Appendix I: Recycling Markets

This appendix discusses typical handling procedures, potential problems or barriers to the recovery process, and potential markets or end-uses for the most common debris generated by construction and demolition including concrete, asphalt paving and roofing, gypsum wallboard, metals, wood, corrugated cardboard, glass and fiberglass, and plastics. Up-to-date manufacturers listings of reused, recycled-content, and by-product based building materials are provided in **Appendix III: Product Directories and Sourcebooks**.

Concrete

Concrete is a mixture of cement and aggregate. It is one of the most common construction materials and can be wasted in great quantities if major building, bridge, or road demolition occurs. Concrete debris can be recovered using one of two strategies: (1) crushing onsite and reusing it as compacted base or drain material, or (2) hauling it to a recycling facility that usually handles other materials, such as asphalt and wood debris as well. Regardless of which recovery strategy is used, the physical processing of the material does not change: the concrete shards are fed into an impact crusher, followed by an electromagnet that removes reinforcing steel, and finally through a series of screens that grade the aggregate according to its size.

Because recycled concrete has been weakened by previous exposure to weather, traffic, and structural stress and strain, it is not as strong or durable as virgin concrete. For this reason, reclaimed concrete aggregate is mostly reused (as a base material or rip rap for erosion control) instead of being recycled as an aggregate for “new” concrete. However, pavement design is changing to accommodate the new characteristics of recycled concrete aggregate. Concrete shards (without rebar) have always been reused as durable “pavers” for low-cost floors, patios, and walkways or as dry-stacked retaining walls. This application is not very popular, however, due to the bulk and weight of the material and the extent to which it must be transported and handled.

Asphalt Pavement and Roofing

Asphalt pavement is handled and processed like concrete, and many crushing facilities accept both materials. Asphalt pavement debris is produced when the old asphalt is removed during road reconstruction projects. Depending on the situation, the asphalt may be co-mingled with or attached to concrete and crushed rock. Typical end-uses include reusing the asphalt aggregate as base or backfill and recycling the aggregate back into asphalt pavement. Recycling asphalt paving has evolved into standard practice for many highway agencies and paving contractors.

Asphalt-based roofing materials include composition shingles, built-up roofing, and torch-down roofing. Asphalt roofing waste is produced primarily from re-roofing "tear-offs" and demolition projects as well as residual scraps from new construction. Since the mid 1970s, the asphalt composite shingle industry has shifted from the use of organic paper felt based shingles to the more fire resistant fiberglass shingles. The major components of asphalt roofing waste include asphalt, mineral filler and granules, glass fiber matting, organic paper felt, and nails. There are a number of potential end-uses for asphalt roofing waste including asphalt paving mixtures, new roofing materials, hot and cold mix repair compounds, and "waste-to-energy" fuel. Because the asphalt roofing industry manufactured asbestos shingles until the mid-1970s, the process associated with handling asphalt roofing waste will be subject to permitting and regulation. Predominant concerns regarding the performance of a product with recycled asphalt roofing include the compatibility of old and new asphalt and the impact of pulverized paper felt. The recycling of crushed and screened asphalt roofing into paving mixtures presents the greatest opportunity because of the ubiquitous nature of asphalt surfaces.

Gypsum Wallboard

Gypsum wallboard is manufactured from gypsum, which is a low-value, plentiful mineral that exists in large natural deposits. Gypsum is also produced as a byproduct of coal-burning power plants and the phosphoric acid industry, which produces fertilizer. Scraps generated during the construction process are clean; those generated during demolition contain paints and fasteners. Within a landfill, gypsum wallboard produces hydrogen sulfide, which creates an acidic leachate. This phenomenon has caused some municipalities to ban the material from landfills.

Although gypsum has a high potential for recycling, it is not yet commonplace to recycle scraps generated at the construction site. Because of contaminants in the form of wall-coverings and paints, “installed” wallboard is not recycled. The major difficulty in recycling wallboard is separating the paper from the gypsum core. Currently, in the two most established value-added markets, soil amendments and recycled-content gypsum wallboard, paper removal causes recycling to be more expensive than using virgin gypsum. Gypsum can also be combined with cellulostic wood wastes to produce an extremely durable, fire-resistant, and paper-less wallboard. A third product made from recycled gypsum is a lightweight non-structural partition block. This is a relatively new market despite studies that prove gypsum byproducts to be suitable for high-strength structural block applications as well.

Metals

Scrap metal recycling is well developed throughout the world, and has been for decades. Although recycled metal is most commonly mixed with virgin metal to make “new” products, there is very little difference in strength performance. Construction and demolition generate both ferrous (steel) and non-ferrous (aluminum, copper, and brass) scrap including siding, roofing, flashing, I-beams, piping, wiring, window frames, and decorative uses. Due to its strength and durability, many metal items, especially structural steel and trusses, can be reused. Regardless of whether metal is reused or recycled, the material’s high value almost always prevents it from ending up in a landfill. Many heavy gauge metal products used in construction, including nails, are manufactured in electric furnaces, which use recycled metals as their primary feedstock.

Wood

Job-sites generate wood in the form of construction, demolition, and landclearing debris. Construction debris includes off-cuts of engineered wood products, solid sawn lumber, and pallets from material deliveries. Demolition generates timbers, trusses, framing lumber, flooring, decking, and millwork, doors, and window frames suitable for reuse or recycling depending on their condition. Wood that is recycled must be free of chemicals, including paint, stain, waterproofing, creosote, pentachlorophenol, petroleum distillates, and pressurizing treatments. The stumps and branches from landclearing can be chipped and composted, recycled as boiler fuel, or reused on-site as landscaping mulch.

High-value end-uses for solid wood material: salvaged wood components and finger-jointed lumber.
High-value end-uses for wood fiber material: paper, particle-board, fiberboard, oriented strand board, parallel strand lumber, and many fiber-cement and wood-plastic composites.
Low-value end-uses for wood fiber: biofuel, mulch, animal bedding, and compost bulking agents.
(Although each end-use has its own specifications, clean, uniform wood debris will achieve the highest possible value.)

Corrugated Cardboard

Building contractors generate used corrugated cardboard from boxes for shipping and storing products such as vinyl siding, hardware, doors, and windows. Most communities have well-developed cardboard-recycling networks consisting of private and municipal collection facilities.

Glass and Fiberglass

Glass found on construction and demolition sites is primarily plate glass from windows and doors (a small amount of bottle glass may be generated by workers). Many builders place fiberglass insulation leftovers and scraps in partition walls for sound deadening. The highest end-use for doors and windows is salvage for resale; however, breakage and obsolescence due to fire and energy requirements can prohibit their reuse. Because plate glass is made of many different processes and ingredients, manufacturers will not normally accept plate glass of unknown origin; however, it is possible to use it as a feedstock for the manufacture of fiberglass.

Plastics

Plastic is the most complex component of construction and demolition (C&D) debris. Many types are generated: *polyvinyl chloride (PVC)* windowframes, floors, gutters, siding, pipe and wiring insulation; *polyethylene (PE)* vapor barriers and packaging; *high-density polyethylene (HDPE)* piping, joint compound, paint buckets, and caulk tubes; *polystyrene (PS)* insulation board; and *polypropylene (PP)* electrical components. Many industries accept specific types of **clean** plastics for various manufacturing operations. While few industries specifically seek plastic from C&D sources, numerous post-consumer plastics are used in the fabrication of piping, insulation, and siding. Job-site recycling suffers from logistical problems associated with cleaning the material and maintaining resin purity.

Appendix II: Straw Building Materials

Of the many typical materials found on a construction or demolition project, straw is not yet a common sight. However, due to the efforts of many straw bale builders and straw product manufacturers, this annually renewable agricultural byproduct is (re)entering the market as a building material. Baled straw is stacked like bricks for both loadbearing and non-loadbearing infill walls, while straw fiber is processed and manufactured as medium density fiberboard, structural stressed skin panels, and non-structural partitions.

Straw is an abundant byproduct of grain production that is currently either burned in the field or plowed back into the soil. While burning is the most expedient disposal method, sustainable farming practices reincorporate a percentage of the post-harvest stubble back into the soil for erosion control, added organic matter, and aeration. Removing straw intermittently from fields not highly prone to wind or water erosion will not harm the soil, and it can provide farmers with additional income on their investment.

The use of straw as a building material is not new. Straw construction has dated back to 5000 B.C. in Egypt. The thousand-year history of straw in Europe and Asia created walls of bundled lengths of straw stacked in mud mortar and loose straw compacted with a clay slip. In the U.S., building with straw began in the late 1800s with the widespread use of stationary balers powered by horse or steam. Settlers of the timber-poor Sand Hills region of Nebraska built houses, schools, and churches with straw bales before the railroad allowed the transportation of wood and brick to the area. The earliest extant straw bale building was constructed in 1903 in Alliance, Nebraska. Although it was abandoned in 1956 and has not been maintained since, the house still stands in relatively good condition. Numerous other examples built throughout the first decades of the 20th century are well-maintained and still in use today.

Figure 76: Real Goods Solar Living Center in Hopland, CA (top); **detail of straw bale wall** (bottom) (Daniel Smith & Associates)

Since 1991, the number of permitted straw bale buildings has grown exponentially. Performance testing in the areas of structure, moisture, and fire has produced an impressive compilation of engineering and scientific data confirming the empirical evidence supplied by historic precedents. Rapidly gaining acceptance among builders and architects, straw bale wall systems are moving beyond the realm of unoccupied sheds and single-story residences: they are increasingly

Figure 77: Trinity Springs bottling facility in Pine, Idaho (top; The Underground Water People) **curves around the springhouse built from dry-stacked stone** (bottom; Erik Barr)**.**

found in larger scale projects. Premier straw bale commercial-scale buildings include the Real Goods Solar Living Center in Hopland, California, designed by Sim Van Der Ryn; and the (admittedly remote) Trinity Springs bottling facility in Pine, Idaho, designed by Daniel Smith & Associates. These two examples attest that this wall system's thermal efficiency, breathability, seismic resilience, fire resistance, and recyclability will find a future in all sectors of the construction industry.

Recently, manufactured compressed straw panels of varying densities have made market inroads as interior partitions, fiberboards, and structural envelope systems. Invented in Sweden in 1935, low-density compressed agricultural fiber panels soon developed into a British product called Stramit by the late 1940s. Today, Stramit Industries, Ltd., produces lightweight paper-faced wall panels with a one-hour fire rating for interior partitions. Measuring 4'x8'x2.25", they are pre-routed for wiring and demonstrate excellent sound absorbency. Several other manufacturers now offer thinner low-density panels without paper for ceiling applications, medium-density straw fiberboard (including straw-plastic composites) for cabinetry and finishes, and thicker straw-wood and all-straw structural panels for exterior envelopes. Agriboard Industries in Fairfield, Iowa, has developed a structural insulated panel that compresses straw between two layers of oriented strand board; Pyramod International manufactures an all-straw stressed skin panel. Both are similar to foam-core structural panels, although they don't yet insulate enough to be considered drop-in replacements.

Increased pressure on forest managers to adopt sustainable logging practices will decrease the supply of lumber and raise its price. In the Northwest U.S., the aftershocks of a shrinking timber industry are manifested by the increasing numbers of signs posted throughout timber-dependent communities, stating *"This Family Supported by Timber Dollars."* In the fertile grain-growing region encompassing portions of eastern Washington and north-central Idaho, a number of straw building material feasibility studies have been conducted. This region not only boasts record yields in grain production but has experienced the closing of many of its lumber mills; these facilities are ripe for reuse. As the use of waste agricultural fibers becomes more widespread in construction, more value-added industries will form similar symbiotic relationships with local farmers, thereby spinning another thread in the web of regional industrial ecosystems.

Appendix III: Product Directories and Sourcebooks

Building for Tomorrow: Buy Recycled Guidebook for the Commercial Construction Industry. Prepared by Stafford Harris Inc. for the National Recycling Coalition's Buy Recycled Business Alliance, 1727 King Street, Suite 105, Alexandria, VA 22314-2720, (703) 683-9025.

Architectural Resource Guide. Association of Designers and Planners for Social Responsibility (ADPSR), Berkeley, CA 94709-0126, (510) 273-2428.

Environmental by Design: Professional Edition (subscription service). Kim LeClair and David Rousseau, P.O. Box 95016, South Vancouver C.S.C., BC, Canada V6P 6V4, (604) 255-4564.

The Environmental Resource Guide. The American Institute of Architects Committee on the Environment, 1735 New York Ave., Washington, DC 20006, (202) 626-7331.

Guide to Resource Efficient Building Elements. Steve Loken, Walter Spurling, and Carol Price, Center for Resourceful Building Technology, P.O. Box 3866, Missoula, MT 59806-3866, (406) 549-7678.

The Harris Directory. B. J. Harris, Stafford Harris, Inc., 1916 Pike Place, Suite 705, Seattle, WA 98101-1056, (206) 682-4042.

Recycled Content Building and Construction Products. Clean Washington Center, 2001 Sixth Avenue, Suite 2700, Seattle, WA 98121, (206) 464-7040.

Recycled Products Guide (Construction and Industrial). Metro Portland, 600 NE Grand Street, Portland, OR 97232-2736, (503) 797-1700.

REDI Guide (Resources for Environmental Design Index), E House IAQ Database, Residential Directory on Disk, Residential Directory, and Commercial Directory. Iris Communications, 258 East 10th Ave., Suite E, Eugene, OR 97401-3284, (800) 346-0104.

Sourcebook for Sustainable Design. Architects for Social Responsibility, Boston Society of Architects, 52 Bond St., Boston, MA 02109-4301.

Sustainable Building Materials Products Directory for Manufactured Housing. Bonneville Power Administration, Portland, OR (503) 230-4242, and Battelle Laboratories.

Appendix IV: C&D Debris Analysis Worksheet

Material	Quantity	Recovery Strategy:	Facility
	Estimate tons and cubic yards	• Separate at source • Time-based removal by hauler • Commingled delivery to recycler • None (disposal to landfill)	• Reuse business • Recycling facility • Feedstock-using industry (Note any material specifications)
Reusable Materials	tons: cu.yds:		
Solid sawn wood	tons: cu.yds:		
Engineered wood	tons: cu.yds:		
Demolition wood (painted or stained)	tons: cu.yds:		
Treated wood	tons: cu.yds:		
Landclearing debris (woody debris to be chipped)	tons: cu.yds:		
Corrugated cardboard	tons: cu.yds:		
Drywall	tons: cu.yds:		
Ferrous metals (steel)	tons: cu.yds:		
Non-ferrous metals (aluminum, copper, brass)	tons: cu.yds:		
Concrete with rebar	tons: cu.yds:		
Concrete without rebar	tons: cu.yds:		
Asphalt roofing	tons: cu.yds:		
Mixed waste (give description)	tons: cu.yds:		

Appendix V: Recycling Economics Worksheet A (Self-Hauling)

Cost of Recycling (R)

Material	Quantity (QTY) (tons or yds³)	Tipping Fee per QTY (TP)	**Subtotal** R_1 (QTY X TP)	Number of Loads (L)	Hours per Load (H)	Truck & Labor Costs/Hour (C)	**Subtotal** R_2 (L X H X C)	**COST OF RECYCLING** (R_1+R_2)

: multiply hourly wage by any additional hours of labor needed to process recyclables:

ADJUSTED COST OF RECYCLING:

Cost of Not Recycling (NR) *(If collected in a Dumpster, calculate the waste cost on the Commercial Collection Worksheet)*

	(tons or yds³)	Tipping Fee per QTY (TP)	**Subtotal** NR_1 (QTY X TP)	Number of Loads (L)	Hours per Load (H)	Truck & Labor Costs/Hour (C)	**Subtotal** NR_2 (L X H X C)	**COST OF NOT RECYCLING** (NR_1+NR_2)
Waste								

Appendix VI: Recycling Economics Worksheet B (Commercial Collection)

Cost of Recycling (R)

Material	Quantity (QTY) (tons or yds³)	Tipping Fee per QTY (TP)	**Subtotal** R_1 (QTY X TP)	Number of Loads (L)	Hauling Fee (H)	**Subtotal** R_2 (L X H)	Months (M)	Rental Fee (R)	**Subtotal** R_3 (M X R)	**COST OF RECYCLING** ($R_1+R_2+R_3$)

: multiply hourly wage by any additional hours of labor needed to process recyclables:

Cost of Not Recycling (NR)

	(tons or yds³)	per QTY (TP)	(QTY X TP)	Loads (L)	Hauling Fee (H)	**Subtotal** NR_2 (L X H)	Months (M)	Rental Fee (R)	**Subtotal** NR_3 (M X R)	**COST OF RECYCLING** ($NR_1+NR_2+NR_3$)
Waste										

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Appendix V: Recycling Economics Worksheet A

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Appendix VI: Recycling Economics Worksheet B

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Annotated Bibliography

A. Waste Prevention

Allenby, Braden R. and Deanna J. Richards, eds. *The Greening of Industrial Ecosystems*. Washington: National Academy Press, 1994.

This book examines "the greening of industrial systems through the lens of industrial ecology." There are a number of short papers that can make good handouts both in regards to the theory and practical application of industrial ecology.

Commoner, Barry. *Making Peace with the Planet*. New York: Pantheon Books, 1990.

Chapter 3, "Prevention vs. Control," describes how during the past two decades changes in the technology of production have resulted in instances where the quality of the environment has been improved. It would make a good introductory reading to Section A.

Fisk, Pliny III. "Integration vs. Conservation: A Renewable Energy Building Block for the 21st Century." *Integration Compendium*. Austin, TX: Center for Maximum Potential Building Systems, Inc., (512) 928-4786.

This paper argues that "integration is fundamentally a more important conservation tool than conservation." Fisk combines natural and industrial systems in architectural design by analyzing metabolic processes and available resources based on input-output data.

Fisk, Pliny III and Gail Vittori. "The Texas Recycled Content / Advanced Green Builder Demonstration Home Project." In *Proceedings for the National Passive Solar Conference*, Washington: 25–28 April 1993.

This paper provides a conceptual overview of the Advanced Green Builder Demonstration Building discussed in **D.1.2 Case Study**. Written before its construction, the focus of the paper is on the ideas that informed the design process rather than a discussion of the materials.

Hawken, Paul. *The Ecology of Commerce*. New York: HarperCollins, 1993.

Paul Hawken addresses the basic question, "How can we create profitable, expandable, companies that do not destroy the world around them?" The entire book is exceptional. Written for a general audience, it is packed with examples that support the arguments. If I were to teach a seminar on sustainable design issues, I'd assign this book.

Mumma, Tracy, et al. *Guide to Resource Efficient Building Elements*, 5th ed. Missoula: Center for Resourceful Building Technology (CRBT), (406) 549-7678, 1995.

This is not just a directory of material-efficient, energy-efficient, and recycled building products. Steve Loken, CRBT founder and president, has done his homework: he discusses the environmental impacts of each category of building components, the use of indigenous resources, and the managing of natural resources. The CRBT offers a number of other publications including a paper on Job-site Recycling and Waste Reduction, Strawbales as a Building Element, and a narrative history of the ReCraft 90 project.

Van der Ryn, Sim, and Stuart Cowen. *Ecological Design*. Washington: Island Press, 1996.

This book is not just an overview of ecological design, but an investigation of design principles that are inherent within any discipline dealing with the preservation and restoration of ecological systems. It is not a detailed technical reference, but a series of well-connected discussions that describe the proliferation of excellent work in ecological design as a whole. An excellent resource guide and annotated bibliography is included.

Young, John E., and Aaron Sachs. *The Next Efficiency Revolution: Creating A Sustainable Materials Economy*. Worldwatch Institute, Worldwatch Paper 121, September 1994.

Well-researched, thorough examination of how current natural resource consumption affects the global environment. The authors focus on the unsustainable practices of primary materials extraction industries and offer a "revolutionary" alternative in the form of recycling, reuse, and remanufacturing.

B. Construction and Demolition (C&D) Recycling

C. T. Donovan Associates, Inc. *Recycling Construction and Demolition Waste in Vermont*. Vermont Agency of Natural Resources, Waterbury: December, 1990.

While this body of research is specific to the Northeast U.S., it is an example of a comprehensive look at all aspects of construction and demolition waste from supplies to markets.

Daly, Herman. *Steady -State Economics*, 2d ed. Washington: Island Press, 1991.

An excellent work that strives to expose the fallacies of our current limitless growth scenario and the narrow view it espouses.

Gershman, Brickner & Bratton, Inc. *Construction, Demolition, and Landclearing Debris Research and Assessment*. Prepared for The Clean Washington Center, Seattle: May 1995.

Similar to the work by C. T. Donovan Associates, this body of research is specific to the Northwest region of the U.S. Organized by typical construction and demolition materials, it provides an in-depth analysis of sources, quantities, markets, improvements, and recommendations.

Lynch, Kevin. *Wasting Away*. San Francisco: Sierra Club Books, 1990.

Probably the most comprehensive book available on the subject of waste, decline, and decay. Kevin Lynch writes from the perspective that these processes are a necessary part of life and growth. The book acknowledges all forms of wasting for virtually every profession. Underlying values that frame the discussions are maintaining health and safety of human settlements, achieving efficiency in land and resource use, and the need for adaptability and recycling.

Malin, Nadav. "What's New in Construction Waste Management." *Environmental Building News* 4, no. 6 (November / December 1995): 1, 12–14.

One of the best publications available on sustainable design and construction. Provides an excellent overview of current job-site waste management strategies.

C. Architectural Reuse

Brand, Stewart. *How Buildings Learn: What Happens After They're Built*. New York: Penguin Books, 1994.

Required reading for a multitude of topics regarding architectural reuse. Chapter 12, "Built for Change," discussed change in architecture and construction methods that support constant revision over time. Adaptive reuse, durability, and design for disassembly are explained in terms of both whole buildings and materials. Chapters 3 and 4 are devoted to "low road" and "high road" concepts of durability and maintenance. Chapter 10, "Function Melts Form," is all about adaptation, flexibility, and "vernacular remodeling" of the home and office.

Catacuzino, Sherban. *Re-Architecture: Old Buildings/New Uses*. New York: Abbeville Press, 1989.

Provides 54 case study examples of adaptive reuse from 15 countries organized by building / building type. The introduction, "The Tradition of Changing Use," outlines the history of reuse from ancient times to the present including examples of planning policies and financial incentives throughout the world.

Diamonstein, Barbaralee. *Buildings Reborn: New Uses, Old Places*. New York: Harper & Row, 1978.

Provides 95 examples of adaptive reuse, with the projects arranged alphabetically by city. Emphasis is placed more on the excitement of reuse than on the economics. The introduction, "Memory's Anchor," is an excellent reading of the "recycling phenomenon" and its relationship to our architectural heritage, philosophical attitudes, politics, and social systems.

Holmes, Hannah. "Reuse It!" *Garbage* V, no. 4 (September / October 1993): 38–43.

Introduces five innovators of reuse, including Jim Broadstreet, an architect and builder well known for his creative ways of incorporating salvaged materials in architecture. [See his book, *Building with Junk*.]

Knapp, Daniel. “Reuse: The Underestimated Source Reduction Technique.” A paper by Urban Ore, Inc., in response to the Massachusetts Department of Environmental Protection, 1991.

Knapp, Daniel, and Mary Lou Van Deventer. “Integrated Resource Recovery Facilities.” A report by Urban Ore, Inc., prepared for the West Virginia Solid Waste Management Board, 1995.

———. “Establishing A Reuse Business.” A report by Urban Ore, Inc., prepared for Recycle Ann Arbor, 1994.

These three papers provide an excellent overview of the reuse business and materials recovery. Daniel Knapp is probably the only Ph.D. that is a general manager of a salvage yard. His perspective on their role within municipal waste management plans is based on both scientific study and first-hand experience. Available from Urban Ore, Inc., Administrative Office, (510) 235-0172.

Landecker, Heidi. “Recycling Redux.” *Architecture* (May 1991): 90–95.

This article highlights the recent work of Dan Rockhill & Associates, a design / build firm that reuses salvaged materials in their residential projects. The buildings are well proportioned and crisply detailed, representing a very discriminating and crafted approach to reuse.

Milligan, Charles, and Jim Higgs. *The Wizard's Eye: Visions of American Resourcefulness*. San Francisco: Chronicle Books, 1978.

A sourcebook of projects and ideas successfully carried out at both the individual and community levels that demonstrate the “vision that sees gold in the stuff that looks like lead.” The introduction by Buckminster Fuller discusses the recirculation of materials. It is an excerpt from *Nine Chains to the Moon* originally published in 1938.

Murtagh, William J. *Keeping Time: The History and Theory of Preservation in America*. New York: Sterling Publishing, 1990.

A good overview of the historic preservation movement as well as solid definitions regarding the confusing language of preservation and reuse.

Shopsin, William C. *Restoring Old Buildings for Contemporary Uses*. New York: Whitney Library of Design, 1989.

Written as a “sourcebook” for practitioners and students, it is intended to “streamline” the practical matters of preservation, restoration, and adaptive reuse. While landmarks and monuments are included, the focus is on the “creative preservation” of ordinary buildings. Chapter 4 discusses the approval process and Chapter 9 describes the trade-offs, limits, and strategies for integrating mechanical, electrical, plumbing, and lighting systems.

D. Design for Materials Recovery

Bone, Eugenia. “The House that Max Built.” *Metropolis* (December 1996): 37–42.

This is a great article describing Pliny Fisk's Advanced Green Builder Demonstration Project in Austin, Texas. This “house” embodies the philosophy of bioregional design researched by the Center for Maximum Potential Building Systems. The building utilizes many regionally significant, recycled-content, byproduct-based building materials as well as an open-ended post and beam framework that allows for disassembly and reuse.

Fisk, Pliny III. “Towards a Theory and Practice of Sustainable Design.” Presented at the *National Convention of the American Institute of Architects* in Boston, 21 June 1992.

A good summary of an approach to sustainable design that is rooted in regional climate and resource conditions. Discusses the basics of bioregionalism, metabolic design, and the development of a boundary-driven framework for life cycle analysis are discussed.

Ivy, Robert A. “Rural Education.” *Architecture*. (October 1994): 62-65.

Provides an good case study of the Bryant house in Masons Bend, Alabama, designed and built by students participating in the Remote Rural Studio at Auburn University. Written from an educational perspective, the terse text focuses on the design process.

LeBlanc, Sydney. “From Humble Sources, Earthy Elegance Springs.” *New York Times* (Thursday, April 18, 1996): C1 & C6.

This article covers the recent work of the Remote Rural Studio at Auburn University. It describes the straw bale Bryant House and the smokehouse and chapel projects from salvaged materials.

McDonough, William. “A Boat for Thoreau: Architecture, Ethics, and the Making of Things.” *Business Ethics* (May / June 1993): 26–29.

Based on his observations of the Earth Summit in Rio de Janeiro, McDonough dicusses his philosophy of design, which acknowledges the scarcity of natural resources and the impact of architecture and construction on the natural environment.

Pawley, Martin. *Building for Tomorrow*. San Francisco: Sierra Club Books, 1982.

The author writes: “This book is an attempt to look at the potential of waste. It is ... founded on a heresy, the idea that there is nothing unnatural about massive overproduction, high levels of waste, and marginal survival — all of which are as much characteristics of the natural world as of our own industrial society. The potential of construction for the absorption of waste in the future is everywhere agreed, but the idea that the whole resource base of the industry might change in the pursuit of this aim is still a dream.”

Wilson, Forrest. “Building with the Byproducts of Society.” *AIA Journal* (July 1979): 40–45.

Forrest Wilson moderated the first International Conference of Garbage Architects, held in May 1979 at Florida A&M. The host was Martin Pawley, then professor of architecture and director of Florida A&M’s Experimental Low-Cost Housing Unit. Other conferees included Witold Rybczinski, then director of the McGill University School of Architecture’s Minimum Cost Housing Group, and Michael Reynolds, architect and builder of Earthships in New Mexico. This article is a discussion of both the background of “secondary use” and the architectural explorations of that time using industrial byproducts.