Executive Summary:
Case Studies 1-4
9/13/2004- 3/31/2006

BACKGROUND OF ORGANIZATION

RE Sources for Sustainable Communities has been operating programs about waste reduction, recycling, air and water quality since 1984. In 1993, RE Sources started The RE Store, a project designed to collect and sell used building materials. With stores in Bellingham and Seattle, The RE Store has become a leader in the used building materials industry. Where some see garbage, The RE Store sees valuable building materials.

The RE Store grew out of a long-felt need to recover and reuse tons of building materials going to waste every year. As homes are remodeled and new buildings built, quality lumber, doors, windows, cabinet sets, and other materials become available. A mainstay of The RE Store operation is the sale and distribution of these still-useable building-materials. Typical inventory includes quality doors, windows, cabinet sets, vanities, sinks, tubs, heaters, lighting, shelves, bookcases, lockers, displays, racks, rails, flooring, tile, molding, antiques, lumber, hardware, granite, bricks, fencing, and more. This service gives Seattle and Bellingham residents the means and opportunity to protect and enhance their homes without adding resource impacts to the environment.

Our licensed and bonded salvage crews provide a wide variety of services, from simple removal of cabinets, windows and doors, to full-scale hand "deconstruction" of entire houses or buildings. Deconstruction, which has grown in importance in recent years, allows The RE Store to recover for resale or recycling as much as 80% of a building, where typical demolition techniques send that material to the landfill.

CONSTRUCTION AND DEMOLITION WASTE BACKGROUND

Construction and demolition (C&D) waste is a major environmental problem. The majority of this waste comes from building demolition and renovation, and the rest comes from new construction. Residential and commercial building sectors contribute roughly equal percentages of waste.

Salvage and reuse of building materials is recognized widely as a high-value waste reduction strategy for contractors and home owners. The Institute for Local Self Reliance reports that over one third of C&D waste is reusable and another 10% is recyclable. Reusing building materials prevents valuable resources from being disposed prematurely, preserves architectural heritage in neighborhoods, and makes reusable materials available to the building trades and the general public at much lower prices through established retail outlets. This is beneficial for both community and economic development.

PROJECT SUMMARY

Through donations and salvage practices, salvage and used building materials stores divert a large volume of materials from landfill disposal each year. Increasingly, "deconstruction," the process of disassembling houses or buildings, is re-emerging as an economically viable and environmentally preferable alternative to conventional demolition. However, not enough is known about the impacts of these practices. Deconstruction businesses and used building materials stores are not known to rigorously track the volume and types of materials being recovered for reuse. One industry estimate—that every dollar of sales represents two pounds of material reused—is an untested measure. This project was designed to address data gaps in the reduce, reuse and recycle hierarchy as it applies to C&D waste, recovered by deconstruction and associated used building materials outlets.

The project was centered on The RE Store, run by the non-profit organization, RE Sources for Sustainable Communities. The RE Store offers full-scale deconstruction services and operates retail outlets for recovered materials in Seattle and Bellingham. With over 10 years of history, The RE Store team includes Washington's most-experienced deconstruction and used building materials professionals.

The project was designed to document specifics about three major advantages of deconstruction:

1. More material can be diverted to reuse and recycling,
2. Original value of building materials can be retained (i.e., more value per ton recovered), and
3. Deconstruction has fewer environmental impacts than conventional demolition.

The project team prepared easy-to-use, data-collection forms that quantified the types and amounts of material diverted by field crews and the time and equipment required to recover these materials. These figures were compared to time and resources required by conventional demolition practices for the same projects. Additional characteristics—average volumes, weights, and monetary values—for all the categories of materials were applied, thus giving detailed picture of the volume, tonnage and value retained by deconstruction and resale by separate categories and an overall total.

PROJECT GOALS

The following case studies set out to:

- document the monetary and environmental benefits of deconstruction versus conventional demolition;
- provide average volumes, weights, and dollar values of different categories of building materials, measured over time and during four case studies;

- archive and present this data documenting the value of reuse in a manner that is useful to those within the solid waste industry and to the public at large.

PROJECT METHODOLOGY

In order to achieve these goals, the project team needed to first identify appropriate case studies. A balance needed to be established regarding the different types of possible projects. Projects in the Bellingham and Seattle area, multi-family homes, urban homes, projects in a rural setting, as well as commercial buildings were all considered as possible case studies.

Additionally, forms (see appendix) and methodology were developed to assist both those in the field with reliable data collection and those processing the data with an efficient means of organizing and presenting the findings.

In the field, deconstruction methodology had already been established, so crews needed only to adjust their work programs to accommodate data collection. This meant that one member of the field crew was assigned to ensure that:

- records of the length, weights, and volumes of the materials salvaged and disposed of were complete and organized;
- records of the vehicles' mileage and fuel consumption were complete and organized;
- the quality of the record-keeping was consistent throughout the case study projects.

Additional data collection and organization was done by the project manager, who was responsible for:

- maintaining all records from the field, as well as organizing and maintaining records of all other materials recycled and land-filled;
- organizing and maintaining labor figures;
- obtaining bids and other figures from outside, conventional demolition contractors by which to compare The RE Store's findings;
- compiling reports of all data collected from the field, as well as describing, through the case study reports, the deconstruction process and methodology for each building deconstructed.

SUMMARY OF FINDINGS

(*Complete details can be seen in project-specific spreadsheets at the end of each case study*)

Compiled results can be seen in tables one, two, three and four.

Table 1 lists the total square footage of each case study building, as well as average and total weight and/or dollar-value figures for materials salvaged for resale, materials recycled, and materials placed in a landfill. Information is presented in terms of: value per square foot of the deconstructed structure; weight per square foot; value per pound of salvaged material; percentage of the deconstructed structure salvaged for resale; percentage recycled; and percentage placed in a landfill, among other values.

Table 2 outlines the total estimated retail value of material salvaged for resale, according to material category. Table 2 also shows the estimated value-per-pound of each category of material. It also lists the total amount salvaged for all four case studies, organized by material category. For example, look to Table 2 to see the price-per-pound value of dimensional lumber, and/or the total weight of dimensional lumber salvaged for resale.

Table 3 lists total labor figures according to job and labor category, i.e. how many labor hours the deconstruction crew spent salvaging, denailing, handling materials during load-out, etc.

Table 4 is a list of environmental benefits derived from using particular salvaged materials. These figures were compiled using New York Waste Match's Environmental Benefits Reuse Calculator.

Case-study specific labor figures, percentages of materials salvaged, recycled and land-filled, and complete salvage inventories are also found at the end of each case study report.

Following each table is an explanation of terms and a list of further findings.

Material Recovered/ Value of Material

According to the four case studies, the generally accepted average price per pound for salvaged material, \$.50/ pound, is close to this report's conclusions—an average value of \$.42/ pound, excluding stone, over the course of the four case studies. The average value-per-pound is affected significantly by the inclusion of stone/brick and concrete— very dense material—which is why the average price per pound is also presented *excluding* stone.

Values vary widely from study-to-study, dipping as low as \$.22 per pound in case studies two and four, and reaching \$.48/ pound in case study one. It should also be noted that the estimated retail price could fluctuate up or down an additional 10-15%, depending on the market for each particular item. Additionally, it should be recognized that material such as lumber, and in some cases stone and brick, whose density gives them a comparatively low value per pound, are also often highly prized by The RE Store's customer base. Large loads of lumber are occasionally purchased at the deconstruction site, or quickly sold once they reach the retail store.

The case study results also show that through deconstruction, RE Store crews salvaged for resale an average of 40% of the deconstructed buildings. An additional ±48% of the buildingsthe materials recycled as hog fuel, sent to Recovery One, a recycling facility at the Port of Tacoma, or recycled locally for its value as scrap metal. That means that on average, almost 90% of the materials from case study buildings were recycled or salvaged for resale, while only 10% of the building materials were sent to the landfill. By comparison, the traditional demolition contractors asked to bid on the case study buildings could, at best, estimate high recycling rates—T n' T Recovery and Demolition estimated that over 98% of the deconstructed building's structures could be recycled, though they estimated that little to none of the material would be re-used. Other estimates were not as high as the figure proposed by T n' T Recovery. Freeman and Sons, in case study 2, proposed to landfill all but a minor quantity of C&D debris.

Labor

The RE Store model also provided paid work for several more people than would conventional demolition, another economic benefit. Over the course of the four case studies, The RE Store employed up to nine people in the field, who were paid a total of $15,473.27, not including benefits or accounting for tax and L&I costs, for a total of 1,89 labor hours. As comparison, the bids given by conventional demolition contractors estimated the jobs would require a combined total of 164 labor hours, or 10.5 ±sixteen-hour days, with the use of a track-hoe. Though the deconstruction process takes longer than conventional demolition, it provides employment to more people over a longer period of time. Look to table three for a breakdown of labor into task-specific categories.

Environmental Benefits

Unfortunately, the study found few secondary resources by which to estimate environmental impacts and benefits of deconstruction compared to demolition, outside of the primary volume and tonnage figures of materials salvaged and recycled by The RE Store crews. However, through the use of New York Waste Watch's "Materials Reuse Benefits Calculator"[1] several figures were established outlining the minimum environmental benefits of salvaging the following materials: dimensional lumber (untreated 2 x 4), plywood sheathing, cedar siding, asphalt shingles, and office chairs. These figures only give a partial picture of the environmental benefits of deconstruction, as many more types of materials were salvaged than were available in Waste Match's index. According to the Waste Match guide to the Benefits Calculator, these "results

[1] See www.wastematch.org/calculator/calculator.htm# to download calculator and see full explanation of benefits.

measure the environmental impacts that would have resulted from extracting and processing raw materials, making them into finished materials, and transporting them from the factory to their points of use. The results also measure the energy that would have been required to produce equal amounts of new products, based on the embodied energy in the reused product."

Further Findings

It can be drawn from client testimony that deconstruction, as opposed to conventional demolition, has other benefits difficult to measure. The general response from both clients and others in the clients' neighborhoods is one of satisfaction at seeing the structure being handled cleanly and comparatively quietly; the deconstruction process creates an easily contained mess. Passers-by are often also intrigued by the process, as it appears unconventional to most people. Further, the model provided by The RE Store should be recognized in relation to its function within a community supporting environmental and community-oriented local business. The RE Store is just as much a product of this community as it is a model of a successful non-profit.

Study results are shown in tables below

Summary of Results: Case Studies 1-4

Table 1	Case Study One	Case Study Two	Case Study Three	Case Study Four	Avg.	Totals
Square footage of structure's footprint	1,292	10,000	1,000	1,333	**3,406.25**	**13625**
Total volume of structure in cubic yds.	110	303	120	140	**168.25**	**673**
Total weight of structure in lbs.	15,921	134,842.41	46,161	76315	**68,752.8**	**273,39.41**
Combined weight of salvaged materials in lbs.	5,523	47,060	27,113	32,705	**28,100.25**	**112,401**
Percentage of building salvaged for resale	34%	35%	58.70%	42.8%	**42.65%**	
Combined weight of recycled materials in lbs.	9,711.6	83,38	17,800	20,730	**33,017.9**	**132,071.6**
Percentage of building recycled	60.5%	62%	38.5%	26.5%	**46.87%**	
Combined weight of materials placed in a landfill in lbs.	781	1,483.26	1,248	22,880	**6,598.07**	**26,392.26**
Percentage of building land-filled	4.9%	1.10%	2.70%	29.90%	**9.65**	
Estimated dollar value of salvaged materials	$2,647.47	$10,407.23	$7,573.60	$7,339.53	**$6,991.96**	**$27,967.83**
Dollar value per square foot	$2.05	$1.04	$7.57	$5.51	**$4.04**	
Weight per square foot of building in lbs.	12.32	13.48	46.2	58.6	**32.65**	
Dollar value per pound of salvaged materials	$0.49	$0.22	$0.27	$0.22	**$0.30**	

Explanation of Table 1:

- "Salvaged" Material refers to items salvaged from the case study sites, for resale at The RE Store retail outlet.
- "Recycled" material refers to wood debris, metal, plaster, recyclable composite roofing and other materials that are not placed in a landfill but diverted from the waste stream for a new life or used as hog fuel.
- The percentage of material salvaged for resale, combined with the percentage of material recycled, yields an average of 89% of the total volume of the building.
- On average, only 9% of the total volume of the material/debris from the case study buildings was placed in a landfill.
- Salvaged material yielded an average resale value of over $4 per square foot.

Table 2

Totals of Salvaged Material According to Material Category				
Item Category	Category Description	Weight	Estimated Retail Value	Value/ lb.
1	Bathroom / Sinks	220.81 lbs.	$180.00.	$0.82/lb.
2	Cabinets	2972.4 lbs.	$1,328.00	$0.45/lb.
3	Closets/Shelving	469.3 lbs.	$156.59	$0.33/lb.
4	Doors	3418.2 lbs.	$1,622.00	$0.47/lb.
5	Electrical	642.3 lbs.	$276.20	$0.43/lb.
6	Flooring	4519 lbs.	$2,350.97	$0.52/lb.
7	Lighting	581.2 lbs.	$312.50	$0.54/lb.
8	Plumbing	123.3 lbs.	$89.50	$0.73/lb.
9	Trim/Moulding	709 lbs.	$236.27	$0.33/lb.
10	Sheet Goods/ Plywood	12672 lbs.	$2,077.10	$0.16/lb.
11	Paneling	358.4 lbs.	$143.40	$0.40/lb.
12	Siding	7990.2 lbs.	$4,870.83	$0.61/lb.
13	Windows	440.2 lbs.	$241.00	$0.55/lb.
14	Lumber	58162 lbs.	$11,059.69	$0.19/lb.
15	Furniture	507.5 lbs.	$61.00	$0.12/lb.
16	Misc.Ext. Hardware	363.9 lbs.	$153.26	$0.42/lb.
17	Gutters/Roof	606.6 lbs.	$395.40	$0.65/lb.
	Structure			
18	Msc. Int	465.4 lbs.	$320.75	$0.69/lb.
	Hardware			
19	Appliances/	1899.7 lbs.	$679.00	$0.36/lb.
	Tools			
20	Metal Recycling	2658.5 lbs.	$372.88	$0.14/lb.
21	Bricks/ Concrete	13762.1 lbs.	$337.50	$0.02/lb.
22	Other: insulation, etc	1869 lbs.	$679.00	$0.36/lb.
	Totals	115,190.2 lbs.	$27,942.84	$0.24/lb.
			Mean Value:	$0.42/lb.

Explanation of Table 2:

- This table lists the combined amounts of materials salvaged from all four case studies, listed according to material category.
- According to the results of the four case studies, lumber has been shown to be the highest value item in terms of gross sales, valued at approximately $11, 060 for more than 15,000 linear feet of dimensional lumber. However, lumber has a per-pound value of only $.19 cents, due to its high density.
- The highest value-per-pound item category was bathroom fixtures/sinks at a value of $.82 per pound.
- The lowest value-per-pound items were brick and masonry, yielding only $.02 per pound.

Table 3
Labor Figures/ Hours Worked per Labor Category

	Drive time	Salvage	Deconstruction	Denailing	Materials Handling	Site administration	Job administration	**Totals**
Case Study 1	11	65	38	7	1	3.5		**125.5**
Case Study 2	45.5	79	150	89.5	159	19	1.5	**543.2**
Case Study 3	13.5	61.5	79	24.5	58	10.5		**247**
Case Study 4	18.65	179.5	87	38.5	92.5	56.5		**472.65**
Totals	**88.65**	**385**	**354**	**159.5**	**310.5**	**89.5**	**1.5**	**1388.65**

Explanation of Table 3:

- The order of combined hours spent per labor category, from most time spent to least time spent, is as follows:
  1. ***Salvage:* 385 hours**
  2. ***Deconstruction:* 354 hours**
  3. ***Materials handling:* 310.5 hours**
  4. ***Denailing:* 159.5 hours**
  5. ***Site Administration:* 89.5 hours**
  6. ***Drive Time:* 88.65 hours**
  7. ***Job Administration:* 1.5 hours**

- “Salvage” refers to any time spent removing non-structural interior or exterior items, such as flooring, cabinets, or bathroom hardware.
- “Deconstruction” refers to time spent taking down any of the building’s structural elements, including wall sheathing, roofing materials, and gypsum board.
- “Materials Handling” includes all time spent loading and unloading trucks and trailers, all time spent moving material to denailing stations, all time spent organizing and making an inventory of material, and all time spent moving material to recycling or waste bins.
- “Denailing” includes all time spent pulling fasteners, hangers, nails, etc. from salvaged material. Material must be clean of nails, etc. before it is taken to the store in order to protect the customer, maintain value, and make it easy to stack and store.
- “Site Administration” includes time spent giving instruction, holding safety meetings, and completing necessary paperwork. The high “Site Administration” figure in case study 4 is due primarily to time spent compiling data for this report.

Table 4

Environmental Benefits Summary				
Material ▶	Wood Framing, untreated	Plywood Sheathing (1/2" thick)	Cedar Siding (1/2" thick, 6" wide)	Asphalt shingles, generic
Square footage▶	13012.465 sq. ft	7416 sq.ft	635 sq. ft.	40 sq. ft.
Benefit▼				
Global Warming[i]	1,881,308	1,453,536	280,670	49,280
Acidification[ii]	485,116.9752	646,668.5256	80,525.4295	9,954.5760
Eutrophication[iii]	474.9316	690.4296	71.1835	13.7800
Fossil Fuel Depletion[iv]	3742.8820	2298.9600	608.5205	261.1960
Water Intake[v]	5908.3596	5709.5748	1448.6890	393.4360
Criteria Air Pollutants[vi]	140.7692	324.0792	41.5925	152.1040
Ecological Toxicity[vii]	1578.7200	n/a	n/a	44.8000
Human Health[viii]	66,961,408.8	n/a	n/a	1,830,729.2
Ozone Depletion[ix]	0.0	n/a	n/a	0.0
Smog[x]	12,270.6012	n/a	n/a	557.0240
Embodied Energy[xi]	192,472.28	134,452.08	21,831.3	1,886.00

Table 4

Explanation of Table 4:
The following explanations are copied from The New York "Waste Match" Guide to benefits, available online at http://www.wastematch.org/calculator/calculator.htm#F.

[i] Global Warming (measured in g CO2 equivalents). The NY Wa$teMatch Reuse Calculator measures the avoided impact on global warming in grams of carbon dioxide. Greenhouse gases other than carbon dioxide are included in the analysis through conversion to equivalent grams of carbon dioxide.

[ii] Acidification (measured in mg H+ equivalents) The NY Wa$teMatch Reuse Calculator measures the avoided impact on acidification in grams of hydrogen ions. Acidifying compounds are converted to equivalent grams of hydrogen ions.

[iii] Eutrophication (measured in g N equivalents) Eutrophication is the addition of mineral nutrients to the soil or water. The NY Wa$teMatch Reuse Calculator measures the avoided impact on eutrophication in grams of nitrogen equivalents. Nutrifying compounds are converted to equivalent grams of nitrogen equivalents.

[iv]Fossil Fuel Depletion (measured in surplus MJ) The NY Wa$teMatch Reuse Calculator assesses fossil fuel depletion in terms of how the amount of energy required to extract a unit of energy for consumption changes over time. Characterization factors have been developed permitting computation of a single index for potential fossil fuel depletion, surplus megajoules (MJ), that can be used to assess the surplus energy requirements from the consumption of fossil fuels.

[v] Water Intake (measured in L)Researchers are beginning to address water resource depletion to account for areas where water is scarce, such as the Western United States. It is important to recognize that this impact addresses only the depletion aspect of water intake, not the fact that activities such as agricultural production and product manufacture may generate water pollution. Water pollution impacts, such as nitrogen runoff from agricultural production, are addressed in other impacts, such as eutrophication. Water intake is recorded in liters, and is used directly to assess this impact.

[vi]Criteria Air Pollutants (measured in MicroDALYs)Criteria air pollutants are solid and liquid particles commonly found in the air. They arise from many activities including combustion, vehicle operation, power generation, materials handling, and crushing and grinding operations. They include coarse particles known to aggravate respiratory conditions such as asthma, and fine particles that can lead to more serious respiratory symptoms and disease. Disability-adjusted life years, or DALYs, have been developed to measure health losses from air pollution. They account for years of life lost and years lived with disability, adjusted for the severity of the associated unfavorable health conditions.

[vii] Ecological Toxicity (measured in g 2,4-D equivalents)This impact measures the potential of a chemical released into the environment to harm terrestrial and aquatic ecosystems. The NY Wa$teMatch Reuse Calculator measures potential ecological toxicity in grams of 2,4-dichlorophenoxy-acetic acid (2,4-D). Other chemicals with potential ecological toxicity are convert to equivalent grams of 2,4-D.

[viii] Human Health (measured in g toluene equivalents) The NY Wa$teMatch Reuse Calculator uses grams of toluene to measure avoided potential human health effects, both cancer and noncancer.

[ix] Ozone Depletion (measured in g CFC-11 equivalents) The NY Wa$teMatch Reuse Calculator measures potential ozone depletion in grams of CFC-11, with impacts from other ozone-depleting substances converted to equivalent grams of CFC-11.

[x]Smog (measured in g NOx equivalents) The NY Wa$teMatch Reuse Calculator measures avoided smog in terms of grams of nitrogen oxides, with other smog-forming compounds converted to equivalent grams of nitrogen oxides.

[xi]Embodied Energy (measured in MJ)Embodied energy is the collective amount of energy used to produce a given product, including all the energy used to make the raw material into the finished product and the transportation used to carry it through the manufacturing process and to its final place of sale or use. The NY Wa$teMatch Reuse Calculator measures embodied energy in megajoules.