WASTE MANAGEMENT
AT THE CONSTRUCTION SITE

Joseph Laquatra and Mark R. Pierce
# WASTE MANAGEMENT AT THE CONSTRUCTION SITE

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INTRODUCTION

Competition in the home-building industry is intense. Profit margins are slim, especially when the price of each house is often set before construction begins. This makes cost control and efficient use of time extremely critical during the construction process. The construction of a single-family home typically produces over two tons of debris material that is becoming increasingly difficult and expensive to discard. Some waste disposal facilities are refusing to accept construction and demolition debris. In fact, a survey of home builders indicated that waste disposal costs negatively affect the economic health of their companies. In response to this situation, progressive and successful builders across the United States are now implementing waste management programs as a critical component of the construction process.

OBJECTIVES

The objectives of this publication are to

1. assist builders in determining both cost-effective and environmentally sound methods for handling and getting rid of construction wastes.
2. To provide accurate, unbiased information that home builders can use to design and implement waste management techniques specific to their firm’s unique circumstances and requirements.

OVERVIEW OF CONSTRUCTION AND DEMOLITION WASTE ISSUES IN THE UNITED STATES

The ancient Roman civilization disposed of solid wastes by throwing them into open, unlined dumps. Gullies, swamps, and abandoned quarries were common sites. Until relatively recently in our history, this was also the most common disposal and siting method used in the United States. In the 1970s, however, serious contamination of ground and surface water was discovered occurring from these unlined dumps. To correct this problem, monitored sanitary landfills began to replace older, unlined dumps. During this same time period the amount of solid waste being generated increased dramatically (see Figure 2). The supply of waste disposal space was decreasing while the demand for space was increasing. The result has been high and constantly increasing waste disposal costs.

As our population expands, it is logical to expect land use demands to increase. As this happens it will become more expensive to find and construct acceptable landfill sites. Although a leveling off of tipping fee costs in some areas of the country has occurred recently owing to completion of new, large, sanitary landfills, the long-term trend will most likely be steadily increasing waste disposal fees.

FIGURE 01 | SIXTY TO NINETY PERCENT OF CONSTRUCTION WASTE, SUCH AS THAT SHOWN BELOW, HAS RECYCLING POTENTIAL.
Managing job-site wastes may be an area for your business to realize significant increases in efficiency in return for a relatively small amount of expended effort. Good managers know that the greatest efficiency gains are made at the margins. For example, once work crews are performing at a high level of efficiency, you will not realize significantly higher gains in productivity (and thus profit margins) by expending further management efforts in this already efficient area. You are more likely to increase profits by examining other areas of your business where management efforts can have the greatest impact on efficiency gains. This publication outlines a simple process that will help you determine if a waste management program could be cost-effective for your firm (see Figure 3). Only a small amount of time and effort is required to determine if the benefits of a waste management program outweigh the costs.

CONDUCT A WASTE COST AUDIT

The first step in this process is conducting a waste cost audit that collects information on your current waste handling and disposal practices, waste generation rates, and disposal fees. Conducting a waste cost audit will tell you how cost-effective your current waste management choices are as well as help inform you of the solid waste disposal issues and regulations in your locality. To assist you in conducting your own waste cost audit, two case study examples are provided. One study follows a production builder through the process as he conducts a waste cost audit for his firm. The second case study follows a custom builder through the waste cost audit process. In addition, the appendix contains forms designed to help you conduct your own audit as well as useful information from residential waste studies done across the United States.

COLLECT INFORMATION

Before you can conduct a waste cost audit you will need to invest a small amount of time collecting information. The more information you gather about a problem, the better your judgment will be when making decisions about possible solutions. Information can be obtained in the form of numbers or statements. Both are used as a basis for decision making. Talking with people is a standard method for collecting information. Ask questions and take notes on the answers and information given. You can also collect information from present and past activities. Referring back to records is a valuable way to collect information about past activities and practices. The following section lists six major areas you will want to investigate. They are: current disposal costs, regulations, alternative practices, waste generation rates, reduction, and reuse possibilities. In addition, suggestions on what information to collect, how to collect it, and why it is important to your waste cost audit are also included for each of the six areas.
KNOW AND UNDERSTAND YOUR DISPOSAL COSTS

Currently, the most common method for handling construction wastes is for builders to contract with a waste hauling service to provide containers at the construction site. Wastes are tossed into containers, which are transported by the waste hauler to a landfill or incinerating facility. The waste hauler charges the builder a fee that includes the cost of his or her services plus tipping fee costs that the waste hauler must pay at the landfill or incinerating facility.

- Do you know how your waste hauler determines what to charge you?
- Do you pay a monthly rental fee for containers placed on your site?
- Do you pay a “per pull” fee? Are you charged a fee each time your waste hauler comes to your site to empty the dumpster?
- Do you pay by volume or weight?

It is important for you to know the answers to these questions because your current waste disposal costs will serve as a benchmark from which to compare costs of alternative methods. If you know and understand your current waste disposal costs and how they are determined, you will quickly be able to identify and take advantage of cost-effective alternatives as they appear in the marketplace.

KNOW STATE AND LOCAL REGULATIONS CONCERNING CONSTRUCTION AND DEMOLITION WASTE IN THE AREAS WHERE YOU ARE BUILDING

The first step in understanding regulations concerning construction and demolition waste is knowing the definitions assigned by the authorities in your locality to the various types of wastes. Most construction and demolition waste is classified as solid waste. In general, three subcategories of waste within the larger general category of solid waste are typically defined. These are inert waste, putrescible waste, and chemical waste. A short description of each category follows:

- **INERT WASTE**: solid waste that does not decompose biologically, burn, serve as food for animals, form a gas, cause an odor, or form a contaminated leachate. Bricks, masonry, and concrete are examples of construction wastes that fall within this category.

- **PUTRESCIBLE WASTE**: solid waste that contains organic matter capable of being decomposed by microorganisms so as to cause a malodor, gases, or other offensive conditions, or that is capable of providing food for birds or vectors. Putrescible wastes may form a contaminated leachate from microbiological degradation, chemical processes, and physical processes.

- **CHEMICAL WASTE**: nonputrescible solid waste, which through chemical or physical processes is capable of forming a contaminated leachate, but no gas is expected to be formed as a result.¹

The Resource Conservation and Recovery Act (RCRA) of 1982 forms the basis for federal laws and regulations that set minimum standards for the handling and disposal of solid waste. Although states may enact more stringent regulations, they must use the regulations outlined within RCRA as minimum standards. As a result, each state will have classifications similar to the three categories mentioned earlier. Be aware, however, that the definitions for each category may vary significantly from state to state. For example, some states classify gypsum as an inert waste whereas others classify it as a putrescible waste. It is important that you know and understand the definitions for each classification for your state. The definitions will have a major impact on the guidelines you are required to follow at your construction sites.

When collecting information about disposal regulations and issues in your area, you may want to seek answers to the following questions:

- Can some materials legally be disposed of on-site?
- Can wood wastes be chipped up and used as ground cover on-site?

Learning about regulations governing construction waste disposal practices will help you to answer these questions. In addition, you will gain several other benefits by learning about the regulations.

First, you will know which wastes can legally be disposed of on-site. For example, most states allow inert material to be buried on the construction site. Some states allow what is called beneficial use deployment, which permits you to process certain waste materials on the construction site and use them in a useful way. Chipping of wood scraps to be used as landscape mulch, for example, can fall into this category. Some states allow
only clean solid wood scraps to be used for mulch; others allow both clean solid wood and manufactured wood scraps (plywood and oriented strand board). It is important to understand clearly the regulations governing construction waste disposal practices.

Second, as you go through the process of educating yourself about regulations, you will be in a better position to change confusing or inefficient regulatory requirements. Can you obtain a printed list of regulations pertaining to construction wastes for your locality relatively easily? Are the regulations presented in a clear, concise, easy-to-read format (not using legal jargon)?

Finally, incorporate your search for regulatory information with your search for information about disposal alternatives (see following section).

IDENTIFY RECYCLING AND ALTERNATIVE DISPOSAL OPPORTUNITIES FOR YOUR WASTE MATERIALS

- Does your area have cardboard recycling facilities?
- Do any firms accept gypsum wallboard scraps for recycling?
- Are there landscape mulch-producing facilities that will accept wood waste?
- Do any local building supply dealers have collection and back haul programs to manufacturers for scrap vinyl siding?
- Do municipal burn plants or electrical generation facilities accept wood wastes at a much lower rate than landfill facilities?

These are the types of questions you will want to answer as you collect information about alternative waste disposal methods that may be available to you. The following suggestions can help you find information to answer these questions:

- Call the government agency that oversees solid waste disposal issues in your state and ask for a list of organizations that accept construction waste materials for recycling.
- Contact the Solid Waste or Public Works Departments in your local county, city, town, and village government offices. Do they have drop-off points to collect separated materials? You may be able to take waste cardboard to a municipal collection site and get rid of it at no charge. If you place cardboard in a roll-off container and are paying on a volume basis, it may be responsible for as much as 15 percent of your waste disposal costs.
- Check the Yellow Pages directory under recycling in your local phone book.
- Ask around. Check with other contractors and businesses for information on recycling opportunities. After identifying organizations in your locality that offer waste disposal alternatives, call or visit each one.
- Find out exactly what materials are accepted and what criteria apply to those materials. For example, if the organization accepts wood waste, does it take only solid wood waste, or will it also accept manufactured wood waste (e.g., plywood, oriented strand board)?
- Ask how clean the waste material needs to be. Can the wood waste have nails embedded in it? If it is acceptable for a small amount of dirt to be mixed in with scrap wood, you can stockpile wood scraps on the ground at the construction site and use a mechanical loader to place the scraps into a truck when hauling them to the recycler. Otherwise, you will need to store scrap wood in a container or load it onto a truck by hand.

Remember that our free-market economy is a powerful force that constantly provides us with new choices. As tipping fees at landfill and incinerating facilities increase, lower-cost alternatives appear in the marketplace. You will, however, need to do some investigative work to learn which alternative opportunities exist in your area. Although tossing all construction wastes into a roll-off container may provide a simple means of getting rid of construction wastes, it may not be the most cost-effective method.

DETERMINE YOUR WASTE GENERATION RATES

You can conduct a waste generation audit to determine the amounts of each waste material generated at your construction sites. As an alternative, you can use existing information about average waste generation rates for new home construction located in the appendix.

Conducting a waste generation audit is neither time consuming nor complicated. At the end of each construction phase, separate wastes into different
piles by material type. For example, at the end of the framing stage separate waste wood into piles according to wood type: solid wood scraps, manufactured wood scraps (e.g., plywood, oriented strand board, particle board), and pressure-treated wood scraps.

The waste audit methods listed in the case studies are merely examples. Whichever method you choose, determining your waste generation rates will allow you to calculate waste disposal costs for each material type. Knowing disposal costs by material type will help you assess the feasibility of alternative waste management techniques. You will also gain useful information about waste reduction strategies.

INVESTIGATE POSSIBILITIES FOR REDUCING WASTE MATERIALS

Reducing waste really means making more efficient use of materials. The end product is the same, but in adopting efficient practices you will purchase less material and generate less waste. You save on both material costs and waste disposal costs. Listed below are several techniques that can be used to increase material efficiency and reduce wastes. As home builders and business people, however, you are best qualified to identify where reduction opportunities exist in your operation and to determine if their implementation is cost-effective for your organization. The important point here is that opportunities for reducing do exist.

Set building dimensions so that lumber can be used efficiently. For example, a house that is 42 or 44 feet long will create less plywood, oriented strand board, and gypsum waste than a house that is 42 feet 8 inches long.

Optimum value engineered (OVE) framing uses techniques that reduce the amount of material required for framing without causing negative effects on the structural integrity of the building. An example of an OVE framing technique is aligning roof trusses directly over studs, using 24-inch spacing for both trusses and studs. This technique allows you to use a single top plate. This method, developed by the National Association of Home Builders (NAHB), reduces material requirements and also results in less waste than standard framing methods. Numerous resources on OVE are available online (search words: “Optimum Value Engineering”) as well as through the NAHB Research Center, The Energy Efficient Building Association, and others.

Negotiating supply and install contracts with subcontractors is a possible method for reducing waste disposal costs. If the subcontractor must purchase materials, he or she will be more motivated to use them more efficiently. Although this method may work for smaller builders, it may be impractical for larger production builders. A framing subcontractor doing work for a production builder may have crews working on several houses at once. The outlay for lumber could be many thousands of dollars. Subcontractors would probably not be able to tie up such a large sum of money in materials. Another possible solution would be to provide a schedule of rewards for crews that use material most efficiently and thereby produce the least amount of waste.

Careful layout of wall sheathing can help reduce oriented strand board waste. Information from your waste audit can help you determine if it would be a good idea to explore this strategy. If, as you conduct your waste audit, you notice large waste pieces of wall sheathing material left over, you may want to suggest a more efficient layout method to your framing subcontractor.

Set up centralized cutting areas at your construction sites. Studies conducted by the Toronto Home Builders Association indicate that when centralized cutting sites are used, lumber consumption and waste can be significantly reduced.

INVESTIGATE POSSIBILITIES FOR REUSING WASTE MATERIALS

Make double use of materials. For example, longer pieces of leftover dimension lumber can be used as nailing material; shorter pieces can be used for blocking and furring.

Pile wastes that may have use as material for small-scale building projects at a designated area on the construction site. Allow construction workers to check this pile at regular intervals for items they may want to take.

Check with the industrial arts department of local schools. Would any of the scrap lumber from your sites be useful for their class projects? Donating scrap material in this way is a good public relations technique, and it also reduces your waste disposal costs.
REVIEW THE COLLECTED INFORMATION

Analyze the information you collected during your waste cost audit. The waste cost review sheet provided in the appendix will help you determine which wastes are cost-effective to manage more closely. Compare the costs of your current waste disposal methods with alternative methods you identified during the information collecting phase of the waste audit (see the case study section for specific examples).

Arranging the collected information into a table will make it easier to compare (see Tables 1, 2, and 3 in case study section). Even if you find it is not yet cost-effective to increase the resources your firm currently spends on waste management, your efforts have not been wasted. You will have gained a better understanding of waste disposal issues facing your firm and community. In addition, the knowledge you have obtained from this investigative process will help you be better prepared to take advantage of any cost-reducing disposal alternatives that may be developed in the future.

DEVISE NEW WASTE MANAGEMENT TECHNIQUES

Combine everything you have learned, and use your imagination to devise new and more cost-effective waste management techniques. Discuss what you have learned from your waste cost audit with your employees and subcontractors. Brainstorm with them to come up with a list of alternative ideas for managing construction wastes. And don't forget that only environmentally sound methods for handling and getting rid of construction wastes are truly cost-effective.

TEST AND IMPLEMENT NEW WASTE MANAGEMENT TECHNIQUES

Before implementing new waste management techniques, first test several plans to determine which methods will work best for your firm. Keep in mind that there will be several ways to implement solutions. For example, you may have determined that you can save money on waste disposal costs by hiring a firm to come to your site and chip wood wastes. But should you pile the wood wastes at each individual house and have them chipped there and made available for free to home buyers? The point is, before implementing a new waste handling practice, first test several plans to determine which methods will work best. You can then implement the most effective techniques as standard waste management practices for your firm.

CLOSING COMMENTS

The purpose of this publication has been to provide information that you can use to determine if devising and implementing comprehensive waste management techniques can increase your firm’s profitability. Information collected through a simple gathering process can be used to help you identify cost-efficient waste management techniques. Important information to gather includes current waste disposal fees, waste disposal regulations in your area, alternatives to landfilling, your waste generation rates, and reduction and reuse possibilities.

STAY AHEAD: START NOW

We recognize that the building business is tough and extremely competitive. It will probably get tougher and even more competitive in the future. That is why in developing and writing this bulletin on construction waste management we have focused on cost efficiency, providing you, the builder, with techniques and methods for decreasing your overall expenditures for waste disposal. This will increase your firm’s competitiveness and profits, which are essential to staying in business. Our research and work indicate that you can save money by closely managing your construction wastes and by seeking alternatives to landfilling. In addition, if you get started seeking reduction, reuse, and recycling opportunities now, you will be staying ahead of the regulatory curve while improving your bottom line.
CASE STUDY FOR ON-SITE RESIDENTIAL CONSTRUCTION
WASTE MANAGEMENT: CUSTOM BUILDER

INTRODUCTION AND BACKGROUND
John typically constructs about 10 houses per year. The construction sites are scattered, and the style and size of each house tends to be very different. John works along with his three employees during the construction of each house. He manages his construction waste by having a 30-cubic-yard container placed on each site at the beginning of the construction process. This case study will follow John through the process as he investigates how cost-effective it would be for him to manage construction wastes more closely.

COLLECT INFORMATION
Currently John pays between $800 and $1,000 per house in waste disposal costs. His past season's total disposal costs were over $9,000. A phone call to his waste hauler provides a thorough description and breakdown of the waste disposal fees he is currently paying.

- $35  fee to deliver container to the construction site
- $125 fee each time container is emptied
- $40  monthly rental fee for container
- $60  tip fee charge per ton of waste material

Rather than conduct an extensive waste generation audit, John will use a shortcut method. Research on construction debris has shown that about 75 percent of this material is cardboard, wood, and gypsum (see Figures 4 and 5). These figures summarize waste audit studies conducted by the National Association of Home Builders Research Center (four sites: Oregon, Michigan, and two in Maryland); McHenry County in Illinois (two Illinois sites); and Cornell University (one New York site). Therefore, he will focus his investigative efforts on these three materials.

Through a phone call to the local solid waste agency, John learns that the county operates an extensive recycling and waste disposal facility. At John's request, a pamphlet is mailed to his office, listing information on state and local regulations concerning construction wastes. In addition, the pamphlet lists disposal fees for various materials and also mentions disposal alternatives available at the county construction and demolition waste processing and transfer facility. Specifically, he learns that:

- the county operates a dumping, processing, and transfer facility just for construction wastes.
- the facility is open to all residents of the county.
- cardboard and all metals are accepted free of charge.
- sorted untreated wood is accepted at $30 per ton. This includes manufactured wood (e.g., plywood, oriented strand board, particle board).
- all other waste construction materials, such as plastic, gypsum, carpeting, and treated wood, are accepted at the rate of $60 per ton.

REVIEW THE COLLECTED INFORMATION
Through a single phone call John has identified options for two of the three materials he has targeted for lower-priced disposal alternatives. After making several more phone calls and asking other home builders, materials suppliers, and subcontractors about their practices, John is able to identify a disposal alternative for scrap drywall. He has learned through his drywall installer about a drywall scrap cleaning service. For a flat fee of $125 per house, this firm will clean the drywall scraps from the house and transport them to a legally permitted disposal facility. The price includes all tipping fee charges.

DEVISE NEW WASTE MANAGEMENT TECHNIQUES
Now John needs to estimate the amount of cardboard, wood, and gypsum waste that is generated from his building activities each year. He does this by examining copies of invoices he received from his waste hauler during the previous year. John determines that he generated 187,000 pounds of waste from the construction of 10 houses during the previous year. This averages out to 9.35 tons of waste generated per house. Applying the average generation rates for cardboard, wood, and gypsum, as indicated in Figure 4, John estimates that each house will produce about 5 tons of mixed waste, 2.5 tons of wood waste, 1.65 tons of gypsum board waste, and 0.2 ton of waste cardboard.
**Figure 04** Percentages of Combined Wood, Gypsum, and Cardboard Waste: By Weight

**Key**
- **All Other Wastes**: 25.9%
- **Cardboard, Gypsum, and Wood Waste**: 74.1%

**Figure 05** Percentages of Combined Wood, Gypsum, and Cardboard Waste: By Weight

**Key**
- **Other Wastes**: 26.5%
- **Cardboard**: 5.5%
- **Gypsum**: 28.0%
- **Wood Waste**: 40.0%
John wants to determine if it would be cost-effective for him to separate his wood and cardboard wastes so that he could take advantage of the price breaks offered for separated materials by the county solid waste authority. To do this he would have to discontinue roll-off service and handle and transport the construction wastes generated from his sites himself. He does the following calculations to determine if this would be a cost-effective option.

Although John could realize significant gross savings by eliminating roll-off service, he would incur costs for purchasing and operating a trailer to store wastes on the construction site and transporting them to the county construction and demolition waste transfer station. He collects more information and does the following calculations to determine if it will be cost-effective for him to do this.

He finds that the purchase price of a new dump trailer with a 12-ton, 13-cubic-yard capacity that can be pulled behind his pickup truck is $5,000. If he takes out a two-year loan at 12.75 percent interest, his monthly payment for 24 months will be $237, or $2,844 per year. Even while paying off the loan for the trailer, John will save $1,416 per year from current waste disposal charges. At the end of two years, the savings he has realized in waste disposal costs will have paid for the trailer. In addition, the trailer will be useful in many other areas of his business. Although John will also incur some costs for transporting the waste material from the construction sites to the county transfer station, he determines that the potential savings far outweigh the costs.

### WASTE DISPOSAL COSTS USING CURRENT METHODS

Per-house costs using current waste disposal methods:

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container delivery fee</td>
<td>$35</td>
</tr>
<tr>
<td>Monthly rental fee: $40 per month x 2 months</td>
<td>$80</td>
</tr>
<tr>
<td>Pull fee: $125 charged each time the container is emptied x 2 pulls per house</td>
<td>$250</td>
</tr>
<tr>
<td>Tipping fee charge: 9.35 tons per house x $60 per ton</td>
<td>$561</td>
</tr>
<tr>
<td>Total per house</td>
<td>$926</td>
</tr>
<tr>
<td>10 houses per year x $926 per house</td>
<td>$9,260 annual cost</td>
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</table>

### WASTE DISPOSAL COSTS USING ALTERNATIVE METHODS

Per-house costs using alternative:

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5 tons of wood waste @ $30 per ton</td>
<td>$75</td>
</tr>
<tr>
<td>Gypsum disposal service $125 per house</td>
<td>$125</td>
</tr>
<tr>
<td>0.2 ton (400 lb.) cardboard, no charge</td>
<td>$00</td>
</tr>
<tr>
<td>5 tons mixed waste @ $60 ton</td>
<td>$300</td>
</tr>
<tr>
<td>Total per house</td>
<td>$500</td>
</tr>
<tr>
<td>10 houses per year x $500 per house</td>
<td>$5,000 annual cost</td>
</tr>
</tbody>
</table>

\[ $9,260 - $5,000 = $4,260 \] gross annual savings using alternative method
CASE STUDY FOR ON-SITE RESIDENTIAL CONSTRUCTION
WASTE MANAGEMENT: PRODUCTION BUILDER

INTRODUCTION AND BACKGROUND
Bob builds about 60 houses per year in a development. Each house is about 2,000 square feet in size. Bob currently manages his construction wastes by placing 30-cubic-yard roll-off containers at centralized locations around the site. His laborers clean the construction sites and use the company pickup truck to haul the waste to the roll-off containers at three intervals in the construction process:
- after the framing, roofing, and siding phase
- after the gypsum board has been installed
- after the interior finish is complete
This case study will follow Bob through the process as he investigates how cost-effective it would be for his firm to manage construction wastes more closely.

COLLECT INFORMATION
Bob pays a disposal fee of $675 per full 30-cubic-yard container. He learns the following information through a meeting with his waste hauler.
- Waste hauler charges $625 per container.
- $50 covers the 8 percent state and local taxes.
- The average weight of a 30-cubic-yard container full of wastes from new home construction is about 6 tons.
- Waste hauler pays a tipping fee of about $50 per ton ($300 per container) to dump at landfill facilities. The remaining $300 per container covers the waste hauler’s overhead and profit.
- Waste hauler also operates a processing facility to prepare waste cardboard for recycling markets. Through calculations Bob determines that his current waste disposal fees are equivalent to approximately 5.6 cents per pound of waste.

LEARN ABOUT STATE AND LOCAL ISSUES AND REGULATIONS CONCERNING CONSTRUCTION AND DEMOLITION WASTE DISPOSAL
Bob learns that the state where most of his building projects are located allows inert wastes to be buried at the construction site. However, any material considered to be a putrescible waste, including wood and gypsum, may not be buried but must be disposed of at a state-permitted disposal facility. In addition, he learns that
- the county in which his current development is located does not operate a recycling program for commercial waste generators.
- state regulations will allow chipping of untreated solid wood waste for use on the construction site if a “beneficial use deployment” permit is obtained through the state’s regional office.
- the state will allow inert wastes—defined as bricks, concrete, and rock—to be buried at the construction site.
- manufactured wood, treated wood, and gypsum scraps must be disposed of at a permitted disposal facility.

REVIEW THE COLLECTED INFORMATION
Bob has done an audit of the waste materials generated at one of the house construction sites on his project. At each cleanup phase he had his laborers separate the wastes by material type. The weight and volume of each waste material was then determined.
For those materials that produce a large volume of waste, such as gypsum wallboard, the laborers simply loaded the truck with the waste gypsum and drove to a nearby truck scale. They estimated the volumes by calculating the size of the truck bed and then estimating the percentage of space the waste material took up in the truck after it was loaded.
For the smaller amounts of waste materials such as asphalt roofing they used a small container to collect scraps and weighed them using bathroom scales. They determined the volume of the scrap roofing material by calculating the volume of the container and keeping a tally of how many containers full of scrap roofing material they collected.

Bob combined into a simple table the waste audit data with the information he collected on his waste disposal costs. He now knows how much he is paying in waste disposal fees for each type of waste material (Table 1).

### TABLE 1: WASTE GENERATION AUDIT

<table>
<thead>
<tr>
<th>WASTE MATERIAL</th>
<th>WEIGHT : LB.</th>
<th>VOLUME : CU. FT.</th>
<th>DISPOSAL COST : BY VOLUME : $0.83/CU. FT.</th>
</tr>
</thead>
<tbody>
<tr>
<td>asphalt roofing</td>
<td>350</td>
<td>15</td>
<td>$12.45</td>
</tr>
<tr>
<td>cardboard</td>
<td>275</td>
<td>45</td>
<td>$37.35</td>
</tr>
<tr>
<td>containers</td>
<td>74</td>
<td>10</td>
<td>$08.30</td>
</tr>
<tr>
<td>gypsum</td>
<td>1,780</td>
<td>100</td>
<td>$83.00</td>
</tr>
<tr>
<td>paper</td>
<td>31</td>
<td>10</td>
<td>$08.30</td>
</tr>
<tr>
<td>plastic</td>
<td>60</td>
<td>15</td>
<td>$12.45</td>
</tr>
<tr>
<td>metal (noniron)</td>
<td>30</td>
<td>30</td>
<td>$00.62</td>
</tr>
<tr>
<td>solid wood</td>
<td>900</td>
<td>54</td>
<td>$44.82</td>
</tr>
<tr>
<td>mfg. wood</td>
<td>500</td>
<td>30</td>
<td>$24.90</td>
</tr>
<tr>
<td>treated wood</td>
<td>100</td>
<td>3</td>
<td>$02.49</td>
</tr>
<tr>
<td>vinyl siding</td>
<td>150</td>
<td>25</td>
<td>$20.75</td>
</tr>
<tr>
<td>other (mixture)</td>
<td>300</td>
<td>17</td>
<td>$14.11</td>
</tr>
<tr>
<td>totals</td>
<td>4,550</td>
<td>325</td>
<td>$270.00</td>
</tr>
</tbody>
</table>

Figure 6 illustrates the percentage of each waste material by weight.

**Figure 06**

- 1. CARDBOARD: 06.0%
- 2. WOOD: 33.0%
- 3. GYPSUM: 38.0%
- 4. PLASTIC: 05.0%
- 5. ASPHALT: 08.0%
- 6. OTHER: 10.0%

Figure 7 illustrates the percentage of each waste material by volume. Because Bob pays by volume, Figure 7 also represents the relative disposal costs for each type of waste material.

**Figure 07**

- 1. CARDBOARD: 14.0%
- 2. WOOD: 26.0%
- 3. GYPSUM: 30.0%
- 4. PLASTIC: 12.0%
- 5. ASPHALT: 12.0%
- 6. OTHER: 05.0%
IDENTIFY ALTERNATIVE DISPOSAL OPTIONS AND RECYCLING OPPORTUNITIES

Bob collects the following information about alternative disposal options and recycling opportunities by making phone calls to his state and county solid waste agencies and to several local recycling and waste disposal firms.

WOOD

Bob contacts Taylor Recycling, a firm located about 24 miles from his construction site that accepts solid untreated wood scraps (e.g., dimension lumber scraps, solid wood pallets). He finds out that

- wood with embedded nails is acceptable.
- Taylor charges a fee of $30 per ton to take this material.
- Taylor does not supply containers or hauling services.
  The builder must make his or her own arrangements for collecting and transporting waste wood material to Taylor’s site.

CARDBOARD

Bob contacts several cardboard recycling firms listed in the Yellow Pages of his local phone directory. From talking to representatives of these firms he learns that, although the market for recycled cardboard is extremely volatile on a day-to-day basis, the average annual market is good. In fact, these firms buy cardboard, but they will accept only bailed cardboard. One of the firms suggests to the builder that he work with his current waste hauler because the hauler has a cardboard baler. In a meeting with his waste hauler, Bob and the hauler work out a deal that advances both of their interests. The waste hauler will place a 20-cubic-yard container at the builder’s development for cardboard collection. The hauler will not charge a fee for supplying the container, emptying it, or accepting the cardboard. Bob’s firm, however, is responsible for separating the cardboard on-site and ensuring that the load is not contaminated with other materials. Contaminated loads will be charged at the full tipping fee rate. The waste hauler gains clean, uncontaminated cardboard that he can bale at his processing facilities and sell to local recyclers. Bob realizes a reduction in his waste disposal costs.

GYPSUM

A gypsum board manufacturing plant is located about 50 miles from Bob’s development site. He calls the plant to inquire if they accept gypsum board scrap for recycling. He learns that, although the plant is currently recycling board scrap, it is only for the wastes produced at its own manufacturing facility. However, they do have future plans to accept gypsum waste from builders. Ongoing research has identified beneficial aspects of using scrap gypsum as a soil amendment. Bob could also ask local or regional environmental officials if he is permitted to grind scrap gypsum on-site and use it for this purpose.

PLASTIC

Bob has learned that markets for scrap vinyl siding are expanding around the country. Vinyl product manufacturers have come to realize that scrap siding is generated in quantities large enough to support demand from manufacturers of pipe, conduit, outdoor furniture, and other products. His vinyl siding distributor may have information about the recycling potential for this material. The Vinyl Institute (VI) is currently involved in this activity and publishes a directory of over 100 companies in the United States and Canada that manufacture products from recovered vinyl. Bob’s waste hauler or the VI could serve as resources for information on this. The VI’s web site is http://vinylinfo.org/index.html. The toll-free number for the VI Environmental Resource Center is 800.969.8469.

METAL

Phone calls to local scrap metal dealers reveal that they will pay for such nonferrous metals as aluminum and copper, and they will also pay for ferrous-based metals that have a high iron content.

ASPHALT SHINGLES

Bob learns by asking around that there is an asphalt recycling plant in the neighboring state of New Jersey. The plant accepts asphalt roofing scraps for a much lower fee than current tipping fee rates. However, the recycling facility is too far away to make the expense of transporting wastes cost-effective.
REVIEWING THE COLLECTED INFORMATION

Bob has reviewed the information he collected and decides that it may be worth using alternative disposal methods for two waste materials—solid wood and cardboard. What follows is the process he uses to determine the cost-effectiveness of these alternatives.

ALTERNATIVES FOR SOLID WOOD WASTE

OPTION 1: SOLID WOOD RECYCLING

Bob knows from the information he has collected that the alternative solid wood disposal cost at Taylor, equal to $0.015 per pound of waste material, is significantly lower than the unit disposal cost he is now paying. However, because Taylor Recycling does not supply containers or hauling services, Bob must determine what his costs will be for collecting and transporting waste wood material to Taylor’s site. He collects the following information to enable him to determine the cost-effectiveness of this option.

- Cost of a new 30-cubic-yard container is $3,360 (including interest for financing).
- A local trucking firm will transport the full container and return it to the construction site for $150.

Bob does the following calculations to determine the annual costs for storing, transporting, and disposing of his solid wood scraps at Taylor.

- Annual cost of waste wood storage: $840
  Depreciating the cost of the container over a four-year period: $3,360 / 4 years = $840
- Annual transportation costs: $600
  2 cubic yards of solid wood waste per house x 60 houses per year = 120 cubic yards of solid wood waste per year = 4 trips to Taylor per year to empty 30 cubic yard container @ $150 per trip = $600
- Annual disposal fees at Taylor Recycling: $810
  $0.015 per pound of material x 54,000 pounds per year = $810

Total annual cost of sending solid wood waste to Taylor = $2,250

OPTION 2: ONSITE CHIPPING OF SOLID WOOD WASTE

To determine the cost-effectiveness of chipping solid wood waste and using the chips as landscape mulch, Bob has his laborers separate and pile the solid wood waste from one house during their cleanup phase. He then has his landscape contractor chip this pile of wood while keeping track of the time required to do this. Bob finds that it requires only 30 minutes to chip the one cubic yard of solid wood waste produced from one house. This works out to approximately $26 per house. Thus by chipping the solid wood waste from each house, Bob determines he can expect an annual cost savings in disposal fees of approximately $1,440. In addition, value is being added to the solid wood waste. The wood chips that are being produced can be used as landscape mulch, which has a value of approximately $20 per cubic yard.

Bob has arranged the collected information and results of his calculations into a table (Table 2). This makes it easier to review and compare the cost of alternatives with the costs of current disposal methods.

Just by separating the cardboard at the site and ensuring that the cardboard collection container is uncontaminated with other materials, Bob realizes a significant reduction in his disposal costs. Because Bob’s laborers must handle each piece of cardboard waste, regardless of whether it is placed in a trash container or a recycling container, little extra time and effort is required to recycle cardboard. Thus his waste handling costs for this material do not increase even though he is separating it. Table 3 illustrates the cost advantages to Bob of recycling cardboard waste compared with current disposal methods.
### TABLE 2: SOLID WOOD RECYCLING COMPARISONS

<table>
<thead>
<tr>
<th></th>
<th>CURRENT COSTS</th>
<th>OPTION 1: SOLID WOOD RECYCLING</th>
<th>OPTION 2: ON-SITE CHIPPING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total per-house disposal costs</td>
<td>$270.00</td>
<td>$258.00</td>
<td>$260.00</td>
</tr>
<tr>
<td>Total annual disposal cost*</td>
<td>$16,200.00</td>
<td>$15,480.00</td>
<td>$15,600.00</td>
</tr>
<tr>
<td>Per-house disposal costs for solid wood</td>
<td>$50.00</td>
<td>$37.80</td>
<td>$26.00</td>
</tr>
<tr>
<td>Annual disposal costs for solid wood</td>
<td>$3,000.00</td>
<td>$2,250.00</td>
<td>$1,560.00</td>
</tr>
<tr>
<td>Total annual savings</td>
<td>baseline</td>
<td>$750.00</td>
<td>$1,440.00</td>
</tr>
<tr>
<td>Total annual reduction in waste disposal cost</td>
<td>baseline</td>
<td>4.6%</td>
<td>48%</td>
</tr>
</tbody>
</table>

* Determined by multiplying per-house disposal cost times 60 houses constructed per year.

### TABLE 3: CARDBOARD RECYCLING COMPARISONS

<table>
<thead>
<tr>
<th></th>
<th>CURRENT COSTS</th>
<th>USING CARDBOARD ALTERNATIVE METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total per-house disposal costs</td>
<td>$270.00</td>
<td>$232.65</td>
</tr>
<tr>
<td>Total annual disposal cost*</td>
<td>$16,200.00</td>
<td>$13,959.00</td>
</tr>
<tr>
<td>Per-house disposal costs for cardboard</td>
<td>$37.35</td>
<td>$0.00</td>
</tr>
<tr>
<td>Annual disposal costs for cardboard</td>
<td>$2,241.00</td>
<td>$0.00</td>
</tr>
<tr>
<td>Total annual savings</td>
<td>baseline</td>
<td>$2,241.00</td>
</tr>
<tr>
<td>Total annual reduction in waste disposal cost</td>
<td>baseline</td>
<td>13.8%</td>
</tr>
</tbody>
</table>
You may find it useful to copy these forms and keep them in a three-ring binder.
**COLLECT INFORMATION | WASTE HAULER FEES IF YOU PAY BY VOLUME**

<table>
<thead>
<tr>
<th>WASTE HAULER:</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHONE:</td>
</tr>
<tr>
<td>HAULER’S DISPOSAL FEE PER CONTAINER:</td>
</tr>
</tbody>
</table>

**OTHER WASTE HAULER FEES**

<table>
<thead>
<tr>
<th>PER PULL FEE:</th>
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</thead>
<tbody>
<tr>
<td>CONTAINER RENTAL FEE:</td>
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<tr>
<td>OTHER:</td>
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<tr>
<td>OTHER:</td>
</tr>
</tbody>
</table>

**SUBTOTAL:**

**TOTAL DISPOSAL FEE PAID PER CONTAINER:**

**DETERMINE YOUR UNIT DISPOSAL COST:**

| CUBIC YARDAGE OF CONTAINER: |

\[
\text{UNIT DISPOSAL COST} = \frac{\text{TOTAL DISPOSAL FEE PAID PER CONTAINER}}{\text{CUBIC YARDAGE OF CONTAINER}} = \frac{\$}{\text{PER CUBIC YARD OF WASTE}}
\]

**CALCULATIONS**

| DISPOSAL FEE PER CUBIC YARD OF WASTE: |
WASTE HAULER:

PHONE:

HAULER’S DISPOSAL FEE PER TON OF WASTE MATERIAL:

OTHER WASTE HAULER FEES

PER PULL FEE:

CONTAINER RENTAL FEE:

OTHER:

OTHER:

SUBTOTAL:

TOTAL DISPOSAL FEE PAID PER CONTAINER:

DETERMINE YOUR UNIT DISPOSAL COST:

CUBIC YARDAGE OF CONTAINER:

UNIT DISPOSAL COST = TOTAL DISPOSAL FEE PAID PER CONTAINER \( \times \) \$ PER TON OF WASTE

WEIGHT OF WASTE MATERIALS PER CONTAINER

CALCULATIONS

DISPOSAL FEE PER TON OF WASTE:
<table>
<thead>
<tr>
<th>WASTE MATERIAL</th>
<th>RECYCLING ORGANIZATION AND PHONE NUMBER</th>
<th>FEES PAID OR CHARGED</th>
</tr>
</thead>
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<tr>
<td>WOOD:</td>
<td></td>
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<td>CARDBOARD:</td>
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<tr>
<td>CONCRETE AND MASONRY:</td>
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<tr>
<td>WASTE MATERIAL</td>
<td>RECYCLING ORGANIZATION AND PHONE NUMBER</td>
<td>FEES PAID OR CHARGED</td>
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<tr>
<td>GYPSUM WALLBOARD:</td>
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<td>PAPER:</td>
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<tr>
<td>PLASTIC:</td>
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<td>NOTES:</td>
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</tr>
<tr>
<td>MATERIAL</td>
<td>VOLUME</td>
<td>WEIGHT</td>
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</tr>
</tbody>
</table>
PHONE NUMBERS:

STATE RECYCLING OR ENVIRONMENTAL AGENCY:

MUNICIPAL SOLID WASTE AUTHORITY:

LOCAL RECYCLING COORDINATOR:

OTHER NUMBERS:

SOME IMPORTANT QUESTIONS TO ASK:

Q: Does your local solid waste authority offer tipping fee reductions or waivers for any construction and demolition materials that have been separated?

Q: What are the categories of solid waste in your locality, e.g., inert, putrescible, hazardous? Can the regulating agency send you a list of typical construction wastes in each classification and handling and disposal guidelines for wastes in each category?

Q: Are any of the wastes typically generated at a construction site considered to be hazardous or require special handling and disposal methods?

Q: What construction wastes can legally be buried on-site?

Q: Can some construction wastes be processed on-site for reuse? For example, can wood wastes be chipped and used as mulch around the structure being built?

Q: Ask for a list of organizations in your locality that accept construction and demolition waste materials for recycling.
A SHORT CUT

Presented below is a table that summarizes seven residential waste audits recently conducted on houses of varying sizes and styles in different areas of the United States.

<table>
<thead>
<tr>
<th>HOUSE SIZE</th>
<th>STYLE</th>
<th>LOCATION</th>
<th>AUDIT BY</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,000 S.F.</td>
<td>1-family, 2-story: custom</td>
<td>OR</td>
<td>NAHB</td>
</tr>
<tr>
<td>2,200 S.F.</td>
<td>1-family, 2-story</td>
<td>MD-1</td>
<td>NAHB</td>
</tr>
<tr>
<td>2,600 S.F.</td>
<td>1-family, 2-story: custom</td>
<td>MI</td>
<td>NAHB</td>
</tr>
<tr>
<td>2,450 S.F.</td>
<td>1-family, 2-story: production</td>
<td>MD-2</td>
<td>NAHB</td>
</tr>
<tr>
<td>2,060 S.F.</td>
<td>1-family, # stories not noted</td>
<td>IL-1</td>
<td>McHenry County</td>
</tr>
<tr>
<td>9,000 S.F.</td>
<td>6-family apartment</td>
<td>IL-2</td>
<td>McHenry County</td>
</tr>
<tr>
<td>9,000 S.F.</td>
<td>1-family raised ranch</td>
<td>NY</td>
<td>Cornell University</td>
</tr>
</tbody>
</table>

As you can see from Figures 4 and 5 (page 9), the combined amounts of waste wood, gypsum, and cardboard generated at each of the seven residential construction sites consistently accounted for about 75 percent of the waste produced during the house construction process. In addition, this percentage seems to hold despite variances in structure size and style (see Table 1). Therefore, if you prefer not to conduct an extensive waste generation audit, you can make use of this information to approximate the amount of these waste materials your firm generates. However, you must first know the total weight of the waste from one house. Your waste hauler can supply you with this information. If you can find workable reduction, reuse, and recycling strategies for just these three materials, you can have a significant impact on your waste disposal costs.
You will combine the information you collected on waste generation rates and your current disposal costs to calculate your disposal costs for each type of waste material on this worksheet.

\[(\text{VOLUME OR WEIGHT OF MATERIAL}) \times (\text{UNIT DISPOSAL COST}) = \text{CURRENT DISPOSAL COST FOR THIS WASTE MATERIAL}\]

<table>
<thead>
<tr>
<th>WASTE MATERIAL</th>
<th>AMOUNT *</th>
<th>UNIT DISPOSAL COST **</th>
<th>WASTE MATERIAL DISPOSAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOLID WOOD WASTE</td>
<td></td>
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<tr>
<td>MFG. WOOD WASTE</td>
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<tr>
<td>CARDBOARD</td>
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<td>PAPER</td>
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<tr>
<td>FE-BASED METAL</td>
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<tr>
<td>NON-FE-BASED METAL</td>
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</tr>
<tr>
<td>CONCRETE AND MASONRY</td>
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<tr>
<td>PVC PLASTIC (VINYL SIDING)</td>
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<tr>
<td>ASPHALT WASTES</td>
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<tr>
<td>GYPSUM WALLBOARD</td>
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</tbody>
</table>

*If your waste hauler charges you based on volume, use number of cubic yards of waste material generated. If your waste hauler charges are based on the weight of waste materials you produce, use pounds.

**You calculated unit disposal cost on the Collect Information: Waste Hauler Fees worksheets.
On this worksheet you will combine the information you collected on waste generation rates and the options worksheet to determine the costs for alternative methods of handling and getting rid of each type of waste material.

\[(\text{VOLUME OR WEIGHT OF MATERIAL}) \times (\text{ALTERNATIVE UNIT DISPOSAL COST}) = \text{ALTERNATIVE DISPOSAL COST FOR THIS WASTE MATERIAL}\]

<table>
<thead>
<tr>
<th>WASTE MATERIAL</th>
<th>AMOUNT*</th>
<th>ALTERNATIVE UNIT DISPOSAL COST**</th>
<th>ALTERNATIVE WASTE MATERIAL DISPOSAL COST</th>
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</thead>
<tbody>
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</tbody>
</table>

*If your waste hauler charges you based on volume, use number of cubic yards of waste material generated. If your waste hauler charges are based on the weight of waste materials you produce, use pounds.

**You calculated unit disposal cost on the Collect Information: Waste Hauler Fees worksheets.
Specific information about waste management programs throughout the United States can be obtained by contacting your state’s environmental agency:

**ALABAMA**  
Dept. of Environmental Management  
Solid Waste Division  
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Division of Environmental Health  
Solid Waste Management Program  
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**CALIFORNIA**  
California Integrated Waste Management Board  
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P.O. Box 4025  
Sacramento, CA 95812-4025  
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916.341.6499

**COLORADO**  
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Hazardous Materials and Waste Management Division  
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**CONNECTICUT**  
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Waste Management Bureau  
Engineering and Enforcement Division  
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William Bider, Director  
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<table>
<thead>
<tr>
<th>State</th>
<th>Contact Information</th>
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| **MISSOURI** | Dept. of Natural Resources  
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                      Solid Waste Program  
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                      Concord, NH 03302  
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| **NEW YORK** | Dept. of Environmental Conservation  
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2 The appendix of this document includes a list of solid waste agencies in each state.
WASTE MANAGEMENT AT THE CONSTRUCTION SITE

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