Cost Assessment for Recycling Construction and Demolition Waste

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An Introduction to Recycling Construction and Demolition Waste

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1. INTRODUCTION

1.1 GENERAL. There is a significant amount of construction and demolition (C&D) waste developed due to construction activities and structure demolition; for example, at some installations, construction and demolition waste accounts for up to 80 percent of the solid waste stream. Demolishing and landfilling the building waste incurs significant life-cycle expense to the Owner as landfill space is diminishing. Landfilling debris unnecessarily wastes both natural resources and valuable landfill space.

1.2 DEMOLITION. Traditionally, buildings are removed by means of conventional mechanical demolition techniques. "Demolition" refers to the razing of a building with heavy equipment in such a way that the building components are rendered into rubble and are fit for nothing more than landfill. Demolition provides no opportunity for cost offsets or to generate income. Many alternatives are being practiced in the commercial market and have proven to be successful at reducing the amount of demolition debris that ends up in the landfill.

1.3 ALTERNATIVES TO DEMOLITION. Alternatives to demolition include recycling, recovery and deconstruction. Recycling includes diverting materials that are not reusable from the solid waste stream and using these extracted materials as feedstock for reprocessing into other useful products. Recovery includes the removal of materials or components from the solid waste stream in a manner that retains its original form and identity, for the purpose of reuse in the same or similar form as it was produced. Deconstruction means systematic dismantling of a building, preserving the integrity of the materials, with the goal of maximizing the recovery of salvageable materials for potential reuse and recycling. While these all sound very logical and simple, there is no "one size fits all" solution. Some options that will work for certain situations will not be feasible for others.

1.4 DECISION MATRIX. Personnel involved in demolition activities need some method to quickly evaluate alternatives to traditional demolition relevant to specific project objectives and conditions. The attached decision matrix includes various project objectives and project conditions that are matched with the alternative methods of building removal. Conventional demolition is considered a benchmark for comparison. Comparing the performance of each of the alternative approaches will enable personnel to assess their feasibility under the specific project limitations. The requirements and constraints surrounding demolition are defined and included in this matrix as project objectives and project constraints. Certain parameters generally govern the successful completion of a demolition requirement. These objectives include: cost constraints, time constraints, quality or expected results, safety, risk tolerance, and ease of implementation and opportunity. Other factors that affect the feasibility include such project conditions as: scope or magnitude of the demolition requirement, type of construction and materials involved, condition of materials that can potentially be salvaged, presence of hazardous materials, wage structures; time constraints, landfill burden, environmental conditions, and availability of market outlets.

1.4.1 HOW TO USE TABLES. Tables 1.1 and 1.2 list these project objectives and project conditions along with the alternative methods of building removal. Each intersection in the table indicates which paragraph number to reference for the corresponding information. The problem of what to do with the waste generated through demolition activities will not simply “go away.” Building waste as a result of demolition activities will increasingly tax the capacity of the nation’s overflowing landfills. This matrix will provide direction and assistance in the recovery and recycling of building demolition waste to reduce landfill volume and conserve resources.

	Demolish	Recycle	Recover	Deconstruct
Cost	2.1.1	2.1.2	2.1.3	2.1.4
Time	2.2.1	2.2.2	2.2.3	2.2.4
Quality/Results	2.3.1	2.3.2	2.3.3	2.3.4
Safety	2.4.1	2.4.2	2.4.3	2.4.4
Risk	2.5.1	2.5.2	2.5.3	2.5.4
Implementation	2.6.1	2.6.2	2.6.3	2.6.4
Opportunity	2.7.1	2.7.2	2.7.3	2.7.4

Table 1.1

Project Objectives

		Demolish	Recycle	Recover	Deconstruct
Project Scope		3.1.1	3.1.2	3.1.3	3.1.4
Hazardous Materials	Asbestos Containing Material (ACM)	3.2.1.1	3.2.1.2	3.2.1.3	3.2.1.4
	Lead-Based Paint (LBP)	3.2.2.1	3.2.2.2	3.2.2.3	3.2.2.4
Site Accessibility		3.3.1	3.3.2	3.3.3	3.3.4
Landfill Burden		3.4.1	3.4.2	3.4.3	3.4.4
Resources		3.5.1	3.5.2	3.5.3	3.5.4
Markets		3.6.1	3.6.2	3.6.3	3.6.4

Table 1.2

Project Conditions

1.5 COSTS. All costs indicated in this publication are in “2002 dollars.” They must be adjusted to reflect current conditions.

2. PROJECT OBJECTIVES

2.1 COST. There will be a cost associated with each method of building removal. For comparison, costs relative to conventional demolition with a standard demolition contract will be used as a benchmark. Total costs include the cost for demolition and the cost for disposal. According to case study data, the cost of disposal can represent up to 50 percent of the total demolition cost. This makes it desirable to explore alternative methods to reduce disposal costs. Project objectives to minimize the cost of building removal should consider initial costs, cost offsets, income potential and life cycle costs associated with each alternative.

2.1.1 DEMOLISH (COST). Initial costs for demolition are low. The cost of conventional demolition (not including asbestos removal or tipping fees) ranges from $3 to $4 per square foot of floor area. If all debris is landfilled, tipping fees may add $2 to $3 per square foot of floor area. Landfill tipping fees for C&D waste landfills vary widely depending on geographic location. Studies show that the national average for C&D tipping fees has risen over the past 20 years from $4.90 to $32.00 per ton. In Portland, OR, tipping fees for C&D debris are high, around $75 per ton. In densely populated areas like northern New Jersey, tipping fees exceed $140 per ton. Demolishing and landfilling building waste incurs significant life cycle expense as landfill space diminishes. The cost of managing and maintaining landfills, along with rising tipping fees, makes this option the least preferable.

2.1.2 RECYCLE (COST). The cost of a recycling program includes payment of wages for separation and removal of desired materials either on-site or off-site. Separating recyclable materials on-site as they are removed from the building adds to the initial cost, but increases the value of the recycled material. These additional costs to extract materials range from $1 to $2 per square foot of building area. The need for added recycling collection containers at the site also increases costs. Table 2.1 lists rental rates for dumpsters.

	(Cubic Yard)	(Ton)	(Cost)
Weekly Dumpster Rental	6	2	$300.00
	10	4	$385.00
	30	10	$650.00
	40	13	$775.00

Table 2.1

Typical rental rates for dumpsters

If waste materials are commingled for delivery to a materials recovery facility for recycling, the costs associated with transportation are a significant part of the dynamics of a recycling operation. The distance that aggregates can be hauled economically varies regionally. Each kilometer that a ton of aggregates is hauled can add 10 to 20 cents to its costs, depending on local aggregates supply and market conditions. In many instances, a demolition budget can be reduced with a carefully planned salvage and recycle operation. Experience shows that recycling can help achieve cost savings of $1 to $2 per square foot of building floor area. If the contractor saves money by recycling, these savings can be passed on to the Owner in the bid or price for demolition. The more material that is recycled, the less waste that ends up in the landfills. Reducing the volume of debris also reduces tipping fees at the landfill. In the recycling industry, landfill-tipping fees have a major impact on the success of a recycling operation. When tipping fees are high, there is more incentive to recycle to save money. In rural areas, where land is relatively inexpensive, the economics of recycling are such that it costs less money to landfill C&D debris. The tipping fee in Moscow, ID, is $20 per ton compared to $75 per ton in Portland, OR. When landfill-tipping fees are low, there is a higher tendency to landfill the material even though it is not environmentally preferable.

Materials with high recycle potential include aggregates, metals, wood, asphalt, concrete, and cardboard. Materials with possible recycle potential include glass, plastics, carpeting and gypsum wallboard. A large quantity of recyclable material has the potential of returning a profit if there is a market demand for it. Handling and hauling costs may be recovered through the value of the recycled materials. However, there is little potential to generate income from simple recycling. There is a wide variation in product prices for processed C&D waste. For example, highly specialized products such as painted landscape rock may sell for as much as $15 per ton, while poor quality fill material might sell for less than $1 per ton. The price for roadbase, which the principal market for recycled aggregates, is much narrower. The reported U.S. sales prices for roadbase ranges from $2.76 to $6.70 per ton. The U.S. market price for wood, sold as a cogeneration fuel, ranges from $5.00 to $17.50 per ton. Using recycled materials in place of virgin materials is a closed loop process that extends the life of natural resources. Life cycle costs can be reduced depending on the level of recycling done. Also, recycled products of all types require less energy to create than their virgin-material counterparts do. As the C&D recycling infrastructure grows, these benefits will begin to contribute to reduced construction product costs.

2.1.3 RECOVER (COST). The handling of materials during salvage creates the cost of recovery. Extra care is needed in the removal of salvageable materials so that they are not damaged. This, in turn, results in additional costs. Additional costs to remove components from a building before demolition can range from $2 to $3 per square foot of building floor area. Table 2.2 lists typical components/materials with a high recovery potential.

Appliances	Dimensional Lumber	LightFixtures	Plywood	Tile
Bathroom Fixtures	Doors	Marble	Shelving	Trim
Bricks	Ductwork	Metal Framing	Siding	Windows
Cabinets	Flooring	Paneling	Soil	Wood Beams
Carpeting	Insulation	Pipes	Stairs	

Table 2.2

Typical Components/Materials with a High Recovery Potential

Buildings containing large quantities of these specialty items may offer significant returns through the resale of the recovered materials. Proceeds from the sale or reuse of the salvaged materials can be used to offset the cost of recovery. Salvaged building materials generally sell for about half the price of new materials. If the materials are sold to a scrap dealer, the return is about half of that, or about 25 percent of the purchase price for new materials. Table 2.3 lists estimated salvage values for some commonly recovered materials. Prices will vary regionally and over time. Table 2.3 includes reasonable estimates based on the year 1999 values.

Item	Description	Unit	Retail Unit Value	Estimated Salvage Value
Metals	Aluminum Scrap	Ton		$480.00
	Brass Scrap	Ton		$560.00
	Copper Scrap	Ton		$980.00
	Lead Scrap	Ton		$380.00
	Steel Scrap	Ton		$35.00
Oak Flooring	2-1/4" wide	SF	$2-$2.50	$0.65-$1.00
	3-1/4" wide	SF	$2-$2.50	$0.65-$1.00
Framing Lumber "higher" quality (#2 grade)	2 x 4 (8'-10')	EA	$≅3.00	$0.90-$1.10
	2 x 4 (12'-14')	EA	$≅4.50	$2.00-$2.40
	2 x 8 (12')	EA	$≅8.75	$3.90-$4.80
	2 x 8 (14'-15')	EA	$≅10.00	$4.50-$5.50
Framing Lumber "lower" quality (construction grade)	2 x 4 (8'-10')	EA	$≅3.00	$0.30-$0.75
	2 x 4 (12' x 14')	EA	$≅4.50	$0.45-$1.10
	2 x 8 (12')	EA	$≅8.75	$0.90-$2.20
	2 x 8 (14'-15')	EA	$≅10.00	$1.00-$2.50
	2 x 12 (10')	EA	$≅10.00	$1.00-2.50
Brick	Flush	EA	$0.30-$0.35	$0.10-$0.20
Windows (double-glazed, aluminum replacements)	31" x 54"	EA	$90-150	$15-$30
	34" x 45"	EA	$90-150	$15-$30
	20" x 36"	EA	$90-150	$10-$15
Doors	36" ext. panel	EA		$0-$15
	18" paneled	EA		$5-$10
	24" paneled	EA		$5-$10
	30" paneled	EA		$5-$10
Tubs/toilets/sinks	Cast iron tub/ stainless steel	EA		$5-$10
Stair units, treads	Oak treads/ units include stringers	EA		$25-$50

Table 2.3

Estimated Salvage Values for Some Commonly Recovered Materials

Extra resources are required to handle and manage a resale operation. Recovered materials need to be stored and if no space is available, renting storage space will add to the overall cost. The Owner can benefit if the recovered material can be utilized for another project, thus avoiding costs elsewhere. For example, concrete can be crushed and reused on-site as fill material. This saves money by avoiding the hauling and dumping charges as well as the cost of the new material. Recovering materials not only keeps them from filling up the landfills, but also conserves natural resources. The availability of natural resources varies from region to region. Where these resources are scarce, an active resale industry exists. Regions with high demand and markets for used materials include the West Coast (California, Nevada, Oregon, Washington and Idaho) and the southwest (Arizona, New Mexico, Texas, Oklahoma, Arkansas, and Louisiana). Recovering materials for reuse has a high potential to reduce the cost for building removal. However, there is relatively little potential of generating income through reuse. The value of recovered material along with reduced dump fees can enable a contractor to reduce the bid price for demolition. Case studies show that recovery and reuse of components can yield a cost avoidance of a few cents to $4 or $5 per square foot of building.

2.1.4 DECONSTRUCT (COST). Initial costs for deconstruction are relatively high. Based on case studies, the cost for deconstruction can add up to an additional $2 to $3 per square foot of building floor area. The single most expensive element of deconstruction is labor. Careful dismantling is labor intensive. Other costs include equipment rental, storage of materials before resale, and transportation of materials. However, decreased costs from avoided time and expense needed to bring heavy machinery to a job site, salvage values and reduced disposal costs can make deconstruction a viable alternative to conventional demolition. Case studies show that the sale of recovered materials could offset expenses by $2 to $3 per square foot of building floor area. When the costs associated with the long-term landfill life are considered, deconstruction is the preferable method. In an area with high tipping fees and well-established end-use markets, it may even be possible to profit from the deconstruction of a building.

2.2 TIME. If time is critical, then conventional demolition may be the only feasible option. Other methods require additional time for contract development, salvage, onsite waste separation and waste removal. “Time is money.” For recycling to be feasible, the additional time spent segregating waste must be offset by the revenue of materials and reduced disposal costs for alternative methods of building removal.

2.2.1 DEMOLISH (TIME). Mechanical demolition is the most time-efficient method in terms of physical work. It requires the least amount of on-site labor hours. Mechanical demolition yields a commingled pile of debris that can be quickly loaded up and hauled away. Unless there is some contaminated debris requiring mitigation, a demolition operation can be completed within a matter of days as opposed to weeks or even months with some other methods.

2.2.2 RECYCLE (TIME). There is no specific time disadvantage to removing materials for recycling if all debris is removed and separated off-site. The time required for on-site removal and separation increases depending on the degree of separation. To save time, a salvage outlet may be contracted to pick up and haul away the materials from the site. Initially, additional time will be required for contract development. Once a recycling contract has been developed and accepted, future contracts for recycling can be readily implemented, and contract development is no longer a factor.

2.2.3 RECOVER (TIME). Recovering building materials for reuse is a viable option when time is not constrained. The time involved in handling, sorting, cleaning, cutting and selling second hand building materials is substantial and can undermine the feasibility of salvage at a demolition job. Duration on-site depends on the extent of the recovery and hand labor required to extract recoverable materials. Extra care and time must be taken to reduce the chances of damaging the materials as they are removed. Separating and sorting materials as they are recovered from the building will increase the total time for on-site removal, but will produce higher quality materials and much higher financial returns. References for deconstruction can also be used for determining the time requirements for recovery. These references are included in the paragraphs below.

2.2.4 DECONSTRUCT (TIME). Relocating or removing the entire building intact as well as panelized deconstruction are rapid forms of deconstruction. However, manual deconstruction is labor intensive and will naturally increase the overall duration of the project. The time requirements for disassembly may vary between three to eight times that of mechanical wrecking. Case studies show that manual deconstruction proceeds at a rate of about 0.3 SF per man-hour for a wood frame building. For example, a 3,600 SF typical wood frame building, at 0.3 SF per man-hour, with a 10-person crew, requires roughly 3 weeks to manually deconstruct. This figure includes handling, on-site processing and project management, and is consistent with R.S. Means productivity data. Table 2.4 lists labor hours recorded for the disassembly and salvage of components from a 2,000 square foot building (made up of four residential units) that was deconstructed as part of the Riverdale Case Study. The Riverdale Case Study was based on a multi-agency (EPA/NAHB/HUD) deconstruction project in Baltimore, MD that implemented pilot deconstruction. These labor hours can be used in combination with more comprehensive references.

	Tasks (Hours)					
Component	Disassembly	Processing	Support	Component Total	Labor Hours	Unit
Interior						
Doors, frames	5.75	5.25		11.0	0.55	EA
Trim, baseboards	4.75	5.0		9.75	0.19	LF
Cabinets	2.75	0.5		3.25	0.27	EA
Plumbing fixtures	7.75	1.75		9.5	0.59	EA
Radiators	1.5	0.5		2.0	0.13	EA
Appliances	0.25	2.75		3.0	0.60	EA
Bathroom floor tile	2.5	0.50		3.0	0.038	SF
Oak strip flooring	19.25	27.0	0.25	46.50	0.038	SF
Plaster – 1st level	34.25	10.0	5.50	49.75	0.012	SF (plaster area)
Plaster – 2nd level	23.75	10.75	2.0	36.50	0.009	SF (plaster area)
Piping and wiring	6.75	3.25	0.50	10.50	0.0072	LBS

Partition walls	6.25	24.75	3.0	34.0	0.18	LF
Windows and trim	10.0	2.5	0.50	13.0	0.54	EA
Ceiling joists	1.0	4.75	0.5	6.25	0.0075	LF
Load-bearing walls	2.75	15.5	1.75	20.0	0.027	LF
Sub-floor – 2nd	16.0	6.0	1.25	23.25	0.023	SF
Joist – 2nd level	7.25	16.25	1.5	25.0	0.027	LF
Sub-floor – 1st	7.75	8.0		15.75	0.016	SF
Joist – 1st level	7.0	10.0		17.0	0.020	LF
Stairs	2.5	0.75	0.75	4.0	0.3	Riser
Exterior						
Gutters, fascias	2.25	1.0		3.25	0.014	LF
Chimney	33.25	40.5	4.75	78.5	0.16	CU FT
Gable Ends	8.0	3.0	0.75	11.75	0.053	SF
Masonry walls – upper	14.75	104.5	20.5	139.75	0.25	SF (brick area)
Masonry walls – lower	15.75	84.0	5.25	105.0	0.078	SF (brick area)
Roof						
Roofing material	17.75	18.25	1.75	37.75	2.68	SF
Sheathing boards	21.25	14.5	1.5	37.25	0.028	100 SF
Framing	7.25	9.75	7.0	24.0	0.021	LF
Shed roof framing	1.25	2.25		3.5	0.036	LF

Table 2.4

Labor Hours for Disassembly and Salvage of a 2,000 SF Building.

While the R.S. Means approach does not address deconstruction specifically, it does provide labor costs associated with selective demolition tasks. For a more complete cost estimate, refer to *R.S. Means Building Construction Cost Data*, R.S. Means Publishers, Kingston, MA. The MCACES is a multi-user software program used for the preparation of detailed construction cost estimates for civil works, and Hazardous, Toxic and

Radiological Waste (HTRW) programs. The supporting databases include a unit price book (UPB), crews, assemblies, labor rates, equipment ownership schedule costs and models. All databases work in conjunction with each other to produce a detailed cost estimate. The JOC technique is based on a comprehensive set of general specifications and a related Unit Price Book (UPB) adjusted for the area where the work will be performed to reflect the cost and type of work anticipated. The UPB contains between 40,000 and 60,000 priced line items. It is organized in 16 Construction Specification Institute (CSI) divisions, which, when factored by the contractor's pricing coefficient, are used to establish firm fixed price delivery orders under the contract. The MCACES databases and the JOC book list specific demolition jobs with the cost and time requirements. The JOC also includes an added line item for the cost of demolition and removal before selective remodeling tasks. The labor and cost required for a salvage or deconstruction operation can be calculated using this data.

2.3 QUALITY / RESULTS. Future plans for the use of the site may affect the selection of the method for removal. Mechanical equipment may be required for cleaning up the site and restoring it to grade. The quality of work and results will vary for each alternative method of building removal and for each building type. If performance objectives are based on the volume of waste reduction, the following results can be expected for each building type. Brick or concrete structures generate about 3.0 cu ft of demolition debris per square foot of floor area and wooden structures generate about 4.5 cu ft of demolition debris per square foot of total floor area. A predominately brick structure can contain up to 80 percent brick by volume. Thus, an active brick-salvaging program could eliminate much of the solid wastes resulting from the demolition of this type of structure. For concrete structures, approximately 50 percent of the demolition waste is composed of concrete, most of which can be recycled and reused. A "typical" older building, which is a predominately wood structure, contains up to 90 percent wood. A careful salvaging operation can provide high-quality lumber and reduce solid waste generation.

2.3.1 DEMOLISH (QUALITY/RESULTS). Demolition takes down the entire structure and hauls away the debris leaving nothing behind. The site surface is typically cleared to grade on completion of the demolition project or contract. Subsurface components are typically abandoned. All debris is landfilled under a conventional demolition project contrary to the objective of reducing solid waste. Opportunities exist to reduce the volume of solid waste using different machinery or techniques for the demolition.

2.3.2 RECYCLE (QUALITY/RESULTS). Recycling is generally efficient for site surface restoration. Recycling bins are organized at the site and site cleanup is coordinated with other demolition activities to clear the site to grade on completion of the project. Recycling is favorable for waste diversion and potentially reduces the amount of solid waste that ends up in a landfill. Site/source separation will yield a greater amount of material that can be recycled. Approximately 70 percent of demolition debris can be diverted from the landfill and recycled, but this figure will vary depending on the type of building being demolished and the effectiveness of the local recycling infrastructure.

2.3.3 RECOVER (QUALITY/RESULTS). This method is generally efficient for site surface restoration. Provisions for removing and disposing of unrecoverable materials and restoration of the site to grade would have to be included in the contract. Typically, subsurface components would be abandoned. With recovery and reuse, there is significant potential to reduce solid waste. Depending on the condition of the structure and material removed, the volume of waste ending up in a landfill can be greatly reduced. Typically, recovering selected building materials for reuse (in addition to the recycling activities described above) can divert as much as 85 percent of the demolition waste.

2.3.4 DECONSTRUCT (QUALITY/RESULTS). Manual deconstruction may leave the site with some building structure remaining. Restoring the site to grade will generally require heavy machinery to remove the remaining elements such as the concrete foundation. If the deconstruction requires that materials be sorted and stored before resale or reuse, clean up may be a problem. The site is likely to be neglected and left disorderly. Deconstruction dramatically reduces the amount of waste that must be shipped to landfills. The amount of reusable lumber and architectural fixtures that can be salvaged for reuse increases with hand demolition. As materials are removed, they can be carefully separated to avoid cross-contamination, thus yielding a higher volume of material for recycling or reuse. Removing a building or major portions thereof intact (in addition to the recycling and recovery activities described above) can typically divert as much as 90 percent of building waste from the landfill.

2.4 SAFETY. The Occupational Safety and Health Administration (OSHA) governs demolition safety with published rules in 29 CFR 1926. These requirements address in detail the types of worker activities and the materials that are regulated. Two materials used extensively in buildings are asbestos and lead-based paint (LBP). Both of these are occupational health hazards and require special management and removal in compliance with OSHA safety standards.

2.4.1 DEMOLISH (SAFETY). Demolition contractors are required by OSHA to take appropriate safety measures when removing hazardous waste and operating heavy mechanical equipment. Noise, dust and falling debris are the major environmental problems associated with mechanical demolition. Airborne asbestos and/or lead containing dust is possible if either is found in high concentrations. Suitable measures to prevent dust formation during wrecking should be instituted. Other hazardous materials such as polychlorinated biphenyls (PCB) and mercury may also be encountered in demolition debris. All workers must be protected in accordance with applicable OSHA regulations.

2.4.2 RECYCLE (SAFETY). Recycling, with the separation of materials, increases the number of tasks performed and creates additional physical and environmental exposure to hazards. Effective implementation of OSHA, USACE and Navy safety and health regulations will control exposure of hazards to personnel performing recycling operations. There may be some concern about asbestos and LBP-contaminated materials being introduced into the recycled materials market. Effective removal of asbestos, LBP, PCB, mercury and other hazardous materials must be monitored to ensure that they are not recycled into feedstock. Generally, recycling does not pose a hazard to the public.

2.4.3 RECOVER (SAFETY). Recovering materials may result in additional occupational exposure to physical and environmental hazards. Workers need to take extra safety precautions when manually removing building components including asbestos and LBP. Effective implementation of OSHA safety and health regulations will control exposure of hazards to personnel performing recycling operations.

2.4.4 DECONSTRUCT (SAFETY). Deconstruction, like recycling, is labor intensive, increases the number of tasks performed, and creates additional physical and environmental exposure to hazards. Effective implementation of OSHA and health regulations will control exposure of hazards to personnel performing deconstruction operations.

2.5 RISK. Certain risks are associated with jobsite physical and environmental hazards. The Owner is responsible for requiring and enforcing appropriate control measures, but the contractor is ultimately responsible for maintaining appropriate control measures. There is typically no risk to the public if a demolition project is performed in accordance with prevailing safety and environmental standards.

2.5.1 DEMOLISH (RISK). The Owner is in a generally favorable position to manage risk relative to cost, time and environmental hazards. The Owner is in somewhat of a less favorable position to manage risk relative to contractor performance. The Owner assumes risk and liability for differing conditions encountered during demolition. The Owner can reduce the probability of differing conditions through a thorough survey of the building and an accurate description of conditions in the contract documents. The Owner is exposed to time and cost impacts relative to differing project conditions resulting in contract changes. If a demolition project is performed in accordance with prevailing safety and environmental standards, there is typically no risk to the public.

2.5.2 RECYCLE (RISK). A recycling program may delay subsequent activities such as the ability to use the site. Unless sufficient liquidated damage provisions are included in the contract, the Owner assumes indirect effects of deficient contract performance. There is typically no risk to the public if a demolition project is performed in accordance with prevailing safety and environmental standards. There is possible exposure to the hazards of asbestos and/or lead if contaminated materials are released to the public through recycling or reuse. The Owner should require a contractor to monitor and control release of contaminated materials into recycled material feedstock.

2.5.3 RECOVER (RISK). The Owner assumes the risk and liability for differing conditions encountered during recovery and removal. The contractor assumes the risk of recovery expenses and the value of recovered materials. Transferring this risk holds the Owner harmless, but at a reduced income due to contingencies. There is possible exposure to the hazards of asbestos and/or lead if contaminated materials are released to the public through recovery and reuse.

2.5.4 DECONSTRUCT (RISK). Personal injury liability is an issue when deconstructing a building since manual labor is used to perform most of the work. The probability of jobsite hazards can be reduced through the administration of a safety management program and adherence to safety and health regulations. With deconstruction, there is a risk of encountering unforeseen conditions. The Owner can transfer the risk of differing conditions, but at a significant price due to inflated contractor contingencies.

2.6 IMPLEMENTATION. Solicitations for traditional demolition contracts are generally in the form of a Request for Proposal (RFP). The lowest qualified bidder is generally selected as the contractor. A typical demolition RFP requires contractors to submit such information as qualifications and description of the proposing organization, a list of sub-contractors, a project schedule, and a list of completed projects and references. Since the method of demolition is irrelevant, no plan or proposal beyond a schedule is usually required. Where a waste plan is required that encourages reuse and recycling, explicit requirements can be added. To achieve higher rates of recovery, building material reuse and recovery must be part of the project planning and contracting process. A typical demolition contract, however, will not work well to ensure maximum waste reduction, reuse and recycling. These goals need to be explicitly outlined and negotiated before the selection of a contractor. Some standard contract formats limit the feasibility of reuse and recycling. Federal, State and local contracting authorities should identify and remove barriers to material reuse and recycling from the language, process and procedures of public contracting. There are model contracts for past projects that can be customized for individual agencies. The scope includes specific deconstruction, salvage, reuse and recycling requirements.

2.6.1 DEMOLISH (IMPLEMENTATION). Demolition requirements are implemented as standard practice for building removal in projects for new construction, and contract methods for standard demolition are already established. However, all new demolition contracts need to include specification requirements for the contractor to track and report the amount of waste disposed in landfills. Demolition is typically executed through competitive bidding or an existing contract. Boilerplate language from a standard model is used in the contract. The nature and extent of the work to be performed is usually described in the "scope of work" section of the document. The same language is also included in the bid solicitation.

2.6.2 RECYCLE (IMPLEMENTATION). The requirement to recycle materials is typically not included in a standard demolition contract, but an incentive clause can simply be added to the contract. In an incentive contract, the contractor has a cost for traditional demolition and waste disposal, but is encouraged to use waste reduction and recycling techniques. The contractor gets paid fully for his awarded bid, but is allowed to profit from any cost reductions realized through recycling. Provisions for handling tasks and the recyclable materials will have to be added to the scope of work. In general, technical requirements and contract provisions shall be developed to include:

- Control of physical hazards;
- Control of environmental hazards;
- Procedures and points of contact for the recycling program manager to work with the contractor to identify local markets for recycled materials;
- Disposition of recyclable material and material to be landfilled; and

- Procedures for tracking and reporting the amounts of waste recycled and disposed of.

2.6.3 RECOVER (IMPLEMENTATION). Most demolition contracts do not contain special language requiring materials recovery. Alternative procedures will have to be described in detail to explain how contractors plan to achieve maximum recovery in their bid response. The weight of materials recovered must be tracked and reported along with the weight of materials recycled. A standard demolition contract with bid alternatives allows contractors to submit an alternate bid for reducing and reusing the predominant C&D materials found in the building. The variations for bid alternatives are endless and offer maximum flexibility. The sale of the building materials from demolition is atypical of traditional practices and may necessitate the development of an entirely new type of agreement. Provisions for transfer of property and material recovery will have to be included in the contract's scope of work.

2.6.4 DECONSTRUCT (IMPLEMENTATION). Development of a contract for deconstruction will require additional time and advanced planning. There are many issues that need to be addressed as conditions will vary greatly from one project to the next, so no standard contract may be acceptable. One way to handle this is to issue a RFP similar to a traditional design or construction RFP. Here the contractor would be given a delivery order for an entire deconstruction project. Another strategy is to use a standard contract with bid alternatives in which bidders are asked to submit an alternate bid for deconstructing the building. This plan for deconstruction before the award of the contract can require guaranteed minimum salvage quantities and allow the contracting entity to compare proposed deconstruction plans to meet project goals.

2.7 OPPORTUNITY. The manual disassembly of wood-framed older buildings, as well as other construction types, represents an excellent opportunity to train low-skilled workers or other personnel with an aptitude and interest in learning the building trades. Trainees learn carpentry and physical worksite-related skills including safety procedures, equipment operation and maintenance, and proper material handling. Also, trainees gain general employment skills, build a work ethic, and learn about leadership, decision-making and team building.

2.7.1 DEMOLISH (OPPORTUNITY). In demolition there is little potential for construction related training for personnel. Demolition jobs require skilled labor in the areas of transportation and heavy equipment operation.

2.7.2 RECYCLE (OPPORTUNITY). The same is true for recycling as for demolition. There is limited potential for construction-related training. Contractors hire trained crews to perform these operations.

2.7.3 RECOVER (OPPORTUNITY). If hand demolition techniques are used to disassemble a building and separate out the recoverable materials, there is significant potential for construction-related training.

2.7.4 DECONSTRUCT (OPPORTUNITY). The highest potential exists for construction-related training in a building deconstruction project. Unskilled laborers can obtain the necessary experience. Deconstruction introduces opportunities for training at a level requiring only worker endurance, ability and willingness to learn. Trainees can learn and practice construction-related skills by performing necessary tasks, but with less concern for risks of poor workmanship.

3. PROJECT CONDITIONS

3.1 PROJECT SCOPE. The scope of a project will affect the viability of each method of building removal. Depending on the method of building removal, there will be certain project constraints. An installation or facility can package projects to optimize the alternative methods. In most cases, the most successful strategy of building removal will involve a combination of demolition and deconstruction to recycle and recover useful materials.

3.1.1 DEMOLISH (PROJECT SCOPE). The scope of a project has no impact on the viability of landfilling debris from demolition.

3.1.2 RECYCLE (PROJECT SCOPE). A project in which materials are recycled instead of landfilled is viable, if the scope of the project is such that there is a high yield of materials for reprocessing. The overall size of the demolition project affects the feasibility, but the success of a recycling operation will also depend on the available recycling facilities in the area. Lack of these facilities in a project area may make the recycling of some materials expensive and/or impractical. The economies of transporting the materials long distance must be weighed against local disposal.

3.1.3 RECOVER (PROJECT SCOPE). A recovery operation is generally effective if the scope of the project contains a large square footage of building to be removed. Larger projects can take advantage of economies of scale to reduce the extra labor costs of on-site preparation and save on landfill fees. Success will depend on the condition and the quantity of the recovered materials. Recovery is feasible if the total value of the items removed, plus the avoided costs for landfill disposal, compensates for the added cost of removal and storage.

3.1.4 DECONSTRUCT (PROJECT SCOPE). Buildings should be identified and deconstructed for their suitable components. Warehouses and certain types of industrial buildings are often good deconstruction candidates, since they are relatively simple structures with few interior partitions and are often unpainted. Valuable materials, (e.g., wood) are relatively easy to access, debris is minimized, and LBP is less likely to be an issue. Residential buildings are generally the second most desirable group of buildings to deconstruct since they are also relatively simple. Although offices and residences are usually less desirable structures, they should still be surveyed for deconstruction since some structures may contain valuable materials or fixtures. Case studies show that a scope of less than five buildings (approximately 10,000 total SF) is still sufficient to attract participation in a deconstruction operation. On the other hand, if a great number of buildings are to be removed at one time (hundreds), the glut of recovered materials may depress resale prices, thus inhibiting economic benefits.

3.2 HAZARDOUS MATERIALS AND WASTE MANAGEMENT. Check specific environmental requirements while in the project planning phase. Federal requirements are found in the Code of Federal Regulations (40 CFR for environmental, 49 CFR for transportation, and 29 CFR for OSHA) and will apply in all states. State environmental requirements may be more stringent; if so, they are layered on top of the Federal requirements and must also be followed to avoid potential legal liability and/or fines. The States will have varying disposal and notification requirements for asbestos-containing material (ACM), lead based paint (LBP) debris, polychlorinated biphenyls (PCB), mercury and other materials. Due to the vintage of facilities, many structures contain these hazardous materials. Because of the presence of these materials, additional measures and precautions are necessary to both demolish a structure and/or recover materials for reuse and recycling. It is the responsibility of the property owner to make reasonable efforts to identify hazardous materials on the site before demolition. Asbestos, lead, PCB and mercury abatement should occur in advance for every building that is being demolished, deconstructed or relocated.

3.2.1 ASBESTOS CONTAINING MATERIAL (ACM). At one time, many different types of building materials contained asbestos because it was plentiful, inexpensive, nonflammable, strong yet flexible, resistant to chemical corrosion, and a good thermal and sound insulation. Asbestos is most commonly found in beam spray, insulation, mastic, floor tile, ceiling tile, siding, transite board and roof shingles. Asbestos is only a health concern when it is exposed, disturbed and friable. Materials become friable if asbestos is liberated from the material matrix. Substances easily crumbled or reduced to powder by hand pressure are termed “friable.” Friable ACM requires full containment, monitoring, notification, and disposal at a special hazardous waste landfill. Substances not producing powder with hand pressure are “non-friable” and can be removed with minimal amount of containment. A building probably has asbestos if:

- It was built between 1955 and 1978 and has ceilings that are bumpy, as if coated with cottage cheese or popcorn;
- It was built between 1940 and 1955 and has hard, rock-like shingles or siding;
- It was built between 1940 and 1983 and has vinyl flooring;
- It was built between 1955 and 1978 and has gypsum drywall walls;
- It has ductwork sealed with white duct tape;
- It has steam lines;
- It has pipe insulation that looks like corrugated cardboard; or
- It was built between 1920 and 1978 and has pipe insulation that is wrapped in canvas.

To be certain if a building material contains asbestos, a pre-design survey must be accomplished to obtain detailed data regarding ACM locations and content in building areas to be impacted. Samples must be taken by a person trained to do so and analyzed in an accredited laboratory. The results will indicate whether the material is positive (>1 percent asbestos) or negative (=<1 percent asbestos).

The OSHA construction industry asbestos standard, 29 CFR 1926.1101 (http://www.access.gpo.gov/nara/cfr/waisidx_01/29cfrv8_01.html) provides detailed work practices and engineering control requirements for asbestos work. EPA’s National Emission Standards for Hazardous Air Pollutants (NESHAPs) protect the public from exposure to airborne contaminants including asbestos. The complete text is found at http://www.access.gpo.gov/nara/cfr/waisidx_01/40cfr61_01.html. Sections 140, 141, 145 and 150 apply. The asbestos NESHAP requires the owner or operator of a demolition or renovation activity to thoroughly inspect the facility for the presence of asbestos including non-friable ACM. If a threshold amount of asbestos will be disturbed, then the installation must provide written notification at least 10 days before beginning work, to the local Pollution Control Agency responsible for NESHAP enforcement in accordance with Title 40 CFR 61.145(b), "Notification requirements." The installation must also comply with asbestos emission control requirements contained in Title 40 CFR 61.145(c), "Procedures for asbestos emission control." If less than the threshold amount of asbestos will be disturbed, only the reporting requirements of Title 40 CFR 61.145(b) apply. Neither the reporting nor emission control requirements apply if less than the threshold amount of asbestos is disturbed in a building undergoing renovation. The threshold asbestos amounts that trigger the reporting requirements are:

- 80 linear meters (260 linear feet) of regulated asbestos-containing materials (RACM) on pipes;
- 15 square meters (160 square feet) of RACM on other facility components; or
- One cubic meter (35 cubic feet) of facility components where the amount of RACM previously removed from pipes and other facility components could not be measured before stripping.

Roofing materials have been specially addressed by EPA in Appendix A to the asbestos NESHAPS. The notification, wetting and disposal requirements are defined for different situations and materials. A/C shingles that are removed and disposed of without crumbling, pulverizing or reducing them to powder, are not subject to the NESHAP waste disposal requirements. Wallboard typically does not contain asbestos, but the joint compound may. OSHA considers the joint compound and wallboard separate materials. NESHAPs considers them as a whole. Therefore, it may be necessary to test samples of both wallboard and joint compound separately to determine worker safety requirements, and also test composite samples of wallboard and joint compound to determine disposal requirements.

3.2.1.1 DEMOLISH (ASBESTOS CONTAINING MATERIAL). Materials that have a high probability of being crumbled, pulverized or reduced to powder as part of demolition must be removed before demolition begins. Friable and most non-friable ACM should be removed by qualified personnel using appropriate controls and protective devices in accordance with OSHA standards and the Clean Air Act Asbestos NESHAP. The disposal of non-friable ACMs is not regulated at the Federal level; however, States may have more stringent regulations. ACM that is removed must be labeled as such, wetted, bagged, transported in covered vehicles with no visible emissions, and disposed of at an authorized landfill. In most cases, these materials can be disposed of in a C&D or municipal solid waste landfill, but State and local regulations should be checked beforehand. State and local agencies which require handling and licensing procedures for landfills can supply a list of "approved" or licensed asbestos disposal sites upon request.

3.2.1.2 RECYCLE (ASBESTOS CONTAINING MATERIAL). Any materials containing asbestos shall not be recycled and must be disposed of properly in accordance with State and local landfill regulations.

3.2.1.3 RECOVER (ASBESTOS CONTAINING MATERIAL). Any materials containing asbestos shall not be recovered or reused. Asbestos removal and remediation cost will be a strong factor in the fate of a structure; whether or not it is economical to reuse or demolish.

3.2.1.4 DECONSTRUCT (ASBESTOS CONTAINING MATERIAL). Before deconstruction and any further activity, all the ACM must be removed by qualified personnel using the appropriate control and protective devices in accordance with OSHA standards and the Clean Air Act Asbestos NESHAP (40 CFR 61 Sections140 - 157).

3.2.1.5 OFFSITE TRANSPORTATION (ASBESTOS CONTAINING MATERIAL). Offsite transportation of asbestos material is regulated under 40 CFR 61 part 150 and also the

Department of Transportation regulations in 49 CFR 171 – 178. These regulations should be consulted prior to transportation.

3.2.2 LEAD-BASED PAINT (LBP). If a structure was built before 1978, it should be assumed that it is coated with LBP. LBP was primarily applied in kitchens, baths, and on wood trim and siding. When an architectural component coated with LBP is displaced and separated from a building during abatement or demolition activities, lead-contaminated debris is generated. The rules for storing, handling, record keeping and disposing of LBP debris are changing. To reduce the costs and remove the obstacles associated with disposal of LBP debris, the USEPA is proposing a rule to shift the regulations from management and disposal of LBP from the Resource Conservation and Reservation Act (RCRA) to a tailored program under the Toxic Substances Control Act (TSCA). Under the RCRA, installations and facilities are currently required to characterize their LBP waste and dispose of it by an approved method. If LBP debris is determined to be hazardous (equaling or exceeding 5 mg/liter lead according to the EPA Toxicity Characteristic Leaching Procedure, or TCLP), then the waste is strictly managed from identification to disposal. Many states have regulations that are more stringent than the Federal standards and installations are required to comply with these more restrictive state standards. Workers exposed to lead are protected by standards established by OSHA. In August 2000, the USEPA issued a policy clarification on how they will regulate the disposal of LBP debris under RCRA. Essentially, any LBP debris from a "residential" building will be considered non-hazardous, by definition. Of course, states will have their own interpretations.

3.2.2.1 DEMOLISH (LEAD-BASED PAINT). LBP debris can be removed from the C&D waste stream and be managed separately, or it can remain in the larger contaminated waste stream which will then all have to be managed as LBP debris. Waste managers must determine whether it is more cost effective to simply dispose of the commingled debris in appropriate landfills, or to remove LBP debris and handle it separately so that the rest of the waste can be reused or recycled. Whole Building Demolition waste, as one commingled pile of rubble, is seldom regarded as hazardous waste under the RCRA.

Often, LBP in demolition debris is not found in high enough concentrations to be hazardous waste and may be disposed of in a C&D landfill among other options. Burning of wood LBP debris, however, may result in lead releases since lead is a metal that is not destroyed through burning. The burning of LBP debris should be discouraged due to potential liabilities associated with disposal of the ash resulting from the burn. Before accepting LBP debris for burning activities, a facility should ensure that there would be no violations of the Clean Air Act permit conditions for burning buildings and that the facility will handle all ash in accordance with the Federal/State hazardous waste regulations. During demolition, mitigation measures to reduce the dust clouds associated with common demolition should be employed to decrease the exposure to lead. Exposure occurs through the inhalation of lead dust or ingestion of deteriorated LBP. Fugitive dust blown to neighboring property can contaminate soil and pass through open windows to settle on exposed surfaces. Typical mitigation involves spraying with water during demolition, watering down rubble pile, and spraying with water during loading and handling. A HEPA vacuum may be used on-site for cleaning up small debris and for vacuuming clothes and tools before exiting the site.

3.2.2.2 RECYCLE (LEAD-BASED PAINT). LBP debris may be recycled and reused in situations where there will be no human contact. The recycling and reuse of LBP debris as mulch, ground cover or topsoil may cause health risks through ingestion of LBP, dust or contaminated soil and should be avoided. If the wood waste is going to be recycled and reprocessed for mulch, composting or biomass fuel, painted or treated wood in general is highly undesirable. There are essentially three options available for the recovery and reuse of lumber that is coated with LBP. Each of these options must be looked at very carefully. If the building, intact, would be hazardous waste, then the performance of any of these three treatments would require a RCRA permit prior to execution of the work. One option is to remove the lead paint from the wood. All LBP removed from a substrate by virtually any method will, almost without exception, be hazardous waste and will be subject to RCRA disposal requirements. The second option is to encapsulate the LBP by painting over it, thus eliminating the exposure pathway of the lead. However, in future demolition, the LBP will be exposed again. The third option is to enclose and permanently seal lead painted materials in place. This process has many applications such as covering lead painted drywall with new drywall, or reversing the painted surface of lumber to expose the unpainted portion of the lumber. Again, this eliminates the pathway for human contact, but would lead to re-exposure under future demolition of the structure. If LBP is transferred to another party for any reason you must notify the recipient in writing of the presence of LBP debris. If the proposed USEPA regulation takes effect, items such as doors and windows that contain lead-based paint could not be reused because the lead could still be harmful to children. According to the proposed rule, LBP components, which have deteriorated LBP on them, must be stripped completely of LBP before being reused. This stipulation severely limits materials that can be recovered and recycled because the cost of removing lead-based paint becomes too expensive.

3.2.2.3 DECONSTRUCT (LEAD-BASED PAINT). Deconstruction results in the disturbance or removal of painted surfaces. Effective implementation of OSHA, safety, health and disposal requirements and procedures will control LBP exposure hazards to personnel performing deconstruction operations.

3.2.2.4 OFFSITE TRANSPORTATION (LEAD-BASED PAINT). The offsite transportation of LBP contaminated debris will be subject to the RCRA waste manifest and requirements, only if the debris has been characterized as hazardous waste under RCRA. If so, 40 CFR Parts 262 and 263 should be consulted prior to packaging, labeling and transportation.

3.2.3 POLYCHLORINATED BIPHENYLS (PCB). At one time PCBs were common components of hydraulic fluids, lubricants, heat transfer fluids and insecticides. They were also used as plasticizers in paints, plastics and rubber products. PCBs were primarily manufactured as dielectric fluid for transformers and capacitors because of their ability to absorb heat, low flammability, low electrical conductivity and favorable dielectric constant. Currently, heat transfer fluids residing in old transformers and capacitors used in power distribution systems are the main sources of PCBs. There may also be PCB-contaminated soil in places where transformers and capacitors have been stored or serviced, transformer fires have occurred, or PCBs have been sprayed as insecticides. Non-Liquid PCBs (NLPCBs) can be found in various items such as fluorescent light ballast potting material, ceiling tile coatings and certain painted surfaces. PCBs are regulated before disposal by their use (i.e., transformers, carbon paper, etc.). However, once the decision is made to end their use, disposal is regulated differently. PCB disposal requirements depend on the type of material being disposed and the concentration of PCBs in the waste. C&D debris is usually regulated as “PCB bulk product waste.” However, PCB bulk product waste does not include debris from the demolition of buildings or other man-made structures that is contaminated by spills from regulated PCBs which have not been disposed of, decontaminated, or otherwise cleaned up in accordance with USEPA requirements. Other types of PCB bulk product wastes are PCB-containing wastes from the shredding of automobiles, household and industrial appliances, or other white goods; PCB impregnated electrical, sound deadening, or other types of insulation and gaskets; or fluorescent light ballasts containing PCBs in the potting material.

3.2.3.1 DEMOLISH (PCB). The Toxic Substances Control Act (TSCA) requires mixtures like construction and demolition debris that include PCB-containing materials to be regulated to the requirements of the highest classification of PCB concentration. For this reason, all known PCB materials should be removed and disposed properly prior to demolition. Manufacturers of PCB-containing materials and equipment were required to label these items with the PCB classification. Where this was not done, owners of these items were required to affix classification labels. Yet even fluorescent light ballasts labeled "no PCB" may contain PCBs in the potting material. Therefore, waste managers must use the TCLP sampling method to characterize waste known to contain either potting material that may contain PCBs or unlabeled capacitors and lighting ballasts. Federal disposal requirements apply to C&D debris contaminated by 50 parts per million (ppm) or greater NLPCBs when originally removed from service, even if the current NLPCB concentration is less than 50 ppm. C&D debris that contained less than 50 ppm NLPCBs before removal from service is not regulated. PCB disposal requirements are contained in 40 CFR Part 761, *Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in*

Commerce and Use Prohibitions and applicable state and local regulations. Several states regulate PCBs and NLPCBs as hazardous waste, and therefore, hazardous waste disposal requirements must be followed in those states in addition to the Federal PCB requirements. PCB bulk product wastes may be disposed of in an incinerator, chemical waste landfill, or hazardous waste landfill, or may be decontaminated in accordance with the detailed procedures in 40 CFR 761.79. The selection of disposal methods is detailed in 40 CFR 761.62. There is also an option to dispose of certain PCB bulk product wastes in a State permitted municipal landfill or non-municipal, non-hazardous waste landfill. These wastes include:

- Plastics (such as plastic insulation from wire or cable; radio, television and computer casings; vehicle parts or furniture laminates); preformed or molded rubber parts and components; applied dried paints, varnishes, waxes or other similar coatings or sealants; caulking; Galbestos; non-liquid building demolition debris; or non-liquid PCB bulk product waste from the shredding of automobiles or household appliances from which PCB small capacitors have been removed (shredder fluff); and

- Other PCB bulk product waste, sampled in accordance with the protocols set out by the EPA that leaches PCBs at 10 μg/L of water measured using a procedure used to simulate leachate generation. In order to dispose of PCB bulk product waste in a State-permitted municipal landfill or non-municipal, non-hazardous waste landfill, there may be additional sampling, recordkeeping and performance requirements that must be satisfied. Carefully review 40 CFR 761.62 if selecting this disposal option.

3.2.3.2 RECYCLE (PCB). PCB bulk wastes must be disposed in accordance with 40 CFR 761.62 and shall not be recycled.

3.2.3.3 RECOVER (PCB). PCB bulk wastes must never be recovered and reused without decontamination. The USEPA regulations for decontaminating PCB bulk product wastes are organized in two parts:

- The first part is a performance-based standard that specifies decontamination standards and requires analytical testing to demonstrate that decontamination has been achieved. Refer to 40 CFR 761.79 for the specific performance requirement. It allows PCBs from liquids, concrete and non-porous surfaces to be removed using chopping, distilling, filtering, oil/water separation, stripping of insulation, spraying, soaking, wiping, scraping, and use of abrasives or solvents. Decontamination waste must be disposed as required based on the concentration of PCBs in the waste.

- The second part of the regulation provides a self-implementing decontamination procedure for PCB containers, movable equipment contaminated with PCBs, non-porous surfaces in contact with free flowing mineral oil dielectric fluid (MODEF), piping and hoses in air compressor systems, and decontamination of metal surfaces using thermal processes. Confirmatory sampling is not required for self-implementing decontamination procedures; however, documentation of compliance with the procedures must be maintained for 3 years after completion of the decontamination procedures (e.g., video recordings, photographs).

3.2.3.4 DECONSTRUCT (PCB). Deconstruction may result in the disturbance or removal of PCB bulk wastes. Effective implementation of OSHA and USACE safety, health and disposal requirements and procedures will control PCB exposure hazards to personnel performing deconstruction operations.

3.2.3.5 OFFSITE TRANSPORTATION (PCB). The offsite transportation of PCB contaminated debris is subject to RCRA waste manifest requirements (40 CFR Parts 262 and 263, and is also subject to the Department of Transportation regulations, 49 CFR Parts 171-178. These regulations should be consulted prior to transportation.

3.2.4 MISCELLANEOUS HAZARDOUS MATERIALS. Many common items contain hazardous waste that will contaminate the rest of the C&D materials if left onsite during demolition. The best management practice is to remove these items prior to demolition or during deconstruction.

3.2.4.1 MERCURY-CONTAINING MATERIALS AND TREATED LUMBER are commonly found in construction and demolition debris. Mercury or mercury vapor can be found in fluorescent light bulbs, high-intensity discharge lamps, thermostats, old mercury-bearing wall switches, and a variety of switches, relays and gauges. Wastes containing these items must be characterized as hazardous or not using the TCLP method.

3.2.4.2 BATTERIES are found in emergency lighting, exit signs, security systems and other alarms. They may contain lead and cadmium.

3.2.4.3 ROOF VENT FLASHINGS often contain pure lead. Lead pipes may also be found in older buildings.

3.2.4.4 LUMBER TREATED WITH CHEMICALS and preservatives that considered for disposal or reuse in a project may require special handling. It should never be shredded for composting or for use as mulch. Burning is inappropriate if the treatment chemical concentrations are high enough to cause the ash to be hazardous waste, or the smoke to be a pollutant. Treated lumber includes marine piling and fenders, utility poles, rail ties, and other dimensional lumber that has been coated or impregnated with pentachlorophenol, creosotes and arsenic compounds. Project managers can reduce treated lumber waste by reusing it in landscaping, berms, parking barriers, retaining walls, fencing, pole barns and other applications calling for treated lumber. Coordinate with environmental managers before reusing treated lumber in situations where chemicals could leach into the ground, or to determine disposal requirements if it cannot be reused.

3.2.4.5 BUILDINGS WHERE PLATING OPERATIONS or extensive parts cleaning occurred may have materials containing regulated heavy metals or solvent chemicals that were spilled. Paint, oil, pesticides or other materials stored on the site must always be removed and properly disposed before demolition.

3.2.4.6 BLUE AND YELLOW PAINTS and coatings may contain regulated levels of cadmium and chromium.

Project managers should coordinate with environmental managers when planning demolition or deconstruction. Environmental Impact Analysis Process (EIAP) and Installation Restoration Program (IRP) documents will provide clues to hazardous materials likely to be encountered. Ensure unspecified materials are sampled, tested and characterized as hazardous or not, and manage them accordingly.

3.3 SITE ACCESSIBILITY. The site's accessibility to equipment, the contractor or the public affects the viability of each method. Site conditions may be favorable for one method of building removal and less favorable for another. Deconstruction is generally applicable to specific sites and situations where demolition by other methods cannot be employed either due to severe restrictions on site access or because it can cause serious nuisance and damage. Such sites are usually found in downtown areas, underground facilities, etc. In these situations, manual deconstruction is a matter of necessity.

3.3.1 DEMOLISH (SITE ACCESSIBILITY). Conventional demolition requires that the site be accessible by truck. This method is generally efficient regardless of accessibility to the site and site conditions. High-rise buildings that are higher than 15 stories must be partially demolished by manual methods. Use of mechanical demolition methods for higher multi-story buildings can cause serious air pollution and hazard problems in the vicinity of these tall structures.

3.3.2 RECYCLE (SITE ACCESSIBILITY). If debris is separated for recycling off-site, site accessibility and site conditions have no impact on the effectiveness of recycling. If debris is separated on-site for pick-up, space will need to be available to accommodate separation activities and collection receptacles. On-site processing requires allocation of space for mobile crushers and screens, as well as space to pile sorted materials. Such space may not always be available.

3.3.3 RECOVER (SITE ACCESSIBILITY). Additional square footage at each building site should be available for separating, processing and removing materials recovered from the building. The most desirable option is to reuse the recovered materials on site. However, that is not always possible and the recovered materials have to be transported to local markets. Truck access should be available around each building's perimeter. Extremely limited space availability and/or truck access to each building may adversely impact the effectiveness of recovery/reuse strategy.

3.3.4 DECONSTRUCT (SITE ACCESSIBILITY). Deconstruction is most feasible if there is an open site that allows ample space for on-site handling and processing of materials as they are removed from the building. The site should be organized so that different types of materials can be segregated simultaneously without conflicting during processing. Marking on the ground with paint for varying dimensional lengths facilitates sorting by size and saves time. Where buildings (or major portions thereof) are to be removed intact, large clearances will be required. If heavy equipment is needed for removal, this will also require additional space on the site.

3.4 LANDFILL BURDEN. Tables 3.1 and 3.2 list the relative landfill burdens per building type. The amount of material generated from demolition activities is generally proportional to the size of the structure being demolished. The materials generated vary according to the construction type. The following examples (of commercial buildings) can be used to estimate the materials of value that can be extracted with each method.

	cubic feet of debris per square foot of floor area (cu ft/SF)
Wood Building	4.5
Brick Building	3.0
Concrete Building	3.0

Table 3.1

Waste generation rates per building type

	% Wood	% Brick	% Concrete	% Metal	% Paper Board
Wood Building	60-75	17-22	10-30	2.5-3	<1
Brick Building	12-32	53-82	12-20	3	1-2
Concrete Building	18-20	20-22	50-51	3	5-7

Table 3.2

Waste composition per building type

3.4.1 DEMOLISH (LANDFILL BURDEN). This method of building removal has the greatest adverse impact on landfills. The traditional method of mechanical demolition was developed without regard to potential environmental impacts. The disposal of wastes generated from conventional mechanical demolition consumes valuable landfill space. One way to reduce the landfill burden is to grind up the resulting demolition debris such that it will require less landfill volume. While this may not save on weight-based commercial tipping fees, it will save the life span of government-owned landfills. Grinding also affords the opportunity to liberate some recyclables such as steel rebar.

3.4.2 RECYCLE (LANDFILL BURDEN). Recycling selected materials can typically divert 70 percent of the waste from ending up in a landfill. Using a sophisticated system of crushers, shakers, screens, magnets and blowers, larger recovery operations can achieve diversion rates as high as 82 percent. Including a recycling operation into the demolition project is an effective means of reducing the landfill burden.

3.4.3 RECOVER (LANDFILL BURDEN). Recovering selected building materials for reuse, in conjunction with recycling, can typically divert as much as 85 percent of the waste from ending up in a landfill. Recovering for reuse is an effective means of reducing the landfill burden. According to the Center for Economic Conversion, the reuse of 1,000 board feet of properly salvaged lumber can replace the harvesting of approximately 10,000 board feet of standing timber.

3.4.4 DECONSTRUCT (LANDFILL BURDEN). Recent deconstruction demonstration projects show that high diversion rates may be achieved. Removing buildings (or major portions thereof) intact can divert up to 98 percent of building waste from landfilling. Deconstruction is highly effective in reducing landfill burden by diverting valuable materials from the nation's overflowing landfills. Relocation preserves both tangible and intangible resources embodied in the structure.

3.5 RESOURCES. Typical building removal requires certain labor and equipment resources. Alternative methods may require other specialized resources that may create an advantage or disadvantage to the owner.

3.5.1 DEMOLISH (RESOURCES). The type of construction, building height, proximity to neighboring structures and rights-of-way are some of the factors that determine the method of demolition. Wood-framed buildings are generally demolished by a bulldozer, while masonry or concrete buildings are more likely to be demolished by a wrecking ball. Mechanical demolition requires the use of heavy equipment including dump trucks, tractors and loaders. Demolition requires workers with experience in the areas of transportation and heavy equipment operation. These jobs are typically high paying and require skilled laborers.

3.5.2 RECYCLE (RESOURCES). Common equipment and labor skills are used for on-site separation of materials. Manual labor is required to supplement mechanical equipment. The type of construction will determine what tools and equipment are required. "If you don't have the right tools, generating a profit from a C&D debris recycling operation can be as difficult as crushing a one-ton slab of concrete with your fist" (World Wastes, May 1998, P. 62). Materials that are not recycled and reused on the site will need to be hauled away by dump trucks.

3.5.3 RECOVER (RESOURCES). Recovery is generally effective using commonly available construction equipment and labor resources. Manually removing materials for reuse requires workers with common building construction skills. Some training may be required if non-construction laborers are employed. If larger structural members are removed, heavy equipment (such as a crane) is required. High-value, low-salvage cost items such as appliances, cabinets, lighting fixtures and architectural elements are targeted and salvaged before the heavy equipment is brought in to clean up the remaining items. More labor hours are required for a salvage operation. These additional handling costs can be reduced if the efficiency of the equipment is increased.

3.5.4 DECONSTRUCT (RESOURCES). Deconstruction is very labor intensive. Workers do not need to be highly skilled, but they do need to have endurance, ability and willingness to learn. Deconstruction also adds another level of jobs including material handlers and distributors. In piece-by-piece wrecking, workers usually employ simple hand tools such as crowbars, sledgehammers, flat screwdrivers, wire-cutting pliers, utility knives, etc.

3.6 MARKETS. Markets and outlets for building construction materials greatly influence reuse and recycling activities. If reasonable profits can be expected from the sale of recycled materials, there is a greater incentive for efficient recovery. If there is not a high demand for a commodity, the material may not be salvaged or recycled. There are several sources that can provide information as to the local market demand, value and outlets for each material or component type.

3.6.1 DEMOLISH (MARKETS). Demolition operations generate a far less desirable waste due to the non-uniform nature of the waste that is commingled with other materials. Very little reusable waste is yielded due to the practice of using heavy equipment to demolish structures.

3.6.2 RECYCLE (MARKETS). Recycling facilities will use their resources to recover materials if reasonable profits can be expected from the sale of recycled materials. If the commodity does not command a high enough price in the market, recycling may prove to be costly. Each project's unique regional situation influences how much profit a recycling operation can expect to make. Recycling rates continue to improve, but one undeniable roadblock to a successful recycling program is the lack of markets for some materials.

3.6.3 RECOVER (MARKETS). The most desirable and most cost effective option is to reuse recovered material on the site. For example, concrete can be crushed and used for fill on site. Salvaged lumber and other building materials that can be used on the site for new construction will minimize the cost associated with transportation and market development. One major barrier to increased recovery rates is the low cost of virgin construction materials. Recycled content materials often cost the same or more than new materials. However, salvaged materials can often be of higher quality than comparable new materials. Old-growth timber is one such example.

3.6.4 DECONSTRUCT (MARKETS). Deconstruction minimizes contamination of demolition debris, thus increasing the potential for marketing the recovered materials. Before deconstruction, it helps to know what materials are worth salvaging so that materials with potential value are not inadvertently destroyed. Hand demolition significantly increases the amount of materials that can be reused and yields materials that are available for immediate resale or reuse.