United States Environmental Protection Agency
Solid Waste and Emergency Response (5306W)
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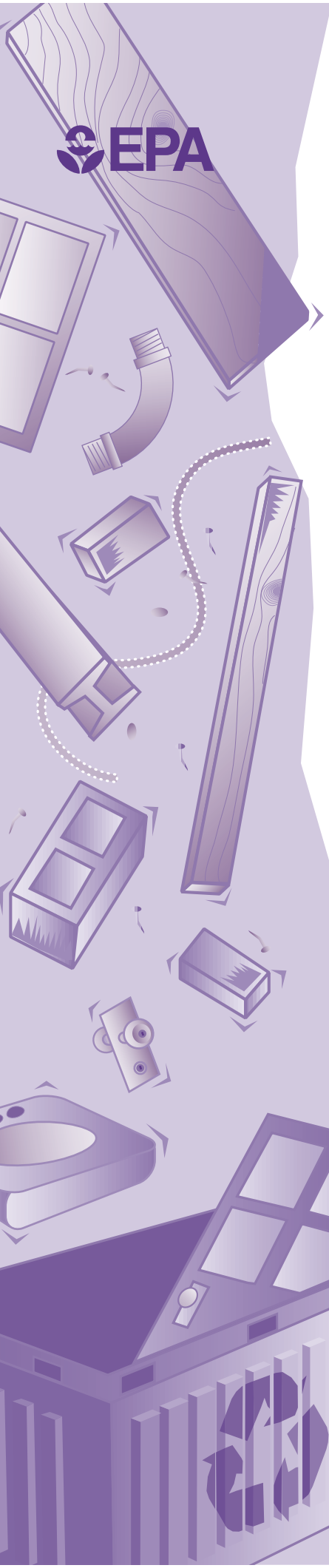
www.epa.gov/osw

Building Savings

Strategies for Waste Reduction of Construction and Demolition Debris from Buildings



The Waste Reduction Record-Setters Project fosters the development of exceptional waste reduction programs by documenting successful ones. These programs can be used as models by others implementing their own programs to reduce disposal. This fact sheet packet is aimed at local governments that want to encourage more building-related construction and demolition debris recovery, building owners and developers interested in green building design, and building contractors seeking a competitive edge.

What is construction and demolition debris?

Construction and demolition (C&D) debris is produced during new construction, renovation, and demolition of buildings and structures. C&D debris includes bricks, concrete, masonry, soil, rocks, lumber, paving materials, shingles, glass, plastics, aluminum (including siding), steel, drywall, insulation, asphalt roofing materials, electrical materials, plumbing fixtures, vinyl siding, corrugated cardboard, and tree stumps. In 1996 the U.S. produced an estimated 136 million tons of building-related C&D debris.[1] This estimate excludes road, bridge, and land-clearing materials, which can be a significant portion of total C&D materials discarded.

How can C&D materials be recovered?

C&D materials can be recovered through reuse and recycling. In order for materials to be reusable, contractors generally must remove them intact (windows and frames, plumbing fixtures, floor and ceiling tiles) or in large pieces (drywall, lumber). Some materials may require additional labor before they can be reused. For example, lumber may need to be denailed and window frames may need some new panes. In order to be recyclable, materials must be separated from contaminants (e.g., trash, nails, and broken glass). This can be accomplished if contractors require workers to sort materials as they remove items from buildings or as debris is produced. Many contractors simply use labeled roll-off bins for storage of source-separated materials. For projects where on-site source separation is not possible, contractors often use C&D materials processing firms.

Benefits of recovering construction and demolition materials

- Reduces the environmental effects of extraction, transportation, and processing of raw materials.
- Reduces project costs through avoided disposal costs, avoided purchases of new materials, revenue earned from materials sales, and tax breaks gained for donations.
- Helps communities, contractors, and/or building owners comply with state and local policies, such as disposal bans and recycling goals.
- Enhances the public image of companies and organizations that reduce disposal.
- Conserves space in existing landfills.

Recovering C&D Materials

The choice of what and how construction and demolition materials can be recovered depends on many factors including the type of project, space on the building site, the existence of markets for materials, the cost-effectiveness of recovery, the time allowed for the project, and the experience of the contractors. Many C&D materials can be reused or recycled.

Type of project: Demolition projects produce much more debris than renovation or new construction for similar sized structures. Wood is a primary component of most residential structures, whereas, steel and concrete are often a primary component of commercial structures. Packaging materials can often be a significant portion of the debris produced during renovation and new construction projects.

Space on the building site: Materials recovery is often easiest if the building site is spacious enough to allow on-site sorting of materials. Having separate containers for each type of materials can reduce contamination.

Materials markets: Contractors can maximize recovery by taking advantage of all available markets for recovered materials. In some areas of the country, specialty hauling firms serving the building industries have emerged. These firms keep abreast of local markets and can advise clients which materials have strong local markets.

Cost-effectiveness: Hauling and disposal costs, the value of recovered materials, and labor costs contribute to whether materials recovery is more or less cost-effective than disposing of materials. Recovery of low-value materials may be cost-effective if disposal costs are high and removal and sorting are not labor-intensive. The added labor necessary to remove items for reuse may be offset by savings from both the avoided costs of purchasing new materials and avoided disposal costs.

Project timeline: Source separation of materials for reuse and recycling can take more time than disposing of all commingled materials and often projects are on a tight schedule due to financing arrangements. Contractors can maximize materials recovery in the time allowed by planning ahead. If necessary, contractors can focus waste reduction efforts on off-site source separation and recycling.

Contractor experience: Contractors well-versed in recovery methods and local markets may be able to recover more materials than contractors unfamiliar with reuse and recovery techniques. The need for project coordinator oversight and educational efforts can be lessened when using a contractor experienced in C&D recovery efforts.

This fact sheet profiles building projects of four distinct types:

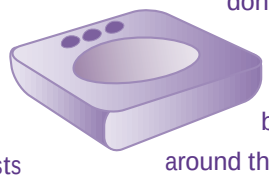
Construction: Putting together all or part of a structure. Most construction site debris is generated from packaging and when raw materials are cut or sized. Workers can save large scraps for use in other projects. Durable packaging can be returned to suppliers. Smaller scraps and non-durable packaging can be source separated when produced, and recycled.

Renovation: Partial removal of a building's interior and/or exterior followed by construction. Contractors can adapt the same recovery techniques as above for renovation projects.

Deconstruction: A "soft" demolition technique whereby workers dismantle a significant portion of a building in order to maximize recovery of materials for reuse and recycling.

Demolition: The complete removal of a building. On most demolition projects, after extracting easily removable materials for reuse or recycling, workers complete the demolition with sledgehammers, explosives, or heavy equipment. Additional recyclables are often sorted from the rubble generated during these demolition activities.

Reuse



Many materials can be salvaged from demolition and renovation sites and sold, donated, stored for later use, or reused on the current project. More than 200 used building materials stores around the country buy and/or accept donations of used building materials. Contractors can avoid the cost of removal by allowing private companies to salvage materials from the site. Organizations that have space may want to consider storing high-value materials for later projects.

Many building materials may be reusable during renovation projects and projects where a new building is built following the demolition of another. Planners can increase reuse potential by making efforts to use the same size and types of materials as in the old construction. Inadequate storage space for materials during the interim from removal to reinstallation may limit reuse as a materials recovery option.

Typical materials suitable for reuse include plumbing fixtures, doors, cabinets, windows, carpeting, bricks, light fixtures, ceiling and floor tiles, wood, HVAC equipment, and decorative items (including fireplaces and stonework).

Recycling

Recycling is often easiest during construction projects as opposed to demolition and renovation projects. During construction, crews can source separate materials as debris is produced. Demolition and renovation project materials often consist of mixed materials and require on- or off-site sorting.

Typical materials recycled from building sites include metals, lumber, asphalt, concrete, roofing materials, corrugated cardboard, and wallboard.

Model Programs — Some Numbers and Descriptions

Record-Setting Program	Project Type	Project Highlights	Recovery Strategy	% Debris Recovered (by weight)
Bagley Downs Apartments Eugene, OR	Demolition and construction	This project created 30 affordable housing units, saved the University of Oregon demolition costs, and preserved a community landmark.	Entire buildings saved by moving them to a new location.	73%
Erickson's Diversified Corporate Headquarters Hudson, WI	New construction	Erickson's planned to incorporate materials recovery efforts during the construction of its new corporate headquarters even though it expected to pay more than if it disposed all materials generated. In fact, the company diverted 69% of the project debris and saved money.	Source separation of materials during construction by all subcontractors.	69%
Four Times Square New York, NY	Demolition and construction	Materials recovery was included in plans from the beginning. The contract included requirements that subcontractors reduce disposal and, as an incentive, they were allowed to retain savings earned through avoided disposal costs and materials revenues.	Pre-demolition salvage, construction materials sorted off-site because of space limitations.	58%
Marion County Senator Block Salem, OR	Demolition	Marion County and Salem Area Transit saved over $160,000 by diverting demolition materials from disposal while using the project as a tool to educate the public on recycling. The county placed ads on TV and radio and placed banners illustrating the project recycling rate around the project site.	Salvage of usable items before demolition. Hand and mechanical sorting of materials after demolition to recover metals, concrete, and asphalt.	82%
Ridgehaven Green Office Building San Diego, CA	Renovation	The city of San Diego wanted to reduce, recycle, and reuse renovation materials from this project in order to comply with California's 50% recycling goal and reduce materials going to the city-owned landfill. In addition to diverting 51% of the renovation materials from disposal, the city also saved $92,000.	Many existing materials refurbished and reused. Materials sorted into labeled dumpsters for recycling.	51%
Stowe Village Hartford, CT	Deconstruction	This demonstration project not only recovered 50% of the materials from six public housing units, it also trained nine public housing residents in deconstruction techniques.	Buildings hand-dismantled to recover maximum usable materials.	50%
Whole Foods Market Corporate Headquarters Austin, TX	Renovation	Recovery of renovation materials saved Whole Foods over $32,000. Reuse of materials, such as ceiling tiles, light fixtures, and doors, helped the company avoid the purchase of nearly $25,000 worth of supplies. The company was also able to take an $8,000 tax deduction for donating salvaged goods to non-profit organizations.	Contracts required recycling and reuse. Materials stockpiled and moved about site for storage due to limited space.	42%

Strategies for recovering construction and demolition materials

Include C&D recovery plans in the project design

Some recovery options may be lost if not considered at the project design stage.

- Reuse of wall panels, ceiling panels, and doors in the Ridgehaven Office Building renovation was possible because the architect planned the new interior to use the same sizes and types of materials used in the building before the renovation.

Include recovery requirements and goals in project specifications and contracts

By including recovery requirements and goals in project specifications and contracts, project planners can signal their commitment to recovery and make subcontractors aware of their responsibilities from the project outset.

- In its contract, Marion County required its demolition contractor to divert materials from area landfills. The county set a diversion goal of 90% based upon research of other similar efforts.
- Although the general contractor for the Ridgehaven Office Building project was initially reluctant to recycle, its contract required it to do so.

Source: Manafort Brothers, Inc.

Deconstruction workers at the Stowe Village site

Educate contractors and crews on materials recovery techniques

Educating contractors and crews on materials recovery techniques and procedures such as sorting and storage methods, recoverable materials, and removal techniques can eliminate contamination problems and increase recovery rates.

- The materials management plan created for the construction of Erickson's Diversified's new headquarters building provided subcontractors with detailed instructions on reuse and recycling techniques, and sorting methods.

Hold subcontractors accountable for materials recovery

Incorporating a mechanism to enforce contract provisions requiring materials recovery gives project managers leverage to ensure efforts are a success.

- The Four Times Square project's environmental consultant included contract requirements that construction contractors anticipate packaging materials generated on the project, work to reduce them, and document their efforts. The construction management firm announced it would withhold payments unless the contractors complied with the contract requirements.
- Whole Foods did not process payments to its general contractor until the contractor submitted forms summarizing its C&D debris recovery efforts.

Provide incentives for recovery

Providing incentives to contractors and crews can create project buy-in.

- During the renovation of the Whole Foods Market Corporate Headquarters Building a portion of revenue from materials sales was used to fund refreshments and a pizza party for the crew.
- As an incentive to encourage recovery, the owners of the Four Times Square office building chose to allow their contractors to retain revenues and savings from materials recovery.

Follow up with contractors and crews during the project

Without feedback, contractors and crews may forget correct recovery procedures or grow lax about implementing them.

- Erickson's Diversified sent a representative to weekly site meetings and its consultant distributed newsletters to crews in order to monitor project progress and keep crews involved in recovery efforts.

Think outside the box

Recovery of C&D materials is a growing field and offers opportunities for creative thinking.

- When the University of Oregon planned to demolish Bagley Downs Apartments, Saint Vincent de Paul stepped forward with the unique idea of moving the buildings to a new location and renovating them. The University of Oregon avoided the costs of demolishing the buildings and 30 affordable housing units were created for about half the cost of building new structures.
- The Hartford Housing Authority undertook the deconstruction of six public housing units at Stowe Village as an opportunity to train public housing residents in the building trades and simultaneously divert materials from disposal.

Construction and Demolition Materials Recovery

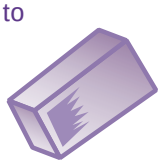
Some Questions and Answers

Q How can I get my subcontractors to recover C&D materials?

A Include contract requirements that subcontractors recover project materials. Also incorporate an enforcement mechanism. For example, make contract payments due only after your subcontractors provide documentation of their recovery efforts.

Q How can I determine what is recyclable or reusable?

A A little research should help you identify what materials to target for recovery. You can talk to others in the building trades to learn what they have done on similar projects. State and local governments often publish directories of recyclers and the materials they accept. Also, check the telephone directory for recyclers and used building materials stores. It may be easier to rely on professional advice. Building site materials management firms and companies specializing in C&D materials recovery operate in some regions and for a fee can handle some or all materials from your site. Another option is to hire a consultant who is familiar with local conditions to draft a materials management plan for your project.



Q How can I get my crews to properly recover materials?

A Constant education and feedback are necessary to ensure on-site sorting and recovery efforts are successful. Regular meetings among client, contractors, and crews provide opportunities to communicate project successes and areas for improvement. Also consider providing incentives to crews as a reward for their efforts. Crews may be more enthusiastic about a program if they benefit personally from it.

Q How can communities prevent buildings from being demolished without materials recovery?

A Some localities have incorporated materials recovery requirements as part of the permit process. Another option is to pass a local ordinance requiring recovery of C&D materials. For example, Portland, Oregon, passed an ordinance, effective January 1, 1996, requiring job-site recycling on all construction projects with a value exceeding $25,000. Localities could pass similar ordinances requiring recovery of demolition materials.

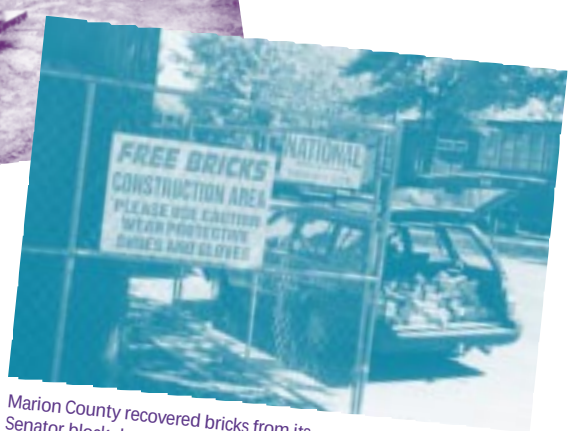
Q Won't my costs increase because salvage and recycling are more labor-intensive than disposal?

A Not necessarily. The costs of labor to salvage and recycle should be weighed against the avoided costs to haul and dispose of materials, and the value of materials that are recovered. Materials recovery often proves to be more cost-effective than disposal.

Q How important is it to keep materials separate on the job site?

A Very important. Materials intended for salvage or reuse can be damaged or destroyed if not properly stored. Even a small amount of other materials in a bin of recyclables can make the entire bin unacceptable for recycling.

Labeled containers for source-separated C&D materials.



Marion County recovered bricks from its Senator block demolition and gave them away free to local citizens.

Tips From Record-Setters

- Ensure that the client and design team share the same environmental goals.
- Establish a clear numerical waste reduction goal for the project.
- At minimum, choose a general contractor and subcontractors who can demonstrate commitment to reducing disposal.
- Involve the general contractor early in the design process.
- Include environmental procedures in the project specifications that address construction materials reuse and recycling.
- Require contractors to estimate waste generated on site, including packaging, so you can anticipate the nature and amount of the recyclable materials that will be generated on site.

- Host a pre-construction meeting and site meetings early in the construction process in order to educate the contractor and workers on the benefits of materials recovery.
- Encourage communication among the client, project facilitators, and contractors over the course of the entire project.
- Create recycling and disposal reduction incentives for the construction crew such as pizza parties.
- Do not over-complicate materials handling guidelines.
- Carefully coordinate reuse of smaller materials such as door hardware.
- Carefully track all data on materials recovery and communicate the results to all involved parties.
- Provide source reduction, reuse, and recycling forms to project managers and waste haulers to make data reporting easier.

Note

[1]U.S. Environmental Protection Agency, *Characterization of Building-Related Construction and Demolition Debris in the United States*, (EPA530-R-98-010), 1998, p. 2-11.

Tips for Municipal Planners to Promote C&D Recycling

- Consider incorporating requirements for recycling of C&D debris in your permit process.
- Use the projects as a promotion to raise awareness about recycling.

The Waste Reduction Record-Setters Project was developed under a U.S. EPA grant by the Institute for Local Self-Reliance (ILSR). For more information on the project, contact ILSR, 2425 18th Street, NW, Washington, DC 20009, phone (202) 232-4108, fax (202) 332-0463, Web site <http://www.ilsr.org>.

Resources

Organizations:

Construction Materials Recycling Association (CMRA)
PO Box 644, Lisle, Illinois 60532
630-548-4510

National Association of Home Builders (NAHB) Research Center
400 Prince George's Boulevard, Upper Marlboro, Maryland 20772-8731
301-249-4000 <http://www.nahbrc.com>

Used Building Materials Association (UBMA)
1096 Queen Street, Suite 126, Halifax, Nova Scotia, Canada B3H 2R9
877-221-UBMA (8262) <http://www.ubma.org>

Publications:

Building for the Future: Strategies to Reduce Construction and Demolition Waste in Municipal Projects, INFORM, Inc.: 120 Wall Street, New York, New York 10005-4001
212-361-2400

Construction Resources: A Waste Reduction Guide for Wisconsin's Builders and Contractors, University of Wisconsin Extension, Solid and Hazardous Waste Education Center: 610 Langdon Street, Room 527, Madison, Wisconsin 53703
608-262-0385

Residential Construction Waste Management: A Builder's Field Guide and *Waste Management and Recovery: A Remodeler's Field Guide*, NAHB Research Center (contact information listed above)

Resource Efficient Building - A Handbook for Building Owners, Designers and Project Managers, Portland Metro: 600 NE Grand Avenue, Portland, Oregon 97232-2736
503-797-1650

Wastespec: Model Specifications for Construction Waste Reduction, Reuse, and Recycling, Triangle J Council of Governments: P.O. Box 12276, Research Triangle Park, North Carolina 27709
919-558-9343

Websites:

King County, Washington's Encompass site <http://www.metrokc.gov/market/map>

The Smart Growth Network <http://www.smartgrowth.org>

The California Integrated Waste Management Board
<http://www.ciwmb.ca.gov/ConDemo>

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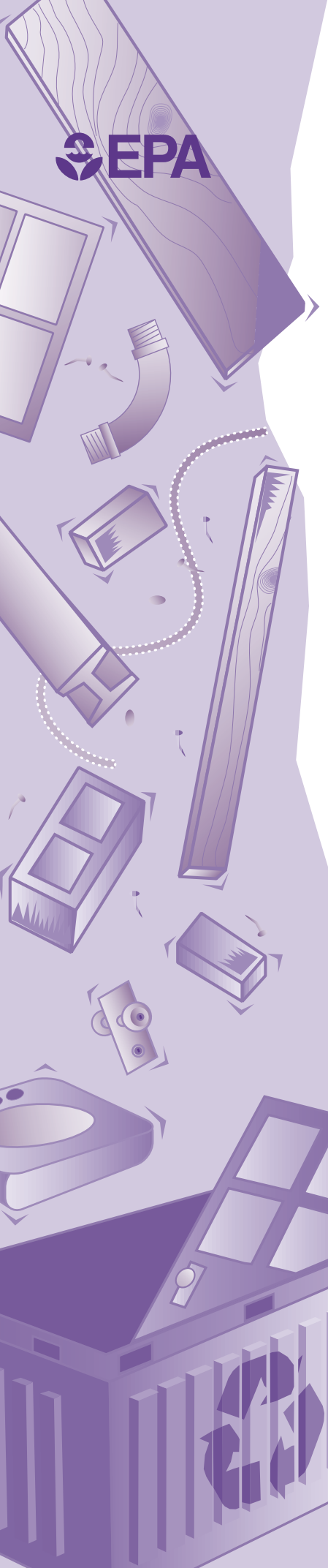
Bagley Downs Apartments

Eugene, Oregon

73% Reduction of Construction and Demolition Materials



Bagley Downs is a 30-unit apartment complex in Eugene, Oregon, that was built using 32 apartment units slated for demolition by the University of Oregon. Due to student opposition, a demand for affordable housing, and the recycling and reuse experience of Saint Vincent de Paul of Lane County, Inc. (SVDP), the University of Oregon donated four buildings from the apartment complex to the City of Eugene. SVDP moved the structures to a new site and used them as the base for constructing eight new buildings. During the project, over 112 tons of material were recovered (86 tons through reuse and salvage and over 26 tons through recycling) and the city saved over $1 million.

Project Description

The Bagley Downs Apartments appear to have nine lives. Originally constructed in Vancouver, Washington, and moved to the University of Oregon in the 1940s, these apartments were saved from the wrecking ball a second time. In 1990, the University of Oregon planned to raze a 244-unit student housing complex in order to build new housing. A student coalition opposed the demolition and requested that the University renovate the units. Although the University was unable to renovate the complex, the city committed time, energy, land, and funds to save 32 of the units in order to address a city shortage of affordable housing. The city has an overall vacancy rate of less than 1%. With city funding, Saint Vincent de Paul moved 32 of the units to a new site and reconstructed them, saving part of a community landmark. Saint Vincent de Paul, which has an extensive history in recycling and reuse, considers moving housing units as a logical next step in reducing the amount of construction and demolition materials going into area landfills.

An experienced moving crew removed asbestos and lead, appliances, cabinetry, and exterior fire escapes from the buildings prior to cutting four buildings (eight units each) in half. The crew used jacks, cribbing, and house-moving dollies to separate the buildings from their foundations. Then the crew loaded the buildings onto special trucks, which carried the buildings to a staging (storage) area.

Once the new site was prepared, the contractor transported the building halves to the new site, removed them from the truck, and placed them on new foundations. The contractor used new materials to seal the ends of the buildings. The new housing complex contains eight buildings with 30 living units plus laundry facilities. After the ends of the buildings were enclosed, the contractor renovated the buildings' interiors and painted the exteriors.

During building removal, 24 tons of wood were ground into mulch; over 2 tons of metal, including the fire escapes and appliances, were

Materials Collected

Recycled
miscellaneous metal (fire escapes, appliances), and wood

Reused
struts, joist, rafters, sub floor, floor stringers, framing, exterior shingles, and plumbing fixtures

recycled; 2 tons of plumbing fixtures were salvaged; and 42 tons of gypsum wallboard, vinyl flooring, wood, and shingles were landfilled.

Costs/Benefits

The Bagley Downs project not only diverted over 112 tons of demolition and construction materials, and supplied the city with 30 additional affordable housing units but also saved the University of Oregon demolition costs and the city of Eugene construction costs. The University of Oregon, which was originally going to demolish the structures, saved approximately $40,000 in demolition costs and over $5,000 in avoided disposal costs. A similar, new 30-unit complex would have cost the city over $2.3 million to construct. Therefore, by reusing the structures, the community saved $1.07 million in the construction of affordable housing.

The overall project costs of $1.25 million included the removing, transporting, and renovating the complex. Planning and development costs of $50,000 were spread across the project and included creating partnerships with the student coalition, the University of Oregon, the City of Eugene, and Lane County. During building removal, labor costs were increased because it took longer for crews to move the units than it would have taken demolition crews to raze them. Equipment costs, however, were similar to those of demolition since large trucks were necessary to move the structures. Hauling and tip fees for recyclables totalled $48 per ton and a local salvage operation removed and hauled salvageable materials at no cost.

During the construction phase, labor costs were greatly reduced by avoiding the need to construct a large portion of the buildings. The cost of using large trucks while moving the buildings was slightly higher than the equipment costs of new construction. The largest savings for the city resulted from the reuse of the structures and their components.

Project Summary

Date Started	Spring 1993
Date Completed	Summer 1995
Project Square Footage	20,000
Total Waste Generated (Tons)	**154.5**
Disposed (Tons)	**42.0**
Total Materials Diverted (Tons)	**112.5**
Recycled	26.5
Reused/Salvaged	86.0
Total Materials Diverted	**73%**
Total Project Cost	**$1,250,000**
Hauling and Disposal Costs ($/ton)	**$48**
Costs of Moving Building and Materials Diversion	
Planning and Development	$50,000
Labor	NA
Hauling and Tip Fees	NA
Revenue/Savings from Moving Building and Materials Diversion	
Revenue from Materials Sales	NA
Savings from Materials Reuse	NA
Savings from Avoided Disposal	$5,400
Estimated Cost of Demolition	**$40,000**
Estimated Cost of Similar New Construction	**$2,320,000**
Savings from Moving Building and Materials Diversion	**NA**
Savings Per Square Foot from Moving Building and Materials Diversion	**NA**

Key: NA = not available.

Notes: Estimated cost of demolition refers to the cost the University of Oregon would have incurred for demolishing the 32 units that were moved. The University of Oregon estimated the demolition cost based on the cost of removal of the remaining units. The estimated cost of construction refers to the cost that the City of Eugene would have incurred to construct a similar complex. SVDP estimated the construction cost of 30 units based on a $2.78 million, 36-unit apartment construction project SVDP finished in 1998.

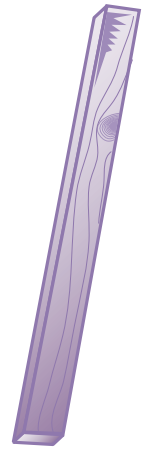
Source: Institute for Local Self-Reliance and Rebecca Lawson, Saint Vincent de Paul, 1999

Source: Rebecca Lawson, Saint Vincent de Paul

Contractor moving one of the buildings for the Bagley Downs apartment complex

Tips for Replication

- Carefully plan the project and coordinate with all participants.
- Watch project costs carefully.
- Work to develop collaborative partnerships among the client/developer, contractor, community, and other involved parties.
- Encourage community participation and seek public support.
- Allot enough time for project completion.
- Use experienced building movers in order to decrease time and cost.



Client/Developer:
St. Vincent de Paul
705 S. Seneca
P.O. Box 24608
Eugene, Oregon 97402
Contact: Anne Williams (Housing Programs Director)
Phone: 541-687-5820 Fax: 541-683-9423
Web site: http://www.svdplanecounty.org

Architect
Donald H. Micken
1948 Olive
Eugene, Oregon 97405
Contact: Don H. Micken (Staff Architect)
Phone: 541-343-1990

General Contractor
2G Construction
1719 Irving Road
Eugene, Oregon 97402
Contact: David Coleman (Project Manager)
Phone: 541-689-3850 Fax: 541-689-3915

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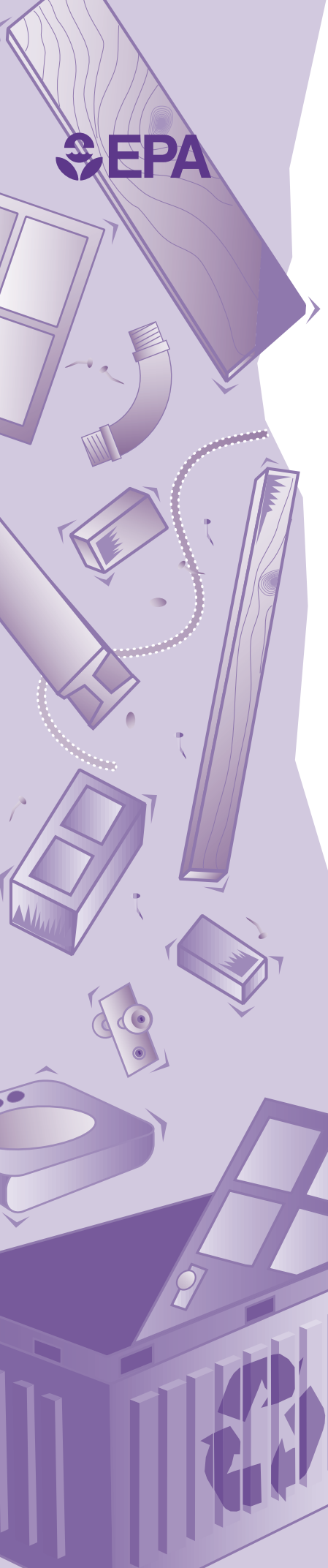
Erickson's Diversified Corporate Headquarters

Hudson, Wisconsin

69% Reduction of Construction Materials



Erickson's Diversified Corporation, a company that develops and manages grocery stores, decided to incorporate environmental considerations into the construction of its new headquarters. In order to reduce the impact on area landfills, Erickson's, along with its consultants and contractor, developed a materials management plan that required diversion of 75% of construction discards by volume. Erickson's reached this goal, diverting 69% of the materials by weight.

Project Description

Although the concept of recovering construction materials was new to Erickson's Diversified, it developed a materials management plan that recovered 75% by volume (69% by weight) of C&D debris generated during the construction of its new headquarters.

The newly constructed headquarters, with almost 28,000 square feet of floor space, consists of two floors and a basement garage.

Implementation of the materials management plan was responsible for much of the project's success. The plan provided subcontractors with instructions on reduction, reuse and recycling techniques, and sorting methods. It required each subcontractor to:

- complete a report on their predicted C&D debris generation;
- designate a contact person who would attend staff meetings and inform other crew members about C&D debris management requirements and project progress;
- source separate materials and document materials generated using a Waste Management Periodic Report;
- minimize storage and packaging discards;
- consider the reuse potential of temporary construction materials such as bracing; and
- use standard size product samples, such as tile, so the samples could be used in the final construction.

Good communication among team members was another major factor in the success of the project. The client, contractor, and consultant presented the project's goals and objectives to subcontractors and their crews in simple, easily understood terms. The client reinforced its commitment to achieving environmental goals by attending weekly site meetings and talking with workers. The project consultant wrote and periodically dispersed newsletters informing all workers of the project's

Materials Collected

Recycled

aluminum cans, cardboard, concrete, miscellaneous metal (cut offs, banding, from shipments, ducts, steel stud cut offs, mattress springs, roof metal, rebar, roof decking), office paper, wood (cut offs, pallets, crating and packaging, old forms)

Salvaged for Reuse

bricks, canvas bags, carpeting, concrete curing tarp, concrete mix, gypsum board, insulation, lumber, miscellaneous metal, metal angle, plywood, steel frames, stone caps and remnants, wire spools, wood and pallets

progress. The consultant invited the general contractor and subs to go on field trips to recycling facilities to reinforce the purpose of recovery. Also, workers were reminded of the project's objectives through daily interaction with lead contacts, the project superintendent, and the project manager. Even the hauler helped facilitate materials recovery and reduce contamination by finding available space for recycling bins, and providing signs labeling each bin.

Erickson's Diversified and its contractor encountered no major obstacles during the project and found that it was easy, cost-effective, and enjoyable to create a C&D debris management plan and implement it on the construction site.

Costs/Benefits

During the construction of its new headquarters, Erickson's Diversified discovered that materials recovery saves money. Initially, the contractor estimated that materials recovery would increase the project costs because of the need for additional recycling bins and separation of recyclables. However, materials diversion costs were less than predicted and, in fact, project costs would have been more if Erickson's Diversified had not required their general contractor to recover construction debris. Recovering the 185 tons of materials diverted required more planning and labor than would have been necessary if the materials had been disposed. For example, Erickson's Diversified paid a consulting firm over $4,300 for planning, developing, and reporting upon the project's progress. The general contractor incurred additional labor costs for source separation and additional crew training. Not all materials recovery methods increased costs. Labor costs were lowered through the reduction of packing materials, because crew members spent less time unpacking materials and hauling packaging to the bins. The hauler handled the removal of recyclables and charged lower rates for this service than for landfilling.

Erickson's Diversified donated all reusable materials to the public and did not receive any revenue from materials diversion.

Source: Amy Briesacher, Erickson's Diversified

Erickson's hauler placed labeled bins for recyclables on the project site.

Project Summary

Date Started	November 1995
Date Completed	December 1996
Project Square Footage	28,000
Total Waste Generated (Tons)	**270.6**
Disposed (Tons)	**85.3**
Diversion (Tons)	**185.3**
Recycled	157.3
Salvaged	28.1
Total Materials Diverted	**68.5%**
Total Construction Cost	**$4,700,000**
Hauling and Disposal Costs ($/Ton)	**NA**
Materials Diversion Costs (Savings)	
Planning and Development	$4,300
Labor	NA
Materials/Equipment	NA
Hauling and Tip Fees	NA
Revenue / Savings from Materials Diversion	
Revenue from Materials Sales	$0
Savings from Materials Reuse	$0
Savings from Avoided Hauling and Disposal	NA
Cost/(Savings) from Diversion	**NA**
Cost/(Savings) per Square Foot	**NA**

Key: NA = not available.

Source: Institute for Local Self-Reliance, Paul Kolias (Watson-Forsberg Co.), and Joel Schurke (LHB Engineers & Architects); 1999

Tips for Replication

- Establish a clear numerical goal for the project.
- Choose a general contractor and subcontractors who can demonstrate a commitment to reducing disposal.
- Provide source reduction, reuse, and recycling forms to project managers and haulers to make data reporting easier.
- Communicate the goal and report project progress, success, and failures to everyone involved.
- If possible, hire haulers who can offer all-inclusive recycling and waste hauling services.

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United States
Environmental Protection
Agency

Solid Waste and
Emergency Response
(5306W)

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Four Times Square

New York, New York

58% Reduction of Demolition and Construction Materials

As of its fifth quarter of construction, the Four Times Square office tower project has demonstrated that materials recovery makes good sense and can save money. By March 1999 , project participants had diverted an average 58% of total demolition and construction discards (59% by weight of demolition debris and, so far, 58% by weight of construction discards) from disposal. Contractors saved over $780,000 in disposal fees and earned over $105,000 in revenue from materials sales by diverting 17,800 tons of materials from disposal.

Project Description

Four Times Square is a 48-story office tower located at the intersection of Broadway and 42nd Street. It is the first office tower to be built in Manhattan since 1988. It is also, due to the commitment of its owners, one of the first office towers of its size designed to address environmental building issues, such as energy efficiency and indoor air quality. The implementation of responsible construction techniques led to the recovery of 58% of overall demolition and construction debris.

The project involved both a demolition phase and a construction phase. Before construction could begin, crews had to remove six buildings. Extensive salvage combined with recycling resulted in the recovery of over 15,000 tons of materials. Prior to demolition, private groups removed all salvageable materials such as doors, copper facial corners, and 112 tons of wood beams. As the structures were removed, the waste hauler carted away over 15,800 tons of metal and rubble for recycling, and the demolition contractor disposed of almost 11,100 tons of materials including unsalvageable bricks and commingled wood, insulation, and gypsum board.

To assure that materials were recovered during the construction phase, project coordinators worked closely with the demolition contractor and required it to report tonnage data on materials recycled or reused. Prior to construction, the owners, principal architects, and construction manager held a pre-construction meeting with the construction contractors to discuss the importance of materials efficiency and recovery. The environmental consultant adjusted the contract to include language that maximized recovery. She also created forms that contractors could use to anticipate packaging waste

Source: Pamela Lippe, Durst Organization

Project participants recycled nearly 2,000 tons during the construction of the Four Times Square building.

Materials Collected

Recycled
(Demolition) steel, scrap metal, brick, concrete, dirt, (Construction) aluminum, miscellaneous metal, cardboard, wood, dirt, and rock

Salvaged for Reuse
ornate stone work, office doors, copper facial corners, and wood timbers.

generated during the construction process. The construction management firm threatened to withhold payments unless the contractors adhered to the contract and completed the forms. Although some contractors were reluctant to complete the forms, no payments were withheld. By the fifth quarter of construction (March 1999), the contractor had recovered 1,900 tons of the construction debris generated.

There was little room to sort and collect recyclables, no space to place drop-off containers, and no room for multiple trucks to pick up materials for recovery or disposal at the construction site. Hoist and elevator operators, busy performing construction tasks, had little time to make multiple trips to move recyclables. Instead the contractor practiced "post-collection recycling" by having all debris hauled to a central site and then sorted.

In addition to recovering materials for reuse and recycling, contractors practiced source reduction during the project. Contractors reduced waste by requiring suppliers to reduce packaging or use durable packaging and by returning some packaging, such as pallets, to suppliers.

Project Summary

Date Started	August 1996
Projected Date of Completion	July 1999
Project Square Footage	
Demolition	462,500
Construction	1,600,000
Total Waste Generated (Tons)	**30,314**
Demolition	27,027
Construction	3,287
Disposed (Tons)	**12,480**
Demolition	11,097
Construction	1,383
Total Materials Diverted (Tons)	**17,833**
Recycled	
Demolition	15,805
Construction	1,904
Salvaged	
Demolition	125
Construction	0
Total Materials Diverted	**58.4%**
Demolition	58.9%
Construction	57.9%
Disposal Costs ($/ton)	
Landfill	$44
Revenue/Savings from Demolition Materials Diversion	
Planning and Labor Costs	NA
Tip Fees for Recyclables	NA
Revenue from Materials Sales	$92,375
Value of Materials Salvaged	$12,500
Savings from Avoided Disposal	$700,920
Revenue / Savings from Construction Materials Diversion	
Planning and Labor Costs	NA
Tip Fees for Recyclables	NA
Savings from Avoided Disposal	$83,755
Total (Savings) from Diversion	**NA**

Key: NA = not available.

Notes: Data reflects figures as of March 1999, before construction was complete. Contractors received all revenue from materials sales. Hauling costs for materials landfilled were not available. Materials diversion through source reduction is not reflected in the percentage of materials diverted.

Source: Institute for Local Self-Reliance, Pamela Lippe, and Mel Ruffini; 1999

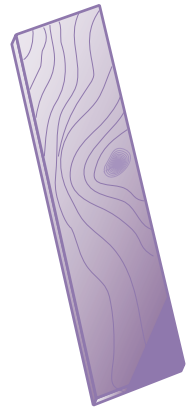
Costs/Benefits

The project contractor realized all savings resulting from materials recovery. The building owners chose to use the possibility of savings as an incentive to encourage recovery and lower contract costs rather than collect the savings themselves. Although cost data attributed to materials recovery are unavailable, the environmental consultant reported that the materials recovery was cost-effective. Disposal tip fees of $44 per ton saved the demolition contractor over $700,000 in avoided disposal costs and the construction contractor over $83,000 from avoided disposal as of March 1999. When combined with the revenue received from the sale of steel and scrap metal ($92,375), wood beams ($7,500), and other salvaged materials ($5,000), the demolition contractor believes these savings far outweighed waste reduction costs for planning, additional labor, and tip fees for recycled materials. The planning and development costs included the fees of the environmental consultant for writing additions to contracts, creating materials tracking forms, organizing team meetings, and overseeing all materials recovery efforts.

Project facilitators considered post-collection recycling the most cost-effective materials recovery technique, because on-site labor was very expensive.

Tips for Replication

- Obtain instructions from the top and communicate them to all project participants.
- Educate contractors about materials recovery techniques and the importance of resource conservation. Ask for their help.
- Ask contractors to avoid generating waste by using reusable containers and requesting materials with reduced packaging.
- Require contractors to estimate waste generated on site, including packaging, so you can anticipate the nature and amount of the recyclable materials that will be generated on site.
- Encourage communication among the client, project facilitators, and contractors.



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United States Environmental Protection Agency
Solid Waste and Emergency Response (5306W)
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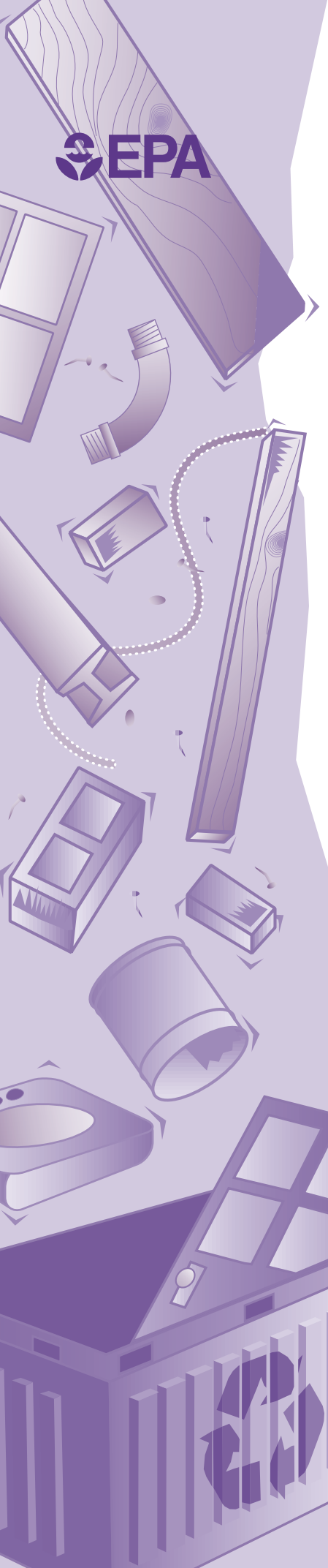
Marion County Senator Block

Salem, Oregon

82% Reduction of Demolition Materials



Marion County and Salem Area Transit saved almost $160,000 when their contractor demolished all the buildings on the city's Senator Block to make space for Salem's new courthouse square. The contractor exceeded the county's landfill diversion goal of 90% by diverting 92% of demolition materials: 13,700 tons (82%) through recycling and reuse, and 1,600 tons (10%) through the generation of wood chips for use as fuel in industrial boilers. Recycling and reuse saved Marion County and Salem Area Transit over $165,000. An additional $58,000 in equipment and labor costs for materials recovery were offset by $188,000 savings in hauling and disposal tip fees and $36,000 in revenue from materials sales.

Project Description

In 1997, Marion County set an example for other demolition projects in the area when it required its demolition contractor, Staton Companies, to divert waste from area landfills while clearing the site for Marion County's new courthouse square and transit station. The county set a goal of 90% landfill diversion based upon its research of other recovery efforts.[1]

The Marion County Senator block consisted of seven buildings, including a parking garage, retail stores, and an apartment building. Prior to demolition, Marion County's Facility Management Department salvaged more than 20 types of items for future reuse, such as light fixtures, air conditioners, and fire prevention equipment. The contractor's crews then removed metal pipes and HVAC ducts from each room using a small loader. The crews also removed asphalt roofing, concrete, and wood, such as large, old growth timbers, small timbers, and doors.

After salvage operations were completed, the contractor's crew demolished the buildings using a large track excavator and a crane with a wrecking ball. The crew then sorted the remaining wreckage, both mechanically and by hand and delivered metal (590 tons), asphalt and asphalt roofing (845 tons), and concrete (11,571 tons) to local recycling companies. These companies recycled these materials into new metal, roadbed mix, and slope stabilization materials. In response to calls from local residents requesting bricks, the contractor had crew members sort 661 tons of bricks into a pile and surrounded the pile with a safety fence. The county then sponsored the "Great Brick

Materials Collected

Recycled

scrap metal (including HVAC ductwork, framing, pipes, conduit, lighting fixtures, structural steel, doors and window frames), structural lumber and trees and stumps, asphalt and asphalt roofing, and concrete

Salvaged for Reuse

bricks, wood (including old growth and small timbers), engraved cinder blocks, marble fireplace, windows, safety equipment (including emergency lights, fire alarm pulls and bells, fire extinguishers , and sprinkler heads), electrical breakers, light fixtures, lighting controls and sensors, time clocks, electrical outlets, water heaters, heat exchangers, circulating pumps, water meters, air conditioners, heaters, thermostats, humidifiers, handicapped accessibility fixtures,toilets and urinals, and doors

Giveaway," a program inviting citizens to take the bricks for reuse. The contractor delivered 1,578 tons of wood to a processor for chipping and use as industrial boiler fuel and the remaining 1,345 tons of mixed demolition materials to various local landfills.

The Marion County Solid Waste Management Department used the demolition as a tool to educate the public about recycling. The County placed advertisements on TV and radio, publicized materials giveaways in the newspaper, and placed highly-visible site banners illustrating the recycling rate of the project.

Project Summary

Date Started	May 1997
Date Completed	August 1997
Project Square Footage	178,780
Total Waste Generated (Tons)	**16,649**
Disposed (Tons)	**2,923**
Landfilled	1,345
Wood Chips for Fuel	1,578
Total Materials Diverted	**82%**
Total Materials Diverted (Tons)	**13,726**
Recycled	13,006
Salvaged for Reuse	720
Total Demolition Cost	**NA**
Hauling and Disposal Costs ($/Ton)	
Landfilled	varied
Incinerated for Energy Recovery	$28
Materials Diversion Costs	
Planning and Development	$0
Labor	$22,500
Equipment	$35,900
Hauling and Tip Fees	$94,500
Revenue/Savings from Materials Diversion	
Revenue from Materials Sales	$36,000
Savings from Avoided Hauling and Tip Fees	$283,000
Cost/(Savings) from Diversion	**($165,700)**
Cost/(Savings) per Square Foot	**($1)**

Key: NA = not available

Notes: Figures may not add to total due to rounding. Disposal tip fees varied by type of materials disposed. Savings from avoided disposal resulted from avoiding costs of hauling and disposing of metals, timbers, bricks, asphalt roofing, concrete, and asphalt. Tonnage diverted does not include materials salvaged by the county because the county did not track these materials tonnages. Materials diverted through salvage by the contractor includes 661 tons of bricks, 56 tons of old growth timbers, and 279 doors (approximately 3 tons).

Source: Institute for Local Self-Reliance, Marion County, Staton Companies, and Harding Lawson Associates; 1999

Costs/Benefits

The County and Salem Area Transit saved over $160,000 ($1 per square foot) by diverting demolition waste. The project was cost-effective because of a savings in hauling and disposal fees for waste. The contractor paid $94,500 to haul and tip recyclable materials. Disposal of these materials would have cost $283,000.

The savings from avoided disposal combined with $36,000 in revenue from materials sales offset the cost of 577 additional labor hours ($22,500) and $35,900 in heavy equipment that were required to sort materials. Revenue from the sale of metal and timbers were $25,000 and $11,000, respectively. The contractor paid to tip all other recyclables.

The contractor did not recover materials, with the exception of asphalt roofing, if the cost was more to recycle it than to dispose of it. According to the contractor, window glass, ceiling tile, and gypsum wallboard could have been recycled, but the hauling and removal costs would have been more than the materials revenue and disposal savings. The contractor also chose to dispose of most of the mixed demolition materials from the largest building because sorting concrete and steel from gypsum board and insulation was too costly.

Overall, the County and Salem Area Transit reduced their demolition costs by 5% and stockpiled tons of reusable building components while diverting 82% of demolition materials from disposal.

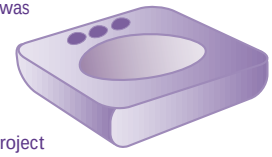
Source: Bonnie McCullough, Marion County

Contractors demolished an entire city block to make way for Salem's new Courthouse Square.

Tips for Replication

- Be careful not to contaminate the recovered materials, so that the materials can be delivered to the processor in a usable form.
- Include reuse, recycling, and waste prevention strategies early in the process.
- Set a goal and require the contractor to recycle.
- Involve and educate the public.

[1]Marion County's goal was based on avoiding landfill disposal. According to its definition, the County surpassed its goal; diverting 82% of the project demolition materials through recycling and reuse and 10% through burning of wood chips as industrial boiler fuel. EPA considers incineration to be disposal; therefore, by EPA's definition, Marion County's diversion rate for the project is 82%.



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Solid Waste and Emergency Response (5306W)
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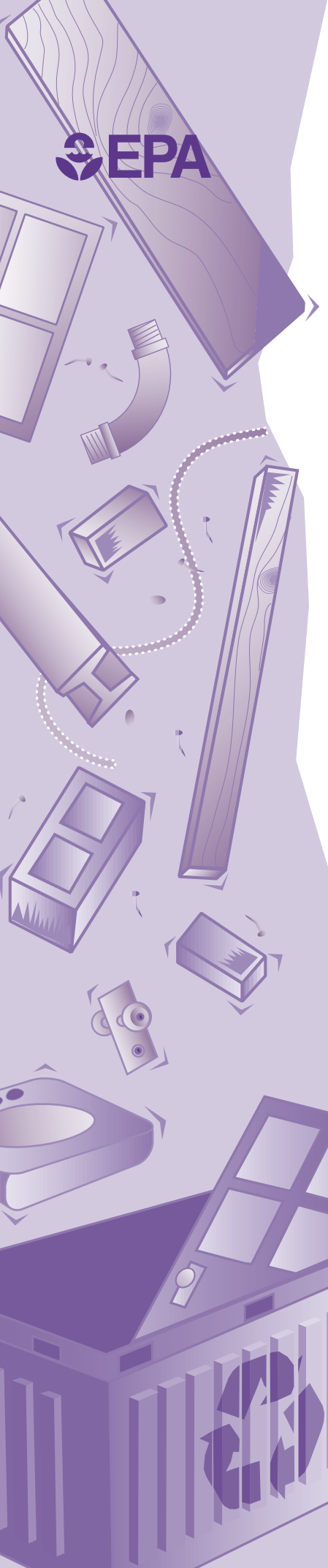
Ridgehaven Green Office Building

San Diego, CA

51% Reduction of Renovation Materials



When the City of San Diego's Environmental Services Department (ESD) renovated the Ridgehaven Office Building into a green building it required that its general contractor divert materials for reuse. The ESD and the city diverted 51% of renovation debris, saved over $93,000, lengthened the life of the local landfill, and showed that cities can help meet California's AB 939 law through the recovery of construction and demolition material. The general contractor also learned that material diversion makes sense. Despite its initial reluctance to follow the reuse and recycling procedures in the project specifications, the company now recovers materials on all construction projects.

Project Description

In 1994 the City of San Diego's Environmental Services Department (ESD), which manages the city's trash and recycling, expanded its office space by purchasing the Ridgehaven Office Building. The department decided to renovate the office structure as a Green Building Demonstration Project, requiring (1) the use of green building materials (containing recycled content or recyclable) and (2) the reduction, recycling, and reuse of all possible renovation materials. ESD was encouraged to divert materials because of AB 939, California's law which requires all state municipalities to reduce their waste by 50% by the year 2000. ESD's ownership of the city landfill was an additional incentive to reduce construction and demolition disposal from the project.

During the renovation, the general contractor removed all internal components, such as furniture, window blinds, doors and assemblies, gypsum panels from interior walls, and acoustical ceiling panels. Crews then stored these materials for refurbishment and reinstallation.

The general contractor recovered other materials through recycling and salvaging. Crew members hand-sorted recyclables into bins and took them to nearby processors. Workers also removed 3,700 square yards of carpet, 450 light fixtures, and 60 mechanical heat pumps. Salvaging companies then removed salvageable materials for reuse by others, saving the city removal, hauling, and tipping fees.

The general contractor's reluctance to recycle was initially an obstacle to materials recovery. The project specifications included requirements, developed by the environmental consulting architect, for the salvage and reuse of building materials and the recycling of construction debris. Project facilitators (ESD, the project architect, and the environmental consulting architect) worked together to assure

Materials Collected

Recycled
scrap metal, concrete, wood (including pallets), cardboard, ceramic toilet fixtures, gypsum wallboard, and cellulose insulation

Reused On-Site
wall panels, acoustical ceiling panels, doors (including frames, thresholds, and hardware), wall coverings, and cabinets and shelves

Salvaged for Reuse
carpet, light fixtures, and mechanical heat pumps

that the contractor followed these specifications. As part of this joint effort, ESD labeled site dumpsters for recycling, clearly identifying them for separate materials.

Another difficulty encountered during the project was the theft of recyclables from the site. These thefts served to illustrate the value of recyclable materials.

Costs/Benefits

Traditionally, debris from most renovation projects are disposed in landfills. ESD, however, saved $93,000 by diverting 51% of the materials removed during their renovation of the Ridgehaven Green Office Building. This savings convinced the general contractor to practice recycling on future projects.

Planning costs were incurred for developing the environmental procedures, which addressed the reuse, salvaging, and recycling of renovation materials; educating and training the general contractor, subcontractors, and crew; and checking to assure that the project's environmental specifications were followed. During the project, additional labor was required to remove, refurbish and reinstall the wall panels, ceiling tiles, doors and door frames, and window blinds. Source separating recyclables also required more labor than simply throwing all renovation materials into one container. Neither the contractor nor ESD paid any fees to haul or tip recyclables.

ESD offset the labor, hauling, and planning costs for the materials recovery program with a $68,800 savings in avoided materials purchases on the Ridgehaven project, the salvage of $15,000 worth of components for use in later projects, over $1,200 in materials revenue, and $21,500 in avoided hauling and disposal fees. The general contractor refurbished and reused many materials, such as wall panels, doors and assemblies, and ceiling tiles, at a lower cost than purchasing new items. The city received materials revenue from the sale of 28 tons of scrap metal ($1,136) and 4 tons of cardboard ($113). The contractor also saved by avoiding the removal, hauling, and tipping of 3,700 square yards of carpet ($10,000); 450 light fixtures ($3,000); and 60 mechanical heat pumps ($2,000), which were salvaged for off-site reuse. Furthermore, total subcontractor costs were $13,500 lower than projected as a result of the waste reduction efforts.

Source: Lynn M. Froeschle, AIA, CSI; © 1996

More than half of the debris was recovered during the renovation of the Ridgehaven Office Building.

Project Summary

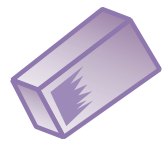
Date Started	1994
Date Completed	1996
Project Square Footage	73,000
Total Waste Generated (Tons)	**366.0**
Disposed (Tons)	**180.0**
Total Materials Diverted (Tons)	**186.0**
Recycled	80.1
Reused On-Site	62.3
Salvaged for Later Reuse	43.6
Total Materials Diverted	**51%**
Disposal Tip Fee ($/ton)	
Landfill	$43
Materials Diversion Costs	
Planning and Development	$13,500
Labor	$13,500
Hauling and Tip Fees	$0
Revenue / Savings from Materials Diversion	
Materials Sales	$1,250
Materials Reuse On-Site	$68,800
Materials Salvage	$15,000
Avoided Disposal	$8,000
Avoided Hauling	$13,500
Subcontracting Fees	$13,500
Cost/(Savings) from Diversion	**($93,050)**
Cost/(Savings) per Square Foot	**($1.27)**

Notes: Figures may not add to total due to rounding. Lynn Froeschle estimated materials diversion costs, savings from avoided hauling, and savings from avoided subcontracting fees as a percentage of the total project costs.

Source: Institute for Local Self-Reliance, and Lynn M. Froeschle, AIA, CSI; 1999

Tips for Replication

- Ensure that the client, the design team, and the contractor share the same environmental goals.
- Identify all possible recyclable and reusable materials prior to renovation.
- Include environmental procedures in the project specifications that address construction materials reuse and recycling.
- Require the contractor to develop a construction recycling plan that compliments the project specifications.
- Host a pre-construction meeting and site meetings early in the construction process in order to educate the contractor and workers on the benefits of materials recovery.



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Solid Waste and Emergency Response (5306W)
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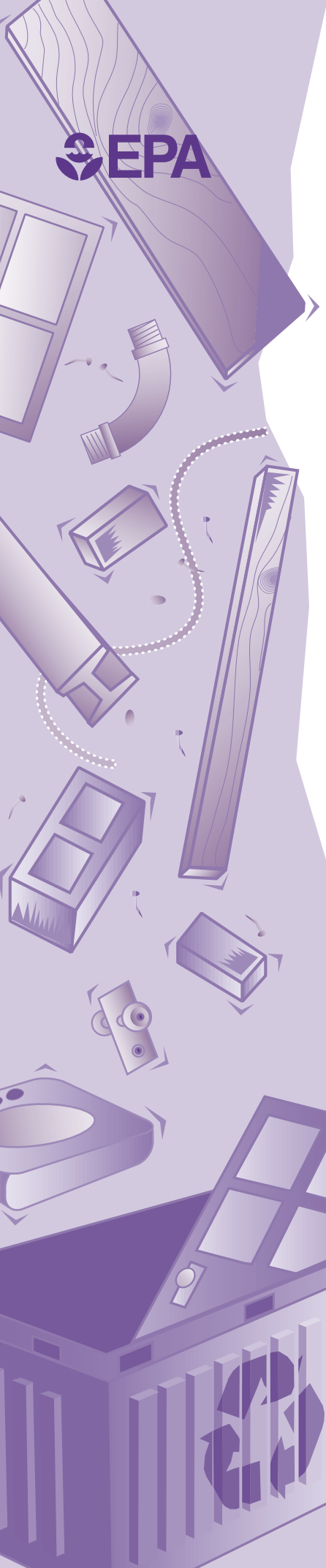
Stowe Village

Hartford, Connecticut

50% Reduction of Demolition Materials



As an alternative to demolition, the Hartford Housing Authority undertook a demonstration project that trained nine public housing residents to deconstruct (hand-dismantle) six public housing units in Stowe Village. Upon completion of the project, the workers had recovered 50% of the materials from the buildings (40% through salvage and 10% through recycling).

Project Description

In fall 1998 the Hartford Housing Authority (HHA) tested an alternative to traditional demolition for removing obsolete buildings from the Stowe Village public housing complex. The complex, built in 1953 and located in the northern section of Hartford, Connecticut, comprised 31 residential buildings (598 units) and related support structures. In this pilot project, staff trained public housing residents in deconstruction techniques (hand-dismantling) while removing Building #28, an 8,250-square-foot building containing six housing units.

HHA's primary project goal was to extend its Family Reunification and Employment Program, which encourages parents to assume their responsibilities as family members and community residents. Because of this goal, the HHA was the first housing authority to require a deconstruction training program as part of development proposals. The project general contractor, Manafort Brothers, Inc. worked with the HHA, Self-Reliance Inc., and the Laborers' International Union to recruit and train nine public housing residents in deconstruction techniques. The general contractor entered into partnership with the HHA and the nine resident workers to form the Hartford Community Deconstruction Service Company.

Source: Manafort Brothers, Inc.

Crews recovered 50% of Building #28 at Stowe Village through recycling and salvaging materials for reuse.

Prior to building removal, a skilled examiner reviewed and documented all salvageable materials. The crew members of the Deconstruction Service Company then removed the plumbing and electrical fixtures, windows, floors, non-load bearing walls, ceiling, roof rafters, and sub-flooring. Crew members dismantled the windows and aluminum frames, and removed, denailed, trimmed, and stacked all salvageable lumber on site. Then a demolition crew, using heavy equipment, knocked down the outer walls and remaining roof components, and removed the foundation. Deconstruction

Materials Collected

Recycled
metal (copper, aluminum, ferrous); cement, aggregate, wood

Salvaged for Reuse
lumber (flooring, roof rafters, floor joist, wall studs); cast iron radiators, sinks, aluminum frame windows, bricks

workers finally gleaned the piles of rubble to recover usable bricks and wood. When finished, the deconstruction crew had recovered 109 tons of materials from Building #28. The remaining materials were removed by a demolition firm for processing (27 tons) and disposal (136 tons).

Costs/Benefits

Because the deconstruction of Building #28 was a pilot project that involved training, the cost of deconstructing the building was higher than normal. A great deal of planning and development was necessary to implement the program. The recovery of materials (such as plasterboard and small wall studs) for training purposes greatly increased the cost of labor. The one-time planning and development cost ($20,000) included the costs of organizing meetings, training deconstruction workers, and recording and reporting data. Once trained, deconstruction crews working in collaboration with an established demolition firm could deconstruct the same square footage for an estimated $10,000 in labor. This would reduce the labor cost on future deconstruction projects by 83%. Therefore, trained crews could deconstruct buildings of similar square footage and materials composition as Building #28 at a cost of $2 per square foot, $1 less than the general contractor's estimate for traditional demolition.

Deconstruction costs of Building #28 were reduced by $300 in revenue from metal recovered for recycling, $8,610 in revenue from sales of salvaged materials, and over $3,000 from avoided hauling and disposal costs. The potential net deconstruction costs on future projects would be reduced to a total of $1 per square foot if these revenues and savings were combined with reduced labor and planning costs.

Overall, the project coordinators believe that the Stowe Village Project achieved the HHA's primary goal and proved to be a cost-effective training program. The project coordinators estimated that deconstruction training cost only $5,600 per worker. The industry/government standard cost for training a worker is $15,000.

Source: Manafort Brothers, Inc.

Crew members hand-dismantling Building #28 at Stowe Village.

Project Summary

Date Started	October 1998
Date Completed	December 1998
Project Square Footage	8,250
Total Waste Generated (Tons)	**265.5**
Disposed (Tons)	**132.8**
Total Materials Diverted (Tons)	**132.8**
Recycled	26.6
Reused	106.2
Total Materials Diverted	**50%**
Hauling and Disposal Costs ($/ton)	**$23**
Net Deconstruction Costs	**$72,107**
Planning & Development	$20,000
Labor	$60,400
Hauling and Recycling Fees	$617
Disposal Tip Fee	$3,083
Materials Sales	($300)
Materials Salvaged	($8,610)
Avoided Disposal	($3,083)
Net Cost per Square Foot	**$9**
Potential Net Deconstruction Cost	**$4,700**
Labor	$10,000
Hauling and Recycling Fees	$600
Disposal Tip Fee	$3,100
Miscellaneous	$3,000
Materials Sales	($300)
Materials Salvaged	($8,600)
Avoided Disposal	($3,100)
Potential Net Cost per Square Foot	**$1**

Notes: SRI calculated potential cost and revenue/savings based upon the following assumptions: (1) at least 30% deconstruction of a building equivalent to Building #28 in size, location, and materials composition; (2) the deconstruction performed in joint-venture with an established demolition company; (3) $23 per ton hauling and disposal costs; (4) $600 for hauling and recycling tip fees; (5) miscellaneous costs including 15% of total for overhead, equipment, and cost of sales; and (6) a crew of five fully-trained deconstruction workers receiving wages and benefits of $200 per day.

Source: Institute for Local Self-Reliance; 1999

Tips for Replication

- Use the request for proposals process to identify a developer and contractor that are experienced with and/or are willing to practice materials recovery.
- Use the Laborers' International Union to train workers in materials recovery methods.
- Carefully track all data on materials recovery and communicate the results to all involved parties.
- Involve city agencies to gather political and financial support.

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United States Environmental Protection Agency
Solid Waste and Emergency Response (5306W)
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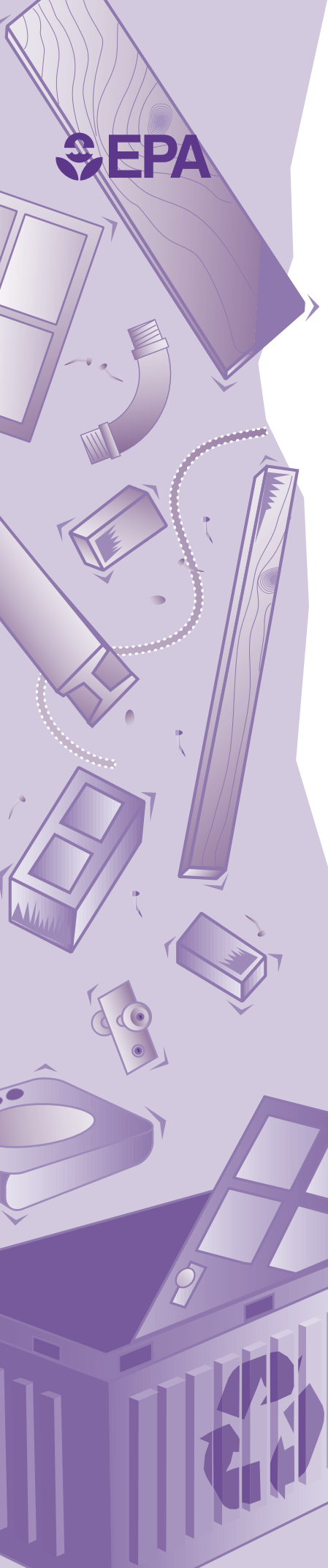
www.epa.gov/osw

Whole Foods Market Corporate Headquarters Building

Austin, Texas

42% Reduction of Renovation Materials



When Whole Foods renovated its corporate headquarters in fall 1998, with the goal to create a "green" commercial building, it required all contractors to reduce, reuse, or recycle their waste. Contractors recovered 42% of the project waste while saving Whole Foods over $2 per square foot. Whole Foods reached this reduction level despite being located in a city that has few established markets for recyclables and four landfills that keep disposal rates low.

Project Description

Whole Foods expanded its corporate headquarters by renovating 4,000 square feet on the third floor of its existing building and over 11,500 square feet on the third floor of an adjacent building. The renovation involved removing all existing materials except for the frame and exterior wall. In order to create a seamless transition between the two buildings, the contractor had to lower one part of the floor and raise the roof of the adjacent building. Whole Foods began planning for the expansion in January 1998 with an overall goal to create a "green" commercial structure within reasonable cost and available technology. To meet this goal, Whole Foods allowed a 10 percent price preference for sustainable building techniques and materials, and the project manager required all contractors to reduce, reuse, and recycle, C&D debris.

The project manager, who was also the sustainability consultant, included a section in the project contract on materials management. This section specified acceptable procedures for reusing and recycling renovation materials. The project manager also required contractors to complete a *Summary of Waste Generated and Recycled for the Project* form. To enforce the provisions in the contract, Whole Foods did not process payments unless the general contractor submitted this form. As an incentive for crew members, the contract allowed for a portion of materials sales revenue to fund refreshments for them.

The general contractor was in charge of all materials management, including recycling structural steel and other metals, and salvaging other building materials. The builder used many salvaged materials in the renovation and donated other reusable materials to various organizations, such as Habitat for Humanity. Overall, project participants diverted 42% of materials generated during the renovation from disposal.

Because the renovation took place on the

Materials Collected

Recycled
structural steel, miscellaneous metals (metal studs, ceiling grid and support wire, conduit, strapping from lumber and deliveries, tubing, piping, and rebar), and cardboard

Reused On-site
mop sink, fire-rated ceiling tiles, light fixtures, HVAC devices, and fire-rated doors and hardware sets

Donated
carpeting, spotlights and track lights, wooden doors, plywood, medium density fiberboard (MDF), soundboard, accordion-folding wall, ceramic floor tile, ceiling fans, cabinets, mirrors, and structural wood and flooring

third floor, staff had to load all materials into a freight elevator and transport it through the loading dock. The loading dock had only enough space for one 30-cubic-yard roll-off at a time and, therefore, staff had to rotate roll-offs for disposal and recycling. Staff had to store materials on the job site until they could be placed into the appropriate roll-off.

Costs/Benefits

The Whole Foods Market Corporate Headquarters Expansion Project has not only served as a prototype for "green" commercial building in Austin, but was also cost-effective. By recycling and reusing materials, Whole Foods saved over $32,000. Even though the company was willing to pay more for using sustainable building techniques, it actually paid less. Reusing materials, such as fire-rated ceiling tile, light fixtures, and HVAC diffusers, saved almost $25,000 in new materials purchases. Avoided disposal saved the project almost $1,200, while revenue from materials recovery totaled over $200. Labor costs for the project totalled almost $83,000 and included costs for the general contractor (6,000 hours), costs for general cleanup (930 hours), and all subcontracted labor. Due to careful planning and the relatively small site area, labor costs for moving materials for reuse to and from on-site storage locations were only $209. Materials diversion did not appear to increase fees subcontractors charged for labor. Materials diversion required additional design, planning, and consulting, which cost approximately $1,400 more than if the project had no materials diversion. Overall, these increased costs were offset by lower costs for waste hauling, disposal, materials purchases, and revenue from materials sales.

Project Summary

Date Started	January 1998
Date Completed	October 1998
Project Square Footage	15,500
Total Waste Generated (Tons)	**55.0**
Disposed (Tons)	**31.8**
Total Materials Diverted (Tons)	**23.2**
Recycled	9.3
Reused	5.4
Donated	8.5
Total Materials Diverted	**42%**
Hauling and Disposal Tip Fees ($/ton)	
Landfill	$51.42
Materials Diversion Costs	
Planning and Development	$1,400
Labor	$209
Hauling and Tip Fees	$0
Revenue/Savings from Materials Diversion	
Revenue from Materials Sales	$226
Savings from Materials Reuse	$24,675
Savings from Avoided Disposal	$1,193
Tax Deductions from Donations	$8,335
Cost/(Savings) from Diversion	**($32,820)**
Cost/(Savings) per Square Foot	**($2.10)**

Notes: Figures may not add to total due to rounding. Shellie Reott calculated savings from materials reuse using avoided purchase price of new materials. Savings from avoided disposal resulted from avoided hauls and disposal of 117 cubic yards of materials.

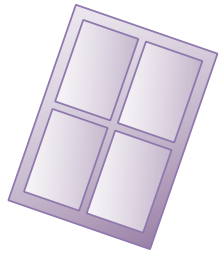
Source: Institute for Local Self-Reliance and Shellie Reott, Earthly Ideas; 1999

Tips for Replication

- Communicate your needs in the specifications and at pre-bid and pre-construction meetings to all players, including the job foreman, materials salesmen, and the project superintendent.
- Involve the general contractor early in the design process.
- Use job-site safety meetings to communicate waste reduction goals.
- Do not over-complicate waste handling guidelines.
- Carefully coordinate reuse of smaller materials such as door hardware.
- Create recycling and waste reduction incentives for the construction crew such as pizza parties and doughnuts for breaks.
- If space is limited, use a separate storage facility for reusable items to avoid unnecessary moving of materials.

Source: Shellie Reott, Earthly Ideas

Contractors sorted over 6 tons of metal into roll-offs for recycling.



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