Solid Waste Reduction and Recycling Demonstration Grant

Vogel Brothers Building Company

Final Report

July 15, 2002

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Project Objectives

The objectives of Vogel Brothers Building Company's (Vogel Brothers) construction waste recycling demonstration project were to:

- Demonstrate the on-site separation of construction materials at a commercial building site,
- Facilitate the reuse and recycling of at least 50% of the construction materials, and
- Obtain the Leadership in Energy and Environmental Design (LEED) waste management certification.

Summary

Vogel Brothers successfully recycled and reused 75% of the construction waste from the 52,000 square foot Affiliated Engineers Inc. (AEI) office building in Madison's University Research Park (Figure 1). Vogel Brothers achieved this high recycling rate by implementing a well-designed recycling plan that was adapted from another construction site. The costs to recycle and reuse the construction waste were approximately the same as if all materials were disposed in a landfill. This report describes the recycling methods, the documentation process, and the results. It evaluates the economic impacts, and recommends ways to improve or adapt a recycling program for other construction sites.

Figure 1. AEI Building under construction

Project Background

Recycling construction waste has the potential to greatly reduce the amount of solid waste being disposed of in local landfills. In Wisconsin, for example, approximately 30% of the non-municipal waste stream consists of construction and demolition debris.[1] In Dane County, the location of this project, construction and demolition debris constitutes as much as 46% of the waste stream.[2]

One way builders are addressing economic and environmental concerns related to construction waste management is by pursuing Green Building certifications. The U.S. Green Building Council certifies buildings using the LEED (Leadership in Energy and Environmental Design) rating system, which includes criteria for recycling construction waste. The LEED certification program is voluntary, market-driven, and based on approved technology. A company earns LEED certification for a building by earning 26-32 points in various categories. Higher levels of certification are available by earning

[1] Wisconsin Waste Characterization & Management Study Update. Franklin Associates, Ltd. Prepared for State of Wisconsin Department of Natural Resources. February 1998. Page 1-14. Table 1-5.

[2] Dane County Solid Waste Manager

additional points. Construction waste management is one of the categories in the certification criteria. A 50% recycling rate will earn one point towards certification, while a 75% recycling rate earns two points towards the LEED rating scale. Although the recycling process is straightforward, learning, implementing, and documenting the necessary practices are time-consuming, and few contractors have experience implementing LEED certification.

Affiliated Engineers Inc. (AEI) planned for their new market-rate, leased office building to meet the LEED certification criteria. They hired the architectural firm Flad & Associates to design the building, and Vogel Brothers to build it. Vogel Brothers' goal was to recycle and reuse at least 50% of the construction waste, thereby earning AEI at least one point toward their LEED certification.

Scope of Project

Vogel Brothers assembled a construction materials management team to research the LEED requirements and develop a Construction Waste Management Plan to meet the recycling requirements. This team consisted of representatives from Vogel Brothers; the client, Affiliated Engineers, Inc.; the architects, Flad & Associates; a non-profit recycling organization, WasteCap Wisconsin; a consulting company, Madison Environmental Group; and a waste and recycling hauler, Green Valley Disposal. The Construction Waste Management Plan identified materials to be recycled, markets for those materials, haulers, receivers, and dumpster sizes. The plan also identified the personnel responsible for sorting, documenting, and scheduling pickups of recyclables from the site. Vogel Brothers established hauling and recycling contracts for the various waste materials (Table 1).

Table 1. Containers, haulers, and recipients of waste materials, as specified in Vogel Brothers' Construction Waste Management Plan.[1]

Waste Material	**Size of container**	**Hauler**	**Recipient**
Garbage	20 cubic yard	Green Valley Disposal	Mallard Ridge Landfill
Corrugated cardboard	6 cubic yard	Green Valley Disposal	Green Valley Disposal Recycling Center
Clean Fill	n/a	Green Valley Disposal and Crowley Masonry (subcontractor)	Madison Crushing and Excavating, and Clayton's Pit, Fitchburg
Wood	20 cubic yard	Lake Country Disposal	Wood Cycle
Metal	12 cubic yard	Green Valley Disposal	Diehl Neumaier, DeForest, WI
Drywall	30 cubic yard	Green Valley Disposal	Helt Farm, Waunakee, WI, or Diamond Star, Poynette, WI
Commingled beverage containers	95 gallon	Green Valley Disposal	Green Valley Disposal Recycling Center
Styrofoam	Plastic garbage bags	Vogel Brothers	Brown Sales, Madison

[1] This table shows anticipated recyclable materials and trash only, and does not include reused

The Construction Waste Management Plan served as a framework for Vogel Brothers to establish an effective recycling system. Vogel Brothers staff and subcontractors began recycling construction waste according to this plan prior to receiving the Department of Natural Resources (DNR) recycling grant in January 2002. When WasteCap Wisconsin and Madison Environmental Group first visited the site in January, the recycling program was already operating in full swing.

A. Locating Signs and Containers for Recycling

Vogel Brothers staff constructed wooden "sandwich board" signs for each of the collection materials: wood, metal, drywall, cardboard, commingled bottles and cans, and trash (Figure 2). Large (12-20 cubic yard) dumpsters were stationed in the building's parking lot. When a dumpster reached capacity, Vogel Brothers contacted the respective hauler to schedule a pick-up.

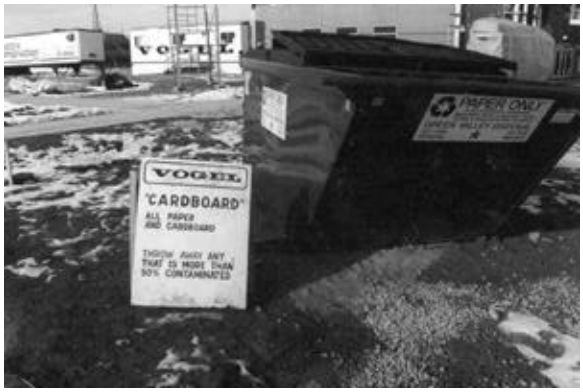

Figure 2. Example of a sign at the cardboard dumpster

B. Instructing and Educating Subcontractors

Every week, Vogel Brothers staff met with subcontractors (Figure 3). These meetings provided opportunities to share information about recycling, answer questions, and address problems. After the DNR grant term began on January 15, 2002, Madison Environmental Group staff attended these meetings and toured the construction site to address workers recycling questions and learn from their experiences. When new materials were generated during the construction process, Vogel Brothers sought Madison Environmental Group's assistance in investigating its recycling potential.

Figure 3. A subcontractor from Lurie Glass installing windows

Figure 4. Monitoring a wood recycling dumpster

C. Monitoring Trash and Recycling Bins

Madison Environmental Group monitored recycling and trash bins weekly to assess compliance (Figure 4), and to communicate with workers on the job site to find out what worked well and what needed improvement in the recycling process. Recycling bins were rarely and minimally contaminated.

Madison Environmental Group and WasteCap Wisconsin assisted workers on the construction site by addressing recycling container needs, answering questions about which materials were recyclable, and finding recycling markets for new materials.

D. Documenting Construction Waste Management

Haulers provided weights (or volumes) and hauling costs for all materials they transported between July 2001 and April 2002. For bulky or irregular materials (wood, drywall, metal, and garbage), haulers reported quantities by weight. For cardboard and commingled beverage containers, haulers reported quantities by volume. We used conversion factors to estimate the weights for these materials.

During site visits to monitor recycling, Madison Environmental Group discovered that subcontractors and workers were reusing some construction waste materials. Vogel Brothers and its subcontractors provided information about the materials that were reused (see following Summary of Waste Report for details on reused and recycled materials).

WasteCap Wisconsin and Madison Environmental Group used the hauling records and information from Vogel Brothers to create an Excel spreadsheet and calculate weights and volumes for recycling, reuse, and trash. The spreadsheet also calculated total costs of hauling, recycling, and disposing waste. Results are presented in the “Summary of Waste” report below. Weights of recycled and disposed materials were entered into the LEED worksheet for Affiliated Engineers’ green building certification.

Madison Environmental Group also visually documented the construction waste management process through photographs.

E. Summary Reports

Upon project completion, 75% of the construction waste materials were recycled and reused. These results exceed the desired recycling/reuse rate goal of 50% and earn AEI two points toward their LEED certification. Table 3 represents the breakdown of recycled and reused materials.

Table 3. Summary of Recycling, Reuse, and Trash disposal

	Tons	**Proportion of Waste Stream (by weight)**
Recycling	60.12	70.40%
Reuse	4.27	4.96%
Trash	26.67	24.64%
Total	91.00	100.00%

Table 4 represents the weight and volume of each material recycled. Recycling represented 70.4% of the total weight of waste from the construction site.

Table 4. Recycled Materials Summary

Material	**Volume (Cubic Yards)**	**Weight (Tons)**	**Percent of Total Weight[1]**
Metal	72	9.41	10.73%
Wood	240	17.74	20.23%
Drywall	119	22.43	25.58%
Commingled bottles and cans	5	0.125	0.14%
Cardboard	284	10.23[2]	13.50%
Styrofoam	25.3	0.19	0.22%
Total	**745.3**	**60.12**	**70.40%**

[1] Including trash and reuse
[2] Cardboard volume converted to weight using 0.035 tons/cubic yard (Green Valley Disposal)

Table 5 represents the weight and volume of each material reused. Reused materials represented 4.96% of the total weight of waste from the site. Most of these materials were saved to reuse on future jobs. For example, several companies saved 5-gallon plastic buckets for use as storage containers, and Vogel Brothers saved plywood for use as boardwalks for muddy construction sites. The electrical subcontractor kept wooden spools for electrical wire, and workers salvaged some miscellaneous waste wood for their personal use.

Table 5. Summary of Materials Reused

Material	Volume (Cubic Yards)	Weight (Tons)	Percent of Total Weight[1]	Receiving Party
Plastic	5[2]	0.04[2]	0.05%	Vogel and subcontractors saved and reused
Metal	6[2]	0.10[2]	0.12%	Vogel and subcontractors saved and reused
Wood	16.5[2]	2.62[2]	3.05%	Vogel and subcontractors saved and reused
Topsoil	6000	1.5[3]	1.74%	Subcontractor removed; used for building landscaping berms
Totals	**6027.5**	**4.27**	**4.96%**	

[1] Including trash and recycling
[2] Estimated from conversion factors and visual estimates
[3] Volume converted to weight using 0.5 tons/ cubic yard

Table 6 represents the amount of material that was hauled to landfills and disposed. Most of the non-recyclable trash went to a conventional private landfill, but the four tons of clean fill material was disposed at a local fill site at no charge.

Table 6. Landfilled Materials Summary

Material	Weight (tons)	Volume (cu yd)	Percent of Total Weight[1]	Receiving landfill
Trash	17.67	210	20.15%	Mallard Ridge, Delavan
Clean Fill[2]	4	8	4.56%	Clayton's Pit, Fitchburg
Totals	**21.67**	**218**	**24.72%**	

[1] Including recycling and reuse
[2] Clean fill was masonry material, removed and disposed by the subcontractor

F. Economic Evaluation

Table 7 represents total disposal costs, cost per unit weight and volume for each material, and recycling and trash totals. Cardboard was the most expensive material to recycle, because hauling the small six-yard containers costs more per unit volume than hauling larger containers. The small containers were used because they have a lid to keep the cardboard dry. In the future, using larger containers (that can be covered) would make recycling cardboard more economical. The cheapest material to recycle (per ton) was drywall, because it is a dense material -- each full dumpster of drywall weighed more than full dumpsters of other materials.

Vogel Brothers did not receive revenue from any of the recycled materials. Scrap metal – particularly aluminum or copper, which are often salvaged separately – can generate

some additional revenue. In this project, however, the revenue from aluminum and copper went to the subcontractors handling those materials. The mixed scrap metal value was not high enough even to offset hauling costs.

Table 7. Costs of Recycling and Disposal.

Material	**Weight** (Tons)	**Hauling** fee	**Tipping** fee and tax	**Total** disposal **cost**	Cost of disposal **per ton**	Cost of disposal **per yard**
Metal	9.41	$660	n/a	$660	$70.14	$8.92
Wood	17.74	$2000	n/a	$2000	$112.74	$8.33
Drywall	22.43	$1170	n/a	$1170	$52.16	$9.83
Commingled bottles and cans	0.125	$200	n/a	$200	$1600.00	$40.00
Cardboard	10.23	$2520	n/a	$2520	$212.84	$8.87
Styrofoam	0.19	n/a	n/a	n/a	n/a	n/a
All Recycling	**60.12**	**$6550**		**$6550**		
All Reuse	4.27	N/a	n/a	n/a	n/a	n/a
Trash	21.67	$862.38	$689.98	$1552.36	$71.64	$7.12
Totals	**86.06**	**$7412.38**	**$689.98**	**$8102.36**		

[1] Volume converted to weight using 0.5 tons/ cubic yard

To assess the overall economic effect of recycling on this project, we calculated the expected disposal costs assuming no recycling program. This calculation is based on the total weight and volume of all types of waste generated on the construction site. To calculate expected tipping fees, we multiplied the tonnage of all waste by the tipping fee per ton of trash disposal. To calculate expected hauling costs, we first divided the total volume of waste by 20 to calculate the number of 20-yard dumpsters required to dispose of the waste. We then multiplied the number of hauls by $94.92, the average hauling cost per 20-yard trash dumpster. The expected cost of disposal on this project without a recycling program is $8026.70. This does not include the 1.5 tons of reused topsoil, because that material would normally not be landfilled.

Table 8. Expected Costs Assuming No Recycling Program

Total tons of waste	84.56
Total yards of waste	992.83
Tipping fees (@ $36.50/ton[1])	$3086.62
Number of hauls (@20 yards per)	49.64
Hauling costs (50 hauls @ $94.92[2] per)	$4746.00
Tax	$228.10
Total disposal cost	**$8060.72**

[1] Tipping fee paid for landfill disposal on this project
[2] Average trash hauling cost calculated over July 2001 to March 2002

The cost impact of recycling at this project can be calculated by:

$8,102.36 (actual costs with recycling, from Table 7)
- **$8,060.72** (projected disposal costs assuming no recycling program, from Table 8)
$ 41.64

The cost difference for recycling at this project was only $41.64. This clearly demonstrates that recycling was a cost-effective strategy for managing the project's construction waste, in addition to the many environmental benefits of avoiding landfill disposal.

G. Evaluation of results and suggestions for improvements

Interviews with Workers on Site

We interviewed construction workers on site to find out what worked well, and what did not. We learned from several people that originally all the dumpsters for recycling and waste were placed in the back of the parking lot rather than adjacent to the construction site. This location was inconvenient for the workers (Figure 5).

Figure 5. Collection containers were placed in the back of the parking lot

To make it easier to load the containers, one cubic-yard metal dock carts were used to collect recyclable materials adjacent to the building. When these dock carts filled up, the material could then be transferred to the 20-yard dumpsters (Figure 6). This intermediate collection site set up resulted facilitated recycling and waste disposal practices.

Figure 6. Drywall is dumped from a one-yard dock cart into a 20-yard recycling collection dumpster.

The project superintendent, mentioned that it would be helpful to learn up-front what materials can and can't be recycled, because they could then anticipate what containers are needed and how to sort waste materials during the construction process.

Many expressed support for the recycling even if it were slightly more time-consuming or costly. An electrician noted that it's easy to separate the materials for disposal, and another noted that once

workers get used to recycling on the job, it would be a habit, just like recycling at home. One worker noticed that on regular construction jobs, where there is only one dumpster for trash, the dumpster fills up quickly and it becomes difficult to dispose of material in an overflowing container. Having several containers on this project alleviated this problem.

The project superintendent expressed great satisfaction with the large volume of material that was being diverted from the landfill. He was so pleased with the results of this project that he wants to implement some recycling measures at future Vogel Brother construction sites.

What Worked Well

Vogel Brothers employees and subcontractors approached recycling with a positive attitude and a willingness to learn. There was very little contamination in the recycling bins, and recycling processors accepted all of the loads as clean and uncontaminated. Pete Runhaar from Green Valley Disposal offered the following insight: “Construction workers are very used to following specific directions and following guidelines once the plan is set out. That’s what they do. So once you lay it out, and you lay it out right, they’re very good at following the specifications.”

Using dock carts to collect recyclable material close to the building was an effective way to save time and trouble for workers placing materials in the recycling bins. If multiple recycling bins cannot be located immediately adjacent to a construction site, this is a good alternative to make it easier to sort recyclable material and minimize time spent on disposal.

The signs that Vogel Brothers made for the collection dumpsters were very effective in preventing contamination. None of the loads of recycling were rejected for contamination during nearly ten months of construction.

Expanding this project statewide would be most successful if companies and employees are willing to learn and try new methods of waste disposal. Setting up a construction waste management plan ahead of time will increase the chances of success because it will familiarize builders with local markets and facilitate communication with haulers and processors.

Suggestions for Improvement

This project’s high rate of recycling and reuse (75%) make it an outstanding example of construction waste management. Still, our qualitative investigation into the process produced ideas for improvement of future projects. Most importantly, we learned that recycling could be more convenient for workers if dumpsters are situated close to the workspace. Likewise, the commingled can and bottle recycling could be made more convenient by placing at least one collection container on every floor of the building.

Vogel Brothers staff expressed a desire to learn more about the disposal of various materials at the early stages of the project. When new or unusual materials were generated, such as various kinds of plastic packaging, it took time to learn whether or not each material was recyclable. Although it is difficult to anticipate the array of

materials that will need to be disposed of, learning from pilot projects like this one will help us find markets for more materials, and educate construction workers in the future.

Although Vogel Brothers signage was effective in helping workers sort recyclables without any contamination, signs can be made simpler to avoid potential confusion about which specific materials are and are not acceptable for recycling. For example, rather than using the term “co-mingles” (Figure 7), we suggest simpler more descriptive terms such as “cans and bottles”.

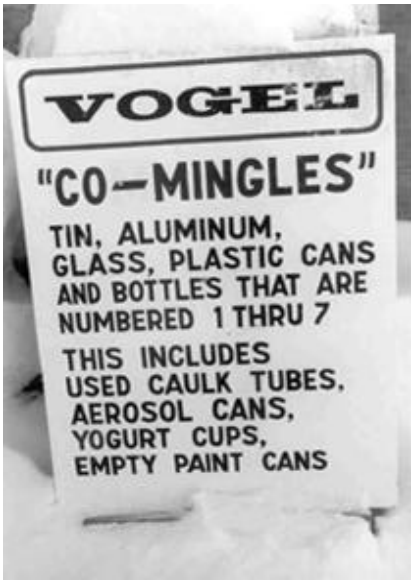

Figure 7. Signage at the barrel where cans and bottles were collected

On many construction sites, waste and recycling containers can become contaminated through illegal dumping by outside parties. The best way to prevent this is to maintain tight security measures (i.e. locking gates to the construction site).

Recycling may save disposal costs in several ways. One way to make recycling more cost-effective is to use larger containers that will need to be hauled less often. Smaller containers cost more per unit volume to haul than larger containers. For this project we used smaller 6-yard containers for cardboard, which needs to stay dry, because they had lids. This resulted in higher hauling costs for cardboard. If larger covered containers are not available, it may be possible to cover a 20–yard dumpster with a tarp to keep it dry when it is not being used.

Reducing volumes may also save hauling costs, especially for bulky materials. Compacting wood in the collection dumpster could save hauling costs. Compaction might be feasible depending on the type of machinery are available on-site.

Choosing recycling haulers also presents opportunities to reduce costs. Finding haulers and processors that can help investigate markets for new materials, and are willing to assist in documenting weights and volumes of materials, will add to a project’s success.

Achieving a 75% recycling rate is a tremendous success. Recycling rates might be marginally increased by identifying markets for the following materials that accounted for part of the remaining (25%) waste stream:

- Ceiling tile scrap (Figure 7)
- Plastic wrap (Figure 8)
- Fiberglass insulation
- Carpet scraps

On many construction sites, there may be insufficient volumes of these materials to justify hauling costs to recycle these materials. However, there may be opportunities to work cooperatively with other near by building projects to collect sufficient volumes to justify hauling costs.

Figure 8. Acoustic ceiling tile scraps in the trash dumpster

Figure 9. Plastic wrap was disposed of in the trash

There are few limitations to adopting construction waste recycling programs statewide. Disposal expenses at this project suggest that cost is not a barrier to recycling construction waste. Markets for various recyclable materials may vary around the state, however, and lack of a local market may make recycling impractical for a particular material.

Sharing Results

The results of this project are being shared within the construction industry and with the general public. On March 8th, Channel 3 featured Vogel's recycling efforts, and Channel 15 TV mentioned the recycling program in their story on April 28 highlighting construction waste recycling projects in Madison. A story about the recycling is being published in the Associated Recyclers of Wisconsin (AROW) bulletin, and in the Daily Reporter, a Wisconsin construction news journal.

Results will also posted on WasteCap Wisconsin's web site, www.wastecapwi.org, and at Madison Environmental Group's website, www.madisonenvironmental.com.

We hope that by spreading the news of this project's success other construction companies and clients will be encouraged to undertake recycling projects in subsequent building projects. The methods here are easily adapted for many types of building projects and the impacts are significant.

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