King County
Department of Natural Resources & Parks
Solid Waste Division

Waste Monitoring Program

Market Assessment of Construction and Demolition Waste Materials

FINAL REPORT 2004

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INTRODUCTION

King County's Waste Monitoring Program is an ongoing study of the waste generated in King County, not including the City of Seattle. This study allows the County to monitor and track changes in waste composition and identify emerging trends. Analysis of information collected in the Waste Monitoring Program helps the County shape its solid waste policy and planning and to measure progress towards waste reduction and recycling goals.

One component of the Waste Monitoring Program is a study of recycling markets for construction and demolition (C&D) waste materials, initiated in 2002. Cascadia Consulting Group, the County's consultant for the Waste Monitoring Program, conducted research through interviews of known C&D processors and end users as well as a literature review of current studies and industry publications. The goal of this market assessment was to investigate and assess the barriers to C&D recycling, opportunities for market development, and strategies the County can use to increase recycling of C&D waste. This report presents the findings of the research and makes recommendations for actions the County can pursue to increase recycling of C&D materials.

PRINCIPAL FINDINGS

This market assessment of C&D materials included research on wood, asphalt shingles, gypsum wallboard, and carpet, with a particular focus on wood. Several promising opportunities for market development are identified in this study. The following sections summarize the principal findings and recommendations of this C&D market assessment.

WOOD

This study focused on recyclable "urban wood" such as dimensional lumber, engineered wood, pallets, crates, roofing, siding, furnishings, and other scrap wood from new construction or manufacturing. In light of the significant quantities of King County's recyclable wood that are disposed annually – an estimated 73,000 tons in 2002 – this study placed a particular emphasis on opportunities to increase recycling of urban wood.

Notable findings regarding wood markets include the continued strength of the hog fuel market, the potential opening of a new market (Boise Cascade's composite building material facility), and the recent collapse of the pulp and paper market for urban wood.

Current Status

- More than 60% of the wood waste generated is recovered for other uses.
- Hog fuel is the primary use of this recovered wood.
- Large quantities of recyclable wood remain in the waste stream.
- The opportunity to use urban wood to make recycled pulp and paper no longer exists, although it was cited in the mid-1990s as a promising and viable end market.

Future Trends

- The pulp and paper market for urban wood appears unlikely to reemerge in the near future.
- The hog fuel market is expected to remain strong for the foreseeable future.
- If successful, Boise Cascade's new composite building material factory will create a large demand for high-quality recovered wood.

Key Barriers to Increased Recycling

- The difficulty of isolating and maintaining a stream of clean wood suitable for higher-value uses, such as for new building products, limits the quantities being sent to such markets.

Key Opportunities

- The large quantities of recyclable wood still disposed provide an untapped supply for potential future increases in recovery.
- Exploring higher-value markets could increase market diversity, competition, and stability for urban wood markets, perhaps leading to higher prices paid and increased financial incentives for recycling.

ASPHALT SHINGLES

Markets for asphalt shingles from King County are virtually non-existent, with the exception of minor quantities that at least one landfill uses for interim cover. This study identified a potential opportunity to develop the use of asphalt shingles in road paving – a market that has proven successful in other areas of the country.

Current Status

- Currently few asphalt shingles are recycled from King County.
- Current markets for recycled asphalt shingles are essentially non-existent, and the only reported market for recovered asphalt shingles is the small amount used as interim cover at landfills.
- No processors of asphalt shingles are located in King County. Processors in Pierce and Snohomish counties face extremely limited end markets for recycled shingles.
- Little economic incentive to recycle asphalt shingles exists, as tip fees charged at processors in Pierce and Snohomish counties are not significantly lower than tip fees for disposal at local facilities.

Future Trends

- No developing markets for recycled asphalt shingles were reported, though the Tacoma Steam Plant may again use shingles as fuel if it reopens.

Key Barriers to Increased Recycling

- Prominent end markets for shingles used in other areas, especially road applications, are not approved in Washington.

Key Opportunities

- If asphalt shingle recycling is to increase in King County, a viable local market will need to be developed.

GYPSUM WALLBOARD

Construction and demolition activities generate large quantities of gypsum wallboard, as it is used in most residential and commercial buildings. Markets for recycled gypsum wallboard are expected to remain strong in the years ahead, and few barriers to recycling gypsum wallboard exist. Accordingly, increasing the quantities recovered from the waste stream is a prime opportunity.

Current Status

- Gypsum wallboard is a highly recyclable material, and a sizeable amount is already recycled from King County. One local processor recently closed, but another nearby facility is increasing its capacity to recycle gypsum.
- The only current market for recycled gypsum wallboard is new gypsum wallboard, but this market is relatively stable and strong, despite some recent changes in processing.

Future Trends

- The solid demand for recycled gypsum wallboard is likely to continue. Although product specifications may pose some limits to future recycling, manufacturers report that room for growth exists.
- The Recovery 1 facility in Tacoma began processing gypsum wallboard from commingled C&D loads in 2003, expanding the supply of recycled gypsum wallboard to regional manufacturers.

Key Barriers to Increased Recycling

- Although some challenges were reported, no significant barriers to gypsum wallboard recycling are apparent. The May 2004 closure of New West Gypsum Recycling's Fife facility has reduced recovery options, but increased capacity at Recovery 1 in nearby Tacoma is expected to handle additional gypsum material.

Key Opportunities

- In British Columbia and other areas, a disposal ban on gypsum wallboard has significantly increased the quantities of gypsum wallboard that is recycled.

CARPET

Approximately 14,400 tons of carpet from King County is disposed each year, and little (much less than 1,000 tons) is recycled. Carpet recycling is technically and economically challenging, and the only reported existing processors are located in Georgia, making transportation a major barrier.

Current Status

- Currently little carpet is recycled from King County.
- Current markets for recycled carpet, mainly located in Georgia, are too distant to be economically viable for King County generators. Furthermore, these markets accept only a limited array of carpet products for recycling.

Future Trends

- The carpet industry has taken some small steps towards increasing carpet recycling, but no firm plans or developments are likely to promote dramatic increases in carpet recycling in King County in the near future.
- Still, companies like Georgia-based Interface are actively working on market-based solutions to carpet recycling through strategies such as redesigned products and a business model to offer carpet as a service rather than a product.

Key Barriers to Increased Recycling

- The large distance to market creates a significant logistical and economic barrier to recycling carpet from King County.
- The high capital costs required to enter the carpet recycling business reportedly dissuade potential new recyclers.
- The technology to recycle current forms of post-consumer carpet back into new carpet is lacking.

Key Opportunities

- Product stewardship may be a long-term opportunity. For example, at least one prominent company, Interface, is in the process of redesigning carpet for recyclability and offering floor covering as a service rather than a product. Under this model, the company assumes responsibility for carpet reclamation or recycling.

RECOMMENDATIONS

Based on the findings of this study, the consultant recommends that King County take the following steps to increase overall recycling of construction and demolition wastes generated in the county:

- Assist with the development of a commingled C&D processing facility in King County.
- Continue to promote source separation as a means of securing some high-grade materials.
- Consider aiding the deconstruction industry as a means of maximizing the value of recovered C&D materials.

Additional, recommendations for each of the specific materials follow. All recommendations are discussed in greater detail in the main body of this report.

Wood

- Where possible, provide drop boxes for clean, urban wood at King County-owned transfer facilities, and adjust rate structures to create financial incentives for their use.
- Modify contracts with private C&D transfer stations to require the separation and recycling of clean, urban wood.
- Assess the environmental trade-offs of using urban wood as hog fuel.

Asphalt Shingles

- Form a partnership to test and pilot the use of recovered asphalt shingles in aggregate road base and hot mix asphalt.
- If such tests and pilot programs are successful, implement programs and policies to increase recovery and maintain quality of shingles from tear-off roofing jobs.

Gypsum Wallboard

- Consider a disposal ban on gypsum wallboard.

Carpet

- Institute government procurement standards that require recycling of carpet installed in government buildings.
- Participate in product stewardship and design initiatives, where feasible.

Chapter 1.
C&D Market Assessment Overview

1.1 INTRODUCTION

This report presents key findings and recommendations from a study of markets for recyclable commodities generated by construction and demolition activities.

The goal of this research was to assess markets for construction and demolition waste materials. Specific objectives included:

- Evaluating the current strength and status of markets for C&D waste materials;
- Estimating current supply and demand of relevant materials;
- Examining potential future markets; and
- Identifying opportunities to overcome barriers, increase recycling, and expand markets for C&D recyclables in the region.

This report presents the results of this assessment. Specific findings and recommendations are presented for wood, asphalt shingles, gypsum wallboard, and carpet. Please note, however, that King County identified wood as a key focus of the study; accordingly, wood is addressed in greater depth.

1.2 METHODOLOGY

In 2002 and 2003, this study collected information on recycling and market opportunities for wood, gypsum wallboard, asphalt roofing shingles, and carpet. The research consisted of interviews with known processors of materials from King County, excluding Seattle, to discuss markets and acquire estimates of amounts recycled in 2002. In-person and telephone interviews were also conducted with end users of the recycled materials. The research also included reviews of current studies and industry publications. Selected information on the status of recycling markets was updated prior to the release of this report in 2004.

1.3 REPORT ORGANIZATION

This report is organized according to the four target commodities of the study:

- **Wood** – Chapter 2;
- **Asphalt Shingles** – Chapter 3;
- **Gypsum Wallboard** – Chapter 4; and
- **Carpet** – Chapter 5.

Following the four material-specific chapters, **Chapter 6** presents **Recommendations** for increasing the recovery and recycling of C&D materials from King County. Two appendices provide additional information on the processing of C&D materials from King County as well as prices and material specifications for end users.

Each of the four material-specific chapters includes the following information:

Definition	This section provides a brief description of the commodity covered.
Background	This section presents background information on the commodity to help understand current market conditions.
Current Supply	This section shows the current supply of the commodity, both disposed and recycled, in 2002. It also lists the companies that process significant portions of the commodity. Appendix A supplements this section with a table of all processors.
Current Market	This section describes the markets to which processors currently send materials. It includes a description of each market and prices that the processors receive if available. Appendix B supplements this section with a table listing 2002 prices and specifications for each market.
Potential Markets	This section identifies other possible markets for the commodity that are not currently utilized.
Conclusions	This section presents conclusions regarding the viability of markets and potential areas for intervention.

Please note that the Wood section is expanded to include two additional sections, **Wood Supply & Demand by Grade** and **Potential Future Supply & Demand by Grade.** These sections describe the grades of wood currently disposed, current markets for those grades, and potential future markets that would maximize value.

KEY TERMS

Feedstock	A material that is used as an input to create another product.
Processor	A firm that transforms recyclable materials into a feedstock for reuse or remanufacturing.
End user	A firm that uses recycled materials as a feedstock to make a product for a consumer.

Chapter 2. Wood

This chapter discusses the market for wood generated by construction and demolition (C&D) activities in King County. In consideration of the large amounts of recyclable wood currently being disposed and used as hog fuel, this study covered wood in greater detail than the other three commodities.

2.1 DEFINITION

This study focuses on recyclable "urban wood" generated by construction, demolition, and remodeling activities.[1] This definition includes the following types of wood:

- Dimensional lumber;
- Pallets;
- Crates;
- Manufacturing scrap;
- Engineered wood;
- Roofing and siding (half of which is assumed to be recyclable);
- Painted or stained wood from new construction; and
- Finished and unfinished furnishings.

Please note that for the purposes of this study, recyclable urban wood excludes creosote and pressure-treated wood, painted wood from demolition or remodeling, other wood, and the half of wood roofing and siding that is assumed to be unrecyclable. Wood generated from land-clearing activities is not included in this study, as these materials typically have different characteristics and recycling markets than most urban wood.

2.2 BACKGROUND

In the mid-1990s, urban wood was seen as a promising alternative to virgin wood in the pulp and paper industry. Several local and regional studies forecasted that the rising world demand for virgin wood, along with decreasing production in the Northwest, would lead to a strong pulp and paper market for urban wood. These studies recommended pursuing pulp and paper as the best potential market for recycling urban wood.

As pulp prices increased dramatically in the mid-1990s (to nearly $900 per ton), the pulp and paper industry, as well as the reconstituted panelboard market, began to experiment

[1] "Urban wood" is secondary wood (i.e., wood that had been made into a product – not logs, stumps, or other land-clearing debris) that is generated by C&D activities or is used in warehousing/shipping and manufacturing (such as pallets and crates). This study focuses on the portion of urban wood that is recyclable.

with urban wood as a feedstock. In King County, several wood processors began selling their wood to the pulp chip markets. Although panelboard markets in Oregon were accepting urban wood, the prices paid were not sufficient to warrant the cost of transportation from King County processors.

However, pulp and paper markets crashed in 1996, with pulp prices falling to below $500 per ton. This drop led to widespread restructuring, including major pulp and paper mill and machine shutdowns, as well as widespread consolidations within the industry. In the subsequent years, worldwide supply has generally exceeded demand, and pulp prices have remained low. The low prices for pulp feedstocks ($50-$100/ton) have made it difficult for urban wood, at $80 per ton, to compete with virgin materials and recycled paper at pulp mills. Wood experts predicted that wood fiber prices would remain stable or decrease during the next 5-10 years, and pulp mills were phasing out their use of urban wood in late 2002.

The result of these changing markets is that the major perceived opportunity of using urban wood in the pulp and paper market has never fully materialized.

2.3 CURRENT SUPPLY

As mentioned above, this study focuses on the recyclable portion of the "urban wood" generated by construction, demolition, and remodeling activities. Table 1 displays King County's urban wood supply in 2002. Note that a large fraction of the total urban wood generated is recyclable.

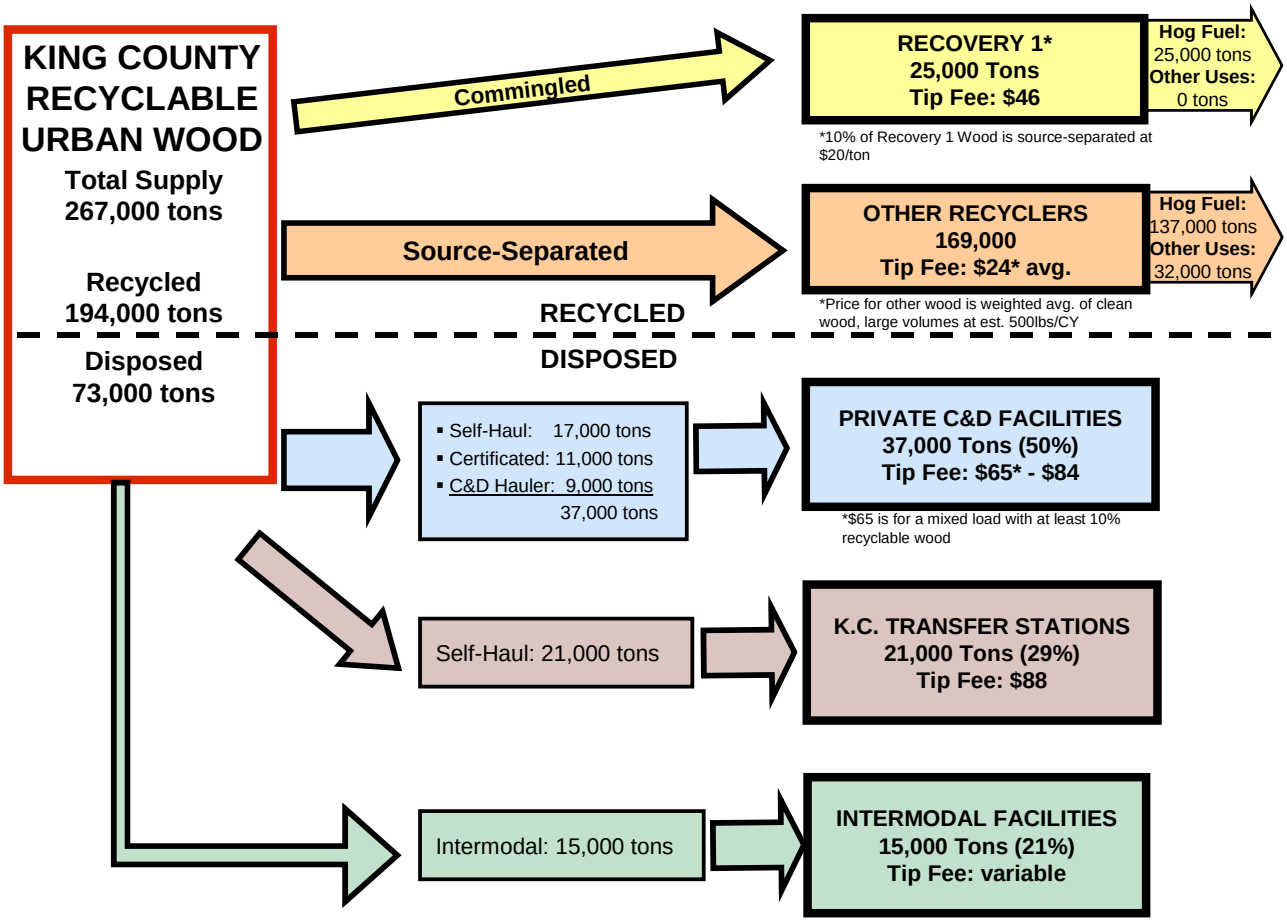
Table 1. King County Urban Wood Supply
Tons/year (2002)

	Total Urban Wood	Recyclable Urban Wood
Disposed	126,000	73,000
Recycled	194,000	194,000
Total Generated	320,000	267,000

As the table indicates, C&D activities in King County (excluding Seattle) generate an estimated 267,000 tons per year of recyclable urban wood. An estimated 194,000 tons are currently recycled. Of the amount recycled, Recovery 1, a commingled processor, handled 13% in 2002; source-separated processors handled the rest. Prominent wood processors serving King County are listed in Appendix A.

Figure 1 depicts the supply of recyclable urban wood from King County. The top half of the chart displays the amounts recycled and divides these by commingled and source separated processors. The bottom half of the chart depicts the portion of urban wood that is currently disposed but could be recycled. Note that about half of the disposed wood (37,000 tons) is handled at the private C&D facilities. King County's previous study of C&D disposal estimated that new construction generates most of this wood (21,000 tons). Demolition activities (9,000 tons), mixed sources (4,000 tons), and manufacturing scrap (3,000 tons) generated the remaining disposed wood.

Figure 1. King County Recyclable Urban Wood Supply & Waste Stream Definitions
Tons/year (2002)



Waste Hauler & Facility Definitions	
Certificated Haulers	Haulers that operate under authority granted by the Washington Utilities and Transportation Commission (WUTC) or haulers that contract with cities to operate a garbage collection company, such as Allied Waste and Waste Management.
C&D Haulers	Companies whose principal business includes demolition and/or hauling of construction and demolition materials, such as large construction or demolition contractors like Bobby Wolford Trucking & Demolition and Nuprecon, Inc.
Self-haulers	Any party other than a certificated or C&D hauler whose primary business is not waste hauling, such as contractors, residents, and small business owners.
Intermodal Facilities	Facilities that receive C&D waste loads from job sites in shipping containers, which are placed on trains destined for regional landfills; Argo Yard, Black River, and Third & Lander are local intermodal facilities that handle C&D wastes.
Private C&D Facilities	Privately owned facilities that accept C&D waste loads for transfer and disposal, including Black River, Eastmont, Auburn, and Third & Lander.

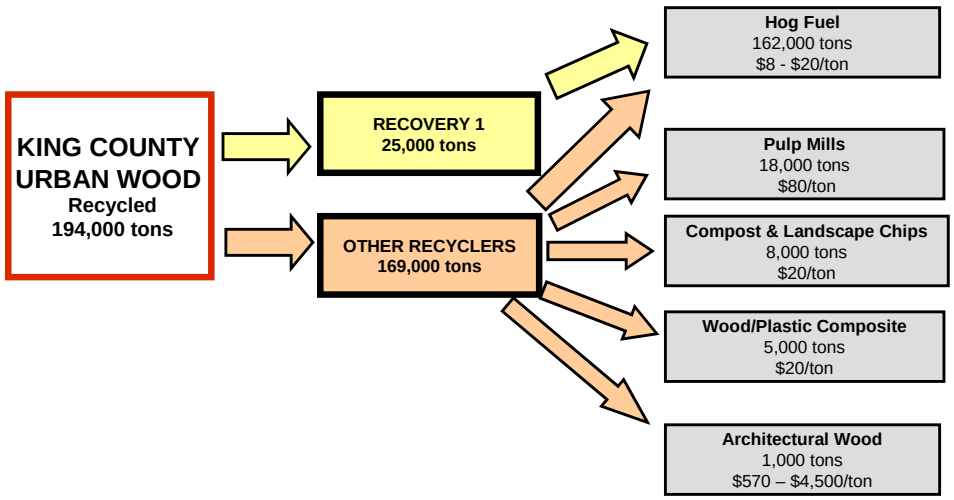
2.4 CURRENT MARKETS

This section covers the markets that accepted urban wood in 2002. It describes their market characteristics, specifications, prices, and barriers. The main markets were as follows:

- Hog fuel;
- Pulp chips;
- Compost/landscape chips;
- Wood/plastic composite building materials; and
- Architectural wood.

Figure 2 shows the quantities in tons that processors sent to the five main markets. Note that hog fuel is the dominant market, though it does not offer the best prices. Despite lower prices, hog fuel remains the primary market largely because other, higher-paying markets have more stringent specifications for the materials that they accept.

Figure 2. Markets for King County Urban Wood
Tons/year (2002); all prices in dollars per bone dry ton[2]



HOG FUEL

Hog fuel consists of ground woodchips that are burned as fuel in biomass boilers. The processor reduces the wood though a hog (grinder) or chipper to produce the coarse fuel chips.

[2] All market prices (but not tip fees) in this report have been converted to dollars per bone dry ton to enable comparisons between market prices. A **bone dry ton** is a ton of completely dry wood, with no moisture content, and is the common unit of measurement in the pulp and paper and hog fuel markets. Prices for markets that do not use bone dry tons for pricing have been converted to bone dry tons by considering the average moisture content of the material. For example, suppose a $24/ton price is paid for a material with an average moisture content of 20%. The price for this material per bone dry ton would be 125% x $24 = $30.00. However, please note that all quantities are simply reported in tons, as materials in the waste and recycling streams have various moisture contents and could not readily be converted to bone dry tons.

MARKET CHARACTERISTICS

Hog fuel is by far the largest market for King County urban wood, consuming an estimated 162,000 tons, or 84% of the current supply. Hog fuel is used at pulp and paper mills, where it is burned in "hogged fuel boilers" to make steam and heat for mill use. Hogged fuel boilers are often part of a larger cogeneration system containing multiple boilers, including recovery boilers for manufacturing byproducts such as waste liquor.

Kimberly-Clark's Everett facility, which installed a modern wood waste boiler in 1995, is purchasing approximately 70% of the hog fuel from King County. The company (formerly Scott Paper) entered into a joint venture to build the facility with the Snohomish County Public Utility District (PUD). Kimberly-Clark operates and maintains the facility, pays for all fuel for 15 years, and receives steam for its paper mill, which produces tissue, paper towels, and napkins. Snohomish County financed the capital costs at $115 million, and it receives the electrical output. Kimberly-Clark is a retail customer of Snohomish County PUD.

The hog fuel market absorbs a tremendous amount of wood each year. Kimberly-Clark alone reported that they burned 525,000 tons of wood in 2002, or about twice the entire annual supply of King County's recyclable urban wood. Some of this wood comes from other areas and from land-clearing sources, though Kimberly-Clark prefers urban wood since it is drier and burns better. Since 2002, the facility's consumption has increased to approximately 600,000 tons annually. Over the next five years, the facility's demand is expected to remain between 600,000 and up to 700,000 tons per year, its full capacity (though maximum capacity varies somewhat with the quality of the hog fuel).

Key end users of urban wood for hog fuel include Kimberly-Clark and other pulp and paper mills, such as the Simpson Tacoma Kraft Company, Rayonier's Grays Harbor facility, and the Longview Fibre Company.

SPECIFICATIONS, PRICES & VIRGIN ALTERNATIVES

The hog fuel market has the least stringent feedstock requirements, and it has a higher tolerance for contaminants than other markets. For example, engineered wood is often accepted, and most burners can take painted and stained wood, as long as it is lead-free. However, wood transported or stored in saltwater is unacceptable, due to emissions generated when burning the wood.

Hog fuel sells for approximately $8-$20/bone dry ton delivered. Natural gas and oil are its most common virgin alternatives. Kimberly-Clark, a major local user of hog fuel, typically relies on natural gas as a virgin alternative. However, hog fuel is generally cheaper than these alternatives per unit of heat energy produced. Research indicates that using wood is cheaper per energy unit than natural gas as long as the price of wood remains less than $40/bone dry ton.[3] Since the current price for hog fuel is $8-$20/bone dry ton, end users have a strong economic incentive to continue its use. Hog fuel derived from land-clearing wood sources provides another alternative to hog fuel from urban wood, though this material is less desirable due to its higher moisture content.

[3] Estimated with a natural gas price of $4.30 per million British thermal units (MBtus).

BARRIERS TO USING URBAN WOOD FOR HOG FUEL

Contacts interviewed for this study generally reported few barriers to using urban wood for hog fuel. The one barrier they did cite was distance to market. In other words, processors must have nearby end users if the market is to be viable. Processors often said that the price paid was just enough to cover transportation costs.

PULP CHIPS

Pulp chips are wood chips used to make paper pulp.

MARKET CHARACTERISTICS

In 2002, approximately 18,000 tons of urban wood was sold to the pulp chip market. The material was used to make corrugated medium and bag stock. Corrugated medium is the wavy center of the wall of a corrugated cardboard box, which cushions the product from shock during shipment. Bag stock is a heavy paper used to make paper bags.

Only one processor (Northwest Wood and Fibre Recovery, Inc.) and one end user (Longview Fibre) were found that handled or remanufactured urban wood for pulp chips in 2002.

SPECIFICATIONS, PRICES & VIRGIN ALTERNATIVES

Pulp chips require a high grade of wood and cannot be made from engineered wood products like plywood or glue-laminated beams. The wood that can be used is dimensional lumber, pallets, wooden crates, mill ends, and manufacturing scrap.

The pulp chip market has the most stringent requirements of the wood markets, with little to no tolerance for any dirt, plastic, or metal contaminants.[4] It also must have the most consistent feedstock size.[5] The tree species of the wood must be known, and different species cannot be combined. Even trace amounts of plastics or debris can have detrimental effects on the end product. Appendix B provides more detail.

In 2002, pulp chips made from urban wood sold for approximately $80/bone dry ton, delivered. The primary virgin alternative for this product is the pulp chips that are a common residual at lumber mills. These virgin pulp chips sell for $50-$100/bone dry ton delivered, depending on the tree species. This price is expected to remain low in the next 5-10 years.

BARRIERS TO USING URBAN WOOD FOR PULP CHIPS

Although using urban wood seems like a promising alternative feedstock, buyers encountered a number of major problems in its use. These difficulties include the following issues.

- **Contaminants**. Although processors (and end users) attempted to remove contaminants, they reported difficulty meeting end user specifications. When

[4] E & A Environmental Consultants, 1997. *Urban Recycled Wood Characteristics Study – Final Report.* Prepared for the Clean Washington Center. October.

[5] *Best Practices in Wood Waste Recycling: Woodwaste Feedstock Specification for Unbleached Kraft Pulp.* Brochure – BP-WW3-0101.

contaminants were present in feedstock, end users reported greatly accelerated wear to their equipment as well as a substandard product.

- **Limited suitability for current pulping process.** Contacts interviewed in this study reported that urban wood does not pulp well due to different character, shape, and particle distribution. In addition, the size variance of urban wood chips can cause an overcooked or undercooked chip. Urban wood is drier, does not absorb pulp chemicals as well, and tends to bridge or hang up on conveyor systems designed for virgin material.

Based on these problems, end users reportedly discontinued the use of pulp chips from urban wood by the end of 2002, with no anticipation of future use. Longview Fibre was the only buyer found that had purchased urban wood for this market, and the company noted that the price was too high (at $80 bone dry ton delivered) and problems too numerous to justify its continued use. The buyer remarked that even if the price discrepancy were much larger, he would not be interested in future use.

COMPOST / LANDSCAPE CHIPS

Compost consists of decomposed organic matter that can be used as a mulch, soil amendment, and fertilizer. Landscape chips are ground, chipped, or shredded wood that is used as mulch.

MARKET CHARACTERISTICS

About 4% (8,000 tons) of King County's recycled wood went to compost or landscape chip applications. The wood is ground and used in a wood-chip mulch product or used as a "bulking agent" in compost production. Soos Creek Organics and Pacific Topsoils were the key processors and end users in 2002.[6] However, severe odor problems forced Soos Creek to cease its operations in Covington in 2003.

SPECIFICATIONS, PRICES & VIRGIN ALTERNATIVES

Unlike the pulp chip market, the compost and landscape chip market has no tree species limitations and can accept small amounts of engineered wood. Still, the wood must generally be free of paints and stains. Urban wood can be added to a compost mix, where it acts as a "bulking agent" to balance the quantities of grass and yard clippings. Generally, this bulking agent comprises about 20% of a compost facility's mix, and the remainder is yard debris. The virgin substitute for urban wood as a bulking agent is green wood or sawdust.

BARRIERS TO USING URBAN WOOD IN COMPOST

End users indicated no major barrier to its use, though the compost marketplace has only limited demand for urban wood. Urban wood can be used as a bulking agent in compost to balance ratios of carbon and nitrogen inputs. Demand for urban wood is limited because yard waste collection programs already deliver large quantities of green wood to compost facilities, and wood can comprise only about 20% of compost content.

[6] In compost and landscape chip markets, processors are also end users who sell the finished product to residents or landscapers.

In general, when grass clippings dominate collected yard waste, facilities are more likely to supplement their mix with outside sources of wood, such as urban wood.

WOOD / PLASTIC COMPOSITE BUILDING MATERIALS

Wood/plastic composite building materials are a relatively new type of product made from recycled plastic and recycled urban wood. Composite building materials are generally made to replace wood products. Current and planned products include siding, lumber, and decking.

MARKET CHARACTERISTICS

Development of the emerging wood/plastic composite market has been underway in the region for several years. Boise Building Solutions, a division of the Boise Cascade Corporation, recently opened a manufacturing facility in Washington to produce clapboard siding products, under the brand name "HomePlate." This product is made from 100% recycled materials, including about half recycled plastic and half recovered urban wood.

The unique feature of these products is that they are specifically designed to use urban wood rather than virgin timber as a feedstock. Although wood/plastic decking exists in the marketplace, currently no house siding material is made from this composite material. Wood/plastic composites are weather resistant, do not easily splinter or warp, and resist rot and insects, providing a longer life than regular wood.

The wood for HomePlate is first sourced and processed by Marathon Wood Recovery, a Boise Cascade program. Marathon has contracted with ReSourcing Associates to procure the wood (as well as plastic) and with Rainier Wood Recyclers in Auburn to perform initial processing of the wood. After the initial processing, the wood is shipped to the Boise Building Solutions mill near Elma in southwestern Washington.

Within the next three to five years, Marathon Wood Recovery plans to source 150,000 tons of urban wood per year from the region between Vancouver, B.C., and Portland, Oregon, as well as from sections of Eastern Washington. However, much of the supply will likely come from King County because of its proximity to Auburn, where the wood is pre-processed at Rainier. Of the 150,000 tons of sourced wood, one third of this amount is expected to consist of fines and small residual wood pieces that cannot be used in the Boise manufacturing process. This residual stream amounts to about 50,000 tons per year and will be sold for hog fuel and other secondary uses.

Boise has invested millions of dollars in the venture and plans to sell up to 100 million square feet of this product when operating at full capacity. In 2003, Marathon sourced 45,000 tons of urban wood, of which 25,000 tons went to Boise Building Solutions for its wood/plastic composite plant in Elma. In the first half of 2004, Marathon sourced 18,000 tons of urban wood, sending 5,000 tons to Boise and selling the remaining 13,000 tons as hog fuel. Due to technical issues at the Boise plant, Marathon stopped sending wood to Elma in April 2004, but production is expected to resume in 2005. When the Boise facility reopens, Marathon plans to increase the amount of urban wood it sources from the current levels up to approximately 12,500 tons per month if the Boise plant reaches its peak production level. The Boise company plans to open more composite manufacturing plants if the current effort proves successful.

SPECIFICATIONS, PRICES & VIRGIN ALTERNATIVES

Rainier Wood Recyclers is contracted to process the wood. They are leasing the previous Northwest Wood and Fibre facility in Auburn, and they have retrofitted the plant to meet Boise's specifications. Because of the product's unique raw material requirements, the facility seeks to obtain dimensional wood in unground form and process it. Panelboard scraps – such as plywood trim, OSB pieces, and particleboard pieces – are not desirable. No maximum size limitation exists, but the wood should not be in pieces smaller than 12 inches in length.

Marathon Recovery is sourcing four grades of wood for their operations. The highest grade, premium wood, contains only dimensional lumber, pallets, crates, mill ends, and manufacturing scrap. This material can go entirely into the production of the wood/plastic composite products, when Boise is accepting such material. A portion of the other three lower grades is separated and used for other uses, including hog fuel. Of all four grades of wood that are accepted at the Auburn plant, most of the cleaner grades are received at no charge, and the commingled grades are accepted with a tip fee up to $20/ton.

BARRIERS TO USING URBAN WOOD FOR WOOD/PLASTIC COMPOSITE

Contacts interviewed for this study report the following barriers:

- **Transportation/logistics.** Potential barriers to this market are transportation costs and the logistics of moving the wood to the pre-processing facility in Auburn. Processors expect that per-ton transportation costs will be higher than for hog fuel, as the larger particle size requirements will mean less weight in each container shipped. Marathon is actively working with wood sources to mitigate this barrier.
- **Marathon prefers source-separated wood.** Marathon has said that a source-separated supply is preferable to commingled loads, due to contamination issues. This preference presents a barrier for current and future commingled suppliers. However, Marathon is currently working with Recovery 1 on best practices to reduce this barrier.

ARCHITECTURAL WOOD

This market involves removing specialty timbers for resale from old buildings. Timbers can then be re-cut to specifications. This wood often exacts a premium price, especially when made from old growth timbers. Wood that is used for structural purposes is also more expensive, and stress patterns must be maintained. This wood sells from $0.50 to $4.00 per board foot. When converted to bone dry tons (for cost comparisons) it commands the highest price at $570-$4,500/bone dry ton. However, supply and demand are limited, making this the smallest market in 2002.

R.W. Rhine in Tacoma is the key processor and end user in this market.

2.5 CURRENT URBAN WOOD SUPPLY & DEMAND BY GRADE

Construction and demolition activities generate many types of wood waste. As discussed above, much of this wood is recyclable. Wood that is not recyclable is generally mixed or treated with paints, stains, or adhesives or is permanently bound with other materials.[7]

Wood that is recyclable can be sold to the above markets, depending on its quality, or grade. For the purposes of this report, recyclable wood is classified as one of two grades, *high-grade* or *low-grade.*

High-grade wood is defined as dimensional lumber, pallets, crates, manufacturing scrap, and specialty wood suitable for architectural reuse. The pulp and paper, panelboard, compost, architectural, and wood/plastic composite markets seek high-grade wood for their use.

Low-grade wood is defined as engineered wood products, recyclable roofing and siding, painted or stained wood from new construction, and finished and unfinished furnishings. Hog fuel is the main market that can readily accept low-grade wood.

Table 2 displays the current King County recyclable urban wood supply, by grade.

Table 2. King County Recyclable Urban Wood Supply by Grade
Tons/year (2002)

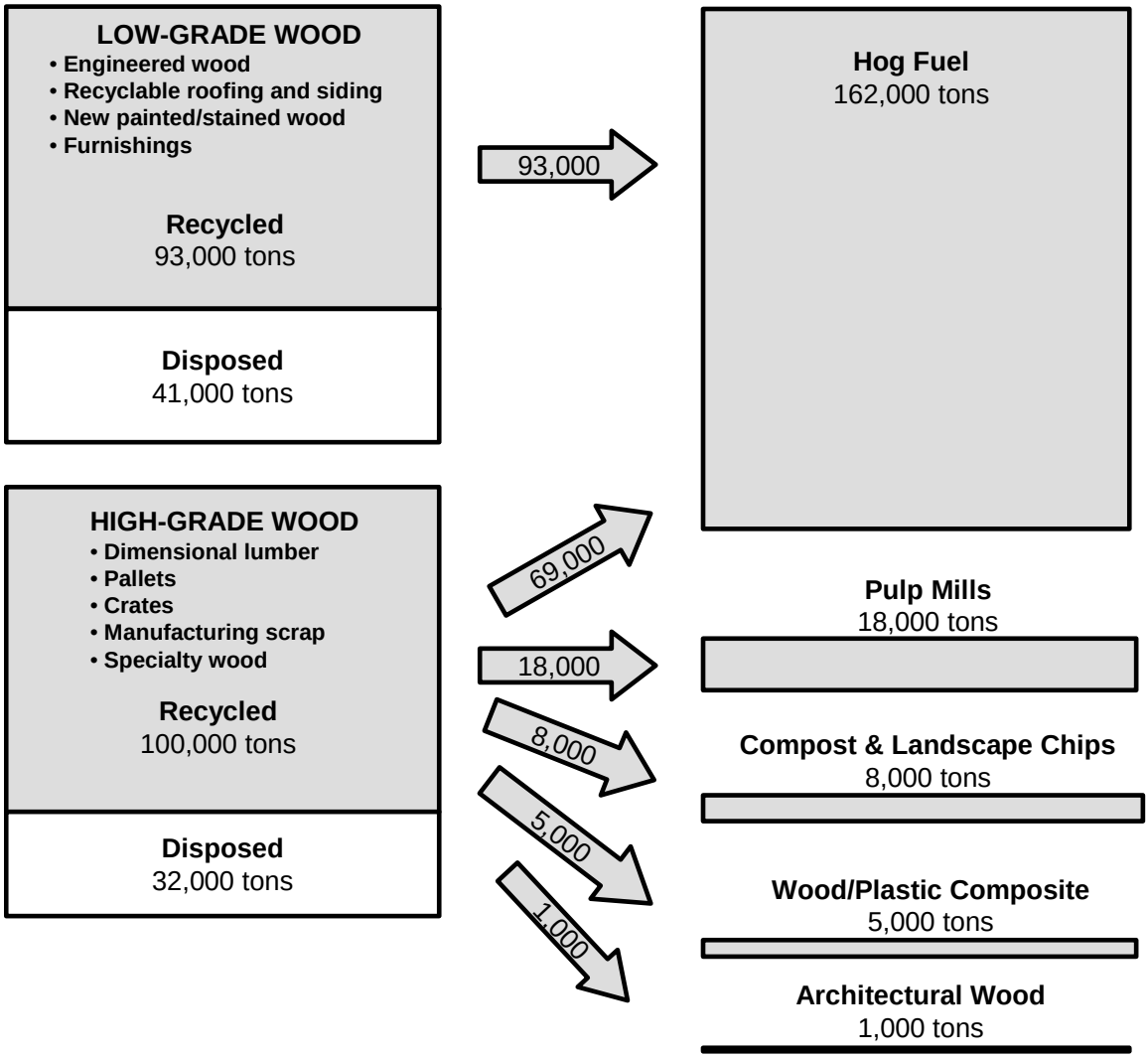
	High-grade Urban Wood	Low-grade Urban Wood	Total Recyclable Urban Wood
Disposed	32,000	41,000	73,000
Recycled	100,000	93,000	194,000
Total Generated	132,000	134,000	267,000

Please note that quantities shown in this report are rounded; thus, they may not add up precisely to the total figures.

Figure 3 shows how the supply of wood grades is used in end products. Note that currently an estimated 69,000 tons of high-grade wood is going towards hog fuel. This wood could go towards higher-value products, such as Boise Cascade's pending wood/plastic composite products.

[7] See section 2.1 for a discussion of which types of wood are considered *recyclable* for this study.

Figure 3. Urban Wood Markets by Grade & Product
Tons/year (2002)



2.6 FUTURE WOOD SUPPLY & DEMAND BY GRADE

Some end users interviewed for this study were able to estimate their future demand for urban wood.[8] In particular, Kimberly-Clark's expected demand for hog fuel and the Boise Company's potential demand for its wood/plastic composite building materials suggest solid demand for urban wood in the future. If the urban wood supply grows with population growth at an estimated 6% over the next 10 years, King County's supply of urban wood could potentially meet this increased market demand. Table 3 displays a possible future scenario in which little wood is disposed as demand for it increases in the marketplace.

[8] Demand for hog fuel was estimated to grow by 10%, due to Kimberly-Clark's expected need for 20% more wood above 2002 levels in the next 5-10 years (only a portion of their wood comes from King County). Wood demand for wood/plastic composite products is based on estimates from Marathon Recovery, which is sourcing the wood for Boise Building Solutions.

Table 3. Potential Future King County Recyclable Urban Wood Supply by Grade

	High-grade Urban Wood	Low-grade Urban Wood	Total Recyclable Urban Wood
Disposed	0	1,000	1,000
Recycled	140,000	142,000	282,000
Total Generated	140,000	143,000	283,000

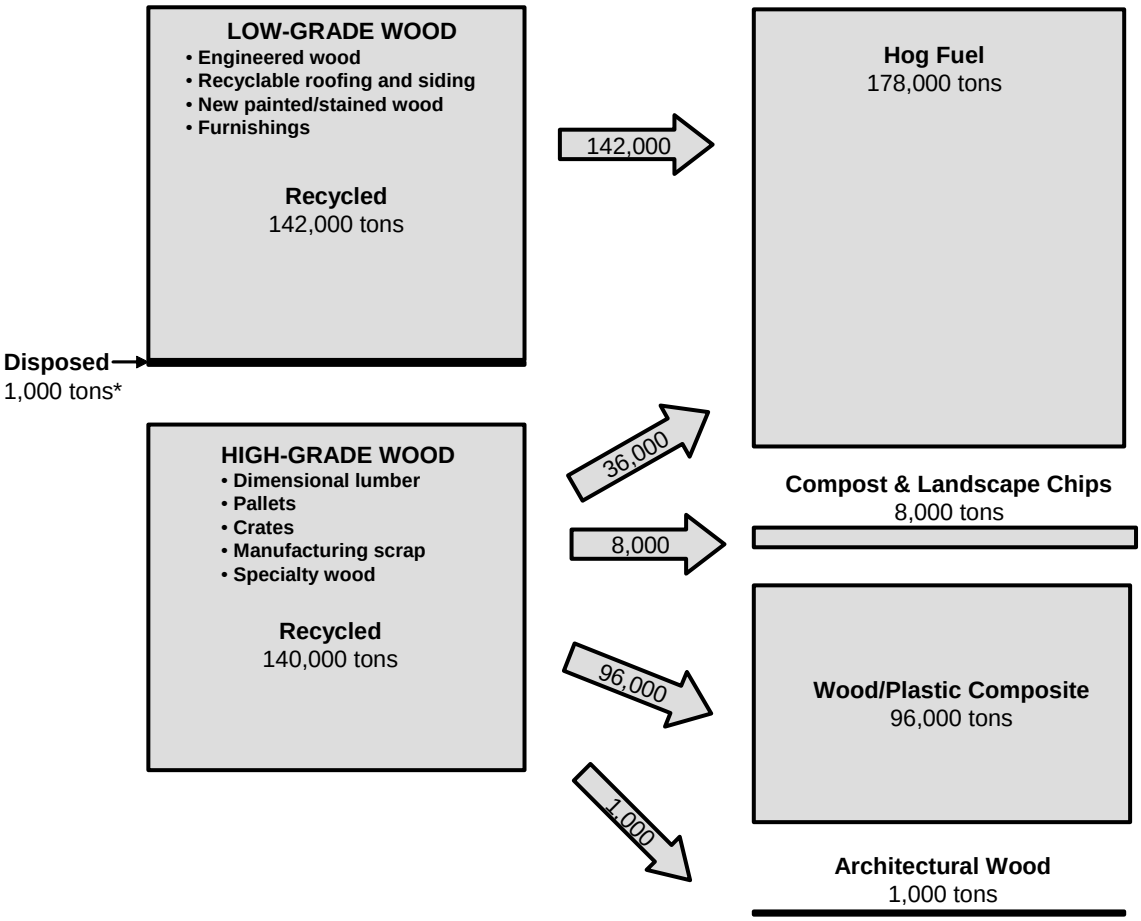
Under this scenario, the projected generation of 140,000 tons of high-grade wood could potentially all be recycled, due largely to the projected demand from Boise, which is expected to make a concerted effort to purchase high-grade wood.[9] In the future, projected demand for low-grade wood for hog fuel is also expected to increase, potentially enabling this market to absorb nearly all of the 143,000 tons of low-grade urban wood projected to be generated and leaving only about 1,000 tons of low-grade wood to be disposed.[10]

Figure 4 shows in more detail the potential future quantities of both low-grade and high-grade wood sold to each market.

[9] This estimate is a 6% increase over the current generation of high-grade wood of 132,000 tons.

[10] This estimate is a 6% increase over the current generation of low-grade wood of 134,000 tons.

Figure 4. Potential Future Urban Wood Markets by Grade & Product



* Note that in this scenario, increased future demand for urban wood leaves only a small fraction – about 1,000 tons – expected to be disposed.

2.7 POTENTIAL FUTURE MARKETS

This section discusses potential markets for King County processors that are not currently being utilized. These include finger-jointed wood and panelboard.

FINGER-JOINTED WOOD

Finger-jointed wood is a product created from small pieces of timber that are joined together to form longer members. The resulting members can then be cut to any size.

MARKET CHARACTERISTICS

Finger-jointed wood is a potential high-value use for urban wood. The products have good stability and do not warp, due to the finger-jointed construction. Five finger-jointed wood manufacturers in Washington could potentially serve as markets for urban wood:

- West Coast Forest Products in Arlington;
- CanforUsa Corp in Bellingham;
- Marson and Marson Lumber in Leavenworth;
- RFP in Spanaway; and
- Truemark Industries in Spokane.

SPECIFICATIONS, PRICES & VIRGIN ALTERNATIVES

One manufacturer currently pays $125-$150 per 1,000 board-feet for the manufacturing ends to make this product. This price translates to roughly $140-170 per bone dry ton, making this a potentially lucrative end use for urban wood.[11]

BARRIERS TO USING URBAN WOOD FOR FINGER-JOINTED WOOD

Contacts interviewed for this study reported that the major barrier is insufficient quantities to make the process worthwhile. One company told of a truss manufacturer that brings in his mill ends, and pays to have them made into vertical finger-jointed studs. The minimum size load that the company accepts is a semi-trailer, which takes the truss manufacturer a month to fill.

RECONSTITUTED PANELBOARD

Reconstituted panelboard consists primarily of small particles of wood that are manufactured into a laminated board product. The panelboard is produced in processes involving pressure, adhesives, and binders.

MARKET CHARACTERISTICS

Market experts predict growth in this market, due to the economics of using less virgin wood in the product, and superior product qualities. The majority of these products are

[11] Estimates were based on a weight of 2,200 lbs/1,000 board feet, and a moisture content of 20%.

manufactured in central Oregon. The main three categories of reconstituted panelboard that used urban wood are as follows.

- **Particleboard** is traditionally made mainly from virgin wood residues that are bonded together under heat and pressure with a urea formaldehyde adhesive. This product can be laminated and embossed. The majority of this product is used in the manufacturing of furniture, doors, cabinets, and fixtures.
- **Hardboard,** which is made from wood fibers consolidated under high heat and pressure. Unlike particleboard, only a small amount of resin is used in production. The largest user is the construction industry, which uses it primarily for exterior applications such as siding.
- **Medium-density fiberboard (MDF),** which is widely used in the manufacture of furniture, kitchen cabinets, door parts, moldings, millwork, and laminate flooring. MDF, which is more like a typical timber, is available as moldings as well as sheets. It is typically manufactured from tree plantation thinnings. The surface of MDF is flat, smooth, uniform, dense, and free of knots and grain patterns, all of which make finishing operations easier and more consistent. Stability and strength are important product qualities.

SPECIFICATIONS, PRICES & VIRGIN ALTERNATIVES

An end user in Oregon was interviewed to provide insight to this market. This user produced both MDF and particleboard using urban wood, and the company had made a significant investment in cleaning equipment and processing modifications to accommodate the urban wood. In 2002, they bought 31,000 bone dry tons.

The user purchased urban wood at $35-$50/ton delivered, which is more than the current rate for hog fuel. The competing virgin alternatives (delivered prices) were:

- Sawdust at $20-25/ton;
- Planer shavings at $40/ton; and
- Ply-trim (plywood trim) pieces at $25-$30/ton.

BARRIERS TO USING URBAN WOOD IN RECONSTITUTED PANELBOARD

This study found the following barriers to using urban wood in reconstituted panelboard:

- **Distance to market.** Transportation costs to Oregon are too high for King County wood processors. Estimates are about $25/ton to transport wood to Oregon.
- **Ease and low price of virgin feedstock.** Virgin feedstock is relatively inexpensive and easier to use. Since the cost of urban wood is not cheaper, little financial incentive exists for end users to buy urban wood for reconstituted panelboard.
- **Metal contaminants** such as nails and screws, are a major problem when using urban wood. These contaminants can cause:
    - *Shortened tool life* – When power tools came in contact with the metal it dulls the blades

- *Legal claims* – When a power tool hits metal, it can cause significant injuries, which have resulted in legal claims against the company.
- *Reduced market competitiveness* – Users did not place a premium on the urban wood. Instead, competitors cited that this manufacturer used "dirty wood" and that the end product was "inferior." Though the company used an air density separator to separate the wood from other materials and a chip washer, they still could not sufficiently clean it. Non-ferrous metal also remained that the magnets could not remove.

Unlike end users in the paper and pulp market, this end user indicated they would consider urban wood again in the future if fiber were scarce. However, currently they felt that the barriers outweighed the benefits and as a result, they are not using urban wood.

2.8 CONCLUSIONS

SUPPLY

This study concluded the following about the supply of urban wood from construction and demolition activities in King County:

- **The current supply of all King County recyclable urban wood is estimated to be 267,000 tons**.[12] Of this total, an estimated 194,000 tons are currently recycled, for a recycling rate of nearly 73%.
- **The current use of high-grade wood for higher-value products is limited.** An estimated 32,000 tons of high-grade, recyclable urban wood are disposed each year. However, this wood would need to be well-sorted and free of contaminants such as grit, nails, and plastics to be usable. In addition, approximately 69,000 tons of high-grade wood are used for hog fuel.
- **Virgin wood is abundant and prices are not expected to rise in the next 5-10 years.**
  - Due to improved forest management techniques, such as regular reseeding and thinning, the supply of timber has increased and stabilized.
  - Technological innovations have dramatically increased the amount of usable lumber per log.
  - Use of engineered wood products, which more efficiently use the available wood supply and can often use a fast-growing tree species are increasing in use.

[12] 267,000 tons are all recyclable wood currently disposed and currently recycled. An additional 53,000 tons of urban wood classified as non-recyclable are also generated and disposed.

DEMAND

The study concluded the following about urban wood demand among end users throughout the Northwest:

- **Hog fuel is the primary end use for recycled urban wood and will continue to provide a strong market in the future.**
  - 82% of all recyclable wood is sold to this market.
  - The price of urban wood is less than half the price of natural gas or oil alternatives per unit of energy produced.
  - Kimberly-Clark bought about 70% of King County's recycled urban wood in 2002. The plant has increased its use of hog fuel since then, and it expects its usage to remain at or above current levels for at least the next five years.
  - Hog fuel requirements are easier to meet than other uses, making it easier for processors to sell to this market.
  - Hog fuel buyers often prefer urban wood over land clearing debris because it is drier and more fuel-efficient.
- **Boise's wood/plastic composite operation could fully utilize King County's current supply of high-grade wood.**
  - If the facility reaches its full operating potential in the next five years, the plan is to source 150,000 tons of clean wood, which could easily capture the available supply. Of that quantity sourced, the Boise plant could use up to 100,000 tons, and the remainder would go to hog fuel and other markets.
  - This product was designed specifically to use urban wood and should not face the same challenges as other products that have to adapt existing equipment to handle urban wood.
  - This product has no virgin substitute for the urban wood, making it more reliant on urban wood than other products.
  - Waste Management's newly opened Cascade Recycling Facility, located in Woodinville in north King County, expects to sell the majority of its recovered C&D wood to this market when Boise begins production. At press time, Waste Management is marketing the recovered urban wood as hog fuel.
- **In the near term, the potential for using urban wood for pulp and paper is extremely limited.** The only mill that accepted urban wood from the region for pulp during 2002 had halted this practice by the end of that year.
  - The price of pulp chips is low and is expected to remain low for the next 5-10 years. This low price does not encourage the use of alternatives such as urban wood.
  - Problems with use of urban wood were never fully resolved. One buyer noted he would not buy urban wood again, even if virgin prices increased, citing problems with contamination.
- **The panelboard market is unlikely to expand,** unless new users emerge in closer proximity to King County and prices for virgin wood supplies rise.

- Transportation costs to facilities in Oregon are too high to make this market viable.
- Additionally, panelboard companies are moving away from urban wood feedstock due to problems with its use. One major buyer of urban wood in Oregon reported discontinuing urban wood purchases as of 2003. No plans for its future use exist, and equipment designed to use urban wood has been decommissioned. If virgin prices rise significantly in the future, urban wood could be reconsidered, though such use is unlikely to occur in the next five years.

OPPORTUNITIES

Based on the barriers, market trends, and current and projected future supply and demand of wood from King County, the following opportunities could increase recovery and reuse of C&D wood.

- **Increase recovery of wood from the C&D waste stream.** Several possible options exist, including:
  - Offer wood recycling options at a reduced fee at all King County transfer stations. An estimated 21,000 tons of recyclable wood are disposed annually at King County-owned transfer stations.
  - Use the contracting process to ensure that private transfer stations provide for recycling of all high-grade wood. While current contracts include incentives for recycling, future contracts should strengthen these incentives or include wood recycling requirements.
  - Assist with the establishment of a commingled processing facility for C&D materials in King County. Currently no dedicated processing facilities for C&D waste exist in King County. (Waste Management's Eastmont and Woodinville sort some materials, like wood, from C&D waste loads, but they are not full-scale commingled C&D processing facilities like Recovery 1 in Tacoma.) The establishment of a local processor would make C&D recycling more convenient for generators and haulers.
  - Implement a disposal ban on clean wood.
  - Consider expanding the type of businesses that the LinkUp program works with to include companies involved in urban wood reuse.
  - Expand outreach and education regarding source reduction and wood recovery by working through local, regional, and national trade associations, such as the Master Builders Association.
- **Adopt a policy on the use of urban wood as hog fuel.** The hog fuel market is currently the strongest market for multiple grades of urban wood. Accordingly, King County should either accept and encourage this end use or actively work to develop and promote alternatives. An assessment of the environmental trade-offs of using urban wood as fuel could support this decision. Operators of hog fuel boilers claim that the use of urban wood instead of fossil fuels reduces emissions of pollutants such as mercury and sulfur dioxide. Other organizations, such as the Washington Toxics Coalition, are concerned about dioxin and other

pollutants from hog fuel boilers.[13] After the Washington State Department of Ecology found dioxin in emissions and ash from hog fuel boilers, the agency identified a high need for additional data and a "potentially high" need for source reduction.[14] King County should conduct an assessment to compile the existing information, conduct additional research if necessary, and set a policy on the use of urban wood as hog fuel in the region.

- **Investigate other, higher-value markets.** In particular, high-grade wood can go to higher-value markets than the hog fuel market. Notable possibilities include providing feedstock for existing finger-jointed wood operations and developing or attracting viable reconstituted panelboard markets to the region.

[13] Washington Toxics Coalition, 2000. *Visualizing Zero: Eliminating Persistent Pollution in Washington State.*

[14] Washington State Department of Ecology, 1998. *Washington State Dioxin Source Assessment.* Publication No. 98-320, July.

Chapter 3. Asphalt Shingles

This chapter discusses the market for asphalt shingles generated by C&D activities in King County excluding Seattle.

3.1 DEFINITION

Asphalt shingles are used as a roofing material, and they are the most popular type of residential shingle used today. In the U.S., 80% of homes are roofed with asphalt shingles, resulting in over 12.5 billion square feet of asphalt shingle products manufactured annually.[15]

3.2 BACKGROUND

Though residential roofing and re-roofing activities generate large quantities of asphalt shingle waste, few opportunities exist for recycling this material. Until recently, the Tacoma Steam Plant accepted asphalt shingles, for a tip fee, to be burned as fuel. Owned and operated by Tacoma Public Utilities (TPU), in partnership with a private company, the plant is now temporarily shut down. The steam plant still has a manager and maintenance personnel on staff, but no definite plans exist to reopen it soon.

In the late 1980s, the Tacoma Steam Plant was equipped with modern combustors to co-fire wood, refuse-derived fuel (solid waste), and coal. In addition, test runs of asphalt shingles were burned on a regular basis. After operating for 13 years as an electric utility, the plant was declared an "incinerator" due to the amount of municipal solid waste being burned, and as a result, it had to meet higher temperature requirements for combustion. Due to its inability to meet these temperature requirements, the plant shut down in 2001.

Recently, TPU addressed the problem that led to its closure, but new issues now make its reopening in the near future appear unlikely. Before it can reopen, the facility must make capital improvements, resolve funding issues, and obtain a permit from the Puget Sound Clean Air Agency. TPU's private-sector partner cites additional economic barriers to continuing the plant's operations. Accordingly, the Tacoma Steam Plant is unlikely to reopen before mid-2005 at the soonest.

After the fuel market ceased, recyclers have had a difficult time finding viable markets for asphalt shingles. One processor remarked that he often hears about the problems with potential new markets but rarely hears about markets that actually accept asphalt shingles. He welcomed any help from state or local governments to test and set specifications for various end products.

[15] Asphalt Roofing Manufacturers Association (ARMA).

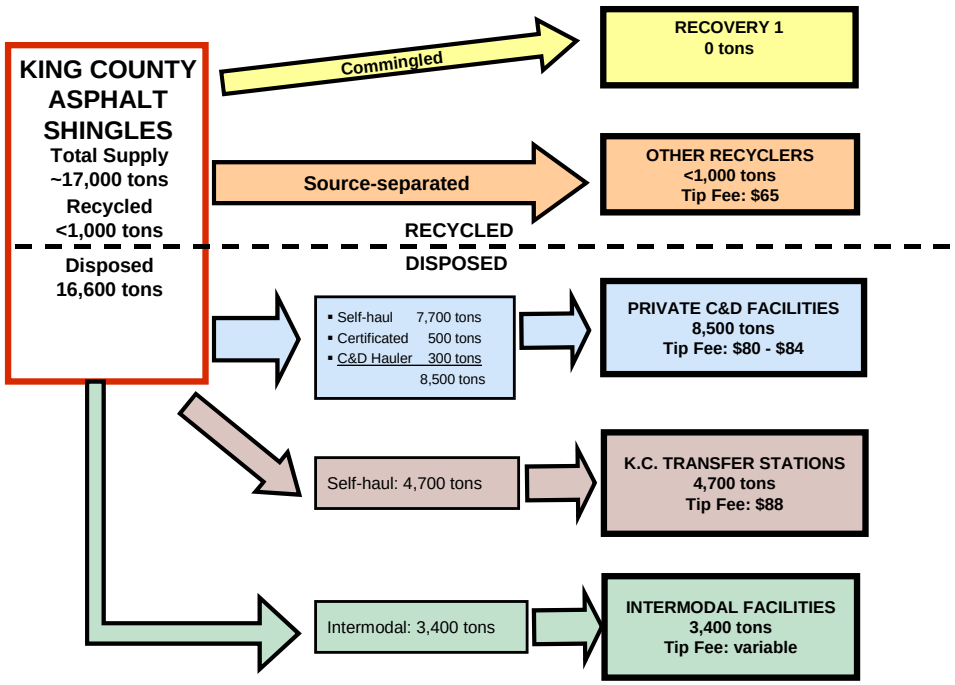
3.3 CURRENT SUPPLY

C&D activities in King County (outside Seattle) generate an estimated 17,000 tons of asphalt shingle waste per year. Less than 1,000 tons of these materials are currently recycled. Neither of the local two processors of asphalt shingles, American Roofing Recyclers and Woodworth and Company, is located in King County. American Roofing is located in Snohomish, while Woodworth is headquartered in Tacoma, with sites in Sumner and Lakewood in Pierce County. The Recovery 1 facility in Tacoma does not currently recycle asphalt shingles, but the company is pursuing a new undisclosed market for the material.

Figure 5 depicts the supply of asphalt shingles from King County. The top half of the chart displays the amounts recycled. The bottom half depicts the portion that is currently disposed but could be recycled. Note that approximately half of the asphalt shingles (8,500 tons) that are disposed are handled at the private C&D facilities. Self-haul customers, mostly roofing contractors, dispose most of the asphalt shingles at these facilities.

As noted on the following diagram, the average tip fee charged by processors is $65 per ton, a $15-$20 per ton saving over disposal in a private C&D facility.

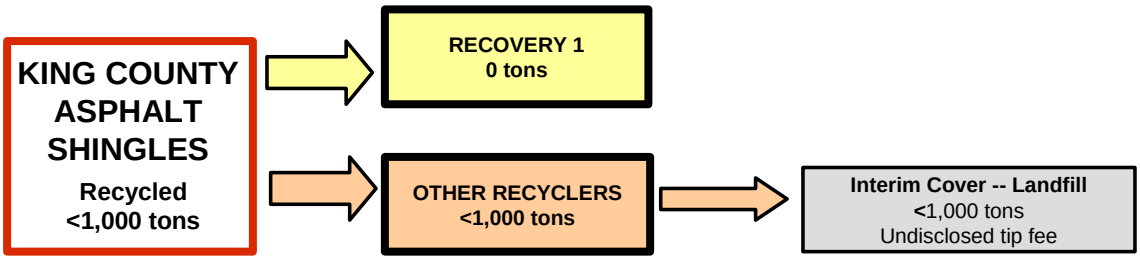
Figure 5. King County Recyclable Asphalt Shingle Supply
Tons/year (2002)



3.4 CURRENT MARKETS

The market situation for asphalt shingles is extremely limited, now that the Tacoma Steam Plant is no longer accepting asphalt shingles. When interviewed, the two processors were stockpiling asphalt shingles in hopes of new markets. However, they reported only one current market: interim cover. Figure 6 shows that less than 1,000 tons of asphalt shingles were recycled from King County in 2002.

Figure 6. Markets for King County Asphalt Shingles
Tons/year (2002)



INTERIM COVER

Interim cover is material used on the outside of landfill slopes and on areas that will not receive waste for six to twelve months. It may also be used to build temporary roads.

MARKET CHARACTERISTICS

The only reported market for asphalt shingles as interim cover is the landfill operated by Pierce County Recycling, Composting, and Disposal; this material is not used in King County. Public Health - Seattle & King County, the local health department, must review and approve any alternative materials prior to use at a landfill.

SPECIFICATIONS, PRICES & VIRGIN ALTERNATIVES

Interim cover is produced by grinding wood and asphalt shingles. Depending on its needs, the landfill accepts it either for free or at an undisclosed tip fee.

BARRIERS TO USING ASPHALT SHINGLES AS INTERIM COVER

Health department approval would be a potential barrier to this use.

3.5 POTENTIAL MARKETS

This section describes the following potential markets for asphalt shingles:

- Hot mix asphalt;
- Aggregate road base;
- Cold patch;
- Fuel; and
- Other miscellaneous.

HOT MIX ASPHALT (HMA)

Hot mix asphalt is the material used for road pavement. Asphalt pavement is also referred to as asphaltic concrete.

MARKET CHARACTERISTICS

Hot mix asphalt (HMA) using recycled asphalt shingles is a large, promising market.[16] Because the asphalt used in shingles is harder than pavement asphalt, the benefits of adding recycled asphalt shingles may include improved properties of the pavement, including reduced rutting and cracking.[17]

SPECIFICATIONS, PRICES & VIRGIN ALTERNATIVES

To be added to HMA, asphalt shingles must first be reduced to half-inch pieces for batch plants and quarter-inch pieces for continuous feed plants. Chemicals are used to restore the asphalt cement binder in the shingle to a more resilient state, and then the asphalt shingles are added to the HMA mix at 5-10% by weight.

When making hot mix asphalt, the blend must be altered to accommodate the hardness of the asphalt in the shingle. Generally a softer grade of asphalt cement is used in a mix with asphalt shingles than would be used in a mix with all virgin materials.

Asphalt shingles cannot be used exclusively to make HMA; rather, they are used only as an additive. As such, they can replace a portion (but not all) of the virgin material – both aggregate road base and liquid asphalt. The liquid asphalt sells for about $170-$230 per liquid ton, and aggregate sells at about $5-$7 ton. Appendix B contains table of specifications for markets for recovered asphalt shingles.

BARRIERS TO USING ASPHALT SHINGLES IN HOT MIX ASPHALT

The biggest barrier cited by contacts interviewed for this study is that asphalt shingles are not approved for use in Washington State Department of Transportation hot mix asphalt projects.

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[16] See www.shinglerecycling.org.

[17] Decker, Dale, 2002. "The Road to Shingle Recycling." *Recycling Today.* September 2002: pp. 28-32.

Snyder, Russell, 2000. "Construction and Demolition: Paving Asphalt's Way for Roof-to-Road." *Waste Age*: April 1, 2000.

Currently Washington State Department of Transportation (WSDOT) has no specifications that include recycled asphalt shingles in paving products. This lack of approval is a major barrier to the use of this material in hot mix asphalt. Costs of pavement are high, and replacement is difficult if specifications are not met.

Numerous states allow small amounts of remanufacturing scrap (and in rare cases, post-consumer asphalt shingles).[18] This exclusion of post-consumer asphalt shingles in most cases may be due to contamination concerns or performance issues, which need more investigation.

Getting a product approved by a state DOT can be time-consuming. An example of the steps that might be needed is as follows:

1. Test in the laboratory;
2. Write draft specifications, which are called Special Provisions (SP);
3. Test in the field, perhaps on a heavily trafficked road such as a truck weigh station;
4. Monitor for several years; and
5. Write specifications called Standard Special Provisions (SSPs). These specifications would then be available for routine use in WSDOT and local government projects.

AGGREGATE ROAD BASE

Aggregate road base is inorganic structural material laid down to form the base of a roadway. It is often made of recycled asphalt and concrete.

MARKET CHARACTERISTICS

Asphalt shingles can be used as part of the aggregate base and sub-base in roadways, parking lots, embankments, and shoulders. Processed asphalt shingles may be blended with recycled asphalt pavement and concrete. Processors that handle materials from King County expressed interest in this market, but they have not sold any large quantities to date.

SPECIFICATIONS, PRICES & VIRGIN ALTERNATIVES

The alternative to using asphalt shingles in aggregate road base is either virgin aggregate material (such as rock or new concrete) or recycled aggregate, which is made of crushed concrete or asphalt. This aggregate material sells for approximately $5-$7 per ton.

BARRIERS TO USING RECYCLED ASPHALT SHINGLES IN AGGREGATE ROAD BASE

As with hot mix asphalt, a barrier to using recycled asphalt shingles in aggregate road base is that asphalt shingles are not approved for use in WSDOT aggregate projects.

[18] These states include Georgia, Maryland, Michigan, Minnesota, New Jersey, North Carolina, Ohio, and Indiana.

One processor cited that there was an unfounded concern that the asphalt shingles would leach toxic materials into the soil.

However, success stories exist even without DOT approval. Maine DOT does not approve the use of asphalt shingles in their own projects, but the Maine EPA has approved the "beneficial use" of asphalt shingles in aggregate road base. As a result, some companies have proceeded with using asphalt shingles in certain applications such as private developments and parking lots. After the EPA rule was enacted in 1998, shingle recycling increased dramatically, and roll-off containers are now present in most transfer stations in the state. One successful company, Commercial Paving Company, has entered the market, and it recycles 16,000 tons of post-consumer asphalt shingles per year.[19] Their largest use is incorporating the asphalt shingles in aggregate base, followed by hot mix asphalt and cold patch.

COLD PATCH

Cold patch is a type of asphalt used to fill potholes and utility cuts; construct small features such as sidewalks; and repair driveways, ramps, bridges, and parking lots. One benefit of using cold patch in these small applications is that heavy equipment may be unnecessary as the patch may be compressed by vehicle traffic.

MARKET CHARACTERISTICS

Manufacturing scrap or old tear-off asphalt shingles can both be included in cold patch.

Some of the reported benefits of using recycled asphalt shingles in cold patch are:

- Patches have a longer life compared to other patch materials; and
- The patch is easier to apply than traditional cold patch, is lighter, and does not harden as quickly.

SPECIFICATIONS, PRICES & VIRGIN ALTERNATIVES

To produce cold patch, asphalt shingles must be ground to quarter-inch pieces and mixed with aggregate ($5-$7/ton) and liquid asphalt ($170-$230/ton). Recycled shingles can replace some (but not all) of the aggregate and liquid asphalt materials used in the virgin alternative.

BARRIERS TO USING RECYCLED ASPHALT SHINGLES IN COLD PATCH

This study found the following barriers to using recycled asphalt shingles in cold patch:

- **Asphalt shingles are not approved for use in WSDOT cold patch projects.** As with the other paving markets no DOT specifications in Washington cover using asphalt shingles.
- **The market is small compared to hot mix asphalt or aggregate road base.** Although promising, this market is much smaller in size due to the small

[19] They plan to increase this number, taking over asphalt shingles for both New Hampshire and Massachusetts. Massachusetts will soon have a landfill ban on asphalt shingles.

quantities needed. For example, the amounts needed for aggregate base or hot mix asphalt when laying a new road far exceed quantities for patching holes on existing roadways.

FUEL

Asphalt shingles can be burned as fuel, given the right kind of combustor and emission controls.

MARKET CHARACTERISTICS

Fuel may become a viable market again if the Tacoma Steam Plant reopens in 2005. The plant manager indicated an interest in burning asphalt shingles again, due to their high energy content and low cost. However, economic forecasts, permitting requirements, and capital improvement needs make the plant's reopening in the near future appear unlikely.

SPECIFICATIONS, PRICES & VIRGIN ALTERNATIVES

Fuel has the least stringent contamination requirements of the asphalt shingle markets, and does not require processing. The asphalt shingles coming from King County were charged a tip fee of approximately $10 ton. Its virgin substitute is coal, which costs $30-$34 a ton, making the asphalt shingles economically desirable. The plant manager reported that burning asphalt shingles resulted in fewer emissions than burning coal. After the asphalt shingles are burned, the residual can be used as pipe bedding, a material to surround and support pipes when they are laid in the ground. Both roofing processors mentioned this option as a potential market. However, applying residuals from shingle combustion as pipe bedding is still in the testing phase and has not gained widespread acceptance.

BARRIERS TO USING RECYCLED ASPHALT SHINGLES AS FUEL

The absence of plants in or near King County that will accept the asphalt shingles is the primary reported barrier.

OTHER MARKETS

Processors are also experimenting with other markets including:

- **Compressed blocks** – These blocks, priced at $15 each, can be used for retaining walls or other applications.
- **Traction material for roadways** – This product is used for snow and ice applications to provide traction. It is priced at $10 per 50-pound bag or $25 per cubic yard.
- **Fuel blocks** – These highly dense fuel blocks, priced at $25/ton, can be burned in furnaces and generating plants.
- **Top-coat dressing** – This product is used with hot tar built-up roofing. It is applied after the top coat is flooded and mopped. The dressing is spread in a thin layer above the cooling hot tar, and it provides an expansion-contraction

material and protects the roof from ultraviolet rays. It is priced at $15 per 50-pound bag or $30 per yard.

3.6 CONCLUSIONS

SUPPLY

This study indicated the following about the supply of asphalt shingles from construction and demolition activities in King County.

- **Most asphalt shingles are disposed rather than being recycled.**
  - Approximately 16,600 tons are disposed yearly, with less than 1,000 tons being recycled.
  - No roofing processors are found in King County, this situation drives up transportation costs.
  - Recycling tip fees are fairly high, at an average of $65 per ton.

DEMAND

The research concluded the following about the demand for asphalt shingles from Northwest end users:

- **Promising end uses do exist, but processors need help with market development.**
  - Potential markets for asphalt shingles could be hot mix asphalt, aggregate road base, and cold patch.
  - Processors report stockpiling materials due to lack of markets.
  - Shingle recycling (especially of post-consumer asphalt shingles) is in its infancy, with only a limited number of states that recycle them successfully.
- **Market acceptance is a bigger concern than economics or production.**
  - End users need to be sure that the products will work as well as the virgin equivalent, or they will not use it.
  - The Washington State Department of Transportation (WSDOT) does not currently approve of asphalt shingles in asphalt, cold patch, or road bed.
  - Using asphalt shingles in road paving/bedding products is not capital intensive, as with some other recycling commodities. Recyclers already exist that could process the end products.
  - Processors did not anticipate any problems in meeting market specifications.

OPPORTUNITIES

Based on the barriers, projected future supply and demand of waste asphalt shingles from King County, the following opportunity could yield substantial results:

- **Work with WSDOT to study use of asphalt shingles in road base and hot mix asphalt.** This work could include the following:
  - Pilot projects which test grinding technologies and recipes; and
  - Test projects with parking lots and low-impact roads.

Chapter 4. Gypsum Wallboard

This section of the report discusses the market for gypsum wallboard generated by C&D activities in King County excluding Seattle.

4.1 DEFINITION

Gypsum board is the principal wall material used in the United States for interior purposes. It consists of a sheet of gypsum covered on both sides with paper facing and paperboard backing. Gypsum board is also referred to as wallboard, plasterboard, gypboard, and rock. Sheetrock® and Gyproc® are registered trade names. The U.S. produces approximately 15 million tons of new drywall per year.

4.2 BACKGROUND

Currently two processors are available for grinding gypsum: BPB and Recovery 1. In May 2004, New West Gypsum Recycling closed its recycling plant in Fife, Washington, just north of Tacoma, after its gypsum recycling agreement with Georgia-Pacific ended.[20] Georgia-Pacific decided to start recycling its own production waste and is no longer accepting recycled gypsum from construction and demolition waste for use in wallboard production. Recovery 1 is seeking to process much of the other gypsum supplies that New West Gypsum previously recovered.

BPB, formerly James Hardy Gypsum, is located in Seattle. BPB is a large, vertically integrated company that mines gypsum and manufactures wallboard, plaster, and other gypsum products. The company recycles gypsum manufacturing scrap as well as post-consumer gypsum wallboard. BPB accepts ground gypsum wallboard from Recovery 1 (and previously accepted material from New West Gypsum). They also process post-consumer gypsum wallboard that is delivered from other sources.

Recovery 1, Inc., located in Tacoma, accepts commingled loads of C&D waste for recycling. The company began test runs of gypsum processing in 2002 and expanded its processing in 2003. Recovery 1 projects quadrupling its gypsum production in 2004 and the near future, as it acquires gypsum waste that New West Gypsum Recycling previously collected. Recovery 1 uses a process that crushes the wallboard rather than grinding it, which reduces the paper content of the recovered gypsum.

It is important to note that some problems with landfill disposal and incineration of gypsum may make recycling more compelling. Hydrogen sulfide gas can be produced when landfilling gypsum, particularly in a wet climate. Several conditions are required,

[20] New West Gypsum is based in Langley, British Columbia, and its Canadian facilities remain operational. The company has been recycling gypsum since 1986, and it has a ready supply in British Columbia, where it is illegal to landfill gypsum in many locations. In B.C., gypsum is banned in landfills from Vancouver to Chilliwack, Whistler, the Okanogan, and Vancouver Island. It is not banned in the northern parts of British Columbia mainly because of transportation costs. In Ontario, it is banned from many, but not all, regional landfills, again mainly because of transportation costs. (Source: New West Gypsum Recycling, 2002-2004).

including a moist, anaerobic environment and a low pH. This gas produces a foul rotten egg odor in small amounts and can be fatal in concentrations of above 300 parts per million.[21] Incineration may also produce this toxic gas, though the plant manager at the Tacoma Steam Plant disputed this finding.

4.3 CURRENT SUPPLY

C&D activities in King County (outside Seattle) generate an estimated 26,000 tons of gypsum waste per year. About 8,000 tons of this supply is currently recycled, and source-separated processors handle most of this gypsum. Recovery 1, a processor of commingled C&D materials, is increasing its gypsum processing, but only about 1,000 tons per year of this material come from King County.

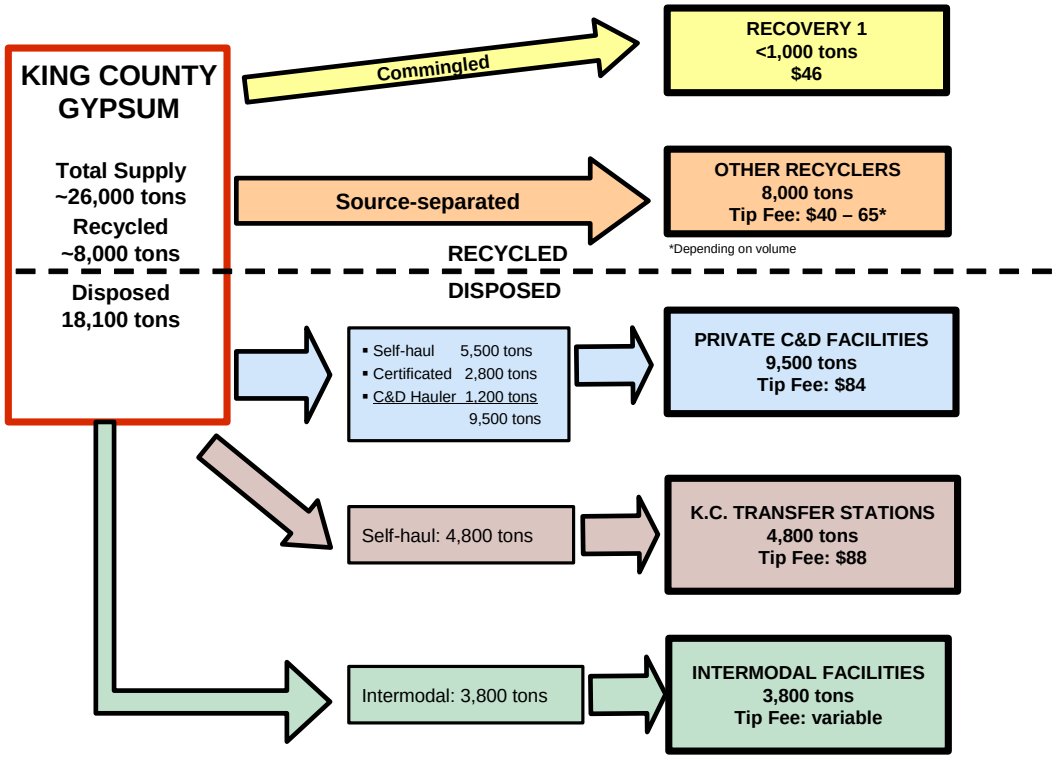
Figure 7 depicts the supply of gypsum from King County. The top half of the chart displays the amounts recycled. The bottom half depicts the portion that is currently disposed but could be recycled. Note that approximately half of the gypsum (9,500 tons) that is disposed is handled by the private C&D facilities. Of this material, most (5,500 tons) comes from demolition activities, but new construction generates a sizable portion (2,800 tons). It is estimated that 12% of new construction drywall is wasted during installation,[22] making new construction a ready source for potential recycling.

As noted in Figure 7, the tip fee of about $40/ton for recycling gypsum is about half that of disposal. BPB, the only processor in King County, however, relies on Resource Recovery Services in Woodinville to consolidate quantities, which increases the cost of gypsum recycling to $65 per ton.

[21] Townsend, Timothy, 2002. "C&D Waste Landfills in Florida: Assessment of True Impact and Exploration of Innovative Control Techniques." University of Florida, Department of Environmental Engineering Sciences. December 31, 2002.

[22] California Integrated Waste Management Board, www.ciwmb.ca.gov/ConDemo.

Figure 7. King County Recyclable Gypsum Supply
Tons/year (2002)



4.4 CURRENT MARKETS

NEW GYPSUM BOARD

Gypsum wallboard is used in the creation of internal walls during building construction.

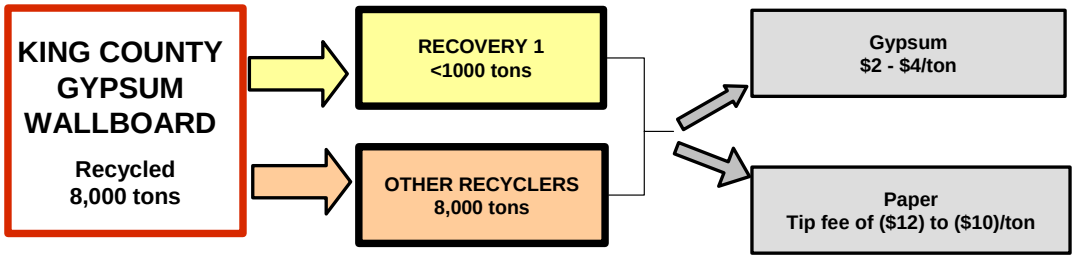
MARKET CHARACTERISTICS

The processors reported that new gypsum wallboard is the only current market for gypsum recovered in King County. The paper backing by-product is either disposed in a landfill or recycled into compost. One processor said that the finished compost containing paper from wallboard was later sold to the Washington State Department of Transportation.

There are only two end users of recycled gypsum in the region. BPB is an end user as well as a processor. The other is Georgia-Pacific, which is an end user but not a processor.

Figure 8 displays the gypsum wallboard market. Local processors recycled 8,000 tons of gypsum from King County in 2002. The price (or tip fee) for the gypsum and associated paper are displayed on the right side.

Figure 8. Markets for King County Gypsum
Tons/year (2002)



SPECIFICATIONS, PRICES & VIRGIN ALTERNATIVES

Recovered gypsum wallboard is either ground or crushed, and the paper is removed. In general, end users reported that their processors did a good job meeting specifications. A typical feedstock requirement is to have the recycled content be at least 92% pure gypsum, with less than 3% paper and less than a 10% moisture content. Appendix B provides a table of specifications.

End users generally paid $2-$4 per ton for the recycled gypsum. The paper was disposed by one processor, but the other two processors recycled it into compost. A private composter charged the gypsum processors $10-$12 ton to accept the paper.

Contacts indicate that new gypsum wallboard could contain up to 15% recycled gypsum. If larger quantities were used, end users report that there would be a degradation in the strength of the new board.

There are two virgin equivalents for the recycled gypsum when it is made into wallboard: one is natural calcined gypsum, and the other is synthetic gypsum. The natural gypsum must first be calcined (partially dehydrated by heating) prior to use. This process removes three-quarters of the water content chemically bound in the gypsum. The result is a dry powder that can then be used in wallboard manufacturing. One wallboard manufacturer used only calcined gypsum as its virgin equivalent for recycled gypsum. Calcined gypsum sells for about $18 per ton.

The other virgin equivalent is synthetic, or flue gas desulfurization (FGD), gypsum, a byproduct of the process that power-generating plants use to remove polluting gases from their smokestacks. One manufacturer reported that they used all FGD gypsum and no virgin gypsum in their finished wallboard. They reported that they negotiated a price for their entire supply with a plant in Chehalis, Washington, and would not disclose their price.

Use of FGD gypsum has been increasing in recent years, and it grew by nearly 80% in 1999. Industry trends show that the use of mined gypsum may decline significantly as greater quantities of synthetic gypsum become available.

End users did not think that either the virgin or synthetic gypsum prices would rise significantly. However, the price differential of about $14 a ton between recycled gypsum wallboard and virgin substitutes was thought to be large enough to support continued use of recycled gypsum wallboard.

BARRIERS TO USING RECYCLED GYPSUM IN NEW WALLBOARD

Contacts interviewed for this study report the following barriers.

- **Insufficient supply of recycled gypsum wallboard.** End users said they would like to have more but it is not available. End users felt that there should be a landfill ban to address this problem, citing Canada's successful ban. Distance to gypsum wallboard processors may also prevent generators from recycling.
- **High recycled content in end product diminishes quality**. With growth in the economy, end users expect to use more recycled gypsum in the years ahead. However, they do not expect to be able to add more than 15% recycled gypsum to new board without sacrificing quality.
- **High costs to dispose of paper backing**. One major processor was unaware of the composting option and was complaining of the high costs of paper disposal.

4.5 POTENTIAL MARKETS

Few viable potential markets exist for gypsum. Land applications are rarely used and are not allowed in King County. One processor told of a new application currently under investigation but would not divulge any details until it was further developed.

4.6 CONCLUSIONS

SUPPLY

The study concluded the following about the supply of gypsum wallboard from construction and demolition activities in King County:

- **The current supply of recoverable gypsum wallboard is estimated at 26,000 tons.** Of this amount about 8,000 tons are presently recycled.
- **Recovery 1 is increasing its capacity for gypsum recycling.** With its new equipment and the closure of New West Gypsum in Fife, Recovery 1 expects to quadruple its quantities of gypsum recovered. Most of the facility's materials come from Pierce County, however, and it appears unlikely that much more than 1,000 tons per year from King County will be processed in the near future.

DEMAND

The study concluded the following about the demand for gypsum wallboard generated by construction and demolition activities in King County:

- **Gypsum is easily recycled with no major technical barriers.** The processing barriers to this market are minor compared to other commodities addressed by this study. The recent closure of New West Gypsum Recycling's Fife facility has reduced options for gypsum recycling, but increased capacity at Recovery 1 in nearby Tacoma is expected to handle additional gypsum material. Recovery 1 also offers the advantage of separating recyclable gypsum from commingled loads of C&D materials.

- **Demand for recycled gypsum for new wallboard will continue to be strong.** As gypsum wallboard output increases under a more healthy economy, end users indicated that they would purchase more recycled gypsum, if it is available. Still, end users report that they are unlikely to be able to use more than 15% recycled gypsum without sacrificing quality in new board products.

OPPORTUNITIES

Based on the barriers, market trends, and current and projected future supply and demand for gypsum wallboard, the following opportunities could be explored:

- **Expand recycling opportunities to increase recovery of gypsum from the C&D waste stream.** For example, King County could expand diversion and collection opportunities by providing drop-off facilities at both King County and private transfer stations. The County could also facilitate the development in King County of facility like Recovery 1, which could recycle gypsum and other materials from commingled C&D waste loads.
- **Gypsum could be banned from landfills**. This practice has been effective in British Columbia.

Chapter 5. Carpet

This chapter discusses the market for carpet generated by C&D activities in King County excluding Seattle.

5.1 DEFINITION

Carpet is available in two forms, tiles and rolls. Rolls of carpet (broadloom) are typically for household floor coverings, and are generally made with a nylon resin known as "nylon 6." Carpet tiles are made primarily for business and industrial uses, and they are generally made with a nylon resin referred to as "nylon 6,6" (also denoted as nylon 6/6). Nylon 6 and nylon 6,6 account for the majority of the face fiber market, but face fiber can also be made of polyester and polypropylene. All types of carpet are constructed with face fiber, primary and secondary backing, and an adhesive layer. Residential carpet typically lasts from 7-10 years and commercial for 5-8 years.[23]

Industrial scrap produced by carpet manufacturers is routinely made into new carpet. However, due to impurities and dyes, post-consumer carpet typically is not made into new carpet. Also, most carpet that is recycled comes from commercial sources. Only about 25% of the installed carpet is commercial; the remaining 75% is from residential sources.

5.2 BACKGROUND

In November 1999, Evergreen Nylon Recycling LLC opened a large recycling facility for nylon 6 (common in residential but less so in commercial carpet) in Augusta, Georgia. This facility was a joint venture of Honeywell and DSM (Dutch State Mines Chemical Company). Honeywell and DSM invested $85 million in the project, and they intended to recycle over 200 million pounds of used nylon 6 broadloom per year into caprolactam, the feedstock for new nylon 6.

Honeywell worked with retailers, dealers, waste haulers, and recyclers to build its national collection network for used carpet. By 2002, it expected to have 150 suppliers in 120 metropolitan areas. Unfortunately, this effort failed and was discontinued in September 2001, less than two years after it began.

Since the plant's closure, little carpet recycling has occurred in King County. Most recycling programs, which are typically operated by carpet fiber manufacturers, provide recycling services only when new product is installed. Some programs require the consumer to pay all shipping costs to remaining carpet recyclers in Georgia, which are two to three times the cost of landfill disposal. This economic hurdle makes it difficult to justify carpet recycling on economic terms.

[23] North Carolina Department of Environmental and Natural Resources, 1998. *Textile: Carpet and Carpet Pad.*

The carpet industry has announced two initiatives to help increase recycling. In 2002, a Memorandum of Understanding for Carpet Stewardship was published. This agreement established an ambitious ten-year schedule to increase the reuse and recycling of post-consumer carpet. By 2012, the parties plan to achieve a landfill diversion goal of 40%. In addition, in January 2003, the Carpet America Recovery Effort (CARE) announced grants up to $50,000 to private-sector companies to encourage recycling and reuse. The grants are available in three categories: Intermediate Processing and End-Use, Enhancement of Collection Infrastructure, and Research and Development of Markets. In 2003, the effort awarded three grants totaling $90,000. CARE has also been working with Los Angeles Fiber to promote a program to recycle post-industrial carpet into carpet cushion. The customer must pay for shipping to California and be willing to buy back the carpet cushion. Though CARE appears to represent a promising start, a longer track record is needed to determine the efficacy of such industry efforts to increase carpet recycling.

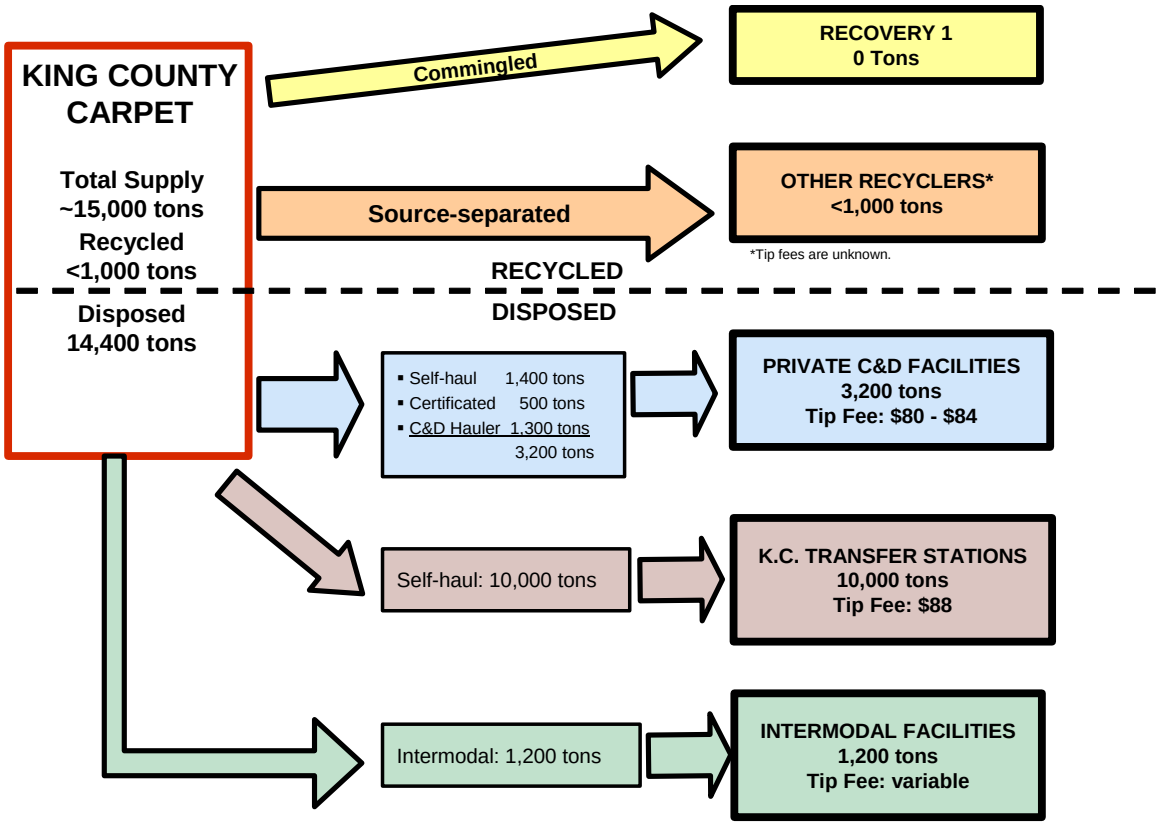
5.3 CURRENT SUPPLY

C&D activities in King County (outside Seattle) generate approximately 15,000 tons of carpet waste each year. Far less than 1,000 tons are presently recycled. Of the carpet recyclers listed in the 2001-2002 *Construction Recycling Directory* for Seattle and King County, only two could be found that recycled carpet from King County.[24] One of these refused to confirm or deny if any carpet was being collected from Washington, citing confidentiality concerns.

[24] King County, *Construction Recycling Directory: Seattle/King County 2001-2002*, October 2001.

Figure 9 depicts the supply of carpet from King County. The top half displays the amounts recycled. The bottom half depicts the portion that is currently disposed, but could be recycled. Note that unlike the other commodities, most disposed carpet (70%) is self-hauled to King County-owned transfer facilities rather than to the private C&D facilities.

Figure 9. King County Recyclable Carpet Supply
Tons/year (2002)



5.4 CURRENT MARKETS

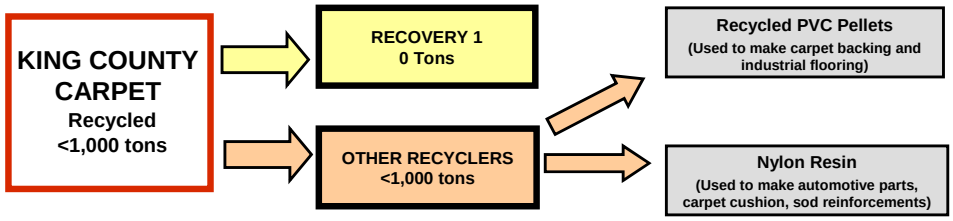
The two major feedstocks produced from recycled carpet are:

- **PVC/nylon pellets**. Collins & Aikman uses recycled PVC/nylon pellets to make carpet backing and industrial flooring.
- **Nylon resin**. DuPont uses recycled nylon resin to make automobile parts, carpet cushion (pad), and sod reinforcements.

Figure 10 shows that less than 1,000 tons of carpet were recycled from King County in 2002. Prices for the recycled feedstocks were not disclosed by the carpet recyclers and could not be found in industry publications. Although Recovery 1 receives some carpet in commingled C&D loads, it does not currently have markets for recycling these materials. (Prior to the Tacoma Steam Plant's shutdown in 2001, Recovery 1 in Tacoma was involved in a pilot project to use non-nylon 6 carpet as carpet-derived fuel (CDF) in

the facility's boilers. However, Recovery 1 abandoned this effort after hazardous materials not associated with carpet manufacture were found to contaminate some carpet samples.)

Figure 10. Markets for King County Carpet
Tons/year (2002)



RECYCLED PVC / NYLON PELLETS

PVC/Nylon pellets are the raw material used to make carpet backing and industrial flooring.

MARKET CHARACTERISTICS

Collins & Aikman is the major processor and end user of the recycled PVC/nylon pellets. Their recycling center is located in Dalton, Georgia. They accept only commercial tiled nylon carpet with a PVC backing. The PVC/nylon pellets are created by shredding and processing the entire carpet (face and backing). The primary uses for PVC/nylon pellets are as follows.

- **Carpet backing.** Collins & Aikman recycles approximately 90% of the reclaimed carpet into carpet backing. The PVC/nylon pellets are combined with other recycled PVC materials such as autombile parts to create a 100% recycled carpet backing, 75% of which is recycled carpet. The company claims that the backing performs even better than backing made of virgin materials. Collins & Aikman reports that after years of perfecting the technology, they are now breaking even using the recycled carpet as a feedstock for their carpet back. Much of their material is collected through a buyback program when new carpet is installed. However, they limit the type of carpet that they will accept.
- **Industrial flooring.** Approximately 10% of the carpet that Collins & Aikman collects is recycled into industial flooring. The end product contains about 65% recycled carpet.

SPECIFICATIONS, PRICES & VIRGIN ALTERNATIVES

The major virgin alternative for carpet backing and industrial flooring is virgin PVC pellets. These PVC pellets sell at about $620-$680 per ton. For a table of specifications, please refer to Appendix B.

BARRIERS

Contacts interviewed for this study reported the following barriers:

- **High transportation costs.** Recovered carpet is bulky, and processors are located in the East. In fact, all recovered carpet is currently shipped to Georgia to be processed.
- **High capital costs are required to enter the market.** Because of the high capital costs required, small scale processing is not economically viable. All known processors are also carpet manufacturers. Manufacturers recycle a large amount of industrial scrap, which allows them to enjoy economies of scale not available to small scale, independent recyclers. For example, Collins & Aikman recycles over three times more industrial scrap than post-consumer carpet.

RECYCLED NYLON FIBER

Recycled nylon fiber is the raw feedstock used to make a variety of nylon products.

MARKET CHARACTERISTICS

Dupont processes any carpet made with nylon fiber. They focus on recycling the nylon from which the following products are made.

- **Automobile parts.** DuPont's largest market for carpet in 2002 was automobile parts, but this market was reported to fluctuate each year. Nylon 6,6 is remanufactured into pelletized resins. These pellets are then sold to automotive companies, which mold the resins into air-cleaner housings and other under-the-hood parts. Over 3 million Ford vehicles now on the road include such parts.
- **Carpet cushion (pad)**. This was DuPont's next largest market. Unlike the automobile parts, this market can use nylon 6,6 and nylon 6, along with other carpet faces excluding wool. The carpet is shredded into long fibers and needle-punched (stitched) together.
- **Sod reinforcement.** Nylon fibers from recycled carpets are mixed with sand, soil, and fertilizer and spread on trays as a base for artificial sports grass. This market is small and accounts for less than 1% of DuPont's recycled markets.

SPECIFICATIONS, PRICES & VIRGIN ALTERNATIVES

Carpet must be shredded and processed for the various consumer markets. See Appendix B for detailed specifications.

Prices were not disclosed by the carpet processors and are not available on industry price lists. Virgin nylon resin is quite expensive and sells for about $2,500-$3,000 per ton. Prices for virgin nylon resin are volatile because they are tied to petroleum prices. Nylon resin, used in the manufacture of carpets and many other materials, is significantly more expensive than the PVC used in the manufacture of carpet backing and industrial flooring.

BARRIERS TO USING RECOVERED CARPET IN RECYCLED NYLON FIBER

This assessment found the following barriers to recycling carpet into nylon fiber:

- **High transportation costs.** Recovered carpet is bulky and processors are located in the East. In fact, all recovered carpet is currently shipped to Georgia to be processed.
- **High capital costs are required to enter the market.** Because of the high capital costs required, small scale processing is not economically viable. All known processors are also carpet manufacturers. Manufacturers recycle a large amount of industrial scrap, which allows them to enjoy economies of scale not available to small scale, independent recyclers. For example, Collins & Aikman recycles over three times more industrial scrap than post-consumer carpet.
- **The wide variability in materials and construction complicates carpet recycling.** DuPont accepts all types of carpets and reports that this is more expensive because various technologies are needed for each carpet type. They report that it costs more to recycle than to use virgin products, but specific prices were not disclosed.
- **Lack of demonstrated technology to turn used carpet fibers back into nylon carpet fiber.** Although some post-industrial carpet is recycled back into carpet, there is a current lack of technology to purify carpet fibers at the end of their useful life for reuse in the raw material of subsequent carpet products.

5.5 POTENTIAL MARKETS

One potential new market is developing in Minnesota. The Minnesota Office of Environmental Assistance (OEA) is working with Nylon Board Manufacturing (NBM), a Minnesota start-up company producing a new building product called Ny-Board™. Ny-Board™ is a nylon/plastic composite sheeting made from post-consumer carpet and waste plastic. It can be used in a variety of ways, including vehicle and construction applications, crafts, and signboards. However, this market is yet unproven.

5.6 CONCLUSIONS

SUPPLY & DEMAND

This research concluded the following points about the supply of carpet from construction and demolition activities in King County:

- **Little carpet is being recycled in King County.**
  - An estimated 14,400 tons are being landfilled each year, of which 10,000 tons are being disposed at King County facilities.
  - Less than 1,000 tons per year are recycled.
  - Processors were often secretive (or did not know) how much carpet from Washington state was being recycled.
- **Recycling carpet is extremely capital intensive, prohibiting easy market entry to additional recyclers.**
  - Current processors are also carpet manufacturers and dominate the market. They recycle far more post-industrial than post-consumer carpet.
  - The technology to recycle post-consumer carpet back into carpet is lacking.
  - Evergreen LLC spent $85 million on their Georgia recycling plant, but it closed within two years.
- **Carpet processors are mainly located in Georgia, making transportation a major barrier.** In the U.S., 80% of all carpet manufacturers are located within a 65-mile radius of Collins & Aikman in Dalton, Georgia.

OPPORTUNITIES

Due to intensive capital requirements and transportation distances, opportunities to recycle carpet are limited. The opportunities that might help foster change are:

- **Use government procurement policies to require recycling of carpet installed in government buildings.** The State of Washington has a contract for floor covering services that mandates recyclability. Municipalities could potentially use this contract or pattern their own contracts on Washington State's bid language.
- **King County could encourage private businesses to take advantage of CARE grants** (up to $50,000) given out for plans to increase recycling and reuse. CARE will be accepting grant proposals for programs which provide for the recycling and/or reuse of post-consumer carpet, or which increase the demand for products made from post-consumer carpet. Individual grants will be available to private sector applicants in each of three categories: Intermediate Processing and End Use, Enhancement of Collection Infrastructure, and Research and Development of Markets.
- **Explore product stewardship and design as a long-term solution.** Interface, a large carpet company based in Georgia, is rapidly emerging as a leader in this field. The company has been redesigning its products and entire business model to focus on selling "products of service." Under this model, floor covering is

leased rather than purchased, and Interface takes the responsibility for maintenance and ultimate removal for reclamation or recycling.

Chapter 6. Recommendations

6.1 Overall Recommendations

- **Assist with the development of a commingled C&D processing facility in King County.** In particular, the development of a facility in north King County could help reduce transportation costs to Recovery 1 in Tacoma, as well as provide a more convenient option for C&D generators in Snohomish, Skagit, and Whatcom counties, some of which currently send loads to Recovery 1. King County could provide permitting assistance, tax incentives, or technical assistance to potential developers to help launch a new facility. Such a facility could play a particularly important role in increasing the recycling of wood and gypsum from King County's C&D waste stream.
- **Provide drop boxes for certain C&D materials at King County-owned transfer facilities, and adjust rate structures to create financial incentives for their use.** Offering drop boxes for the collection of clean wood and gypsum at King County transfer stations would help divert recyclable C&D materials disposed at these facilities.
- **Continue to promote source separation as a means of securing some high-grade materials.** Source separation may be the best option for maintaining the clean streams of high-grade materials desired by some end markets. In particular, Boise Building Solutions' desire for clean, high-grade wood may give source separation some economic advantage over commingled processing. In addition, gypsum markets also currently prefer source separation, although Recovery 1 recently introduced an option for separating gypsum from commingled loads. King County should continue to promote source separation of high-grade materials as a practice that can save contractors money. This promotion could be accomplished through the King County and Seattle contractors' guide to job site recycling, through web sites about job site recycling, and perhaps through technical assistance and outreach.[25]
- **Consider aiding the deconstruction industry as a means of maximizing the value of recovered C&D materials.** Deconstruction is an emerging field that systematically disassembles buildings and salvages most or all of these materials for resale or recycling. The success of businesses such as the Re-Store in Seattle and Bellingham points to the ability of deconstruction to compete economically with demolition. Because materials are source-separated at the site, they can generally command higher market prices. Furthermore, recycling rates for deconstructed buildings are high. King County could support the deconstruction industry through grants, pilot projects (if necessary), promotion

[25] Business and Industry Resource Venture and King County Solid Waste Division, 2002. *Contractors' Guide*. Seattle Public Utilities and King County. www.resourceventure.org.

assistance, or directly contracting for deconstruction services when County buildings must be replaced or renovated.

6.2 MATERIAL-SPECIFIC RECOMMENDATIONS

WOOD

- **Use the contracting process to ensure that private transfer stations provide opportunities for recycling clean, recoverable urban wood.** King County's current contracts for C&D disposal facilities expire in 2004. While current contract include some recycling incentives, future contracts could require that either (1) any loads with a certain quantity of recyclable urban wood be processed, and that corresponding financial incentives be offered for clean loads; or (2) disposal of clean, recoverable urban wood at the facilities be prohibited.
- **Consider a disposal ban on clean wood.** King County could ban the disposal of recyclable wood materials at transfer stations and in waste collection.
- **Adopt a policy on the use of urban wood as hog fuel.** The hog fuel market is currently the strongest market for multiple grades of urban wood. Accordingly, King County should either accept and encourage this end use or actively work to develop and promote alternatives. An assessment of the environmental trade-offs of using urban wood as fuel could support this decision. Operators of hog fuel boilers claim that the use of urban wood instead of fossil fuels reduces emissions of pollutants such as mercury and sulfur dioxide. Other organizations, such as the Washington Toxics Coalition, are concerned about dioxin and other pollutants from hog fuel boilers.[26] After the Washington State Department of Ecology found dioxin in emissions and ash from hog fuel boilers, the agency identified a high need for additional data and a "potentially high" need for source reduction.[27] King County should conduct an assessment to compile the existing information, conduct additional research if necessary, and set a policy on the use of urban wood as hog fuel in the region.
- **Expand outreach and education regarding source reduction and wood recovery** by working through local, regional, and national trade associations, such as the Master Builders Association.
- **Investigate other, higher-value markets.** In particular, high-grade wood can go to higher-value markets than the hog fuel market. Notable possibilities include providing feedstock for existing finger-jointed wood operations and developing or attracting viable reconstituted panelboard markets to the region. The LinkUp program may be able to provide assistance to businesses in these efforts.

[26] Washington Toxics Coalition, *Visualizing Zero: Eliminating Persistent Pollution in Washington State*, 2000.

[27] Washington State Department of Ecology, *Washington State Dioxin Source Assessment*, Publication No. 98-320, July 1998.

ASPHALT SHINGLES

- **Form a partnership to test and pilot the use of recovered asphalt shingles in aggregate road base and hot mix asphalt.** This study identified a strong need for a new market for recovered asphalt shingles. One possible market could be the use of asphalt shingles in paving projects. Numerous other states have developed specifications that allow for the use of recovered asphalt shingles in aggregate road base and/or hot mix asphalt. King County could collaborate with WSDOT, shingle processors, and potentially a university engineering department to conduct tests and pilots of aggregate road base and hot mix asphalt that include recycled asphalt shingles. If successful, this process could lead to new DOT specifications and a new market for recovered asphalt shingles.
- **If the above tests and pilots are successful, implement programs and policies to increase recovery and maintain quality of tear-off asphalt shingles.** This study's research found that the supply of waste asphalt shingles was much greater than the current demand. If a paving market can be developed, further work may be necessary to recover the estimated 16,600 tons of asphalt shingles currently disposed each year. A particular focus may be needed on solutions to recover and maintain a quality stream of tear-off asphalt shingles (those from demolition activities as opposed to manufacturing scrap or new construction) that can often be contaminated with nails and other materials not suitable for paving markets.

GYPSUM

- **Consider a disposal ban on gypsum wallboard.** Banning disposal of gypsum wallboard may be an effective means of increasing recycling. Markets for recycled gypsum are expected to remain strong, and a gypsum ban such as that instituted in British Columbia would help increase the supply of recycled gypsum in the marketplace.

CARPET

- **Institute government procurement requirements that require recycling of carpet installed in government buildings.** Government procurement requirements can be effective at transforming markets and stimulating innovation. Washington State has a contract for floor covering services that mandates recyclability. King County could potentially use this contract or pattern its own contract and bid language after Washington State's contract. The key requirement in the contract would be to mandate recyclability and/or product take-back.
- **Participate in product stewardship and design initiatives, where feasible.** The barriers to recycling post-consumer carpet in its current form are virtually insurmountable. However, long-term potential likely exists in redesigning carpet and floor-covering systems specifically for waste reduction and recyclability, a movement currently led by Georgia-based Interface. King County can encourage these developments locally through procurement requirements (as above), by promoting grants offered by the Carpet America Recovery Effort, or by working

through the carpet subcommittee of the Northwest Product Stewardship Council, of which King County is a member.

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Appendix A. Processors of King County C&D Materials

WOOD PROCESSORS

Processor	Location (all in Washington)
American Roofing Recyclers	Snohomish
AWR	Redmond
Bobby Wolford	Maltby
NW Wood and Fibre Recovery	Auburn
Pacific Topsoil	Mill Creek
Rainier	Covington
Recovery 1	Tacoma
R.W. Rhine	Tacoma
Soos Creek	Covington (closed; now part of Cedar Grove)
Squak Mountain Materials	Renton
Woodworth	Tacoma

ASPHALT SHINGLE PROCESSORS

Processor	Location (all in Washington)
American Roofing Recyclers	Snohomish
Woodworth and Company	Tacoma

GYPSUM PROCESSORS

Processor	Location (all in Washington)
BPB (formerly James Hardy)	Seattle
New West Gypsum	Fife (closed in May 2004)
Recovery 1	Tacoma

CARPET PROCESSORS

Processor	Location
Collins & Aikman	Dalton, GA
DuPont	Calhoun, GA

Appendix B. Specifications & Prices Paid by End Users

Following are detailed market specifications and prices paid by end users for the commodities discussed in this report.

Specifications & Prices Paid for Recovered Wood

Market	Specifications *(may vary by mill and end product)*	Price (per bone dry ton)	Possible Virgin Alternatives	Price for Virgin Alternative (per bone dry ton)
Structural/architectural wood	Stress patterns must be maintained for structural wood	$570-$4,500[28]	None	None
Pulp chips	• Length: max. 1-3/4", min. 5/16" • Geometry: prefer a true sliced chip instead of a hogged or shredded shape • Hardwoods are acceptable but must be kept separate • Zero tolerance for dirt, plywood, particle board, plastics, laminates • Tree species affects brightness	$80	Pulp chips from mill residuals, also pulp logs, recycled paper, and paperboard	$50-$100, depending on tree species
Wood/plastic composite	• Length: no max, 12" in length (preprocessed wood waste) • Trace amounts of large fiber composites (OSB, plywood) • Zero tolerance for small fiber composites (particleboard, MDF) • Wide tolerances for tree species variation	$20	None (product is designed to use urban wood)	N/A
Reconstituted panelboard	• Length: ¾"-inch max, 1/8" min • Geometry: accept hogged, shredded, and chipped feedstocks. • Wood species specifications vary by mill and region • Wood with binders (plywood, OSB, particleboard, MDF): max. 10% • Rocks, glass, ferrous and non-ferrous metals: maximum allowed is 0.1% by weight	$35-$50	Particleboard uses mill residues, sawdust, planer shavings; hardboard & MDF use mill residuals, roundwood log, plantation thinnings	$20-$40

[28] Based on price of $0.50-$4.00/board foot, 2.2 lbs/board foot and 20% moisture content.

Compost/landscape chips	• Length: 1” to 8” • Geometry: a coarse/shredded material is typically acceptable instead of a chipped material • All tree species accepted • Plywood and particleboard 5%	$20	Sawdust, yard waste, green wood waste	$25[29]
Hog fuel	• Length: 3” • Geometry: coarse and shredded wood waste is acceptable • All tree species accepted • Some mills accept engineered wood • Wood transported/stored in saltwater is unacceptable	$8-$20	Natural gas (most common), oil, sawdust, mill residues	$40[30]

[29] Price per bone dry ton of sawdust.

[30] Wood would have to cost $40/bone dry ton to equal cost per BTU of natural gas currently at $4.30 MMBTU.

Specifications & Prices Paid for Recovered Asphalt Shingles

Market	Specifications	Price (per bone dry ton)	Possible Virgin Alternatives	Price for Virgin Alternative (per bone dry ton)
Interim cover	Ground ¾ minus, mixed with wood shingles for temporary road bedding at landfills	Free to small tip fee	Gravel	$3-$4
Hot mix asphalt	Ground to ¼ to ½ inch minus	*	Liquid asphalt	$170-$230
Aggregate road base	Ground to ¼" to 1" inch minus, then mixed with aggregate	*	Virgin aggregate Recycled aggregate	$5-$7
Cold patch	• Ground and screened to ¼ inch minus, then mixed with aggregate • If asphalt shingles are tear-offs then solvent must be added to rejuvenate the old oxidized asphalt	*	Liquid asphalt	$170-$230
Fuel	Prefer unprocessed asphalt shingles; wood, nails tolerated in small amounts	$10 tip fee	Coal	$30-$34

**No price data could be found on these products being sold in Washington. Commercial Paving Company, located in Maine, sells all three paving products, but does its own grinding as well as mixing of the end product.*

Specifications & Prices Paid for Recovered Gypsum

Market	Specifications	Price (per bone dry ton)	Possible Virgin Alternatives	Price for Virgin Alternative (per bone dry ton)
Gypsum wallboard	• Must be greater than 92% pure gypsum • Must have less than 10% moisture content • Must be less than 3% paper • Any paint must be lead-free; nails must be removed	$2-$4	Calcined Gypsum FGD gypsum (synthetic)	$18 calcined[31] Undisclosed FGD
Compost (produced from paper)		$10-$12 tip fee	Yard waste	$10-$25 tip fee

[31] U.S. Geological Survey, *Mineral Commodity Survey*, January 2003.

Specifications & Prices Paid for Recovered Carpet

Market	Specifications	Price (per bone dry ton)	Possible Virgin Alternatives	Price for Virgin Alternative (per bone dry ton)
Carpet backing	Nylon 6 or 6,6 face fiber, but must have vinyl backing	$25[32]	Virgin PVC pellets	$620-$680
Industrial flooring	Nylon 6 or 6,6, face fiber, but must have vinyl backing	$25	Virgin PVC pellets	$620-$680
Automobile parts	Uses recycled 6,6 nylon in combination with thermoplastic resin reinforced with mineral and glass. Shred fibers to 1/16" and melt into resin	Undisclosed	Nylon 6,6 Resin	$2,800 – 3,000[33]
Carpet cushion made from carpet	All carpet face fiber (except wool); fiber length at least 1/8"; made by needle punching carpet fibers	Undisclosed	Nylon 6, Nylon 6,6	$2,480-$3,000
Sod reinforcement	Nylon fibers from recycled carpet are mixed with sand, soil, and fertilizer, then spread on trays as the base for sports grass	Undisclosed	Nylon 6, Nylon 6,6 Resin	$2,480-$3,000

[32] Based on price of PVC regrind or flake, *Plastics News*, February 2003. Pellet price not published or disclosed.

[33] *Plastics Technology Journal*, January 2003