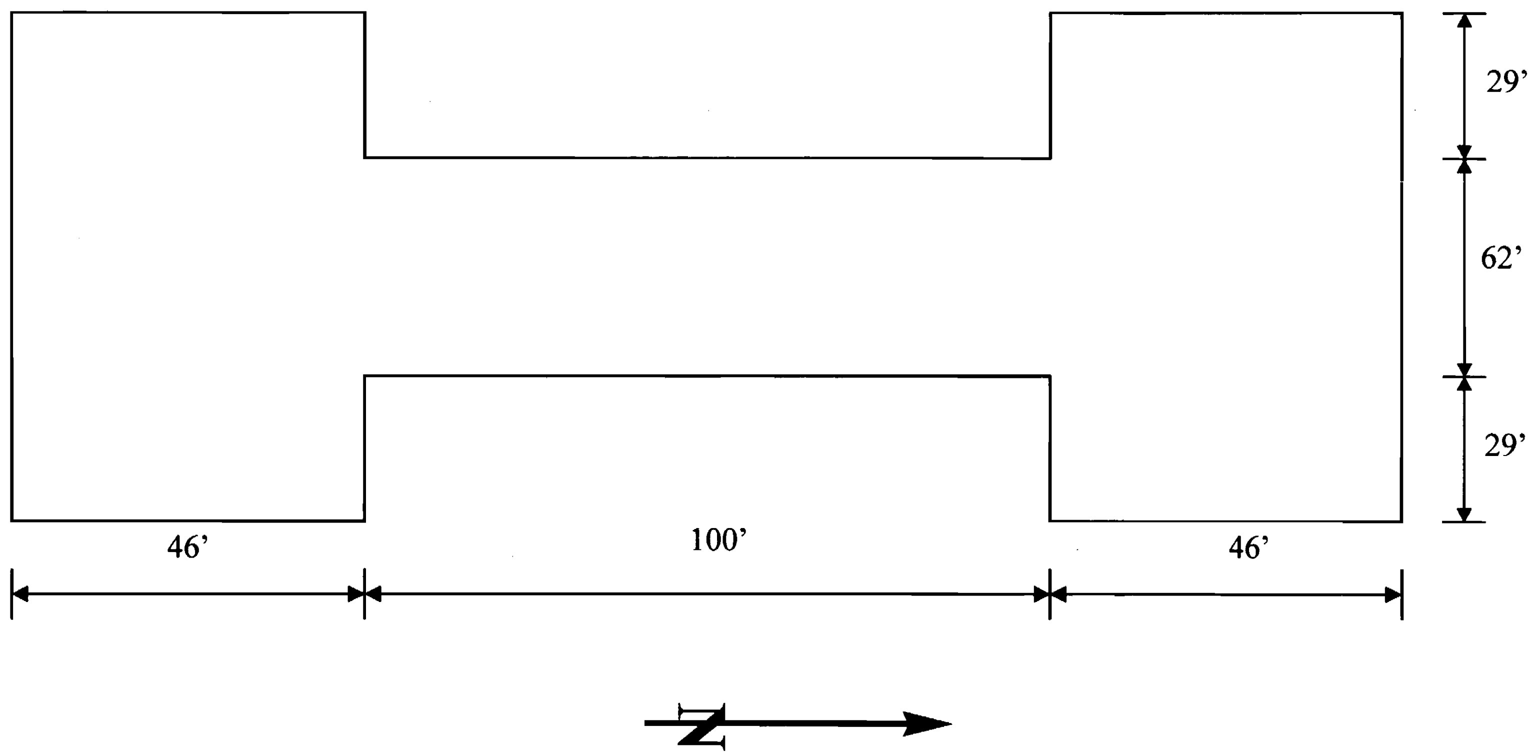

Figure 5.1 General plan view of Tyler Hall

Any concrete demolition was also performed after the interior walls were removed, to allow for easier access to the slabs and stairwells. Windows on each floor were removed and replaced soon after the demolition on that floor was completed. This kept out rain and allowed the building to be closed in during the winter months (Noonkester, 1996).

The construction process followed the same general pattern as the demolition process. Plumbing, electrical, and HVAC work began on the top floor and proceeded down to the lower level. New walls and partitions were constructed in the same sequence. A new lobby, 24'x 38', was also constructed on the back of the building to provide a central security desk for night monitors (Noonkester, 1996).

5.3 Demolition Details

To provide better insight into understanding waste management on this project, the focus is on the demolition process and the waste materials generated during this phase of construction. The total demolition process took approximately fourteen weeks to complete. B&A had no waste management plan for this project, and therefore, landfilled all of the demolition waste.

The actual demolition process was performed in a very simple and efficient manner. A dumpster was placed below the windows closest to the demolition, then a metal chute was constructed from the window down to the dumpster. Demolition materials were cut small enough to fit through the window and were then dropped down the chute into the dumpster. Using the window openings for debris removal saved B&A labor costs as workers did not have to carry wastes up and down stairs (Noonkester, 1996).

B&A took the time to estimate the major waste components prior to construction to establish a total cost for the demolition work. This estimate, which essentially covered the assessment portion (the first part) of the waste management plan, included the major waste materials, the quantities of waste materials, the weights of waste materials, and the total labor costs to remove the debris. The original demolition estimate sheet, shown in figure 5.2, gives the costs for labor, equipment, and material disposal. Equipment costs for the demolition include only the cost of the actual dumpster, $18.00/wk and the cost for the disposal company to pull the dumpster off the site to the landfill, which was $87.64/pull. A "rubbish fudge-factor" of 10% was used to account for some discrepancies between estimated and actual weights for the demolition materials.

5.4 Choosing Waste Management Techniques

The second portion of the waste management plan according to the flowchart in chapter 4, is to choose a waste management technique for the project. As stated earlier, B&A did not use a waste management plan, but instead, landfilled all the demolition wastes. Landfilling the demolition waste was a viable disposal method for two main reasons: first, a landfill that accepted the demolition debris was located within ten minutes from

Tyler Hall Renovation Project

Labor hours per week	45	Work hours per week	40	Overtime	5

MATERIAL	QUANTITY		UNITS PER HOUR	WEIGHT		CREW	HOURS	MAN HOURS	COST
Plaster	88172	SF	840	146940	Lb	H1	104.97	1,364.57	11,178.95
Steel	88164	LF	550	528984	Lb	H1	160.30	2,083.88	17,071.76
Ceilings	55918	SF	760	269120	Lb	H1	73.58	956.49	7,835.88
Susp Ceilings	2782	EA	700	2782	Lb	H1	3.97	51.67	423.26
Windows	194	EA	16	29100	Lb	H1	12.13	157.63	1,291.31
Doors	432	SF	20	23328	Lb	H1	21.60	280.80	2,300.40
C.M.U.	1236	SF	200	122100	Lb	H1	6.18	80.34	658.17
Lath & Plaster	46948	SF	300	106700	Lb	H1	156.49	2,034.41	16,666.54
Concrete	1050	SF	50	33600	Lb	H1	21.00	273.00	2,236.50
Conc. Steps	3	CY	6	12150	Lb	H1	0.50	6.50	53.25
	TOTALS			1274804	Lb		560.71 Crew Hours	7,289.28 Man Hours	**59,716.02**
				637.402	Tons				

Equipment	Cost per Week		Weeks	Cost	Dumpster	
Bobcat	$0.00		14.02			
Truck/w Oper		$45	$/hr	******		
Dumpster	$18.00		14.02		$252.36	
Pulls	$87.64			75	$6,573.00	
					$6,825.36	Dumpster Total
Power equip.					$4,389.07	
Rubbish FudgeFactor			10%		**$11,214.43**	Equipment total

Dump Fees	Tons	Cost	Total
	701.14	$47.00	**$32,953.68**

LABOR/BURDEN	**$59,716.02**
OVERTIME	**$111.97**
EQUIPMENT	**$11,214.30**
DUMP FEES	**$32,953.68**
TOTAL	**$103,995.97**

H1 Crew cost per hour		($/hr)
1	Foreman	12
1	Foreman	12
11	Laborers	82.5

Figure 5.2 Original B&A demolition estimate for Tyler Hall renovation

the project site; and second, tipping fees at that landfill were only $47/ton. As stated earlier in this chapter, the case study analysis is performed in retrospect, meaning that all inputs relating to cost, time, and availability of resources are given based on the same time frame as the project. The analysis for this case study deals strictly with the demolition in Tyler Hall because an accurate estimate was made regarding the quantities of the wastes—these wastes and quantities are listed in table 5.1. The steel wastes in Tyler Hall were members used for framing the interior walls. Ceilings consisted of the track system used to support the suspended ceiling tiles. The type of waste management technique chosen is typically dictated by the largest quantity (in tons) of the wasted material—this is where the most savings are realized. In this example, steel makes up almost a third of the total waste

Table 5.1 Estimated materials and quantities from Tyler Hall demolition

Material	**Quantity (tons)**
Plaster	73.5
Steel	264.5
Ceilings	134.6
Suspended Ceilings	1.4
Windows	14.6
Doors	11.7
C.M.U.	61.0
Lath & Plaster	53.3
Concrete	16.8
Conc. Steps	6.1

on the project. Ceilings are the next largest waste source, followed by concrete and masonry (C.M.U) combined, plaster, then lath and plaster. Listing wastes by the greatest weight establishes a precedence for finding alternative disposal sources.

The proposed method of waste management is to recycle the heaviest waste components. Waste minimization is not used in this analysis because this portion of the project only deals with demolition debris and not new construction wastes. Recycling is chosen because steel, concrete, and masonry makes up almost one half of the total waste weight, and eliminating these wastes will provide substantial disposal savings.

5.5 Economic Assessment of Waste Disposal Alternatives

After the preliminary waste management technique(s) are chosen, the economic analysis is performed to verify the initial plan. The following sections outline the steps used to assess waste management costs for the Tyler Hall demolition.

5.5.1 Modifications to the Waste Cost Worksheets

The first step is to set up the waste cost standard (WCs) and waste cost alternative (WCa) worksheets. There may be some modifications necessary to adapt the original template discussed in chapter 4, to meet the requirements of a particular project. In this case study, the equipment and transportation costs were calculated as percentages of the total respective costs, based on weight. An example illustrating how to find the total equipment cost and transportation cost for the standard disposal of plaster is provided below.

Example 1: Calculating standard equipment and transporation disposal costs for plaster

Data to calculate equipment costs for plaster:

Dumpster $252.38

Power equipment $4,389.07

Total waste weight: 701.14 tons

Plaster waste weight: 73.47 tons

Equipment costs for plaster (standard disposal):

Es = $252.39*(73.47 tons / 701.14 tons) + $4,389.07*(73.47 tons / 701.14 tons)

Es = $486.36

Data to calculate transportation costs for plaster:

Total cost to pull dumpsters: $6,573.00

Total waste weight: 701.14 tons

Plaster waste weight: 73.47 tons

Ts = $6,573.00*(73.47 tons / 701.14 tons)

Ts = $688.76

The completed WCs worksheet for the demolition work in Tyler Hall is shown in table 5.2. These costs are calculated in the same manner for the WCa worksheet—the only modification made to the WCa worksheet is the addition of excess transportation costs. This is simply the cost, per mile, to transport the filled container to a location other than the landfill. This cost is then multiplied times the total number of miles (roundtrip) to the alternative disposal facility. The initial WCa worksheet is shown in table 5.3. CR, the cost ratio in table 5.3, shows values less than one—the reason for this is that the tipping fees are not included with the alternative cost calculation. These costs, and other relevant costs, will be added in a later section to produce the final assessment.

Table 5.2: Waste cost standard (WCs) worksheet for Tyler Hall demolition

Material	Quantity (tons)	Standard Disposal				
		Ls ($)	Es ($)	Ts ($)	Fs ($/ton)	WCs ($/ton)
Plaster	73.47	11178.95	486.36	688.76	47	215.15
Steel Part	264.492	17071.76	1705.89	2479.53	47	127.54
Ceilings	134.56	7835.88	890.76	1261.46	47	121.23
Susp Ceilings	1.391	423.26	9.21	13.04	47	367.28
Windows	14.55	1291.31	96.32	136.04	47	151.74
Doors	11.664	2300.40	77.21	109.35	47	260.22
C.M.U.	61.05	658.17	404.14	572.33	47	73.78
Lath & Plaster	53.35	16666.54	353.17	500.14	47	375.39
Concrete	16.8	2236.50	111.21	157.50	47	196.12
Conc. Steps	6.075	53.25	40.22	56.95	47	71.76

Table 5.3: Initial inputs using (WCs) costs for the waste cost alternative (WCa) worksheet for Tyler Hall demolition

		Alternative Disposal											
Material	Quantity	La	Ea	Pa	Ta	Excess haul costs	Round trip dist.	Da	Lfa	Wd	Wlf	WCa	CR
	(tons)	($)	($)	($)	($)	($/mile)	(mi)	($/ton)	($/ton)	(tons)	(tons)	($/ton)	
Plaster	73.47	11178.95	486.36		688.76					73.47		168.15	**0.7815**
Steel Part	264.492	17071.76	1750.89		2479.53					264.5		80.54	**0.6315**
Ceilings	134.56	7835.88	890.76		1261.46					134.6		74.23	**0.6123**
Susp Ceilings	1.391	423.26	9.21		13.04					1.391		320.28	**0.8720**
Windows	14.55	1291.31	96.32		136.40					14.55		104.74	**0.6903**
Doors	11.664	2300.40	77.21		109.35					11.66		213.22	**0.8194**
C.M.U.	61.05	658.17	404.14		572.33					61.05		26.78	**0.3629**
Lath & Plaster	53.35	16666.54	353.17		500.14					53.35		328.39	**0.8748**
Concrete	16.8	2236.50	111.21		157.50					16.8		149.12	**0.7604**
Conc. Steps	6.075	53.25	40.22		56.95					6.075		24.76	**0.3450**

5.5.2 Completing the Waste Cost Alternative Worksheet

After the WCa worksheet is established, several sections must be analyzed and calculated before it is complete. The first area which must be addressed is the recyclability of the waste materials listed. In this project, there were very few materials, other than the steel, concrete, and masonry (C.M.U) which had the potential to be recycled. Some of the materials, such as windows and doors were either too old or inefficient to be reused, while others, such as plaster and ceiling tiles had no market for recycling. Because of these factors, the only materials which were analyzed for recycling were steel, concrete, and masonry.

5.5.3 Steel Recycling

Initially, steel was analyzed for recyclability due to the large quantity of waste that was projected for the demolition. A scrap metal dealer was located in Pulaski, Virginia, that was in business at the same time of the project (June 1993-July 1994) and also accepted the same types of steel wastes. Doug Aust, a sales representative from Gem City Iron and Metal, estimated that his company paid between $50-$70 per ton of scrap steel during the time frame of this project—the price varies depending on the quality of the steel (Aust, 1996).

The second factor involved with recycling steel involves the costs associated with transporting the scrap material from Radford, Virginia to Pulaski, Virginia—a roundtrip distance of roughly 46 miles. A local waste disposal company was contacted to provide cost data for transporting the wastes over this distance. Blue Ridge Disposal, in Christiansburg, Virginia, estimated that the cost to transport the dumpster from the site in Radford to the facility in Pulaski would be $1.00 per mile—this price is in addition to the $87.64 charged to pull each dumpster from the site (Curtis, 1996). Blue Ridge Disposal also emphasized that the weight limit for transporting construction dumpsters (20 cubic yards) was around 5 tons (Curtis, 1996). Because the weight limit for transporting the dumpsters to Pulaski is 5 tons, this changes the equipment costs for steel recycling. Another factor which affects the total cost of steel recycling is the extra labor cost, Pa, to prepare the material for processing at Gem City Iron and Metal. Pa is calculated as a percentage of the original labor cost, La. The following example shows how the equipment and transportation costs are calculated to account for the increases in total labor, extra trips (pulls) to the recycling facility, and dumpster rental fees.

Example 2: Calculating the equipment and transportation costs for recycling steel

Increase in labor costs:

Total demolition labor costs for steel: $17,071.76

Pa = extra labor cost to prepare the material for recycling (% increase above the total demolition labor cost or labor hours—in this example, a factor of 50% was used)

Pa = 0.5 * $17,071.76

Pa = $8535.88

Example 2 (cont.): Calculating the equipment and transportation costs for recycling steel

Extra costs to transport the steel to the recycling facility:

Dumpster capacity: 5 tons

Total weight of waste steel: 264.49 tons

Cost per pull: $87.64

# of trips = 264.49 tons / 5 tons

# of trips = 53 trips

Ta = 53 trips * $87.64/trip

Ta = $4,636.00 + mileage (see spreadsheet)

Increase in dumpster rental fees and total equipment costs:

Total labor hours to remove steel: 160.30 hours

Extra labor (time) to prepare steel for recycling (same factor used to find Pa): 0.5

Dumpster rental fees: $18.00/week

Power equipment costs: $4,389.07

Total weight of steel waste: 264.49 tons

Tototal weight of demolition waste: 701.14 tons

Ea = (((160.30 hours * 0.5) / 40 hours/week) * $18.00/week) + (264.49 tons / 701.14 tons)* $4,389.07 + (264.49 tons / 701.14 tons)* $4,389.07 * 0.5

Ea = $36.07 + $1655.68 +$827.84

Ea = $2519.60

5.5.4 Concrete and Masonry Recycling

Recycling the concrete and masonry demolition wastes on this project involved a procedure similar to that for steel. Several local concrete producers were contacted to investigate the availability of on site aggregate crushing or mobile crushers. All the representatives contacted within 20 miles of the job site did not have the facilities to crush old concrete at the time of the project—nor do they have the facilities at the present time. The next alternative was to contact a local quarry to investigate crushing the wastes. David Ryan, vice president of Sisson & Ryan, Inc., in Shawsville, Virginia, explained that quarries could not bring concrete or masonry wastes on site due to the liability associated with hazardous waste or other contamination issues (Ryan, 1996).

Another option investigated was to bring in a small size portable crusher to crush the 84 tons of concrete and masonry and reuse the aggregate as subbase (#57 stone) under the sidewalks. The major obstacle with using a portable crusher is the mobilization costs, versus the small quantity of wasted concrete. David Turley, editor of C&D Debris Recycling estimates that at least 150-200 cubic yards of waste concrete is necessary to justify mobilization costs for a portable crusher (Turley, 1996). In this case, 84 tons of concrete and masonry waste equates to around 45-50 cubic yards of concrete. The other drawback to this option is that equipment dealers do not have concrete crushers for rent in the area surrounding the project. The main reason is that waste concrete is a good fill material, especially in the mountainous topography of southwestern Virginia. The result is a very low demand for recycling concrete (Thomas, 1996).

The next option in the decision to recycle concrete and masonry wastes, is to look for any possible recycling yards outside of the local region. The closest recycling yard that accepted waste concrete during the construction project, was located in North Carolina. The Phoenix Recycling Corporation, is a small C&D waste recycler located approximately 252 miles southeast of the Tyler Hall construction site in Wilson, North Carolina. Phoenix Recycling accepted concrete wastes with and without rebar at a cost of $14/ton during the entire construction period (Brickner, 1995). The following example demonstrates how the extra labor, extra equipment, and transportation costs are calculated for concrete and masonry wastes.

Example 3: Calculating the extra labor costs, equipment costs, and transportation costs for C.M. U

Increase in labor costs:

Total demolition labor costs for C.M.U: $658.17

Pa = extra labor cost to prepare the material for recycling (% of the total labor cost—in this example, a factor of 20% was used)

Pa = 0.2 * $658.17

Pa = $131.63

Example 3 (cont.): Calculating the extra labor costs, equipment costs, and transportation costs for C.M. U

Extra equipment costs:

Extra labor (time) to prepare C.M.U for recycling (same factor used to find Pa): 0.2

Power equipment costs: $4,389.07

Total weight of steel waste: 61.05 tons

Tototal weight of demolition waste: 701.14 tons

Ea = ((61.05 tons / 701.14 tons)* $4,389.07) + ((264.49 tons / 701.14 tons)* $4,389.07 * 0.2)

Ea = $382.17 + $76.43

Ea = $458.60

Transportation costs for extra trucks to Wilson, North Carolina:

Hourly operating costs, including operator: $45/hr.

Total roundtrip distance from Radford, VA to Wilson, NC: 504 miles

Average distance covered by each truck per hour: 50 miles/hr

Maximum load each truck can carry: 15 tons

Total weight of C.M.U waste: 61.05 tons

Ta is not calculated because costs are converted to a per mile basis

Total cost per hour for truck = $45/hr

Example 3 (cont.): Calculating the extra labor costs, equipment costs, and transportation costs for C.M. U

Transportation costs for extra trucks to Wilson, North Carolina (cont.):

Excess haul costs = ($45/hr / 50 mi/hr) * (61.05 tons / 15 tons)

Excess haul costs = $3.66

Round trip distance = 504 miles

5.6 Finding Limits for Waste Disposal Alternatives

One of the advantages to having a waste management plan calculated on a spreadsheet is that economic limits can be established. These limits allow a contractor to know when it is no longer economical to continue with the disposal technique, which in this case, is recycling.

5.6.1 Finding Limits for Recycling Steel

The first unknown variable for recycling steel demolition wastes is the factor used to calculate the extra preparation labor, Pa. Tables 5.4, 5.5, and 5.6 show how CR increases as Pa is increased. These values are based on receiving $50.00/ton for scrap steel. The limit for preparation labor costs is 1.1 (110%) times the demolition labor cost for steel. Preparation labor may need to be monitored, especially if it is the first time that recycling operations have been attempted. A learning curve effect might mean that labor costs will begin higher, but ultimately lower, as crews learn how to clean and remove the steel

Table 5.4: CR calculation using a factor of 0.5 (50%) for extra labor, Pa

		Alternative Disposal											
Material	Quantity	La	Ea	Pa	Ta	Excess haul costs	Round trip dist.	Da	Lfa	Wd	Wlf	WCa	CR
	(tons)	($)	($)	($)	($)	($/mile)	(mi)	($/ton)	($/ton)	(tons)	(tons)	($/ton)	
Plaster	73.47	11,178.95	486.36		688.76					73.47		$168.15	
Steel Part	264.492	17,071.76	2519.60	8535.88	4,636.02	1	46	-50		264.5		$83.07	0.6513438
Ceilings	134.56	7,835.88	890.76		1,261.46					134.6		$74.23	

Table 5.5: CR calculation using a factor of 1.1 (110%) for extra labor, Pa

		Alternative Disposal											
Material	Quantity	La	Ea	Pa	Ta	Excess haul costs	Round trip dist.	Da	Lfa	Wd	Wlf	WCa	CR
	(tons)	($)	($)	($)	($)	($/mile)	(mi)	($/ton)	($/ton)	(tons)	(tons)	($/ton)	
Plaster	73.47	11,178.95	486.36		$688.76					73.47		$168.15	
Steel Part	264.492	17,071.76	3556.30	18,778.93	$4,636.02	1	46	-50		264.5		$125.72	0.985724
Ceilings	134.56	7,835.88	890.76		$1,261.46					134.6		$74.23	

Table 5.6: CR calculation using a factor of 1.2 (120%) for extra labor, Pa

		Alternative Disposal											
Material	Quantity	La	Ea	Pa	Ta	Excess haul costs	Round trip dist.	Da	Lfa	Wd	Wlf	WCa	CR
	(tons)	($)	($)	($)	($)	($/mile)	(mi)	($/ton)	($/ton)	(tons)	(tons)	($/ton)	
Plaster	73.47	11,178.95	486.36		$688.76					73.47		$168.15	
Steel Part	264.492	17,071.76	3,7928.08	20,486.11	$4,636.02	1	46	-50		264.5		$132.83	**1.04145**
Ceilings	134.56	7,835.88	890.76		$1,261.46					134.6		$74.23	

scraps. Equipment costs must be monitored also, but this is simplified with a spreadsheet, by inserting a ratio of the preparation labor divided by the demolition labor. This ratio ensures that the factor used to compute Pa is also used to compute the extra equipment costs. Another issue that impacts economic limits for steel recycling is the scrap value. $50.00/ton is used in the case study to provide a conservative estimate, however, if the scrap value increased, preparation costs would also rise without detrimentally affecting recycling operations. Table 5.7 provides several variations for excess preparation costs versus scrap values per ton—these preparation factors are the economic limits for recycling steel.

Table 5.7: Preparation cost limits (factors) for various salvage values for steel

Factor Pa	Percentage of Labor, La (%)	Salvage value ($/ton)	CR
1.1	110	50	.9857
1.1	110	55	.9465
1.2	120	60	.9630
1.3	130	65	.9795
1.4	140	70	.9961

5.6.2 Finding Limits for Concrete and Masonry Disposal

Limits for recycling concrete and masonry wastes are calculated similar to steel disposal limits. The first issue that must be addressed is the fact that the cost ratio for the concrete exceeds 1.0. According to the CR equation in chapter 4, the concrete wastes should not be included in the recycling process. This is a situation where a contractor can use the waste management spreadsheet to analyze the excess costs associated with recycling a particular material. Table 5.8 displays the calculated CR for concrete and masonry wastes. In this case, C. M. U has a CR value of 0.87674, regular concrete has a CR value of 1.07843, and the concrete steps have a CR value of 0.86776. The costs associated with concrete and masonry recycling are fixed with respect to the equipment and transportation costs. The extra labor factor of 20% is assumed to calculate Pa, because some of the concrete and masonry may need to be broken into smaller pieces to reduce the excess space associated with transporting demolished concrete. This leaves the mileage as the determining factor for recycling the materials. Table 5.9 displays the mileage limits of all the concrete and masonry materials for this project. Table 5.9 demonstrates that the roundtrip travel distance for C. M. U. wastes and the concrete step wastes is about 650 miles. This means that if a concrete recycler is located within a 325 mile radius of the project, then it will be cost effective to recycle these wastes. The 16.8 tons of regular concrete provide more restrictions than the previous two waste sources. The costs to recycle regular concrete are greater due to the higher labor and preparation labor costs versus the small quantity of waste. It is only economical to recycle regular concrete waste within a 122 mile radius (245 miles roundtrip) of the project. This is an example of how a contractor can decide which wastes are the most economical to recycle. The best case scenario is if a disposal resource can be located within 122 miles of the project, and will take all of the concrete and masonry wastes. However, if a concrete recycler can not be

Table 5.8: CR calculations for recycling concrete and masonry wastes

		Alternative Disposal											
Material	Quantity	La	Ea	Pa	Ta	Excess haul costs	Round trip dist.	Da	Lfa	Wd	Wlf	WCa	CR
	(tons)	($)	($)	($)	($)	($/mile)	(mi)	($/ton)	($/ton)	(tons)	(tons)	($/ton)	
C.M.U.	61.05	658.17	458.60	131.63		3.663	504	14		61.05		$64.69	**0.87684**
Concrete	16.8	2,236.50	126.20	447.30		1.008	504	14		16.8		$211.50	**1.07843**
Conc. Steps	6.075	53.25	45.63	10.65		0.3645	504	14		6.075		$62.27	**0.86776**

Table 5.9 CR calculations to find the mileage limits for recycling concrete and masonry wastes

		Alternative Disposal											
Material	Quantity	La	Ea	Pa	Ta	Excess haul costs	Round trip dist.	Da	Lfa	Wd	Wlf	WCa	CR
	(tons)	($)	($)	($)	($)	($/mile)	(mi)	($/ton)	($/ton)	(tons)	(tons)	($/ton)	
C.M.U.	61.05	658.17	458.60	131.63		3.663	650	14		61.05		$73.45	**0.99557**
Concrete	16.8	2,236.50	126.20	447.30		1.008	245	14		16.8		$195.96	**0.99920**
Conc. Steps	6.075	53.25	45.63	10.65		0.3645	660	14		6.075		$71.63	**0.99819**

located within 122 miles, then the regular concrete should be lanfilled. The remaining C.M.U and concrete step wastes can be transported to the Phoenix Recycling Corporation because the mileage restrictions for these materials are well within the 325 mile limit.

5.7 Summarizing the Results

The final step in this case study is to present the results along with any other information that may be helpful in analyzing the waste management plan. For the Tyler Hall demolition, there are two summary worksheets included to represent the savings that are realized by recycling steel, and the savings realized by recycling steel, concrete, and masonry. The worksheets also include the new cost to perform the demolition, based on the recycling savings, and the percent savings in the overall demolition. Table 5.10 shows the summary worksheet, using only steel as the recycled material—this is the minimum that can be economically recycled on this project. Table 5.11 shows the summary worksheet that includes steel, concrete, and masonry recycling—these are the maximum number of materials that can be economically recycled. An asterisk indicates the chosen method of disposal (recycling or landfilling) for each material.

This chapter has provided a case study to demonstrate how the separate portions of the waste management plan fit together. The case study also provides a practical example of how alternative disposal options can be limited and in some cases unavailable. The waste management plan however, was used to find and calculate the most effective method for waste disposal.

Table 5.10: Summary worksheet for Tyler Hall demolition, recycling only steel

Waste Management Plan Summary Worksheet				
Tyler Hall Demolition				
Material	**Quantity**	**CR**	**Recycle/Reuse**	**Landfill**
	(tons)			
Plaster	**73.47**			
Steel	**264.49**	0.5956	*	**0.595614**
Ceilings	**134.56**			
Susp Ceilings	**1.39**			
Windows	**14.55**			
Doors	**11.66**			
C.M.U.	**61.05**			
Lath & Plaster	**53.35**			
Concrete	**16.80**			
Conc. Steps	**6.08**			
Original demolition cost			**$103,996.10**	
Materials eliminated from landfill				
		standard	**alternative**	
		disposal	**disposal**	**savings**
	(tons)	**($/ton)**	**($/ton)**	**($)**
Steel	264.49	127.54	75.96	$13,641.28
	Total Savings			**$13,641.28**
	New demolition cost			**$90,354.82**
	% difference			**13.12%**

Table 5.11 Summary worksheet for Tyler Hall demolition, recycling steel, concrete, and masonry

Waste Management Plan Summary Worksheet				
Tyler Hall Demolition				
Material	**Quantity**	**CR**	**Recycle/Reuse**	**Landfill**
	(tons)			
Plaster	**73.47**			
Steel	**264.49**	0.5956	*	**0.595614**
Ceilings	**134.56**			
Susp Ceilings	**1.39**			
Windows	**14.55**			
Doors	**11.66**			
C.M.U.	**61.05**	0.6662	*	**0.666196**
Lath & Plaster	**53.35**			
Concrete	**16.80**	0.9992	*	**0.999196**
Conc. Steps	**6.08**	0.6512	*	**0.651204**
Original demolition cost			**$103,996.10**	
Materials eliminated from landfill				
		standard	**altervative**	
		disposal	**disposal**	**savings**
	(tons)	**($/ton)**	**($/ton)**	**($)**
Steel	264.49	127.54	75.96	$13,641.28
C.M.U.	61.05	73.78	49.15	$1,503.45
Concrete	16.80	196.12	195.96	$2.65
Conc. Steps	6.08	71.76	46.73	$152.05
	Total Savings			**$15,299.43**
	New demolition cost			**$88,696.67**
	% difference			**14.71%**

Chapter 6

Conclusion

This chapter emphasizes the concluding thoughts pertaining to the benefits of waste management plans and closes the discussion by providing new directions for future research.

6.1 Concluding Thoughts

A final question pertaining to C&D wastes is: why are waste management techniques not used more in construction? One answer is that contractors are simply not interested in C&D wastes because wastes are a byproduct of a constructed facility—emphasis is generally placed on building the final product, within the schedule and the budget. Another answer is that many contractors may not know how to begin a waste management plan. The true irony is that in many cases, a few phone calls and a couple of hours working with a spreadsheet are all that is necessary to save thousands of dollars. The savings realized can provide a competitive advantage that may be the difference between bidding and winning contracts.

The benefits that come from waste management vary depending on factors which are unique to every project. These factors are as unique to waste disposal as they are to estimating, scheduling, or project management. The true benefit gained from this research is not the ability to calculate the economics of disposal alternatives, but rather to use this information as a tool to begin the movement towards environmental responsibility, or greenness. Only after these steps are realized and practiced, will the construction industry be able to explore new disposal alternatives with confidence

6.2 Future Research

Waste management is an area which has great potential for further research in the construction industry. This is because waste disposal is only beginning to become a focus point for regulating and controlling construction costs. Some of these sources include investigating alternative waste disposal methods, implementation issues for initiating a waste management program, methods for organizing historical waste disposal data, and development of specialized software for waste assessment.

One very prominent source of future research is the investigation of alternative waste disposal methods. Some of the best areas to look for new waste disposal methods are in industries that have already been forced to make changes in disposal practices. Several sizable organizations include manufacturing companies, automobile manufacturers, and chemical producers. Alternative waste disposal methods from these types of industries need to be analyzed for their effectiveness and possible implementation into construction practices. This is very plausible, especially for systems which are prefabricated or built in controlled environments such as warehouses. Just-In-Time management is an example of an alternative disposal technique that needs further investigation to determine the benefits/drawbacks that occur during implementation.

Another subject for further research is the implementation of waste management plans into actual construction projects. The design of waste management plans has been the focus for this thesis, but there are still many implementation issues which a contractor may face when trying to initiate waste management. Further research into issues such as education of the workforce, safety during implementation, and communication of disposal intentions between general contractors and subcontractors are all areas which would improve the transition from limited waste management to large scale waste management.

Organizing historical waste management data is another area requiring further research because it is crucial to the success or longevity of a waste management program. Historical data for waste management is very dynamic because costs for any WMP can change. Analyzing and archiving historical data becomes very important with respect to productivity and labor costs. In many cases these costs determine how well, or how quickly a crew can learn and implement waste management techniques. This can provide valuable information both economically and geographically. Developing a system or methodology to record and access historical waste disposal data may provide a link to better waste management and more accurate estimates especially on difficult projects such as demolition or salvaging operations.

One final area which may require future research is the computerization of a waste management plan. At a time when there are software packages for many aspects of construction, such as estimating or scheduling, the development of a software program for establishing waste management plans would provide a contractor with another tool to better assess project costs. Waste management software should include several important aspects: first, a method to catalog waste types, quantities, and costs; second, a method to quantify, list, and choose disposal alternatives; third, a method to display chosen waste management techniques and costs; and finally, a method to log and track historical waste disposal data for future use and assessment. This type of software would provide contractors with a more standardized format for calculating and presenting waste management costs.

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Appendix A

This appendix lists current material exchange networks across the United States and Canada. The information is presented in the following format:

NAME OF EXCHANGE NETWORK
Contact Person
Address
Phone/Fax Number
(Region Served by the Network)

An added list in this section gives the URL's for exchange networks which provide on-line listings for materials.

Canada

Alberta Waste Materials Exchange (AWME)
Ms. Cindy Jensen
Building 350
6815 - 8th Street, NE
Calgary, AB T4N 6K8
403 297-7505 FAX 403 297-7548
(AB)

British Columbia Waste Exchange (BCWE)
Ms. Jill Gillette
Suite 102, 225 Smithe Street V6B 2X7
Vancouver, BC V6B 2X7
604 731-7222 (will change March 25th)
FAX 604 734-7223 (will change July 1st)
(BC)

Canadian Chemical Exchange (CCE)
Mr. Phillipe La Roche
P.O. Box 1135
Ste-Adele, QU J0R 1L0
800 561-6511 FAX 514 229-5344
(Canada)

Canadian Waste Materials Exchange (CWME)
Dr. Robert Laughlin
2395 Speakman Drive
Mississauga, ON L5K 1B3
905 822-4111 ext. 265
FAX 905 823-1446
(Canada)

Manitoba Waste Exchange (MBWE)
Mr. Todd Lohvineko
1812-330 Portage Avenue
Winnipeg, MB R3C 0C4
204 942-7781 FAX 204 942-4207
(MB)

Canada (cont.)

Ontario Waste Exchange (OWE)
Ms. Mary Jane Henley
2395 Speakman Drive
Mississauga, ON L5K 1B3
905 822-4111 ext. 656 or 358
FAX 905 823-1446
(Ontario)

Durham Region Waste Exchange
Ms. Elaine Collis
Region of Durham
Public Works Department
Box 603, 105 Conaumers Drive
Whitby, ON L1N 8A3
416 668-7721 FAX 416 668-2051
(Durham:ON)

Essex-Windsor Waste Exchange
Mr. Steve Stephenson
Essex-Windsor Waste Management Committee
360 Fairview Avenue West
Essex, ON N8M 1Y6
519 776-6441 FAX 519 776-4455
(Essex-Windsor:ON)

Waterloo Waste Exchange
Mr. Mike Birett
Region of Waterloo
925 Erb Street West
Waterloo, ON N2J 3Z4
519 883-5137 FAX 519 747-4944
(Waterloo:ON)

Quebec Materials Waste Exchange (QMWE)
Dr. Francois Lafortune
14 Place Du Commerce, Bureau 350
Ile-Des-Soeurs, QU H3E 1T5
514 762-9012 FAX 514 873-6542
(QU)

Canada (cont.)

Saskatchewan Waste Materials Exchange (SWME)
Mr. Eugene Ogu
515 Henderson Drive
Regina, SK S4N 5X1
306 787-9800 FAX 306 787-8811
(SK)

United States

Alabama Waste Materials Exchange (ALME)
Ms. Linda Quinn
411 East Irvine Avenue
Florence, AL 35630-4621
(AL)

Alaska Materials Exchange (AME)
Ms. Andrea Meyer
441 W. 5th Avenue, Suite 300
Anchorage, AK 99501
907 272-5364 FAX 907 272-4117
(AK)
Arizona Waste Exchange (AZWE)

Mr. Barrie Herr
4725 E. Sunrise Drive, Suite 215
Tucson, AZ 85718
602 299-7716 FAX 602 299-7716
(AZ)

Arkansas Industrial Development Commission (AIDC)
[IL IMES participator]
Mr. Ed Davis
1 Capitol Mall, Room 4B215
Little Rock, AR 72201
501 682-1370 FAX 501 682-7341
(AR)

California Waste Exchange (CWE)
Ms. Claudia Moore
P.O. Box 806
Sacramento, CA 95812-0806
916 322-4742 FAX 916 327-4495
(CA Hazardous Waste)

California Materials Exchange (CALMAX)
Ms. Joyce Mason
c/o California Integrated Waste Management Board
8800 Cal Center Drive
Sacramento, CA 95826
916 255-2369 FAX 916 255-2220
(CA Solid Waste)

Florida Recycling Material System (FRMS)
Dr. Paul Still
2207 NW. 13th Street, Suite D
Gainsville, FL 32609
904 392-6264 FAX 904 846-0183
(FL)

Hawaii Materials Exchange (HIMEX)
Mr. Jeff Stark
P.O. Box 1048
Paia, HI 96779
808 579-9109 FAX 808 579-9109
(HI)

Hudson Valley Materials Exchange (HVME)
Ms. Jill Grouper
P.O. Box 550, 1 Veterans Drive
New Paltz, NY 12561
914 255-3749 FAX 914 255-4084
(NY, Hudson Valley)

Industrial Materials Exchange (IMEX)
Mr. Bill Lawrence
506 2nd Avenue, Room 201
Seattle, WA 98104
206 296-4899 FAX 206 296-3997
(OR,WA)

Indiana Materials Exchange
Mr. Jim Britt
P.O. Box 454
Carmel, IN 46032
317 574-6505 FAX 317 844-8765
(IN)

Industrial Materials Exchange Service (IMES)
Ms. Diane Shockey
P.O. Box 19276
Springfield, IL 62794-9276
217 782-0450 FAX 217 782-9142
(AR,IL,KY,MO,OK,WI)

Intercontinental Waste Exchange (IWE)
Ms. Lisa Militano
6401 Congress Avenue, Suite 200
Boca Raton, FL 33487
800 541-9444 FAX 407 393-6164
(US, Canada, Caribbean)

By-product and Waste Search Service (BAWSS)
Ms. Susan Salterberg
75 BRC-University of Northern Iowa
Cedar Falls, IA 50614-0185
319 273-2079 FAX 319 273-2926
(IA)

Kansas Materials Exchange (KME)
Mr. Russell Fallis, Jr.
P.O. Box 152
Hutchinson, KS 67504-0152
316 662-0551 FAX 316 662-1413
(KS)

KY Department of Environmental Protection (KY DEP)
[IL IMES participator]
Mr. Charles Peters
14 Riley Road
Frankfort, KY 40601
502 564-6716 FAX 502 564-4049
(KY)

* Businesses Allied to Recycle through Exchange and Reuse (BARTER)
Mr. Jamie Anderson
2512 Delaware Street, SE
Minneapolis, MN 55414
612 627-6811 FAX 612 627-4050
(MN)

* Minnesota Technical Assistance Program Materials Exchange (MNTAP)
Ms. Helen Addie
1313 5th Street, Suite 207
Minneapolis, MN 55414
612 627-4555 FAX 612 627-4769
(MN)

* Olmstead County Materials Exchange (OCME)
Mr. Jack Stanfield
2122 Campus Drive, SE
Rochester, MN 55904
507 285-8231 FAX 507 287-2320
(MN)

* Review Materials Exchange
Mr. Adam Haecker
345 Cedar Street, Suite 800
St. Paul, MN 55101
612 222-2508 FAX 612 222-8212
(MN)

* Southeastern Minnesota Recyclers Exchange (SEMREX)
Ms. Anne Morse
121 W. 3rd Street
Winona, MN 55987
507 457-6464 FAX 507 457-6469
(MN)

* Tri-County Materials Exchange (TRI-MEX)
Mr. Doug Lien
601 N. 20th Avenue
St. Cloud, MN 56303
612 255-6140 FAX 612 255-6146
(MN)

* Western Lake Superior Sanitary District
Mr. Jamie Harvey
2626 Courtland Street
Deluth, MN 55806
218 722-3336 ext. 440
FAX 218 727-7471
(MN)

Missouri Environmental Improvement Authority
[IL IMES participator]
Mr. Thomas Welch
325 Jefferson Street, Box 744
Jefferson City, MO 65102
314 751-4919 FAX 314 635-3486
(MO)

Mississippi Technical Assistance Program (MISSTAP)
Ms. Pat Lindig
P.O. Drawer CN
Mississippi State, MS 39762
601 325-8068 FAX 601 325-2482
(MS)

Montana Industrial Waste Exchange (MIWE)
Ms. Dee Durand
P.O. Box 1730
Helena, MT 59624
406 442-2405 FAX 406 442-2409
(MT)

National Materials Exchange Network (NMEN)
Mr. Bob Smee
4708 E. Jaremko Street
Mead, WA 99021
Modem # 509 466-1019
(US, Canada)

WasteCap - New Hampshire Material Exchange (NHME)
Ms. Emily Hess
122 N. Main Street
Concord, NH 03301
603 224-5388 FAX 603 224-2872
(NH)

New Mexico Materials Exchange (NMME)
Four Corners Recycling
Mr. Dwight Long
P.O. Box 904
Farmington, NM 87499
505 325-2157 FAX 505 326-0015
(NM)

Northeast Industrial Waste Exchange (NIWE)
Ms. Carrie Mauhs-Pugh
620 Erie Boulevard West, Suite 211
Syracuse, NY 13204
315 422-6572 FAX 315 422-4005
(MD,NY,OH,PA,ME,VT,MA,RI,CT,NJ,DE,WV,VA,DC)

Ohio WasteNet
CEC Consultants
6907 Brookpark Road
Cleveland, OH 44129
216 749-2992 FAX 216 398-8403
(OH)

Oklahoma Waste Exchange Program (OWEP)
[IL IMES participator]
Ms. Dianne Wilkins
1000 NE. 10th Street
Oklahoma City, OK 73117-1212
405 271-1400 FAX 405 271-8425
(OK)

Pacific Materials Exchange (PME)
Mr. Bob Smee
4708 E. Jaremko Street
Mead, WA 99021
509 466-1532 FAX 509 466-1041
(ID,ND,NE,NV,SD,UT,WY,VA,TN,NC,GA)

Portland Chemical Consortium (PCC)
Dr. Bruce Brown
P.O. Box 751
Portland, OR 97207-0751
503 725-3811 FAX 503 725-3811
(OR)

Resource Exchange Network for Eliminating Waste (RENEW)
Ms. Hope Castillo
P.O. Box 13087
Austin, TX 78711-3087
512 463-7773 FAX 512 475-4599
(TX,LA,OK,AR,NM, Mexico)

Rocky Mountain Materials Exchange (RMME)
Mr. John Wright
1445 Market Street
Denver, CO 80202
303 744-2153
(CO)

South Carolina Waste Exchange (SCWE)
Mr. Doug Woodson
Rt. 1, Box 388A
Prosperity, SC 29127
803 364-1008 FAX 803 364-0667
(SC)

Southern Waste Information Exchange (SWIX)
Mr. Gene Jones
P.O. Box 960
Tallahassee, FL 32302
800 441-7949 FAX 904 574-6704
(KY,TN,NC,SC,GA,AL,MS,FL,Puerto Rico)

Southeast Waste Exchange (SEWE)
Ms. Maxie May
Urban Institute
University of North Carolina, Charlotte
Charlotte, NC 28223
704 547-4289 FAX 704 547-3178
(US)

Trans-Continental Materials Exchange
Ms. Rita Czek
1419 CEBA
Baton Rouge, LA 70803
504 388-4594 FAX 504 388-4945
(US, Canada, Overseas)

Vermont Business Materials Exchange (VBMX)
Ms. Connie Leach Bisson
P.O. Box 630
Montpelier, VT 05601
802 223-3441 FAX 802 223-2345
(VT)

Note: * denotes Future Minnesota Alliance Participators

On-Line Material Exchange Networks

Environ Business Line
Waste Exchange Network
http://www.ark.org/wen.htm

Chicago Board of Trade Recyclables Exchange
http://www.cbot.com/recyclables/

The Hawaii Materials Exchange
http://maui.net/~mrghimex/himex1.html

Upstate New York Materials Exchange
Managed by the Ontario County Solid Waste Department
http://www.recycle.net/recycle/exch/mat-ex/index.html

National Materials Exchange Network
http://www.earthcycle.com/g/p/earthcycle//

The Recycler's Exchange
http://www.recycle.net/recycle/RNet/RE_fp.html

Texas Natural Resouce Conservation Commission (TNRCC's) Waste Exchange Program
http://www.tnrcc.state.tx.us/admin/topdoc/pd/002/

Economic Development Association of Skagit County
204 Wext Montgomery, P.O. Box 40, Mount Vernon, WA 98273 USA
MATERIALS WASTE EXCHANGE
Environmental Industries Program
http://www.mcguire.com/eip/exchange.htm

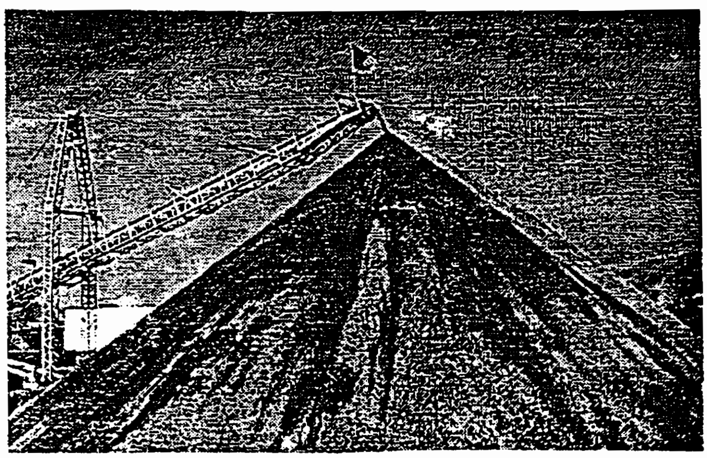
The Southwest Virginia CommoditiesTrader
http://www.bev.net/blacksburg/pdc/arrc/trader.html

Appendix B

This appendix provides an example of a C&D waste management resource guide from the Los Angeles, California area.

CONSTRUCTION AND DEMOLITION WASTE RECYCLING GUIDE

Recycling Construction and Demolition Waste in the Los Angeles Area



COME FULL CIRCLE
Integrated Solid Waste Management Office
1995 Winner
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Issue No. 14 (Rev. January 2, 1996)

City of Los Angeles
Board of Public Works
J.P. Ellman

Bureau of Sanitation
Delwin Biagi

Integrated Solid Waste Management Office
Lupe Ma' Vela

ISWMO Project Staff
Kelly Ingalls

LISTINGS IN THIS GUIDE:

For recycling processors of wood, wood pallets, and green materials, contact ISWMO and request the **"Wood You Recycle?"** guide - Phone (213) 237-1444.

If you have any questions or comments regarding this guide (or recycling issues for commercial/industrial facilities, governmental agencies, public service institutions, schools, universities, or multi-unit residential buildings located in the City of Los Angeles), please contact:

Integrated Solid Waste Management Office, 200 North Main Street, Room 580 CHE, Los Angeles, CA 90012; phone (213) 237-1444; or FAX (213) 847-3054.

The Integrated Solid Waste Management Office (ISWMO) is organized within the Los Angeles Board of Public Works, Bureau of Sanitation, to develop and implement effective source reduction, recycling and re-use programs and policies. ISWMO provides technical assistance, fosters public/private recycling partnerships, and helps to develop new markets for recyclable materials.

The company listings presented in this guide were provided by construction and demolition materials processors through field contacts and telephone interviews, and all listings were confirmed in writing with the companies listed. The list of scrap metal dealers was provided by the Institute for Scrap Recycling Industries (ISRI). We hope it is helpful to your organization in your recycling efforts.

THIS GUIDE DOES NOT CONSTITUTE AN ENDORSEMENT BY THE CITY OF LOS ANGELES OF ANY BUSINESS ENTITY, PRODUCT, PROCESS, OR SERVICE.

What is Construction and Demolition Waste?

Construction and demolition waste (or C&D waste) is material generated in the construction and demolition of buildings, roads, homes, tenant improvements, landscaping, and hardscaping. This waste stream includes, but is not limited to: concrete, asphalt, gypsum, wood waste, glass, ferrous and non-ferrous metals, red clay brick, and corrugated cardboard. This guide provides information on how to reduce disposal of construction and demolition debris in local landfills. It also provides information on reducing, re-using, and recycling the volume of construction and demolition materials at the source.

In addition to this guide, the Integrated Solid Waste Management Office (ISWMO) also publishes the **"Wood You Recycle?"** guide, which deals specifically with recycling wood, wood pallets, and green materials. You may obtain a copy by phoning ISWMO at (213) 237-1444 or sending a FAX to: (213) 847-3054.

Extending the Life of Our Landfills

Landfill space in the Los Angeles area is rapidly decreasing. In 1989, the State of California enacted legislation requiring that localities reduce the waste they send to landfills 25% by year 1995 and 50% by the year 2000. The City of Los Angeles' Solid Waste Generation Study finds that nearly 15% of the solid waste generated in Los Angeles in 1990 and disposed in Class III landfills was construction and demolition debris. Therefore, it is vital that this waste stream be managed through source reduction, re-use, and recycling efforts. Fortunately, there can be considerable cost savings for construction and demolition contractors who practice construction and demolition materials management. These savings will increase as landfill capacity diminishes and disposal costs increase in the coming years.

Conserving Our Natural Resources

Construction and demolition materials can be recycled into a number of useful products. Concrete and asphalt wastes are crushed for use as aggregate base in road construction; metal can be sold as scrap to processors for recycling. Wood wastes can be used for soil amendment; good quality red clay brick is marketed by building materials companies; and corrugated cardboard can be recycled into new cardboard packaging. All of these recycling efforts help to conserve natural resources, one of the primary goals of solid waste management.

Reducing Your Waste Hauling and Disposal Costs

If your construction and demolition waste materials are currently being sent to the landfill, your disposal costs may be unnecessarily high. The tipping fees for concrete and asphalt at Class III landfills, for example, currently average $35.00 per ton. Tipping fees at concrete and asphalt recycling facilities can/be as low as $5.00 per ton. Your company may be able to save money through avoided disposal costs and earn some money from the sale of pre-sorted materials such as scrap metal and cardboard.

The cost of transporting materials to recycling processors maybe a concern to contractors. One estimate indicates that transportation costs are $65.00 per hour. As shown in the listings in this guide, Los Angeles has many recycling facilities, some of which are located close to Class III landfills. Contractors can make arrangements to have bins provided and have construction and demolition materials source separated and hauled from construction sites. There are processing firms that will provide on-site crushers for recycling and re-use of concrete and asphalt, which may reduce hauling and disposal fees and be sold for use on construction sites. Waste haulers may offer special services, at reduced fees, for source-separated construction materials.

Beginning a Construction and Demolition Waste Recycling Program

The first step in recycling your construction and demolition waste materials is to pre-assess the amounts and composition of your waste; the time frame in which materials will be generated; and the amount of space available for separation of materials at the site. With this information, you can begin to determine what wastes will be generated and if quantities will be significant enough to warrant source separation. Depending on the availability of storage and hauling, decisions can be made as to that materials to separate out from the mixed wastes. Of course, the more materials which are eliminated from the mixed wastes, the more money you can save.

The Re-Use Concept: Materials Exchanges

Some materials can be separated and re-used in their existing form at the site or by other businesses and organizations. By participating in a materials exchange, a company can improve its bottom line: reducing disposal fees and saving money. This may require advance planning. There are several organizations that may be able to re-use your unwanted materials:

LA Shares

LA Shares is a non-profit materials exchange program that accepts excess materials from individuals and corporations and distributes them to various non-profit organizations throughout the City. Examples include movie sets donated by motion picture studios for reuse by theater groups, or cabinets donated by developers during a building demolition project. Donations to LA Shares are tax-deductible. LA Shares can be contacted at (213) 485-1097.

California Materials Exchange (CALMAX)

State of California has initiated a materials exchange program called **CALMAX.** If you generate large quantities of a certain waste material, CALMAX could be for you. CALMAX will list any waste or excess material in its bi-monthly publication at no charge. CALMAX may help you find a user or buyer for your unwanted material. CALMAX can be contacted at (800) 553-2962.

HABITAT FOR HUMANITY-LOS ANGELES (HFH-LA)

A non-profit housing organization, Habitat For Humanity uses volunteer labor and donated materials to build and rehabilitate housing for low-income families and sells them to low-income families at cost.

HFH-LA relies heavily on donations for its building supplies, and is often is in need of a wide variety of construction materials, some of which can be previously-used materials. For example, plywood and dimensional lumber are greatly needed. ***Because HFH-LA has limited storage space, moves from site to site, and must comply with strict building codes, any donations must be pre-approved and arranged with HFH-LA in advance.***

If you have materials that can be re-used by this organization, contact: HABITAT FOR HUMANITY-LOS ANGELES, 3580 Wilshire Blvd., Suite 1660, Los Angeles, CA 90010 or call Mary Hagerty at (213) 386-9930.

Managing Construction and Demolition Waste: A Checklist

1. CONDUCT AN INFORMAL WASTE AUDIT

Determine the amounts, types, and time frame for construction and demolition materials generated by your projects. Calculate any possible cost savings from reducing a portion of this waste stream, in terms of disposal cost avoidance and transportation time.

2. REDUCE

Investigate strategies for reducing construction and demolition waste materials. Proper materials management practices can result in cost savings. Assure that precise estimates are made prior to purchasing materials, and that accurate measurements are made prior to cutting materials so that excess scrap and end cuts can be avoided. Consider having materials pre-cut at lumber yards, using engineered wood products, steel framing, or other pre-manufactured components.

3. RE-USE

Consider the potential for others to use the materials you normally discard. Consider planning ahead and phoning CALMAX, LA Shares, or Habitat for Humanity-Los Angeles to list such materials to arrange donations.

Conduct site pre-assessments to evaluate the kinds of materials that can be salvaged for re-use, such as cabinets, architectural wood work, light fixtures, and appliances.

4. RECYCLE

Investigate the companies listed in this guide that can recycle some of your construction and demolition wastes from both source-separated or mixed loads. Be sure to compare the costs of recycling with the costs of disposal.

5. EDUCATE EMPLOYEES AND SUB-CONTRACTORS

Whatever waste reduction strategies you choose, remember that it is crucial to educate and motivate your employees and sub-contractors for maximum participation. Emphasize that source reduction, re-use, and recycling is everybody's business.

SECTION 1

BASE MATERIALS

LISTINGS OF INERT MATERIALS RECYCLING PROCESSORS

LOCATED IN THE LOS ANGELES AREA

The following companies accept inert materials, such as asphalt, asphalt millings and grindings, concrete, rocks, and slump stone (decorative concrete block), for the purpose of recycling.

RECYCLING PROCESSOR	TYPES OF MATERIALS ACCEPTED/ PROCESSED	CONDITION OF MATERIALS AND LIMITATIONS	SERVICES OFFERED OR FEES	COMPANY END-PRODUCT
AGGREGATE RECYCLING SYSTEMS INC. 6208 South Alameda Street Huntington Park, CA 90255 Phone: (213) 588-4868 Fax: (213) 588-4868 Hours: 7 a.m. - 5 p.m. M - F (24 hours available call for Sat & Sun delivery) Contact: Sam Chew	**SEPARATED OR MIXED LOADS OF:** CONCRETE ASPHALT ROCK SAND GRAVEL CONCRETE BLOCK SLUMP STONE	Maximum Size: 4 feet long by 4 feet wide by 12 inches thick. Materials can include rebar and wire mesh Cannot accept more than 15% SANDY DIRT Cannot accept CLAY, RED CLAY BRICK, TRASH or VEGETATION.	Fees are subject to change. Call office for current prices. Extra charge for oversize and materials with rebar. Portable Crushing Equipment also available for on-site jobs.	CRUSHED MISCELLANEOUS BASE (CMB) - Meets Green Book Specs. CLASS II AGGREGATE - Meets Blue Book Specs. PROCESSED MISCELLANEOUS BASE (PMB) - Meets Green Book Specs.
AMAN BROS Mailing Address: P.O. Box 4233 Covina, CA 91723 Phone: (818) 966-4287 FAX: (818) 915-3244 **PLANT LOCATION:** 900 Greenwood Monterey Park, CA (Potrero Grande & Greenwood) Phone: (213) 728-2491 Contact: Frank Ehrig	**SEPARATED OR MIXED LOADS OF:** CONCRETE ASPHALT ROCK SAND GRAVEL CONCRETE BLOCK SLUMP STONE	Maximum Size: 2 feet long by 2 feet wide by 12 inches thick. Materials can include rebar up to #4 size or wire mesh. Cannot accept CLAY, RED CLAY BRICK, TRASH or VEGETATION.	Fees are subject to change. Call office for current prices. Extra charge for oversize and materials with rebar or wire. Portable Crushing Equipment also available for on-site jobs.	CRUSHED MISCELLANEOUS BASE (CMB) - Meets Green Book Specs. CLASS II AGGREGATE - Meets Blue Book Specs.

RECYCLING PROCESSOR	TYPES OF MATERIALS ACCEPTED/ PROCESSED	CONDITION OF MATERIALS AND LIMITATIONS	SERVICES OFFERED OR FEES	COMPANY END-PRODUCT
BLUE DIAMOND MATERIALS MAIN OFFICE: 16080 Arrow Highway Irwindale, CA 91706 MAIN OFFICE HOURS: M-F, 6:30-5:00 Phone: (800) 300-6120 FAX : (818) 337-3401 Contact: Gabe Adnoff, Spvr. Recycled Materials Dept.	ASPHALT ASPHALT MILLINGS & GRINDINGS CONCRETE CONCRETE BLOCK SLUMP STONE PORCELAIN (e.g. old toilets), but phone first	Maximum Size for ASPHALT and CONCRETE: 2 by 3 feet, and 1 foot thick Additional charge for REINFORCED CONCRETE (metal rebar or wire mesh) Cannot include more than 10% SANDY DIRT	Fees are subject to change and vary with site; call Main Office for information. Additional charge for oversized materials.	CRUSHED MISCELLANEOUS BASE (CMB) - Meets Green Book Specs. CLASS II AGGREGATE - Meets Blue Book Specs. PROCESSED MISCELLANEOUS BASE (PMB) - Meets Green Book Specs.
SITE LOCATIONS, Blue Diamond Materials				
SITE HOURS All Locations M-F, 7-3:30 Sat.: Call for Hours	IRWINDALE 13550 E. Live Oak 605 Fwy/Live Oak		LONG BEACH 6956 Cherry Ave. Cherry N/O 91 FWY California South of Spring	
LONG BEACH HARBOR 1605 Pier D Street	SANTA MONICA 24th S/O Michigan		SOUTH GATE 5625 Southern Ave. Also Supplies: RECYCLED ASPHALT CONCRETE (RAC) - Meets Green Book Specs.	
WILMINGTON 2400 E. Pacific Coast Highway	WILMINGTON Alameda S/O Sepulveda		UPLAND 1499 Benson Ave. Benson N/O Foothill	
CORNERSTONE RECYCLE GROUP 17731 Raymer Street Northridge, CA 91325 Phone: (800) 278-6753 FAX: (818) 993-3367 Contact: Paul Hurley	IN-PLACE: ASPHALT CONCRETE CONCRETE BLOCK ROCK	Processes oversize, with rebar and wire mesh, at contractor's site. Works in confined locations.	On-site crushing only	CRUSHED MISCELLANEOUS BASE (CMB) - Will Crush to Meet Green Book Specs. CLASS II BASE (CLII) - Will Crush to Meet Blue Book Specs. PROCESSED MISCELLANEOUS BASE (PMB) - Will Crush to Meet Green Book Specs.

RECYCLING PROCESSOR	TYPES OF MATERIALS ACCEPTED/ PROCESSED	CONDITION OF MATERIALS AND LIMITATIONS	SERVICES OFFERED OR FEES	COMPANY END-PRODUCT
DAN COPP CRUSHING MAIN OFFICE: 1300 N. Hancock St. #B Anaheim, CA 92807 Phone: (714) 777-6400 FAX: (714) 777-6410 SANTA FE SPRINGS PLANT 12017 Greenstone Ave. Santa Fe Springs Phone: (800) DUMPSITE (North of Sunshine Ave.) Hours: M-F 7-4:30; Sat. by appointment	CONCRETE ASPHALT CONCRETE BRICK CONCRETE WITH REBAR OR WIRE MESH OVERSIZE CONCRETE	Clean Materials Only No DIRT, GLASS, WOOD, TRASH, or other DELETERIOUS MATERIALS	Call office for current dump prices. Portable crushing available also.	CLASS II 3/4" AGGREGATE BASE - Meets Blue Book Specs. CRUSHED MISCELLANEOUS BASE (CMB) - Meets Green Book Specs. PROCESSED MISCELLANEOUS BASE - Meets Green Book Specs.
INDUSTRIAL ASPHALT Main Office: TECHNICAL 16009 Foothill Blvd. Irwindale, CA 91706 PH: (818) 856-6790 FX: (818) 969-2918 Main Office Contact: Dan Chapman (Director)	CLEAN ASPHALT MILLINGS AND GRINDINGS ONLY		Fees are subject to change. Call office for current prices.	Recycled Asphalt Concrete (RAC) - Meets Green Book Specs.
INDUSTRIAL ASPHALT PLANT LOCATIONS (GREATER LA AREA ONLY):				
IRWINDALE 16005 Foothill Blvd. Irwindale (818) 334-4913 Contact: Bill Watts District Manager	**LOS ANGELES** 2715 E. Washington Bl. Los Angeles (213) 268-2886 Contact: Neil Stern District Manager	**SUN VALLEY** 11447 Tuxford St. Sun Valley (818) 767-7119 Contact: Paul Hughes District Manager	**WILMINGTON** 1601 N. Alameda Wilmington (310) 834-2655 Contact: Terry Prentice District Manager	**OTHER AREAS** Contact the Main Office for a list of recycling locations outside the greater Los Angeles area.
J.A. JAMES CONSTRUCTION COMPANY 1150 No. Hellman Ave. Ontario, CA 91764 Phone: (909) 944-1001 FAX: (909) 944-7770	**IN-PLACE:** ASPHALT PAVEMENT	In-place asphalt pavement up to 12" thick, at contractor's location, no stockpiles.	Provides in-place asphalt pulverizing services; call for estimates.	

RECYCLING PROCESSOR	TYPES OF MATERIALS ACCEPTED/ PROCESSED	CONDITION OF MATERIALS AND LIMITATIONS	SERVICES OFFERED OR FEES	COMPANY END-PRODUCT
MASTER RECYCLING COMPANY, INC. 2845 Durfee Ave. El Monte, CA 91732 Phone: (818) 442-4242 FAX: (818) 444-4648 Contact: Jim Nevarov	**SEPARATED:** CONCRETE ASPHALT ROCK SAND RED CLAY BRICK CLEAN & MIXED WOOD, NAILS, STAPLES - OK **But NO WET WOOD** MIXED WASTES - OK. **NO STUMPS, ROOTS, PALMS, YUCCA, or IVY, are accepted.**	No Size Limitations for ASPHALT and CONCRETE RED BRICK can be broken, loose, or palletized	Will schedule regular pick-ups; roll-offs are available; Will provide on-site source separation; Extra charge for MIXED WASTE loads; fees vary with type & condition of wastes.	
NEWMAN AND SONS, INC. Mailing Address: P.O. Box 877 Sun Valley, CA 91353 **PLANT LOCATION:** 9005 Bradley Ave. Sun Valley, CA 91352 (5 Freeway to the Penrose off ramp) Phone: (213) 875-1622, (818) 767-0700 or (818) 983-2120 FAX: (818) 767-2279 Contact: Dave Dodge, Dennis Newman	**SEPARATED OR MIXED LOADS OF:** CONCRETE ASPHALT ROCK SAND CONCRETE BLOCK	Maximum Size: 4 feet long by 4 feet wide by 12 inches thick. Materials can include rebar up to #4 size or wire mesh. Cannot accept CLAY, RED CLAY BRICK, TRASH, or VEGETATION.	Fees are subject to change. Call office for current prices. Extra charge for oversize and materials with rebar or wire.	CRUSHED MISCELLANEOUS BASE (CMB) - Meets Green Book Specs. CLASS II AGGREGATE - Meets Blue Book Specs.
RECYCLED BASE MATERIALS, INC. Mailing Address: P.O. Box 579 Sun Valley, CA 91353 Office Location: 9050 Norris Avenue Sun Valley, CA 91352 Phone: (818) 767-3088 FAX: (818) 767-3169 Office Hours: M-F 8-5 Contact: Mark Christie	**IN-PLACE:** ASPHALT CONCRETE CONCRETE BLOCK ROCK	Processes oversize, with rebar and wire mesh, at contractor's site. Works in confined locations.	Provides mobile equipment for on-site crushing of materials.	CRUSHED MISCELLANEOUS BASE (CMB) - Will Crush to Meet Green Book Specs. CLASS II BASE (CLII) - Will Crush to Meet Blue Book Specs. PROCESSED MISCELLANEOUS BASE (PMB) - Will Crush to Meet Green Book Specs.

RECYCLING PROCESSOR	TYPES OF MATERIALS ACCEPTED/ PROCESSED	CONDITION OF MATERIALS AND LIMITATIONS	SERVICES OFFERED OR FEES	COMPANY END-PRODUCT
SHAMROCK BASE Main Office: 3100 No. Broadway Los Angeles, CA 90031 Phone: (213) 223-2366 FAX: (213) 223-2360 **PLANT LOCATION:** 551 Mission Rd., Los Angeles (Mission at Macy) Contact: Roy Belmonte	**SEPARATED OR MIXED LOADS OF:** ASPHALT CONCRETE CONCRETE BLOCK	Size: 2 feet by 2 feet Cannot accept more than 10% SANDY GRANULAR SOILS	10-Wheeler $50 Semi-End $60 Extra Charge for rebar and oversize, from $5 to $50 per truck.	CERTIFIED METRO SAND CRUSHED MISCELLANEOUS BASE (CMB) - Meets Green Book Specs. Lean CONCRETE MIXED Aggregate Certified for Century Freeway
SIMI VALLEY BASE Mailing Address: P.O. Box 729 Moorpark, CA 93020 PLANT LOCATION: 240 West LA Avenue Simi Valley, CA Phone: (805) 520-3595 (805) 529-7974 Hours: M-F 7-4; Sat. & Sun. by arrangement	**CLEAN:** ASPHALT CONCRETE CONCRETE BLOCK ROCK SLUMP STONE	Maximum Size: 4 feet long by 2 feet wide by 12" thick. Cannot accept more than 15% SANDY DIRT May charge extra for materials that exceed maximum size. Extra charge for materials with rebar, and for materials with wire mesh.	BOOK RATES: (Call for Volume Quotes) Pick-Up: $20 w/rebar: $30 Bob-Tail: $40 w/rebar: $60 10-Wheeler: $60 w/rebar: $100 Semi: $100 w/rebar: $150	PROCESSED MISCELLANEOUS BASE (PMB) - Meets Green Book Specs.
25TH STREET RECYCLING, INC. Mailing Address: P.O. Box 579 Sun Valley, CA 91353 **OFFICE/PLANT LOCATION:** 2121 E. 25th Street L.A., CA 90058 Phone: (818) 767-3088 Fax: (818) 767-3169 Office Hours: M-F 8 - 5 Plant Open 7 - 3 call for additional hours Contact: Mark Christie	**SEPARATED OR MIXED LOADS OF:** ASPHALT CONCRETE CONCRETE BLOCK ROCK SAND	Maximum Size: 2' X 3' X 1' Will accept Reinforced CONCRETE, CONCRETE with WIRE MESH, & OVERSIZE Will accept PORCELAIN TOILETS (advance arrangements required). No RED CLAY BRICK, WOOD, PLASTIC, or TRASH	Additional charge for Reinforced CONCRETE, CONCRETE with WIRE MESH, & OVERSIZE	CRUSHED MISCELLANEOUS BASE (CMB) - Meets Green Book Specs. CLASS II AGGREGATE - Meets Blue Book Specs. PROCESSED MISCELLANEOUS BASE (PMB) - Meets Green Book Specs.

RECYCLING PROCESSOR	TYPES OF MATERIALS ACCEPTED/ PROCESSED	CONDITION OF MATERIALS AND LIMITATIONS	SERVICES OFFERED OR FEES	COMPANY END-PRODUCT
VALLEY BASE MATERIALS Mailing Address: P.O. Box 579 Sun Valley, CA 91353 **OFFICE/PLANT LOCATION:** 9050 Norris Avenue Sun Valley, CA 91352 Phone: (818) 767-3088 FAX: (818) 767-3169 Office Hours: 8 - 5 Plant Open 24 Hours; call in advance for night drops. Contact: Mark Christie	**SEPARATED OR MIXED LOADS OF:** ASPHALT CONCRETE CONCRETE BLOCK ROCK SAND	Maximum Size: 2' X 3' X 1' Will accept REINFORCED CONCRETE, CONCRETE with WIRE MESH, & OVERSIZE Will accept PORCELAIN TOILETS (advance arrangement required). Cannot accept more than 15% SANDY DIRT No RED CLAY BRICK, WOOD, PLASTIC, or TRASH	Additional charge for REINFORCED CONCRETE, CONCRETE with WIRE MESH, & OVERSIZE	CRUSHED MISCELLANEOUS BASE (CMB) - Meets Green Book Specs. CLASS II AGGREGATE - Meets Blue Book Specs. PROCESSED MISCELLANEOUS BASE (PMB) - Meets Green Book Specs.

SECTION 2

LISTINGS OF PROCESSORS OF RED CLAY BRICK LOCATED IN THE LOS ANGELES AREA

The following companies provide services for processing red clay brick material, by cleaning, palletizing, and transporting it from demolition sites. Some facilities will accept self-hauled materials by prior arrangement. Contact the companies in advance listed to arrange for site inspections.

RED BRICK RECYCLING CONTRACTOR OR FACILITY	ACCEPTANCE OR DELIVERY OF MATERIALS	CONDITION OF MATERIALS AND LIMITATIONS	SERVICES OFFERED OR FEES
A-1 BUILDING MATERIALS 2210 East South Street Long Beach, CA 90805 Phone: (310) 531-1874 FAX: (310) 634-0559 Contact Person: Robert Riddle	Company has a site to which materials can be delivered. If approved for purchase, company will pick-up materials.	Processors must call in advance to arrange an inspection of materials. Bricks must be palletized prior to pick-up. **Minimum Quantity:** At least one pallet of bricks, estimated at 500 Bricks per pallet.	**SERVICE PROVIDED:** Company will pick-up and pay for High-Quality Red-Clay Brick from processors for re-sale. ALSO INTERESTED IN HIGH-QUALITY RED CLAY ROOFING TILE (SPANISH TILE). **CHARGE TO CUSTOMER: None** - Company pays for materials.
BOURGET BROS. BUILDING MATERIALS 1636 11th Street Santa Monica, CA 90404 Phone: (310) 450-6556 FAX: (310) 450-2201 Contact: Miguel Macario	Company has a site to which materials can be delivered. If approved for purchase, company will pick-up materials.	Processors must call in advance to arrange an inspection of materials. Bricks must be palletized prior to pick-up. **Minimum Quantity:** At least one pallet of bricks, estimated at 500 Bricks per pallet.	**SERVICE PROVIDED:** Company will pick-up and pay for High-Quality Red-Clay Brick from processors for re-sale. **CHARGE TO CUSTOMER: None** - Company pays for materials.
DEMOLITION BRICK SALES c/o West Coast Land Clearing P.O. Box 90126 Long Beach, CA 90809-0126 Phone: (310) 591-6640 Fax: (310) 599-2787 Contact: Dave Thomas	Can arrange to receive 20-30 truck loads of clean bricks [at its site], palletized or loose bricks, subject to available space. It will also haul bricks away for processing at its own site.	Contractors or individuals with red bricks for processing should call to arrange an inspection of materials. **Minimum quantity:** At least 10,000 bricks for processing.	**SERVICE PROVIDED:** Building demolition company cleans, stacks, or palletizes red clay bricks at contractor's or individuals' site. Will either leave processed bricks at site for re-use, or haul bricks away to process at its site and sell. Sells palletized bricks to contractors and building supply companies. Takes broken or unacceptable bricks to an inert fill for disposal. **CHARGES TO CUSTOMERS:** Charges for processing at sites are based on bids or time and materials. No charge for materials delivered to site, per prior arrangement.

RED BRICK RECYCLING CONTRACTOR OR FACILITY	ACCEPTANCE OR DELIVERY OF MATERIALS	CONDITION OF MATERIALS AND LIMITATIONS	SERVICES OFFERED OR FEES
MASTER RECYCLING 2845 Durfee Avenue El Monte, CA 91732 Phone: (818) 442-4242 Fax: (818) 444-4648 Contact: Jim Nevarov	Company provides on-site collection bins and hauling services for red bricks. Accepts materials at its site, but recommends calling in advance.	Contractors or individuals with red brick to be delivered to the site or picked up at their location should call to make arrangements in advance.	**SERVICE PROVIDED:** Company accepts loose, broken and palletized red bricks delivered to its processing facility. It will clean, stack, and palletize loose bricks for resale to building materials suppliers. Can provide pallets and staff for on-site separation of red bricks by arrangement. **CHARGES TO CUSTOMERS:** Charges vary, based on bid or time and materials for individual jobs.
HTP ENTERPRISES, INC. Mailing Address: P.O. Box 21414 Los Angeles, CA 90021 Phone: (213) 629-2389 FAX: (213) 629-4409 Contact: George Perez Hiram Perez, Hugo Perez	Company does not have a site to which materials can be delivered or stored.	Contractors or individuals with red brick for processing should call to arrange an inspection of materials. Minimum quantity: To be arranged.	**SERVICE PROVIDED:** Building demolition company provides on-site processing of red-clay bricks: cleans and palletizes materials. Will transport palletized or loose bricks to locations designated by customer. **CHARGES TO CUSTOMERS:** Charges based on bid or time and materials for individual jobs.
SEPULVEDA BUILDING MATERIALS **MAIN OFFICE/TORRANCE SITE:** 2936 Sepulveda Blvd. Torrance, CA 90505-2894 Phone: (310) 325-2173 FAX: (310) 325-5340 Contact: John Connors, Marketing Executive	Will only accept materials delivered to its sites for purchase by prior arrangement, inspection, and approval.	Contractors or individuals with red brick for sale should call to arrange an inspection of materials. **Minimum quantity:** To be arranged.	**SERVICE PROVIDED:** Building material suppliers purchases high-quality bricks only. Will provide pallets and hauling services. Does not have staff to clean and stack bricks onto pallets, but could recommend a company to do the cleaning, etc. Must inspect materials in advance and must supervise demolition. NO HAZARDOUS MATERIALS ACCEPTED. **CHARGES TO CUSTOMERS:** No charge for providing pallets, hauling services, or delivery if materials are purchased.

SITE LOCATIONS, Sepulveda Building Materials

GARDENA SITE	LAGUNA NIGUEL SITE
359 East Gardena Blvd. Gardena, CA 90248-2815 Phone: (310) 325-2173 Fax: (310) 217-0193 Contact: Nacho Encisco (If delivering Samples of bricks to this Gardena site, need to send to attention of Nacho Encisco)	(Main Contact for Purchase and Sales of Red Brick) 28092 Forbes Road Laguna Niguel, CA 92677-1288 Phone: (714) 364-2100 Fax: (714) 364-3468 Contact: Dan Lewis, Tony Lake or Gerry Samano

SECTION 3

A LISTING OF SCRAP METAL DEALERS IN THE LOS ANGELES AREA

The following scrap metal dealers will accept metals generated through construction and demolition activities. Contractors are urged to call the companies first to determine the types, amounts, and condition of materials they will accept.

Company Name	Address	Telephone
AZUSA		
AZUSA STEEL PRODUCT	1168 West Gladstone Azusa, CA 91702	(818) 334-7841
CARSON		
CARSON RECYCLING	P.O. Box 4483 Carson, CA 90749-4483	(310) 835-9109
NATIONAL METAL AND STEEL CORP.	22010 So. Wilmington Ave. Ste #102 Carson, CA 90745	(310) 549-6143
CHATSWORTH		
VALLEY RE-CYCLING	20220 Plummer St. Chatsworth, CA 91311	(818) 885-6225
COLTON		
HUGO NEU-PROLER CO. - COLTON IRON & METAL	790 E. "M" Street Colton, CA 92324	(714) 825-1662
COMPTON		
COMPTON IRON AND METAL	503 So. Alameda St. Compton, CA 90220	(310) 639-7070
P & R METALS, INC.	2222 No. Alameda St. Compton, CA 90222	(213) 774-0595
ROCKMAKER SCRAP METAL	2195 So. Santa Fe Compton, CA 90221	(310) 639-4922
CUDAHY		
GRANDE VISTA STEEL	4611 Cecelia Cudahy, CA 90201	(213) 773-8032
EL MONTE		
B&D AUTO & TRUCK SALVAGE	12301 E. Valley Blvd., El Monte, CA 91732	(818) 444-9530
FONTANA		
DAMILLE METAL SUPPLY, INC.	13230 San Bernardino Rd. Fontana, CA 92335	(213) 587-6001
FRANKEL IRON & METAL CO.	15615 Arrow Blvd. Fontana, CA 92335	(909) 823-3431
GARDENA		
IDEAL METAL & SALVAGE CO.	18700 So. Broadway Gardena, CA 90248	(310) 324-1191
HUNTINGTON PARK		
DAMILLE METAL SUPPLY, INC.	8201 Santa Fe Huntington Park, CA 90255	(213) 587-6001
JOS LEVIN & SONS	2863 E. Slauson Huntington Park, CA 90255	(213) 588-4207
IRWINDALE		
HUGO NEU-PROLER CO. - IRWINDALE IRON & METAL	2495 Buena Vista Irwindale, CA 91706	(818) 359-5815
LA MIRADA		
STAR SCRAP METAL CO., INC.	14372 E. Firestone Blvd. La Mirada, CA 90638	(714) 994-3450 or (310) 921-9442

Company Name	Address	Telephone
LONG BEACH		
ALPERT & ALPERT	21930 Wilmington Long Beach, CA 90810	(213) 775-6791 (310) 834-2659
HIUKA AMERICA CORPORATION	482 Pier T Ave., Long Beach, CA 90810	(310) 682-1000
STANDARD SCRAP METALS & RECYCLING COMPANY	2032 E. 220th St., Long Beach, CA 90810	(310) 835-0115
STATE SALVAGE CO., INC.	22500 So. Alameda St. Long Beach, CA 90810	(310) 835-3849
CLEAN STEEL, INC.	2061 E. 220th St. Long Beach, CA 90810	(310) 830-6010 (213) 775-1131
LOS ANGELES		
A & S METAL RECYCLING	2261 E. 15th St. Los Angeles, CA 90021	(213) 623-9443
ALPERT & ALPERT IRON & METAL	1815 So. Soto St. Los Angeles, CA 90023	(213) 265-4040
AMANA METALS	9405 So. Alameda St. Los Angeles, CA 90002	(213) 564-3211
ATLAS IRON & METAL CO.	10019 So. Alameda St. Los Angeles, CA 90002	(213) 566-5184
C & M METALS, INC.	1709 E. 24th St. Los Angeles, CA 90058	(213) 234-4662
COMMONWEALTH RECYCLING	10307 So. Alameda St. Los Angeles, CA 90023	(213) 249-4915
EKCO METALS	1700 So. Perrino Pl. Los Angeles, CA 90023	(213) 264-1615
HUGO NEU-PROLER CO. - DOWNTOWN METAL CENTER	2728 Long Beach Ave. East Los Angeles, CA 90058	(213) 234-1883
HUGO NEU-PROLER CO. - PACIFIC INDUSTRIAL METAL	10313 So. Alameda Blvd. Los Angeles, CA 90002	(310) 538-5360
KRAMER METALS - FERROUS METALS DIVISION	1000 E. Slauson Ave. Los Angeles, CA 90011	(213) 233-4201
LEVAND STEEL & SUPPLY CORP.	P.O. Box 24846 Los Angeles, CA 90024	(310) 823-4453
MID-CITY IRON & METAL CORP.	2104 E. 15th St. Los Angeles, CA 90021	(213) 747-4281
SPECTRUM ALLOYS, INC. - FERROUS METALS DIVISION	1760 East Slauson Avenue Los Angeles, CA 90058	(213) 587-2277
LYNWOOD		
HUGO NEU-PROLER CO. - ALAMEDA STREET METALS	10313 So. Alameda St. Lynwood, CA 90002	(213) 564-5601
ONTARIO		
AMERICAN METAL RECYCLING	2202 So. Milliken Ave. Ontario, CA 91761	(909) 988-8000
ONTARIO METAL RECYCLING	717 So. Taylor Ave. Ontario, CA 91761	(909) 983-0655

Company Name	Address	Telephone
PICO RIVERA		
SOS METALS, INC.	5103 Paramount Blvd. Pico Rivera, CA 90660-0704	(310) 949-4446
SAN FERNANDO VALLEY		
MAX SCRAP METALS	21608 Nordhoff Street Chatsworth, CA 91311	(818) 709-4100
HUGO NEU-PROLER CO. - VALLEY IRON & METAL	9754 San Fernando Road Sun Valley, CA 91352	(818) 767-5022 (213) 875-2520
SAN PEDRO/TERMINAL ISLAND/WILMINGTON		
HIUKA AMERICA CORP.	2000 No. Gaffey St. San Pedro, CA 90731	(310) 816-3000
HUGO NEU-PROLER CO. - (MAIN OFFICE)	901 New Dock Terminal Island, CA 90731	(213) 775-6626 (310) 831-0281
G. HARRIS INTERNATIONAL, INC.	1025 MacFarland Ave. Wilmington, CA 90748	(310) 513-1424
SANTA FE SPRINGS		
STATE IRON & METAL CO.	13780 E. Imperial Hwy. Santa Fe Springs, CA 90670	(310) 921-9974
SOUTH GATE		
FAIRWAY SALVAGE	12428 Center St. South Gate, CA 90280	(310) 630-8766
ISWMO wishes to thank the Institute of Scrap Recycling Industries (ISRI) for its assistance in compiling this list.		

SECTION 4

LISTINGS OF FACILITIES THAT ACCEPT CORRUGATED CARDBOARD FOR RECYCLING IN THE LOS ANGELES AREA

The following companies accept cardboard generated from construction, demolition, and tenant improvements for the purpose of recycling. It is recommended to contact companies in advance to determine conditions for acceptance, and fees paid for materials.

Company Name	Address	Telephone
BURBANK		
BURBANK RECYCLE *Accepts all cardboard, including wax coated, in any form. May furnish roll offs.*	500 South Flower Street; Burbank, CA 91502	(818) 841-9700
CANOGA PARK		
ELITE RECYCLING *Accepts all cardboard, including wax coated.*	20934 Sherman Way; Canoga Park, CA 91303	(818) 999-0444
GOLDEN STATE FIBRES *Accepts baled cardboard only. May provide pick up services and furnish roll offs.*	8000 Deering Avenue; Canoga Park, CA 91304	(818) 713-9330
CHATSWORTH		
ACE RECYCLING SCRAP *Accepts flattened, non-wax coated cardboard. May provide pick up services.*	21250 Nordhoff Street; Chatsworth, CA 91311	(818) 882-1400
VALLEY RECYCLING *Accepts non-waxed coated cardboard in any way.*	20220 Plummer Street; Chatsworth, CA 91311	(818) 885-7318
COMMERCE		
TZENG LONG USA, INC. *Accepts flattened, non-wax coated cardboard. May provide pick up services and furnish roll offs or flatbed.*	2081 South Vail Avenue; Commerce, CA 90040	(213) 722-5353
COMPTON		
SUMMIT, PULP AND PAPER, INC. *Accepts non-waxed coated cardboard in any way. May furnish roll offs.*	1601 S. Anderson Avenue; Compton, CA 90220	(310) 604-3270
CULVER CITY		
THE PICK UP ARTISTS *Door to door pick up service for a fee. Not a buy-back center.*	10536 Culver Boulevard, Suite B Culver City, CA 90232	(310) 559-9334
GARDENA		
AMBIT PACIFIC *Accepts non-wax coated cardboard in any way. May provide pick up services and furnish roll offs.*	16228 South Figueroa Street, Gardena, CA 90248	(310) 538-3798
LOS ANGELES		
ACTIVE NEIGHBORHOOD RECYCLING CENTERS *Will accept cardboard in any way. May furnish roll offs.*	2000 W. Slauson Avenue; Los Angeles, CA 90047 5601 E. Valley Blvd; Los Angeles, CA 90032	(213) 295-7774 (213) 221-2555

Company Name	Address	Telephone
LOS ANGELES (Continued)		
ANGELUS WESTERN PAPER FIBERS *Accepts non-wax coated cardboard in any way. May furnish roll offs and balers.*	2474 Porter Street; Los Angeles, CA 90021	(213) 623-9221
BTM *Accepts non-wax coated cardboard loose, baled, or compacted. May furnish containers and balers.*	P. O. Box 641461; Los Angeles, CA 90064	(310) 477-9636
BASIC FIBERS, INC. *Accepts non-wax coated cardboard loose, baled, or compacted.*	6019 S. Manhattan Place; Los Angeles CA 90047	(213) 753-3491
BESTWAY RECYCLING *Accepts non-wax coated cardboard loose, baled, or compacted. May provide roll offs.*	2268 E. Firestone Blvd.; Los Angeles CA 90002	(213) 588-8157
CITY FIBERS *Accepts non-wax coated cardboard in any way. May furnish roll offs.*	2500 South Santa Fe Ave.; Los Angeles CA 90058	(213) 583-1013
DATA MANAGEMENT *Accepts flattened cardboard, wrapped with twine. Fee structure, if any, depends on volume. May furnish roll offs.*	6709 La Tijera Boulevard; Los Angeles CA 90043	(213) 295-9956
EXPRESS RECYCING *Accepts cardboard in any way, including wax coating, if mixed with non-waxed coated cardboard. May furnish 3-yard bins or roll offs.*	701 East Florence Avenue; Los Angeles, CA 90001	(213) 759-3396
HARLEY METALS COMPANY *Accepts non-wax coated cardboard in any way. May furnish roll offs.*	3315 East Washington Boulevard Los Angeles, CA 90023	(213) 264-0646
L. A. RECYCLING CENTER *Accepts American Standard Cardboard with no metal, staples, or wax coating.*	1000 North Main Street; Los Angeles, CA 90012	(213) 221-9188
L. A. CONSERVATION CORPS *Accepts non-wax coated, flattened cardboard. May pick up. Provides recycling education. May provide pick up services.*	380 W. Martin Luther King Blvd. Los Angeles CA 90015	(213) 231-1149
LOS ANGELES PAPER BOX & BOARD MILLS *Accepts clean and baled double-lined kraft, old corrugated containers, hi grades, chip and boxboard only.*	P. O. Box 60830; Los Angeles, CA 90060	(213) 685-8900

Company Name	Address	Telephone
LOS ANGELES (Continued)		
SMURFIT RECYCLING COMPANY *Accepts non-wax coated, separated cardboard, free from contaminants and solid waste. May furnish 3-yard bins or roll-offs and pay provide pick up services.*	3033 East Washington Boulevard Los Angeles CA 90023	(213) 263-2103
SOUTHCOAST RECYCLING *Accepts non-wax coated cardboard in any way. May furnish roll offs.*	4560 Doran Street; Los Angeles, CA 90039	(213) 245-5133
SUMMIT, PULP AND PAPER, INC. *Accepts cardboard that is free of contaminants. May furnish equipment and may provide pick up services.*	2016 East Bay Street; Los Angeles, CA 90021	(213) 627-7351
WEYERHAEUSER *Accepts non-wax coated, empty cardboard, flattened or unflattened that is not contaminated. May furnish bailer.*	6625 Stanford Avenue; Los Angeles, CA 90001	(213) 750-0134
MONTEBELLO		
BELMONT FIBERS *Accepts non-wax coated cardboard in any form.*	1736 Chapin Road; Montebello, CA 90640	(213) 727-9232
NORTH HOLLYWOOD		
ALPHA RECYCLING, INC. *Accepts non-wax coated cardboard in any way.*	13314 Saticoy Street; North Hollywood, CA 91605	(818) 982-5800
NORTHRIDGE		
BMN RECYCLING, INC. *Accepts non-wax coated cardboard in any condition. May furnish roll offs.*	19031 Parthenia Street; Northridge, CA 91324	(818) 772-1944
SAN PEDRO		
ECO-WASTE RECYCLING *Accepts flattened or unflattened cardboard that is wax coated or not.*	P. O. Box 463; San Pedro CA 90733	(310) 519-8209
SAN PEDRO RECYCLING *Accepts cardboard flattened or unflattened.*	1900 North Gaffey; San Pedro, CA 90731	(310) 548-0232
SOUTH GATE		
TZENG LONG USA, INC. *Accepts non-wax coated, flattened cardboard. May furnish roll offs or flatbeds and may provide pick up services.*	5445 Tweedy Boulevard; South Gate, CA 90280	(213) 569-9023
SUN VALLEY		
COMMUNITY RECYCLING & RESOURCE RECOVERY, INC. *Accepts non-wax coated, flattened or unflattened cardboard.*	9147 Degarmo Street, Sun Valley, CA 91352	(818) 767-6000

Company Name	Address	Telephone
TORRANCE		
SMURFIT RECYCLING COMPANY *Accepts non-wax coated cardboard in any way. May furnish roll offs. May provide pick up services.*	20502 South Denker Avenue; Torrance, CA 90509	(310) 533-0333
VAN NUYS		
ACTIVE NEIGHBORHOOD RECYCLING CENTER *Accepts cardboard in any way. May furnish roll offs.*	14300 Bessemer Street; Van Nuys, CA 91401	(818) 785-0600
ENVIRO TRADING, INC. *Accepts non-wax coated cardboard in any way. May furnish roll offs.*	15105 Raymer Street; Van Nuys, CA 91405	(818) 786-4493
LIFE-CYCLE RECYCLING *Accepts flattened cardboard; may provide pick up services. Manufactures and sells recycling bins.*	P. O. Box 55502; Van Nuys, CA 91413-0502	(818) 995-7872
WILMINGTON		
POTENTIAL INDUSTRIES *Accepts non-wax coated, flattened cardboard. May provide roll offs.*	922 East "E" Street; Wilmington, CA 90744	(310) 549-5901

SECTION 5

LISTINGS OF SALVAGE YARDS IN THE LOS ANGELES AREA

The following companies accept materials salvaged from residential, commercial, or industrial buildings for re-use. It is important to call the companies listed in this section in advance to determine whether a site visit by the company is needed to evaluate salvageable items for acceptance, or to determine whether the company will pay for particular items, or charge to remove them.

RECYCLING FACILITY	TYPES OF MATERIALS ACCEPTED/PROCESSED	CONDITION OF MATERIALS AND LIMITATIONS	SERVICES OFFERED	COMPANY END-PRODUCT
ACE RECYCLING 21250 Nordhoff St. Chatsworth, CA PH: (818) 882-1457 HOURS: 7:30 - 5 M - F 7:30 - 2:30 SAT CONTACT: Harvey Skylar	IRON AND CHAINLINK FENCES, BATHTUBS, METAL ITEMS, NEON AND OTHER SIGNS, WATER HEATERS, METAL DOORS AND WINDOWS, SCREENS, INSULATED WIRE AND MORE	REUSABLE CONDITION PLEASE CALL FIRST	MAY CONDUCT SITE VISIT MAY PICK UP MAY PAY FOR ITEMS	RECYCLED ITEMS FOR RESALE OR RE-USE
BIG TEN 757 W. Woodbury Rd. Altadena, CA 91001 PH: (818) 791-9747 HOURS: 9:30 - 5:30 M - SAT CONTACT: Fred Alexander	BATHTUBS (PICKED UP AT NO CHARGE), CHANDELIERS, FRENCH DOORS, HARDWARE, WINDOWS, LIGHTING FIXTURES, LUMBER FOR EXAMPLE ACTUAL 2X4S, SINKS, GATES, WROUGHT IRON FENCES, PLUMBING FIXTURES, HOT WATER HEATERS, FURNACES, GLASS, AIR CONDITIONERS AND MORE	REUSABLE MATERIALS, SPECIALIZE IN CRAFTSMAN AND BUNGALOW TYPE FIXTURES	WILL MAKE SITE VISIT WILL PICK UP MAY PAY FOR ITEM IF DELIVERED	SALVAGED ITEMS FOR RE-USE
BOURGET BROS. BUILDING MATERIALS 1636 Eleventh St. Santa Monica, CA 90404 PH: (310) 450-6556 FAX: (310) 450-2201 HOURS: 7 - 5 M - F 8 - 5 SAT CONTACT: Miguel or Dave	USED BRICK, MISSION ROOF TILE, AND FLAT, BROKEN CONCRETE (NO CURBING) ONLY	PURCHASE OF USED TILE, USED BRICK - 5,000 OR MORE PIECES	MAY MAKE SITE VISIT PLEASE CALL FIRST	RECYCLED BRICK, ROOF TILE, AND BROKEN CONCRETE
CLEVELAND WRECKING 3170 E. Washington Los Angeles, CA 90023 PH: (213) 269-0633 FAX: (213) 262-9514 HOURS: 8 - 5 M - F 8 - 1 SAT CONTACT: Larry Geisser	DOORS, TOILETS, CABINETRY, ROOF TILES, WINDOWS, WASH BASINS AND MORE - IN USABLE AND SALABLE CONDITION	PLEASE CALL FIRST FOR ALL NECESSARY INFORMATION	WILL CONDUCT SITE VISIT DEMOLITION AND VENDOR SERVICES-DEMOLITION OF RESIDENTIAL, COMMERCIAL AND INDUSTRIAL BUILDINGS	SALVAGED ITEMS FOR RE-USE

RECYCLING FACILITY	TYPES OF MATERIALS ACCEPTED/PROCESSED	CONDITION OF MATERIALS AND LIMITATIONS	SERVICES OFFERED	COMPANY END-PRODUCT
FREEWAY BUILDING MATERIALS 1124 South Boyle Ave. Los Angeles, CA 90023 **PH:** (213) 261-8904 **HOURS:** 8 - 4 M - SAT **CONTACT:** Alexandro	SALVAGED BRICK, LEADED GLASS AND OTHER WINDOWS, WROUGHT IRON AND CHAINLINK FENCES, GATES, HEATERS, SHUTTERS, PORCELAIN PEDESTAL SINKS,TOILETS, BATHTUBS, KITCHEN AND OTHER CABINETS, STOVES, REFRIGERATORS, PIPE, ROOFING TILES, DOORS, LIGHT FIXTURES, TOILETS, SINKS, LUMBER, AND OTHER REUSABLE ITEMS	REUSABLE ITEMS ONLY FOR RESIDENTIAL AND COMMERCIAL RESTORATION, REHABILITATION, AND NEW CONSTRUCTION PLEASE CALL FIRST	RENTS ARCHITECTURAL ARTICLES AND VINTAGE ITEMS FOR THEATER, MOVIES,AND TELEVISION PROPS RETAILS TO THE PUBLIC MAY MAKE SITE VISITS MAY PICK UP AND PAY FOR USABLE ITEMS VENDOR	SALVAGED RESIDENTIAL AND COMMERCIAL ARTICLES
L. A. WRECKING 1600 S. Santa Fe Ave. Los Angeles, CA 90021 **PH:** (213) 622-5135 **HOURS:** 8 - 5 M - F 8 - 3 SAT **CONTACT:** Paul Pulido	CLAW FEET, PEDESTAL SINKS, TOILETS, PLUMBING PARTS, BATH TUBS, LEADED GLASS, GLASS PANES, LOUVERED AND OTHER WINDOWS, RESIDENTIAL AND COMMERCIAL DOORS, INCLUDING FRENCH DOORS, FURNITURE HARDWARE, LIGHT FIXTURES, FLORESCENT LIGHTING, FIRE PLACE SCREENS, WATER HEATERS AND MORE	PLEASE CALL FIRST	MAY PICK UP MAY PAY FOR ITEMS IF THEY ARE DELIVERED VENDOR	SALVAGED ITEMS FOR REUSE
LIZ'S ANTIQUE HARDWARE 453 So. La Brea Ave. Los Angeles, CA 90036 **PH:** (213) 939-4403 **FAX:** (213) 939-4387 **HOURS:** 10 - 6 Mon - SUN until 9 p.m. TH	DOOR, WINDOW, CURTAIN AND FURNITURE HARDWARE, PLUMBING AND LIGHTING FIXTURES, AND BATH ACCESSORIES	REUSABLE CONDITION PLEASE CALL FIRST	WILL DO FIELD INSPECTIONS MAY PICK UP AND MAY PAY FOR ITEMS PROVIDES PROP RENTAL SERVICES TO THE FILM INDUSTRY SELL TO THE PUBLIC FOR RENOVATION PROJECTS	SALVAGED RESIDENTIAL AND COMMERCIAL ARTICLES

RECYCLING FACILITY	TYPES OF MATERIALS ACCEPTED/PROCESSED	CONDITION OF MATERIALS AND LIMITATIONS	SERVICES OFFERED	COMPANY END-PRODUCT
MRM BUILDING MATERIALS 5277 Valley Blvd. Los Angeles, CA 90032 PH: (213) 222-9191 FAX: (213) 222-9167 HOURS: 7:30 - 5 M - F 7:30 - 4 SAT CONTACT: Gloria or Eric	DOORS, WINDOWS, HARDWARE, LUMBER, CABINETS, FIREPLACE MANTELS, BATHTUBS, TOILETS, WASHBASINS, WROUGHT IRON AND CHAIN LINK FENCING, FLUORESCENT AND OTHER LIGHT FIXTURES, BRICK, WOODEN AND METAL DOORS, AND OTHER RE-USABLE ITEMS	REUSABLE CONDITION PLEASE CALL FIRST	VENDOR MAY DO SITE VISIT MAY PAY FOR ITEMS SELECTED	RESIDENTIAL, COMMERCIAL AND INDUSTRIAL SALVAGED ITEMS FOR RESTORATION, REHABILITATION OR NEW CONSTRUCTION
MALIBU MASONRY SUPPLY 3730 Cross Creek Rd. Malibu, CA 90265 PH: (310) 456-2203 FAX: (310) 456-8569 HOURS: 7 - 5 M - F 8 - 3 SAT CONTACT: Ruby	USED BRICK ONLY	PREFERENCE FOR SIMON SAND MOLD BRICK THE LEAST NUMBER ACCEPTED IS TRUCK LOAD OF 12 PALLETS	VENDOR SERVICES	USED BRICK
MANCHESTER SASH & DOORS 1228 W. Manchester Ave. Los Angeles, CA 90044 PH: (213) 759-0344 CONTACT: Bud Wolski	BUILDERS' HARDWARE, LOCKS, HINGES, WINDOWS, SASHES,AND DOORS	PLEASE CALL FIRST MUST SEE ITEM	SUPPLIES WINDOWS AND DOORS, FOR RESTORATION WORK DOOR KNOB MUSEUM	BUILDERS' HARDWARE
SINALOA MATERIALS 4165 So. Central Ave. Los Angeles, CA 90011 PH: (213) 233-4277 HOURS: 8 - 5 M - SAT CONTACT: Silvestre	DOORS, WINDOWS, KITCHEN CABINETS, BATHTUBS, SHOWER DOORS, TOILETS, WALL HEATERS, WATER HEATERS, AND IRON AND CHAIN LINK FENCES, LUMBER FOR EXAMPLE 2X4, 2X6, AND 2X12	PLEASE CALL FIRST	WILL MAKE SITE VISITS MAY PAY FOR ITEMS IF IN USABLE CONDITION AND IF DELIVERED	RECYCLED RESIDENTIAL AND COMMERCIAL ARTICLES
SQUARE DEAL PLUMBING AND HEATING SUPPLIES 2302 E. Florence Ave. Huntington Park, CA 90255 PH: (213) 587-8291 FAX: (213) 587-0422 HOURS: 8 - 5 M - SAT CONTACT: Adam	TUBS, WASH BASINS, TOILETS SPECIALIZE IN COLOR PLUMBING FIXTURES	PLEASE CALL FIRST MAY PAY FOR ITEMS	SUPPLY PLUMBING AND HEATING PARTS AND MATERIALS MAY CONDUCT SITE VISITS RENTALS TO FILM INDUSTRY	REUSABLE PLUMBING FIXTURES AND PARTS

RECYCLING FACILITY	TYPES OF MATERIALS ACCEPTED/PROCESSED	CONDITION OF MATERIALS AND LIMITATIONS	SERVICES OFFERED	COMPANY END-PRODUCT
WEST JEFFERSON BUILDING MATERIALS 5001 W. Jefferson Blvd. Los Angeles, CA PH: (213) 731-9494 FAX: (213) 735-7911 HOURS: 6 - 4 M - F 7 - 3 SAT CONTACT: Mario Romero	USED BRICK ONLY	PLEASE CALL FIRST	MAY MAKE SITE VISIT	USED BRICK
SCAVENGER'S PARADISE 5453 Satsuma Ave. North Hollywood, CA 91604 PH: (213) 877-7945 HOURS: 12 Noon - 5 M -SAT or by Appointment CONTACT: Rick Evans Casey Cannon	IRON WORKS, WINDOWS, DOORS, CAPITOLS, CORBELS, CLAW FEET TUBS, COLUMNS, SCONCES AND CHANDELIERS, WINDOW GRILL- WORK, BALCONIES, STONEWORK, VICTORIAN FRETWORK... ALMOST ANY ARCHITECTURAL ITEM FROM RESIDENTIAL, COMMERCIAL STRUCTURES AND SOME INDUSTRIAL	REUSABLE ITEMS ONLY	MAY DO SITE VISIT DISPLAYS ARCHITECTURAL PIECES IN NOVEL AND VARIED WAYS TO ENCOURAGE REUSE VENDOR SERVICES	SALVAGED RESIDENTIAL, COMMERCIAL, AND SOME INDUSTRIAL ITEMS

SECTION 6

LISTINGS OF TRANSFER STATIONS AND MIXED DEBRIS PROCESSING FACILITIES THAT PROCESS CONSTRUCTION AND DEMOLITION MATERIALS FOR RECYCLING IN THE LOS ANGELES AREA

The following firms recover some construction and demolition materials either from clean, source separated wastes delivered to their facility, or from mixed waste loads for the purpose of recycling. Each company should be individually contacted to determine specific requirements for acceptance of materials, pricing, and how recycling activity is documented.

TRANSFER STATIONS	TYPES OF MATERIALS RECOVERED/ PROCESSED	CONDITION OF MATERIALS AND LIMITATIONS	SERVICES OFFERED OR FEES	END-PRODUCT
BOIJON RECYCLING 400 East Live Oak Irwindale, CA 91108 Phone: (818) 359-4111 Contact: Dennis Magrdichian Hours: M-F 7-5; Sat. 7-5	**MIXED WASTE LOADS:** CONCRETE CONCRETE BLOCKS ASPHALT SLUMP STONE DIRT REBAR RED BRICK Not more than 5% WOOD GREEN MATERIAL BULKY ITEMS OVERSIZE MATERIALS	No HAZARDOUS MATERIALS No ASBESTOS	Sorts mixed waste loads. Delivered to site. Does not provide bins or pick-up services	
CENTRAL L.A. TRANSFER STATION 2201 East Washington Blvd. Los Angeles, CA 90021 Phone: (213) 746-9700 Contact: Jerry Perisi Bernie Huberman	**CLEAN, SOURCE SEPARATED:** CONCRETE ASPHALT INTERIOR DEMOLITION WASTES WOOD WASTES METAL **MIXED WASTES**	No HAZARDOUS MATERIALS No ASBESTOS	Provides On-Site Consultations Allows discounts for certain materials, based on quality & type of loads Charges $5 per ton for clean WOOD loads	
COMMUNITY RECYCLING AND RESOURCE RECOVERY TRANSFER STATION 9147 DeGarmo Avenue Sun Valley, CA 91352 Phone: (818) 767-6000 (213) 875-0587 Contact: Denny Asfar Dave Ashworth	**MIXED WASTE LOADS:** WOOD CINDER BLOCK BRICK CONCRETE ROCK AND GRAVEL METAL SEPARATES FINES AND DIRT FOR LANDFILL COVER OR FILL DIRT	No HAZARDOUS WASTES	Sorts mixed waste loads; Fees based on recyclability of waste loads. Provides pick-up services and bins (under Crown Disposal Service)	

MIXED DEBRIS RECYCLING	TYPES OF MATERIALS RECOVERED/ PROCESSED	CONDITION OF MATERIALS AND LIMITATIONS	SERVICES OFFERED OR FEES	END-PRODUCT
FALCON REFUSE CENTER INC. 3031 E. "I" Street Wilmington, CA 90744 Phone: (310) 590-8531, ext. 2 Contact: Dirk Gartrell Hours: M-F 6-5; Sat. 6-2	**CLEAN SOURCE SEPARATED:** WOOD/DEMO WOOD DUNNAGE, PALLETS, CRATES, BLOCKS & WOOD FENCES	MIXED LOADS - OK VERY LIMITED PAINT No LEAD PAINT No TREE TRIMMINGS No PALM, IVY, YUCCA or STUMPS NAILS or STAPLES OK	Roll-offs available. Will schedule regular pick-ups. Call for prices	
HAYDEN BROS. Calabasas Landfill 5300 Lost Hills Road Agoura, CA 91301 Phone: (818) 889-0363 Contact: Ken Hayden Hours: M-Sat. 8-5	**MIXED WASTE LOADS:** CONCRETE CONCRETE BLOCK ASPHALT ROCKS SLUMP STONE RED BRICK DIRT REBAR OR WIRE MESH **Not more than 5%** WOOD GREEN MATERIALS BULKY ITEMS OVERSIZE MATERIALS	No HAZARDOUS MATERIALS No ASBESTOS	Sorts mixed waste loads. Delivered to Site. Does not provide bins or pick-up services.	

SECTION 7

GLASS
RECYCLING PROCESSOR
LOCATED IN THE LOS ANGELES AREA

The following company accepts plate glass for the purpose of recycling.

RECYCLING PROCESSOR	TYPES OF MATERIALS ACCEPTED/ PROCESSED	CONDITION OF MATERIALS AND LIMITATIONS	SERVICES OFFERED OR FEES	COMPANY END-PRODUCT
ALL-WASTE RECYCLING, INC. **Irwindale** 545 East Live Oak Irwindale, CA 91706 Contact: Tom Vossman or Ray Torres Phone: (818) 303-5335 FAX: (818) 357-3056 **Huntington Park** 2315 Nadue Street Huntington Park, CA 90255 Phone: (213) 588-8328 Hours: M-F 6-5, Sat 6-3	**SEPARATED OR MIXED LOADS OF:** CLEAN PLATE GLASS Will also accept SAFETY GLASS or TEMPERED GLASS, case by case.	Call to set up account to set up on-site collection bins; Call to make arrangements to drop materials at plant.	Will provide on-site collection bins for fees.	PLATE GLASS CULLET CLEAR, AMBER & GREEN GLASS CULLET

CONSTRUCTION AND DEMOLITION WASTE TERMINOLOGY

CLASS III LANDFILL

A permitted landfill that accepts non-hazardous waste such as household, commercial, and industrial waste, including construction and demolition waste.

CONSTRUCTION AND DEMOLITION WASTE

Solid wastes, such as building materials; and packing and rubble resulting from construction, remodeling, repair, and demolition operations on pavements, houses, commercial buildings and other structures.

INERT FILL

A permitted facility that accepts inert waste, such as asphalt and concrete, exclusively.

INERT SOLIDS OR INERT WASTE

A non-liquid solid waste including, but not limited to, soil and concrete, that does not contain hazardous waste or soluble pollutants and does not contain significant quantities of decomposable solid waste.

PROCESSING

The reduction, separation, recovery, conversion, or recycling or solid waste.

RE-USE

The use, in the same form as it was produced, of a material which might otherwise have been discarded.

RECYCLING

The process of sorting, cleansing, treating, and reconstituting solid waste or other discarded materials for the purpose of using the altered form. Recycling does not include burning, incinerating, or thermally destroying solid waste.

Recycling Construction and Demolition Waste
Articles, Available Specifications, and Publications

Steve Apotheker, "Construction and Demolition Debris - the Invisible Waste Stream," Resource Recycling, December 1990, pp. 66-74.

Jospeh P. Curro, "An Inside View of C&D Recycling," Biocycle, March 1991, pg. 31.

"Diverting Commercial Building Materials," In Business, November-December 1992, pp. 52-53.

Christine T. Donovan, "Construction and Demolition Waste Processing: New Solutions to an Old Problem," Resource Recycling, August 1991, pp. 146-155.

Jim Goddard and Debbi Palermini, "Managing a Resourceful Renovation," Resource Recycling, August 1992, pp. 86-96.

Integrated Solid Waste Management Office, "Solid Resources Management Specifications", Los Angeles 1995, Call: (213) 237-1444

John Jesitus, "Construction and Demolition: Recycling Efforts Building," MSW Management, November-December 1992, pp. 36-42.

Zev Kalin, "Canada Targets C&D Debris," Biocycle, January 1991, pp. 35-36.

Steve MacDonald, "Wood Waste Recycling: Linking Generators and Processors," Resource Recycling, November 1992, pp. 43-48.

Richard Montanari, "This Old-New House," Recycling Today, November 1991, pp. 58-61.

Bruce W. Piasecki, et. al., "Managing Construction and Demolition Debris: Trend, Problems, and Answers," Associated Building Contractors of the Triple Cities, Inc. (New York, March 1990).

City of Redondo Beach, California, "Construction and Demolition Management," 1993.

Toronto Homebuilder's Association, "Making a Molehill Out of a Mountain," (Toronto, 1990).

Toronto Homebuilder's Association, "Making a Molehill Out of a Mountain II," (Toronto, 1991).

Toronto Homebuilder's Association, "Making a Molehill Out of a Mountain II, Technical Report: Renovation Pilot Projects," (Toronto, June 1991).

Triangle J Council of Governments, "Waste Spec, Model Specifications for Construction Waste Reduction, Re-use, and Recycling," (North Carolina, July 1995) Call: (919) 549-0551

Randy Woods, "C&D Debris: A Crisis is Building," Waste Age, January 1992, pp. 26-36.

For a **"List of Available Publications Regarding Construction and Demolition Recycling,"** contact: Portland Metro, Solid Waste Department, 600 NE Grand Ave., Portland, Oregon, 97232-2736, PH: (503) 797-1650 FX: (503) 797-1795

Vita

David Jarman was born in Newport News, Virginia in 1972. He grew up in Seaford, Virginia and graduated from York High School, Yorktown, Virginia in 1990. He began his undergraduate degree at Virginia Tech in the fall of 1990. After participating in the cooperative education program, as a survey technician at the Thomas Jefferson National Laboratory in Newport News, he received his bachelors degree in Civil Engineering in May 1995.

He began his graduate studies with the Construction Engineering and Management Division in the Via Department of Civil Engineering at Virginia Tech in August 1995. He completed his masters degree in December 1996.