Sustainability in Practice:

Reducing Construction Waste in the

Ontario Residential Construction Industry

by Teresa Janine Paul, Habitat Associates

with the Ontario Home Builders' Association

September 1997

CMHC Project Officer: Terry Marshall

This project was carried out with the assistance of a financial contribution from Canada Mortgage and Housing Corporation under the terms of the External Research Program. The views expressed are those of the author and do not represent the official views of CMHC.

ABSTRACT

This project's objective was to identify the most effective strategies for minimizing residential construction waste in Ontario. As a collaboration between a consulting firm and the Ontario Home Builders' Association (OHBA), the focus was to identify *voluntary* ways to cut waste, and to determine how to *implement* an effective strategy to assist home builders with minimizing waste.

The study was conducted in two phases. Phase 1 analyzed construction waste management practices in Ontario, including waste generation rates, trends and individual reduction initiatives, through interviews with builders and related industries, and book research. Key considerations for implementing a waste reduction strategy for Ontario were identified. In Phase 2 an implementation strategy to be led by the OHBA was developed.

Phase 1 generated several conclusions; two notably address the objectives. First, minimizing construction waste generation should be emphasized over separation and recycling. Reduction is typically the preferred of the 3Rs, but in addition to being the most effective way of minimizing waste, it has potential to save money. This message is capable of attracting attention, encouraging serious consideration, and permanently changing practices. Secondly, builders' practices are very diverse, suggesting that there is considerable opportunity to increase awareness about waste avoidance techniques. Effectively communicating with builders and their workers is challenging, so that significantly reducing waste will involve improving awareness of both the general benefits of waste reduction as well as specific techniques that can reduce waste.

Alternative outreach strategies were formulated in Phase 2. A grassroots approach to assist builders address waste was selected based on comments received from builders and the experience and resources of the OHBA,. Two documents were produced, the first designed to assist local Home Builders' Associations (HBAs) raise awareness about the benefits of waste reduction, and the second to provide HBAs and home builders with practical tips, testimonials and cost-savings data. The documents can be used in several ways.

ACKNOWLEDGEMENTS

This study required the time and cooperation of many in the construction sector. The following builders, waste management firms, product representatives and agencies have assisted us throughout the study, and we would like to express our appreciation for their enthusiasm and invaluable contributions.

Alpha-Tec Consulting & Construction, Toronto
Challenger Homes, Edmonton
Dacon Corporation, Kingston
Dalron Homes, Sudbury
D.G. Pratt Construction Ltd., Barrie
Dimark Construction Inc., Waterloo
Geranium Homes, Toronto
Greenpark Homes, Concord
James Keating Construction Ltd., Elora
Kimberly Homes, Windsor
Landmark Homes Inc., Edmonton
Maberly Housing, Maberly
Marshall Construction & Consulting, Belleville
Mercedes Homes, Hamilton
Metrus Development Inc., Concord
Monarch Construction Limited, Kitchener
Monarch Construction Limited, Willowdale
Mountainview Homes, St. Catharines
Rawlings Homes, London
Reid's Heritage Homes, Guelph
Sal Dan Developments Ltd., Sault Ste Marie
Thomasfield Homes Ltd., Guelph

Arborea Tree Service and Forestry, Concord
BFI Waste Systems, Kitchener
Harbour Front Recycling Inc., Hamilton
Hersey Recycling & Disposal, Guelph
Horizon Enterprises, Kitchener
Laidlaw Waste Systems Ltd., Guelph, Hamilton
Modern Landfill Inc., Model City, New York
Philip Environmental Inc., Hamilton and London

AMD Clean Up Services, Windsor
Anderson & Associates Inc., Mississauga
Kent Trusses, Barrie
New West Gypsum Recycling Inc., Oakville
Owens-Corning Canada Inc., Rexdale
Sarmazian Bros. Ltd., Guelph

Air Solutions Inc., Cambridge
Buchan, Lawton, Parent Limited, Ottawa
Build Green Inc., Mississauga
Canada Mortgage and Housing Corporation Staff
Canadian Home Builders' Association
Canadian Wood Truss Association
McLeod Associates, Toronto
Clean Washington Center, Seattle, Washington
Hamilton-Halton Home Builders' Association
Environment Canada, Waste Prevention Div., Hull
Friar Forest Products Ltd., Monetville
Greater Edmonton Home Builders' Association
Greater Toronto Home Builders' Association
London Home Builders' Association
National Association of Home Builders Research Center, Upper Marlboro, Maryland
Northeast Sustainable Energy Association, Greenfield, Maryland
Ontario Ministry of Environment and Energy
Ontario Waste Management Association, Toronto
Ottawa-Carleton Home Builders' Association
Public Works Department, City of Edmonton
Public Works Department, City of Sarnia
R2000 Office, Toronto
Recycling Council of Ontario, Toronto
REIC Consulting Ltd., Aurora
Regional Municipality of Ottawa-Carleton
Torbsa Ltd., Orangeville
Waste Management Department and Landfill, City of Guelph
Waste Reduction Institute for Training & Applications Research, Minneapolis, Minnesota
Waste Reduction Office, Regional Municipality of Waterloo
Wood Truss Council of America, Madison, Wisconsin

EXECUTIVE SUMMARY

One of the major challenges facing all advocates of sustainable development is putting theory into practice. The sound management of construction waste is one of many factors related to sustainable development that must be addressed by the housing industry.

This project's objective was to identify the most effective strategies for minimizing residential construction waste in Ontario. This involved looking at work already done on the subject, as well as interviewing several builders on their waste management practices. The study covered Ontario, which was considered to represent the situation across Canada inasmuch as Ontario contains a wide geographic territory, large and small building companies, and densely populated urban through remoter rural areas. As a collaboration between a consulting firm, Habitat Associates, and the Ontario Home Builders' Association (OHBA), regulatory mechanisms were downplayed in favour of identifying *voluntary* ways to cut waste, and earmarking ways to effectively *implement* a strategy to assist home builders with minimizing waste.

The study was conducted in two phases. Phase 1 analyzed construction waste management practices in Ontario, including waste generation rates, trends and individual reduction initiatives. This involved interviewing builders and related industries, and book research. Key considerations for implementing a waste reduction strategy for Ontario were identified, and in Phase 2 an implementation strategy to be led by the OHBA was developed.

In Phase 1, it was confirmed that many in the home building industry regard waste management as a minor issue. Many builders equate waste minimization with recycling, and therefore see "waste management" as a costly, "do-good" endeavour. Part of the reason for this is society's emphasis on recycling, as well as disappointment resulting from failed ventures to recycle certain construction wastes. When applied to residential construction waste, with so many generators and few really tenable recycling opportunities, recycling truly is costly and time-consuming.

Furthering the reticence that many builders feel about addressing waste, the past ten years has seen the construction waste situation change entirely. In the late 1980's, construction waste management began to be seriously addressed because waste disposal costs were skyrocketting and landfill bans for some construction wastes began to affect operations. In the early 1990's, the province of Ontario struck a Construction and Demolition (C&D) Waste Reduction Strategy Team to identify practical ways of achieving the province's waste reduction target of reducing waste by at least 50 percent by the year 2000 compared to 1987 levels. In 1994, provincial regulations were introduced affecting waste management in several industries, including residential construction. In contrast to these developments, in the early 1990's, de-regulation led to competition between landfill sites, and tipping fees plummeted. The sudden drop in landfill costs together with the rise of big disposal companies offering automated separation of mixed wastes meant that construction waste disposal has become cheaper and less complicated, and therefore less a concern for the home builder. This, despite the fact that landfills are nearing capacity and society continues to struggle with the costs of the waste burden.

Through the ups and downs of regulatory climates, recession and boom economies, tentative recycling opportunities, and confusion about what sustainable development means and entails, excessive waste continues to be a nuisance, consciously or unconsciously. Some builders have recognized that waste needs to be addressed, and have tackled it. In talking to a cross-section of builders, we found that it matters not where in the province a builder is located or how big a company is. Whether a builder has addressed waste depends on the philosophy of the individual builder and their ability to realize their vision. Furthermore, each builder has a unique way of managing waste and obtaining cooperation from labourers and subcontractors. We did find overall that good (i.e. persistent, informative, two-way) communication about why waste should be minimized is important, as are the adoption of methods that have a positive impact on profit margins (i.e. modular design, precise ordering, careful handling and storage).

Several conclusions were drawn from the first phase of the study, but two emerged as key to addressing the objectives, i.e. facilitating voluntary acceptance of waste minimizing practices and enhancing the reach and impact of the message. First, minimizing construction waste generation should be emphasized over separation and recycling. Reduction is typically the preferred of the 3Rs, but besides being the most effective way of minimizing waste, it has the potential to save money. This message is capable of attracting attention, encouraging serious consideration, and permanently changing practices. Reducing materials consumption also has a truly positive environmental impact.

Secondly, builders' practices are very diverse, suggesting that there is considerable opportunity to increase awareness about waste avoidance techniques. Effectively communicating with builders and their workers is challenging, for many reasons. Builders are numerous and a heterogeneous group, their building techniques and waste management practices vary widely because most builders learn on the job, they are loosely-knit as an industry, and the responsibility for waste rests at many levels from the building designer through to the subcontractors. Effectively reaching all those with a role to play in reducing waste is not easy, and therefore will require effort. Significantly reducing waste will involve improving awareness of both the general benefits of waste reduction as well as specific techniques that can reduce waste.

The second phase of the project was devoted to developing an outreach program. Based on the conclusions of Phase 1, five potential outreach strategies were formulated. Builders and others were asked to comment on the effectiveness of each alternative strategy. Based on builders' feedback and the experience and resources of the OHBA, a grassroots strategy to assist Ontario builders reduce waste was selected. Two products were generated. The first is a kit designed to assist local Home Builders' Associations (HBAs) with initiating a local campaign or event to raise awareness of the benefits of waste reduction. It is primarily intended for use by local Home Builders' Associations, but might also be useful to related industries and industry associations (e.g. building material product suppliers and manufacturers) whose products reduce waste and who would benefit from opportunities to raise their visibility among home builders. The second document provides details that can be used as background information by those hosting an event, and can also be used directly by home builders. It contains practical information, testimonials and cost-saving data. The documents will be provided to local HBAs and home builders in several ways, including distribution at conferences, by direct mail, and features in the OHBA's magazine.

TABLE OF CONTENTS

TABLE OF FIGURES

1.0 INTRODUCTION

1.1 STUDY PURPOSE

One of the major challenges facing all advocates of sustainable development is putting theory into practice. The sound management of construction waste is one of many factors related to sustainable development that must be addressed by the housing industry.

This project's objective is to identify the most effective strategies for minimizing residential construction waste in Ontario. As a collaboration between a consulting firm, Habitat Associates, and the Ontario Home Builders' Association (OHBA), regulatory mechanisms were downplayed in favour of identifying *voluntary* ways to cut waste, and identifying ways to effectively *implement* a strategy to assist home builders with minimizing waste.

1.2 METHODS

Phase 1 addressed how construction waste is managed in Ontario, and what the impediments are to reducing waste. This involved identifying and evaluating different strategies for reducing residential construction waste by visiting construction sites, holding discussions with builders, waste management officials and related industries, and reviewing studies across Canada and the United States. We considered how province-wide variations may affect waste characteristics, generation rates, recycling opportunities and successful reduction practices.

At the end of Phase 1, several conclusions were drawn. Based on these conclusions, several potential directions were identified that the OHBA might pursue in order to implement a waste reduction plan on behalf of Ontario home builders.

In Phase 2, five alternative strategies for delivering a waste reduction program were outlined. These options were faxed to fifteen home builders and two home builders' associations for comment. Based on the feedback received plus the experience and resources of the OHBA, a grassroots strategy was selected. Two outreach documents were developed to support the delivery of the program; they were reviewed by four home builders, one product manufacturer, five industry association representatives and three government representatives before being finalized.

2.0 THE CONSTRUCTION WASTE SITUATION

2.1 WASTE TYPES, VOLUME, DESTINATION

Figure 1 illustrates the waste types and quantities generated on residential construction sites based on available reports.

There is considerable variability in the amounts of waste produced. This degree of variability has been noted elsewhere. For example, the Toronto Home Builders' Association (THBA 1990) reported that builders' estimates of the amount of their waste production were so variable that either building practices were very diverse or that many builders had a limited understanding of their waste generation. A study conducted in Metropolitan Toronto (1991) concluded that the construction and demolition (C&D) sector is different from other sectors when it comes to solid waste because C&D waste is extremely variable and erratically produced, and affected by factors such as size of buildings, materials, market (luxury or utility) and contractors.

It is worth noting that house size does not of itself account for the variation, because data expressed as quantity per unit floor area (e.g. per 100 metres ^{2}) does not remove the variability (i.e. Fig. 1b). Regional factors might be expected to influence building styles and therefore materials used, degree of waste avoidance due to local disposal costs or landfill bans, or availability of alternatives to disposal such as recycling markets. However, the data and discussions with builders reveal that the amount and types of waste produced by builders within any one place can be as large as those between regions. For example, differences between builders in Edmonton (CMHC 1993a) are significant (Fig. 1b).

The degree of architectural complexity clearly affects the amount of waste arising from materials that require cutting, like dimensional and sheet materials, (Drerup et. al. 1995). Auditing methodology could account for some of the variation, although the differences apparent between builders within the same study (i.e. CMHC 1993a) suggest otherwise. Overall, the data and the literature suggest that variation in waste types and quantities generated on construction sites has at least as much to do with differences between builders' practices as with other factors such as regional differences or measuring methodology.

Wood is clearly the largest contributor to the waste stream. In Edmonton, audits conducted before and after a waste minimization effort showed that dimensional lumber can be reduced by well over half (CMHC 1993a; City of Edmonton et. al. 1994 and 1996). A similar conclusion was reached by the National Association of Home Builders (NAHB) Research Center in the United States, which found that there are many opportunities for more efficient use of framing materials with big savings for builders (NAHB 1996).

Drywall is the next most abundant waste material produced on residential construction sites. Technological developments facilitating the separation of paper from gypsum have accelerated the development of recycling markets for drywall. Also, the discovery in the 1980's that gypsum reacts (with bacteria, organic matter and moisture) in landfills to produce unacceptably high levels of hydrogen sulphide led to bans at some landfills (Recycling Council of Ontario 1995). Although

Figure 1. Waste Produced According to Waste Audits

the cost of recycling drywall is not low (a tipping fee of $40/tonne is charged at New West Gypsum in Oakville, and collection facilities may charge double this amount), New West claims to recycle about 75 percent of drywall scrap generated within a 2-hour drive of Oakville (approximately 1,000 to 1,200 tonnes of drywall scrap each month, on average). In other parts of Ontario, drywall scrap may be landfilled or recycled into pet litter, soil amendments, compost and related products.

Masonry tends to be buried on the builders' next construction site or left on site for the home buyer's use. Asphalt shingles are primarily landfilled; some are recycled, where facilities exist. Masonry, asphalt and chipped wood are used by landfills for daily cover and/or road base. Usually reduced tipping fees reflect that some value is attributed to these materials when put to one final use before being buried.

Some materials have well developed recycling markets, notably steel and cardboard. Steel and cardboard have steady markets which pay for scrap, though prices for these materials can be highly variable.

Each material has unique problems and opportunities. While metals can be recycled and the metal recycling industry is well established, the quantity of metals generated on residential construction sites is so low that many builders landfill it along with other waste. Vinyl is recyclable and scrap vinyl has a reasonably high market value, but the small amount of waste generated on construction sites and a lack of infrastructure to get materials back to suppliers or recyclers in clean batches make cost-effective recovery difficult. Some builders make a point of separating these recyclables even if quantities are small.

Most construction wastes other than wood, drywall, cardboard and masonry are landfilled, and some is burned. The technology for recycling plastic and carpeting waste is developing, but market conditions have slowed the progress of this research and the short-term prospects for alternatives to landfilling.

2.2 TRENDS IN CONSTRUCTION WASTE DISPOSAL

A few years ago, construction waste management and job-site source separation would have been considered nearly synonymous. Where recyclable scrap materials have more value when clean and separated by type, mixing them together should obviously be avoided. While source separation still makes sense for certain jobs, there is a growing trend "backwards," towards single-bin disposal. Many contractors find commingled disposal more cost-effective, and waste management companies claim to be able to recycle more waste when it is separated at a specialized facility (Malin 1995).

The availability of Material Recovery Facilities (MRFs) for C&D wastes is increasing. Using a combination of manual separation and sophisticated mechanical processors with crushers, magnets and shakers, MRFs achieve remarkably high diversion rates (~82 percent) (Malin 1995). MRFs discourage source separation because separation and finding uses for materials is their stock in trade. MRFs claim that materials separated on the construction site are inevitably contaminated and almost always need separation offsite anyway.

Waste processors are interested in finding the highest-value use for materials. For example, using wood as landfill road base is less profitable than selling it for higher value products such as compost or fibre board. Promoting the most valuable use of a waste material is not only good for MRFs but is also preferable from resource management and social cost perspectives.

Further supporting the trend away from at-source separation are the changing economics of landfilling. The cost of landfilling in Ontario, after increasing steadily for many years, dropped dramatically in the 1990's. Municipal landfills now compete with privately owned landfills here and across the United States and Quebec borders. Deregulation at the Canada/U.S. border is blamed for huge decreases in the cost of waste disposal. In Hamilton, for example, tipping fees rose gradually from $6/tonne in 1975 to $180/tonne in 1990, an increase of 3000 percent over 15 years; in 1991 the price fell by more than half to $70 (Trueman 1996). This changed waste management trends overnight. Municipalities within driving distance of cheap disposal alternatives (usually private landfills outside of Ontario, i.e. in the U.S. and Quebec) are having to lower tipping fees in order to compete, otherwise projected revenues are too low to allow the municipal landfill to stay in operation.

Theoretically, it should cost less to send clean, separated recyclable materials to recyclers than to either landfills or MRFs, but the trend is currently moving away from source separation for economic reasons.

2.3 ECONOMIC FACTORS

Builders interviewed for this study are spending anywhere from less than $100 up to $1,000 per house on waste disposal (Fig. 2). The literature reports the following average costs per house for waste disposal: the Toronto Home Builders' Association (THBA) $300 in 1990 (THBA 1990), the Regina Home Builders' Association $311 (reported in CMHC 1995), in Edmonton $300 to $450 (City of Edmonton et. al. 1996), and in the United States $511 (U.S. dollars) (NAHB 1996). The NAHB Research Center estimates that even though disposal costs may represent only about 0.5 percent of a home's total construction costs, this can represent up to five percent of the profit on a home (NAHB 1997).

Figure 2 reveals that not all builders know their waste management costs. The THBA also found that many builders do not know their full waste-related expenditures (THBA 1990). Many of the costs cited in Fig. 2 and in the literature represent direct costs such as tipping fees and bin rental, and generally do not include labour, vehicle and other incidentals, nor indirect fees charged by subcontractors for clean up and disposal.

A survey by Kalin Associates (CMHC 1993a) did not determine waste management costs, but did find that while 60 percent of Canadian builders taking CMHC's waste management challenge workshops in 1991 initially thought managing construction wastes would increase costs in the short run, after two years only 13 percent had increased cost, 38 percent had no effect on their bottom line, and 17 percent saved money. The assumption that more sophisticated waste management practices are costly to implement represent one important impediment to waste minimization.

Certain construction wastes have relatively high market value as commodities, in particular cardboard and metals. These materials have been recycled for many years, and so have established recycling markets with well developed collection and distribution systems. The value of these materials as commodities can be high enough to support recycling, but because prices and therefore diversion rates can be unstable, and volumes generated on construction sites are so low, recycling is at times considered impractical.

Solutions for reducing packaging waste and wastes generated in small quantities have been considered over the years. Various experiments to take back packaging or scrap have not succeeded in North American markets. (Few of these have been published.) In Michigan, a pilot project involving installers bringing vinyl siding cutoff waste back to the supplier as they return for new materials found that the value of vinyl did not offset the container fee service (NAHB 1997). As long as landfilling costs are cheaper than recycling, few recycling or packaging take-back opportunities can be expected to develop, at least without government regulation. Despite general interest in environmental responsibility, the current economic and regulatory climates clearly discourage such initiatives, though this situation may change over time.

It is important to note that scrap lumber, the largest material generated on construction sites, has a very low dollar value as a recyclable commodity. It has some value at landfills (as road base or daily cover, hence no tipping fee for wood at some landfill sites) and at industrial or energy plants (which pay for wood as a fuel source), but its plentifulness and the relatively low value of end

Figure 2. Ontario Builders' Waste Management Practices, Waste Quantities per House, and Waste Destinations

system	disp.cost / house[a]	description	waste quantity/house	material	handler[b]	end use
A		builder provides full service clean up using pick-up truck and staff dedicated to cleaning	600+ lb 1500 lb 50 lb 5-10 lb 150+ lb 5-10 lb 36 sq ft 1-200 straps 10 lb 1/2 lb 45-50 bags 200 sq ft 4500 sq ft 10 lb 20-50 ft 5 bags	•wood •drywall •masonry •cardboard •asphalt •fiberglass •pinkboard •metal: steel aluminum •plastic: plumbing bags polywrap misc. •vinylsidng •taping •garbage	builder “ “ “ “ “ “ “ “ “ “ “ “ “ “ “	→landfill road base→landfilled →municipal landfill bin→manufacturer→recycled →buried →municipal landfill bin→mill→recycled →landfill road base→landfilled →landfilled →landfilled →landfilled →municipal landfill bin→recycled →landfilled “ “ “ →recycled into plastic wood →landfilled →landfilled
B	$100 to $150	builder provides full service clean up using pick-up truck and full time staff	4-6 cu yd 1.5 cu yd 2 wheelbarrows 2 cu ft 5 bags 2 cu yd 0.5 cu yd	•wood •drywall •masonry •cardboard •asphalt •fiberglass •metal •plastic •vinylsidng •flooring	builder “ “ “ “ “ “ “ floor trade	→firewood picked up from jobsite[c] →mixed with fill on site as soil amendment →moved to low-lying areas, not backfilled around house →composted on soil surface →stockpiled→roadbuilder→recycled →landfilled →scrap yard→recycled →burned or landfilled →landfilled →landfilled

Figure 2 (cont'd). Ontario Builders' Waste Management Practices, Waste Quantities per House, and Waste Destinations

C	<$100	trades and builder clean up with pick-up truck	~1 tonne total 65-65 straps <50 lb <1 bag ~1 bag	•wood •drywall •metal •masonry •plastic •foam	builder drywaller builder " " "	→free firewood[c] or landfilled →municipal landfill OR →nursery as soil amendment →scrap yard→recycled →buried →landfilled →landfilled
D	$300[d]	builder cleans up with pick-up truck	just under 1 lugger bin	•wood •drywall •cardboard •remainder	builder builder/hauler builder/hauler hauler	→free wood bin at office[c] →30-40% wall cavities, rest landfilled →burned OR →mill→recycled →landfilled
E[e]		backhoe filled by labourer is transported to two 40 cu yd bins		•wood •remainder	hauler hauler	→MRF[f]→reused, recycled or landfilled →MRF→reused, recycled or landfilled
F	$300-400	builder provides 2 bins: 1 for wood, 1 for general waste; subtrades responsible for own disposal	20-30 yards total ~50% wood ~50% other	•wood •remainder	hauler hauler or trade	→MRF→chipped→burned/landfilled/mulched →MRF→reused, recycled or landfilled
G		builder has holding area for stock-piling waste outdoors and 40 cu yd bins		•wood •drywall •cardboard •tires •fibreglass[g] •remainder	builder " " " " "	→central storage area→firewood → central storage area→manufacturer→recycled → central storage area→mill→recycled → central storage area→recycled →manufacturer→recycled OR →landfilled →municipal landfill
H	$120-$180	builder provides 5 20 cu yd bins for mixed waste and 1 6 cu yd bin for metal; provides space for drywaller who manages own bin	~2.28 tonnes (of this, 51% was diverted at MRF and sold in 1993)	•comingled waste •drywall	hauler drywaller	→MRF→landscaping/farm animal bedding/composite board manufacturer (wood) →scrap yard→recycled (metal) →reused, recycled or landfilled (remainder) →manufacturer-run depot→manufacturer→recycled

Figure 2 (cont'd) . Ontario Builders' Waste Management Practices, Waste Quantities per House, and Waste Destinations

I	<$100	builder supplies 2 cu yd boxes for wood; empties with forklift; other trades do own disposal, but builder provides 3 cu yd containers for general waste and collects into 40 cu yd lugger		•wood •remainder	builder hauler or trade	→free wood bin[c] →MRF→reused, recycled or landfilled
J	$500-$1,000	hauler manages one 6 cu yd bin for mixed waste per house		•comingled waste	hauler	→MRF→burned or soil amendment (wood) →manufacturer→recycled (drywall) →mill→recycled (cardboard) →scrap yard→recycled (metal) →landfilled (remainder)
K	$450	independent clean up service; trades pile wastes in garage, cleaner collects each week	2.5 to 3 tonnes including wood (wood: 5 to 10 cu yd of total)	•wood •remainder	cleaner cleaner	→delivered free of charge as firewood →landfilled

[a] Cash costs. Most of these estimates (except system J) do not include time spent by the builder for bin administration or clean up, vehicle costs, labour costs, etc. or subcontractor fees for disposal.

[b] In general, plumbers, electricians and flooring dispose of their own waste; roofers and drywallers may or may not remove their own wastes; framing and masonry wastes are handled directly by the builder.

[c] Builders offering free wood say it is gone within hours. This includes dimensional and manufactured wood, and wood as small as 6" long. This method is widespread insofar as it is not confined to small or northern communities, although in cottage country people come looking for it and it does not even get into a pile.

[d] This builder claims to spend $200 less on waste disposal per house than his competitors, and $300 to $400 less on materials through engineering, ordering and managing trades to minimize waste.

[e] This builder prefers to use system J, where it is available. Although the cost of system E has not be calculated, system J, although appearing expensive, is considered better and more cost-effective overall, after labour and equipment costs are considered. Furthermore, system J tends to keep the building site clean.

[f] Material Recycling Facilities use either municipal or private landfill. Depending on the size of the MRF, they may own and operate their own landfill.

[g] Occasionally, fiberglass has been separated by the builder and sent back, along with bags, to the manufacturer for recycling with the next delivery.

uses for wood, compared to materials like metals or cardboard, make wood a material with many recycling challenges.

Finding economically viable uses for large volume wastes would seem a logical priority. Harbour Front Recycling Inc. of Hamilton, specializing in C&D waste, is preparing to build a fibre board manufacturing facility, the first of its kind in North America to produce 100 percent recycled board. This kind of development should increase the value of scrap wood. Such initiatives require huge investments and must be done on a large scale.

Because of the low market value and few recycling opportunities for wood waste, reducing the generation of wood waste in the first place should be considered a priority. Fortunately, studies have shown that wood waste generation can be significantly reduced. Dimensional lumber, in particular, can be reduced significantly with waste reduction effort (Fig. 1). A study conducted in Edmonton (City of Edmonton et. al. 1994 and 1996) (where 3 successive audits were conducted: one before the waste minimization effort, the second after a waste minimization challenge, and the third two years later) showed that dimensional lumber waste could be reduced by half. This study also demonstrated that after the initial attempt, further waste reduction can be realized over time.

Use of pre-cut and pre-assembled wood products (e.g. roof and floor trusses) could be part of an approach to minimizing construction waste, as could re-consideration of material use at the architectural stage. The latter approach is being pursued by at least two U.S. teams, the National Association of Home Builders (NAHB) Research Center and the Waste Reduction Institute of Minnesota (WRITAR). There is some excitement about this approach because of the positive financial impact, since money can be saved not only on waste disposal but also as a result of the purchase of fewer materials.

The NAHB Research Center concluded that builder interest in waste reduction and recycling is driven primarily by considerations of cost and convenience, and that innovative construction waste management techniques must address at least one of these considerations to be widely embraced. One supplier was quoted as saying “if your’re asking them to do it and it saves them money they’ll do it - if it doesn’t save them money they won’t” (NAHB 1996). The focus for most builders and tradespeople is simply to get the job done.

3.0 WASTE MINIMIZATION STRATEGIES

3.1 MAIN STRATEGIES

Generally, the methods that have been used to minimize construction waste can be categorized into the following main strategies:

The **3Rs**: reduction, reuse and recycling, represent the most familiar framework for addressing waste.
Development of Recycling Markets has received considerable attention.
Educational and Promotional Programs demonstrate and promote alternatives to conventional waste generation.
Partnerships and Incentives can overcome the reality that no one stakeholder or interest has sufficient resources to effectively address waste reduction single-handedly.
Design Innovations cover an array of waste reduction strategies, such as minimizing waste through design, incorporating material-saving construction techniques, and improving the precision of materials estimating and delivery.
Policy and Legal strategies include the adoption of regulations, landfill bans and subcontractor agreements.

3.1.1 The 3Rs

The 3Rs have been the traditional focus of waste minimization in all sectors, including construction. The soundness of this approach lies in its ranking of reduction as preferred over reuse, followed by recycling as the least favoured approach.

Reduction is considered an effective means of addressing waste, and emerges as the key strategy for construction waste minimization, as we shall see.

By *reducing* the amount of waste generated, not only does less waste need disposal but fewer materials are consumed. This results in cost savings both at the purchase and disposal stages, providing not only economic but also environmental benefits. The importance of reduction as a means to minimize construction waste is amplified by the fact that wood, the largest single component of the construction waste stream, has low value as a recyclable commodity (compared to metals or cardboard, for example) and wood waste can be significantly reduced, as studies have shown (CMHC 1993a; City of Edmonton et. al. 1994 and 1996; see Fig. 1).

The greatest opportunity for reducing waste in construction is at the design stage. Design considerations affect materials use, and these factors along with estimating procedures, have a major impact on the quantity of material used and waste generated (WRITAR 1995). In addition, improved material handling and efficient methods of construction can also contribute significantly to waste reduction. Materials use decisions raise issues of aesthetics, functionality, ease of application or installation, and longevity. Ordering materials specifically sized for a job (i.e. pre-cut or partially assembled products) reduces waste because usually a manufacturer is better equipped than a builder to recover scrap and re-incorporate it into the manufacturing process (WRITAR 1995). Selection of durable materials, selection of recycled or used materials,

selection of materials with low embodied energy and made with manufacturing processes that lower environmental impact can also be considered reduction opportunities. The earlier in the design process that reduction can be incorporated, the better. Design inefficiencies cannot be compensated for in later stages of construction.

In parts of the United States, pre-fabricated housing is becoming increasingly popular. This has the potential to reduce not only site-generated construction waste, but total construction waste per home because it is much easier to find uses for all but the smallest pieces of material in a plant production setting. However, to date no one has quantified the impact of pre-cut or pre-assembled products on the overall residential construction waste stream.

The key to *reuse* is considered to be held by the sub-trades (CMHC 1995). Reuse of formply and bracing by foundation contractors is a good example. Many builders already use off-cuts from framing lumber for bridging or blocking, excess insulation in interior walls for soundproofing, and durable packaging as trash bags. Because many reuse techniques are already practised, new reuse opportunities may be limited (Region of Waterloo 1996).

Currently there is much interest in de-construction, which is a form of building material reuse. De-construction is an alternative to demolition and can also be employed during renovation. Designing buildings that acknowledge the end of their useful life and facilitate the reuse of components can certainly reduce construction waste in the broad sense, but as this subject is in itself substantial, is somewhat peripheral to the immediate objectives of the present study, and is being addressed elsewhere, readers are referred to work being done by byDesign Consultants of Ottawa and Pearl Poddubiuk Architects of Montreal.

A great deal of emphasis has been placed on *recycling*, in part because people tend to hear about recycled products through marketing efforts and in part because among the 3Rs, recycling most resembles disposal in practice and so has been easiest to promote. The better that scrap materials can be separated (e.g. plastics segregated by type), the more valuable they are to recyclers. Once separated, recyclable materials must be kept clean. Poor storage can spoil good material making separated, clean materials otherwise unacceptable. Good super-vision, container placement and signage are all important to the success of jobsite recycling.

Conditions favourable for recycling include established outlets for recyclable materials, a level of construction activity compatible with using large containers for stockpiling, and reduced tipping fees for separated loads (NAHB 1996).

Amassing recyclable materials makes them more attractive to recyclers. Because recyclers often have minimum quantity requirements in order to make acceptance of scrap worthwhile, collecting materials in a central location increases the likelihood that the material will find markets and that delivery will not be prohibitively expensive. This is an “economy of scale” challenge. In Edmonton a centralized depot system was considered successful in pooling recyclable construction wastes, but unfortunately, is not continuing because of a lack of markets for the materials. Keeping separated materals clean is another formidable challenge.

In theory, source separation is important for recycling since double-handling adds to the time and cost of waste management. Independent operations like drywalling or carpeting are

considered good candidates for recycling because the prospects for separation at source are high (i.e. materials are handled once and there is a smaller chance of contaminating scrap with materials from other operations). Similarly, having subtrades dispose of their own wastes increases the opportunity for return of recyclable materials to the source.

Separating material that is normally landfilled should reduce the cost of landfilling the remaining materials, at least in theory. The reality, however, is that source separation of wastes at job sites is more likely to be stimulated by high landfill costs, landfill restrictions and limits placed by haulers, than by awareness on the part of contractors, and the trend is increasingly towards commingled loads separated at MRFs, as discussed earlier.

3.1.2 Development of Recycling Markets

As has been noted, material recovery facilities (MRFs) are taking more and more construction waste. These industries do not promote separation of material types at the construction site, but mechanically separate mixed wastes at their facilities. MRFs can achieve remarkable diversion rates, and uncover and develop high-value uses for materials.

Recyclable materials generated by construction may be recycled into products that may or may not be building materials, and similarly recycled-content building materials may or may not use construction wastes.

Recycled content building materials are at a competitive disadvantage with regard to cost, availability, and proven performance. New products lack economies of scale in terms of production and distribution and thus are more likely to be at least marginally more expensive than conventional products. Cost of recycled-content building materials was one of the most significant obstacles cited by builders. Also, to compete, alternative materials must show up on the job at the right time (not too early or late); and the crew must be prepared for the new material or system (NAHB 1996).

Recycled content building materials are perceived, by some builders, to be inferior in quality, as builders' experience has not always been good. Furthermore, builders require information on cost, product availability and performance, require it from a single source, and it must be up to date (NAHB 1996). Delays or difficulty getting this information leads to frustration and slow progress. Furthermore, recycled-content building materials are of limited interest to the homebuyer.

Much effort has also gone into finding and listing recycled building materials and suppliers, by groups like those backing the Build Green Program, the NAHB Research Center, and the Clean Washington Center. The Build Green Program is an initiative to maximize the utilization of recycled materials in construction and renovation. Other projects too, such as the and Green on the Grand, the Waterloo Region Green Home and other programs sponsored by CMHC, CANMET (Energy, Mines and Resources Canada), and Environment Canada are successfully sourcing recycled building products. There is a feeling among builders that the Build Green Program has not provided needed information to builders which is up to date, accurate and informative. In 1997, the Build Green Program is being revitalized by involvement of TerraChoice Environmental Services Inc., the organization behind the EcoLogo. It is expected

to go beyond promoting recycled building products, to a more comprehensive mandate relating to all aspects of green construction, including consideration of all phases of the building life cycle (siting, design, construction, operations, maintenance, retrofit and demolition). Initiatives may be both at the national and international level.

To address some of the issues surrounding the uncertainty of performance of recycled content building materials, the U.S. Home Builders' Association Research Center is currently working with a firm to market a database on recycled-content/resource efficient building materials. As part of its publication list, the Research Center now offers REDI^{TM}, a continually updated product database for recycled-content/resource efficient building materials, including information about product performance and availability.

Directories or data bases of local recyclers and waste haulers who offer construction waste recycling services have been compiled by several municipalities (e.g. Waterloo Region, Guelph**,** Region of Ottawa-Carleton), local home builders' associations (e.g. London) and others and others (e.g. Recycling Council of Ontario, Clean Washington Center). There is a perception that recyclers are closing down as fast as they are opening up, and that such directories are immediately out of date. Those who have used them say that recyclers listed are often too far away, or may not accept materials due to over-supply. This supply-demand imbalance is not unique to the construction industry, but it certainly discourages at-source separation, and ensures recycling remains the least practical of the 3Rs.

A number of factors make the development of recycling markets difficult. A report of the Canadian Construction Association and the National Round Table on the Environment and Economy report (1992) sums up these as follows:
• by nature the construction industry is segmented,
• the industry, in its great majority, is comprised of small firms,
• sites for storing materials are limited in size,
• materials with the highest recycling value are generated in the smallest quantities, and
• there is a lack of established recycling/reuse markets.

Development of recycling markets has been stimulated by new product opportunities, but recycling remains undoubtedly an expensive way to manage waste.

3.1.3 Educational and Promotional Programs

Two projects prove the value of educational and promotional programs. CMHC concluded that anticipated costs, often used as an excuse to avoid or delay implementing on-site waste diversion, are not incurred in the majority of cases (CMHC 1994). In Edmonton, waste quantities were shown to reduce over time, through the development of a comprehensive educational program (City of Edmonton et. al. 1996).

Educational programs include tip sheets for builders and trades (e.g. City of Edmonton et. al. 1996; Regional Municipality of Waterloo 1996; WRITAR 1995), handbooks (e.g. London and District Construction Association et. al. 1994; Regional Municipality of Waterloo 1996), directories of Recyclable Materials Markets (e.g. CMHC 1995; City of Guelph 1995; Ontario Ministry of Environment and Energy 1994) , seminars or workshops (e.g. ETA Group 19--; City

of Edmonton et. al. 1994), and awards programs. Educational programs are of little use without promotion or other effective means of getting the message to audiences.

Relevant information is available; however the challenge is delivery. Although handbooks and tip sheets have been developed, often these contain too much information, information that is obvious, already in practice, too general or impractical. It has not been easy to achieve a balance between delivering, on the one hand, enough information specific to a trade or task with, on the other hand, too much information which easily becomes unapproachable. The challenge is exacerbated by the wide diversity of practices in use by builders and sub-trades, because distilling salient information for an audience with such a wide range of experience is very difficult. Perhaps Edmonton has produced the best documentation, with loose sheets (no binder) and a single, unbound page per trade (Fig. 3).

Promotion could involve marketing waste management efforts to home buyers. It has been suggested that an awareness program for new home sales personnel to assist new home buyers in making informed decisions about house construction and components could have a significant impact on building practices and waste generated. For example, a better understanding of how engineered wood products utilize fewer natural resources and produce less waste, and resultant savings in disposal costs and ultimately house cost, would lead to a higher use of these material-saving products. According to some of the builders we interviewed and others (e.g. Vanderwell 1988), many builders do not practice advanced framing techniques (see Section 3.1.4) because they are finding that home buyers believe that houses built with less wood are inferior.

Builders have mixed feelings about promoting a waste minimization policy. Some builders feel that homes constructed with resource-efficiency in mind should be marketed as such to help distinguish them in the marketplace (NAHB 1996), while others are afraid of "incur-ring wrath" (CMHC 1994) for not doing more. One builder felt this should not be used as a sales tool (CMHC 1994). While ideally home buyers may wish to support environmentally conscious builders, and should have an opportunity to learn that options exist, most home buyers do not base decisions on such criteria, specify waste management practices nor make inquiries into the matter (CMHC 1994; NAHB 1996). In addition, sales staff, particularly for larger production builders, may not be equipped to answer such questions.

Ongoing educational opportunities for tradespeople exist within labour unions, through trade and construction associations and via suppliers. Continuing training and education offered through these resources, however, are rarely taken by tradespeople, according to a U.S. study (WRITAR 19--). Providing information at point of purchase (e.g. product displays, informative or instructional brochures) could provide information to target audiences.

Both the CMHC Waste Management Challenge and the Edmonton Partners in Clean Construction initiatives reveal that once initiated, waste minimization programs can begin a process that

Figure 3. Trade Factsheets

reduces waste increasingly over time. This suggests a strong role for education and promotion.

3.1.4 Partnerships and Incentives

Partnerships are becoming increasingly common and necessary. While, by nature partnerships are difficult to control and therefore results can be unpredictable, by nature too all participants benefit in ways not otherwise possible. There are many forms of partnership and many reasons to explore them, including:

- Financing: most partnerships provide an economic benefit, whether short- or long-term.
- Ability: in a partnership, certain tasks are easily done by one organization that would be cumbersome or impossible for another to undertake.
- Credibility: by involvement or mere endorsement, associating with partners of repute can significantly enhance the credibility and image of an initiative, as the chances of one of the partners being recognized by the target audience is increased.
- Capability: more can be accomplished with partners, because in theory the whole can achieve more than the sum of its parts.

Loosely defined, partnerships may involve one group offering incentives to another. For example, one builder offered his drywaller a case of beer if he could put all the drywall waste into the wall cavities. Although this type of incentive is not recommended (for safety reasons), this exercise succeeded in demonstrating to the drywaller that it could be done, and since then 30 to 40 percent of this builder's drywall scrap is regularly stored in wall cavities. The success of this approach has a number of elements: as an invitation rather than an edict, and in speaking the language of the tradesperson, it treated the tradesperson as an partner. The drywall contractor accepted the challenge voluntarily, applied his professional expertise to the task, and shared the rewards.

One Ontario builder who achieved significant reductions in waste, remarked that subtrades do not really need incentive programs, but rather need to understand what the builder wants and why. Other builders also reported good cooperation from subcontractors as a result of informing them about the impact of wasteful practices on the environment, particularly forests, and how, in the long run, not wasting raw materials keeps the cost of their houses down and demand for their jobs high. These builders have found that unless the reasons for minimizing waste are explained, workers have a tendency to think that what the builder really wants is to make more money, which does not lead to cooperation.

Formation of a jobsite recycling committee made up of builders, waste management companies, local recycling and solid waste officials, and recycling companies was recommended by the U.S. Home Builders' Association (NAHB 1996). Such groups would be well-positioned to collect information for resource guides, develop emerging opportunities, promote award programs, offer training seminars, or any number of other services and benefits.

Partnership can succeed in getting information to people in manageable parcels and to target audiences through appropriate avenues. There might be a role for partners (e.g. suppliers, landfills, building departments) to deliver information collected by others. For example, the long

lists of tips that have been compiled might have greater impact if they were individually posted as "tip of the day" at local landfill sites or at building departments.

A centralized depot system for use by several builders is a form of partnership that was reasonably successful in Edmonton (see Profile C in Appendix 1). This system, which was coordinated by the developer for a fee ($200/house), delivered a cost-effective, convenient, storage and sorting facility, addressed the economy of scale challenge, and provided continuing educational support, and convenience. On-site depots with clean and accessible material handling and storage could also reduce waste by promoting reuse of smaller pieces, although this was not allowed in the Edmonton pilot project. In one U.S. study (reported in NAHB 1996), centrally located containers were ruled out because of their inconvenience for subcontractors and their potential for creating untidy and unsafe job sites. Some Ontario builders feel that centralized depots have too many disadvantages and would not work. It is felt that builders would not pool money to rent and service bins, that problems of drive-by contamination after hours is too significant, a site supervisor would be needed to control access, and that overall the logistics are too complicated for the gain.

While education to increase awareness is an effective tool, and incentives and deterrents may also be effective, involving people directly brings about the most practical and therefore viable solutions. One Ontario builder reported meeting weekly with supervisors and labourers in order to improve quality and productivity. What changed was the quality of the relationships between people, with new ideas and cooperation resulting from the improved communication and mutual respect. Treating employees more like partners eventually led this company to reduce its disposal costs by approximately $200 per house, plus an additional $300 to $400 saved through reduced materials purchases.

Though recycling is expensive, some recycling occurs for stewardship or public relations reasons. Occasionally, product manufacturers provide cardboard recycling centres, or take back scrap or packaging waste, sometimes for individual customers (e.g. fiberglass scraps and bags). While some manufacturers value "greening" their image among customers (e.g. page 12, Appendix 2), economics are very important (see Section 2.3). Joint stewardship programs may be worth pursuing, particularly if there are public relations benefits to be gained, and if the potential benefits and the roles of partners are mutually developed and clearly defined.

3.1.5 Design Innovations

Design innovations are particularly effective at waste *reduction*. Examples of design innovations include:

- designing projects to minimize, within building codes, the amount of materials being used
- designing floor plans that conform as much as possible standard materials sizes (e.g. board lengths, carpets)
- using standard, modular building units which are either pre-cut or partially assembled prior to delivery to the construction site
- using pre-fabricated (pre-cut or partially assembled) materials such as roof and floor trusses, engineered wood I-joists, and structural insulated panels.

Known as optimum value engineering (Vanderwell 1988), value-engineering (NAHB 1996) or advanced framing (WRITAR 1995), reducing construction costs through a systematic approach to efficient use of labour and material resources has an enormous potential for waste reduction. Optimum value engineering (OVE) is based typically on a 24 inch construction module, in which the placement of the aligned framing members of floors, walls, or the roof define the basic architectural components of the house. By simplifying construction techniques to conform to the module and using sound engineering practices, less material and less labour results in a more easily constructed and less expensive home (Vanderwell 1988). OVE techniques can pertain to components other than wood framing, including final architectural finishing and plumbing, heating and electrical systems.

The NAHB Research Center first developed the concept in the 1970's, when they built a conventional house and a prototype OVE design. Comparing labour and materials costs, the OVE house had achieved a total cost saving of approximately 12 percent. In the 1980's, a study commissioned by Alberta Municipal Affairs estimated costs of labour and materials of a range of OVE techniques. Estimated savings were in the ten percent range; cost savings according to trade are shown in Fig. 4. Recently, the NAHB tested two design and estimating software packages for their ability to increase efficiency of structural framing. They determined that material and cost savings amounted to between $500 and $1,000 per house; a breakdown of savings by technique are included on pages 14 and 15 of Appendix 3.

Many builders do not practice material reduction techniques that other builders use regularly, such as A-line framing, 2-stud corners, ladder block for drywall stops, and other techniques (Lund, pers. comm.). The reasons for this are several. Some builders have simply never been exposed to these techniques, having learned what they know from other builders on the job. Perceived added structural rigidity of conventional techniques or assumed code compliance can also be responsible (Vanderwell 1988). Furthermore, material-saving techniques have been equated with "low quality" buildings (Vanderwell 1988). Overall, the lack of wide acceptance for efficient building techniques means that more construction material, and cutoff waste, is generated in construction than is really necessary.

Designing houses to fit standard materials sizes can detract from the appearance of the house, and aesthetically, some changes will be considered unacceptable. One house generated 1730 kg drywall waste, representing close to 35 percent of the total quantity of drywall delivered to the site. This was attributed to complicated house geometry (Drerup et. al. 1995). Window dormers, vaulted ceilings, and more complicated roof lines can have a significant impact on the amount of waste generated.

Builders considering value engineering from the perspective of waste reduction believe that effective waste reduction can be achieved only through a comprehensive re-education process involving architects, engineers, builders, and inspectors (NAHB 1996). In practice, a construction management firm may be needed to supply value-engineering services to general contractors and their designers. The Waste Reduction Institute in Minnesota is focussing on ways to incorporate these features into the software programs that home builders' designers use.

Figure 4. Optimum Value Engineering Cost Comparison Summary

Source: Vanderwell 1988

Computer-aided design (CAD) and estimating software and, more importantly, the linkage between the two, offer a useful tool to builders interested in minimizing the amount of materials purchased. *Premium* software programs offer a direct link between the design and estimating capabilities — a link that provides updated material lists automatically as design changes are made. Other programs offer varying degrees of integration, and may require manual recalculation, although these database-oriented programs can create a variety of cost alternatives relatively quickly (NAHB 1996).

Resource efficient building practices that are new to local building inspectors can greatly limit their incorporation by builders. Local building inspectors assume risks for themselves and the municipality when they sign-off on the final project inspection. They may resist allowing new construction materials or techniques that are unfamiliar to them. One study (WRITAR 1995) reported a case where a building inspector was unwilling to accept a new technique. It took signed structural calculations from a registered engineer to convince the city official that the design was acceptable. This time-consuming and expensive step is not likely to be undertaken by many builders. A possible solution might involve meeting with building inspectors at the plan review stage, which can simplify review of construction documents and eventually site visits and sign-offs (WRITAR 1995).

New construction techniques also involve training tradespeople. Perhaps one of the best ways to do this is through the builder himself on the jobsite. This can be particularly challenging for builders who feel they cannot afford to educate trades who are not employed on an exclusive or full-time basis. On-site demonstrations might also work, but would require a high level of coordination and follow-up.

While designing for waste minimization has the most potential for reducing waste quantities and can yield economic savings, achieving this potential requires commitment and coordination. Some Ontario builders have made the necessary adjustments, and while their estimated savings may not be entirely unbiased, real savings have been realized (see Appendix 3 for examples of several builders' cost savings). Unbiased, as-built cost comparisons have yet to be produced. Furthermore, builders need time-tested solutions and are not interested in experimenting for the sake of reduction, and have to deal with resistance from clients, building inspectors and sub-contractors (WRITAR 1995).

3.1.6 Legal

Other ways of minimizing waste include legal and semi-legal mechanisms. These include detailed tender and contract agreements or clean-up clauses between general contractors and sub-trades, landfill bans, and legislation like that created by the province of Ontario in 1994 requiring waste audits and waste reduction workplans (i.e. Regulations 102/94 and 103/94). Regulation and enforcement are not favoured by the industry. Because this study is a joint effort with the Ontario Home Builders' Association, its focus is on finding and developing voluntary solutions, therefore legal mechanisms will not be discussed in detail.

3.2 WASTE MINIMIZATION INITIATIVES AND STUDIES

Several studies have addressed construction waste. The salient findings of these are summarized below. Detailed profiles of some are provided in Appendix 1.

Individual builders have also taken initiatives to reduce their waste generation; several of these are described in the next section.

a. Canada Mortgage and Housing Corporation - Kalin Associates Inc.

In 1990, CMHC helped fund a committee to implement recommendations of the Toronto Home Builders' Association (see study g, below), and became involved in waste management pilot projects in Vancouver, Toronto and Montreal. This gathered experience developed into a workshop called The CMHC Residential Construction Waste Management Challenge, which was taken by builders across the country in 1991. Follow-up studies involving questionnaires to participants shortly after the workshops and two years later yielded a great deal of relevant information from builders who had had an opportunity to apply waste minimization principles to their own businesses. Some of the most relevant findings are summarized in Profile A (Appendix 1).

Perhaps the most significant finding was that anticipated costs, often used as an excuse to avoid or delay implementing on-site waste diversion, are not incurred in the majority of cases. For example, whereas immediately after the workshops 60 percent of participants believed managing construction waste would increase costs in the short term, after two years of implementation only 13 percent reported increased costs, 38 percent reported little or no effect on the bottom line, and 17 percent saved money (Kalin Associates 1994).

Other significant findings include:

- Almost half of the respondents after two years of implementation had difficulty separating and/or storing waste on the construction site.
- No builder used an available video or brochure, but principally made use of lecture style briefings and informal instruction.
- The follow-up survey (Kalin Associates 1994) recommended that workshops and training materials already developed should be used by organizations who offer training programs to builders and renovators.

b. National Association of Home Builders Research Center (U.S.A.)

The United States National Association of Home Builders Research Center recently completed a three year project funded by the U.S. Environmental Protection Service to develop, demonstrate, and disseminate innovative residential construction waste management. The detailed report was published in 1996, followed by a builder's field guide (NAHB 1996 and 1997, respectively).

The detailed report concluded that builder interest in waste reduction and recycling is driven primarily by considerations of cost and convenience, and therefore innovative construction waste management techniques must address at least one of these considerations to be widely embraced

by builders. It also concluded that no single waste minimization strategy is universally applicable. Local solutions are required for local construction waste management issues, and builders and key businesses (such as waste management firms, manufacturers, solid waste officials) must identify and develop local opportunities.

Three case studies quantified the potential impact of value-engineering, i.e. the reduction of construction costs through systematic approach to building based on efficient design and construction principles. Two used computer-aided design (CAD) and estimating software, and the third documented jobsite practices and waste generation rates of a builder who employs a system of value-engineering techniques. Wood savings were calculated to be $960 and $130 for a sophisticated and more basic software package, respectively (see data provided in Appendix 3). The third case study estimated that framing material purchase price was reduced by about $1.50 per square foot, and that 65 percent less wood waste was generated, resulting in another $100 savings in disposal costs.

Ten jobsite recycling pilot projects were also documented. These demonstrated that several conditions have an impact on both diversion rates and cost savings, including • proximity to landfill and tipping fees • availability of local recycling outlets for construction waste materials • building type and production level • commitment level (the greater the level of commitment of a builder, the easier it was to obtain cooperation from subtrades) • size of the construction company (smaller builders could implement a successful recovery plan faster than a larger production builder could), and • availability of hauling options (container size, hauler's fee structure and alternative material destinations). Limited savings were associated with recycling, and most builders cited small cost saving as the main impediment to jobsite recycling.

One of the ten pilot projects, Jordan Commons, a well-publicized Habitat for Humanity project in south Florida., used a waste collection depot system. Waste containers were located in a collection centre within 600 yards from active construction sites. Thirty-gallon plastic cans labeled for metal, cardboard, beverage containers and general waste were placed at active construction sites and hauled to the collection centre. This system was considered responsible in part for the significant (75 percent) diversion from landfill rate and 50 to 60 percent decrease in disposal costs. While the project is atypical (it relies in part on volunteer labour for source separation), it demonstrates the magnitude of savings that are possible with source separation where waste reduction is a priority.

The study concluded that waste disposal costs for the general contractor were significantly reduced by requiring subcontractors to dispose of their own waste. However, while builders' *direct* waste disposal quantities and costs may be reduced, the study did not address whether this approach actually reduces the amount of waste generated, whether any diversion from landfill is achieved, and whether subcontractor fees are increased to cover additional labour or disposal costs.

An important conclusion was that it is difficult for builders, particularly site superintendents, to assign priority to innovative construction waste management when other site considerations, e.g. subcontractor scheduling, building inspections, and change orders, involve more significant costs.

c. Partners in Clean Construction - Edmonton

A concerted effort to reduce residential construction waste began in 1991 in Edmonton. Starting with a waste audit and industry challenge, a group of agencies (see Profile C, Appendix 1) built a partnership, developed an educational forum, conducted a pilot test, and evaluated the results. The study report calls itself a blueprint for action for the residential construction industry.

The Partners in Clean Construction approach was unique in that it tested a centralized depot run by the developer for use by different home builders. For a flat fee of $200, builders hauled waste to a site managed by a part-time attendant who monitored waste quantities, arranged pickup, assisted in minimizing contamination, provided continuing education, and secured the site. The depot system is no longer in use, however, due to a lack of markets for recyclable materials.

The project demonstrated the immense value of a comprehensive educational program. A breakfast session used educational materials including a video and, for each of the subtrades, specific workshop materials and tip sheets. A separate focus on each individual trade (Fig. 3) may be partially responsible for their success, as this would put salient information to the right people without providing overwhelming volumes of detail. While incentives and deterrents were acknowledged as having the potential to be effective, involving people in a cooperative way was found to be key to finding viable solutions. Sub-trades are reported to have bought into the program willingly and without difficulty. The impact of the educational effort, having raised awareness of the full (environmental and economic) costs of waste, seems to have paid off in positive attitude and in significant and continuing reductions in waste generated.

The project demonstrates that improvement can continue beyond the initial effort. Waste audits were conducted before and after the initial waste minimization effort (four houses each). A full educational program followed, and a third series of audits (25 houses) were done. Data from the three consecutive audits demonstrate that waste quantities continued to fall (see Figures 1 and 5). Wood waste fell initially by an average of 43 percent in the pilot study (1992), and after further program development dropped another 32 percent.

Figure 5. Partners in Clean Construction: Waste Production (kg/100m^2 of floor area)

	before challenge (1992) (avg. of 4 houses)	after pilot (1992) (avg. of 4 houses)	after program development (1995) (avg. of 25 houses)
dimensional lumber	631	357	244
plywood/OSB†	279	274	206
drywall	389	419	318
corrugated cardboard	112	78	75
other	393	326	308
TOTAL	1804	1454	1157

† oriented strand board

The data show that dimensional lumber waste is both the largest single material generated by construction and the material most responsive to reduction efforts. Dimensional lumber waste was reduced by well over half (61 percent overall).

d. Environment Canada's National Network on Sustainable Construction

Environment Canada has developed a National Network on Sustainable Construction. The purpose of the Network is to promote the transfer of information and technology on sustainable construction with a special focus on cost effective management of C&D waste and green building products.

The Network is intended to provide practical information on sustainable construction that will be of interest to contractors, builders, facility and property managers, the general public and other groups. Key components include a sustainable construction newsletter (Wastenot) and an Internet web site (www.cdwaste.com). The intent is to make the Network self-sustaining by using existing databases, reports, case studies and success stories, encouraging user participation and applying cost recovery principles.

The Internet site (available in both English and French) contains case studies which demonstrate diversion successes in residential, commercial and industrial projects. It also contains reference documents, training materials, links, a service directory, design documents and specifications, a what's new section, and a submittal form for businesses to submit their information.

e. WRITAR (Waste Reduction Institute for Training & Applications Research)

WRITAR (The Waste Reduction Institute for Training & Applications Research in Minneapolis) conducts research and publishes information aimed at construction waste *reduction*. In addition to their emphasis on the use of fewer materials and elimination of waste at the source, their documentation addresses use of toxic materials. Increasing the projected lifetime of new buildings to reduce wastes generated from maintenance, demolition and replacement, is also a strong theme.

WRITAR reports success using individuals on job sites to allegedly complete periodic reports as a way to gain insight from workers on specific ways to minimize waste. The site visitors use informal chats to re-inforce the rationale for reducing waste, to provide continuing education, and to collect practical suggestions. WRITAR also reports that free lunches for tradespeople have been a worthwhile communication mechanism.

They documented the case of a builder who made specific requests of a product supplier to reduce packaging, which led to the creation of a new type of shipping container. Not only did the builder's efforts reduce packaging waste, it also eliminated or avoided:

- time spent unpacking materials
- time spent carrying packaging waste to dumpsters
- costs to suppliers of packaging materials, and
- cost of disposal.

f. Province of Ontario

In 1992, the Waste Reduction Office of the Ontario Ministry of Environment and Energy assembled a C&D Waste Reduction Strategy Team. The Team, comprised of representatives from the construction industry, recycling associations, government agencies, labour and public interest groups, was charged with identifying practical ways of diverting C&D materials from

landfill (OMEE 1993). The goal was to achieve, for this sector, the province's waste reduction target of decreasing waste by at least 50 percent by the year 2000 compared to 1987 levels.

The Strategy Team identified lack of information as a main impediment for C&D waste minimization. Information was found to be lacking on the following: how design affects waste production, availability of products and their impact on waste production, diversion opportunities, and recycling activities (Ward 1993).

In 1994, the province introduced legislation requiring builders constructing more than 2,000 m^2 to develop waste management plans. As of July 1996, the Ministry of Environment and Energy is reviewing details of this legislation. Notwithstanding this legislative mechanism, the Ministry is interested in promoting voluntary action, and did produce a number of documents including reports, guides, brochures and a directory of C&D processing and reuse facilities.

g. Toronto Home Builders' Association

The Toronto Home Builders' Association (THBA) is considered to have pioneered the work on construction waste. In their landmark document "Making a Molehill Out of A Mountain" a construction waste audit provided some of the original information on which materials were being produced in residential construction and in what quantities. This initiative stimulated the CMHC Waste Management Challenge Workshops.

The THBA took action in large part because of escalating landfill costs as well as an increasing trend towards landfill bans. This genesis re-inforces the conclusion made by the NAHB (1996) that economic forces drive waste reduction efforts.

The Build Green Program was another product of the THBA's initiative. Initially, the Build Green Program was run by the Greater THBA in partnership with ORTECH International. Mainly the Program tested and marketed recycled-content building materials. In 1997, the GTHBA is stepping out of the Build Green Program, and a new partnership between ORTECH International and TerraChoice, the organization behind the EcoLogo, is planning to re-vitalize it. The new Build Green Program is expected to address a wider mandate relating to all aspects of green construction and all phases of the building life cycle.

h. Ville Lora's Friendly Home, Elora

James Keating Construction Ltd., with Admiral Environmental Consulting and the Elora Centre for Environmental Excellence, conducted a waste audit on the construction of "Ville Lora's Friendly Home." As part of this project, manufacturers were contacted regarding manufacturing processes, employee health and safety practices, transportation costs, life expectancy, guarantee and availability.

Little product information materialized, however some progress was made with some manufacturers. The extruded polystyrene manufacturer took back their packaging waste when the next load was delivered. A tractor trailer load of insulation batts materials were made to order (i.e. cut to fit 19.5" stud spacing).

By adopting building techniques that reduce waste, and working in cooperation with material suppliers, this project demonstrated that residential construction can be nearly waste free. Of the total waste generated during the audit (1308 kg), 1178 kg (90 percent) was diverted from landfill.

i. Region of Waterloo

In 1996, the Waste Reduction Office at the Region of Waterloo produced a handbook for the C&D industry on cutting costs through waste reduction. It was distributed at a seminar given in March of that year. The handbook was to be part of a C&D strategy which was some years in the making, but which was eventually rejected by the Regional Council after the handbook was produced and distributed.

While the handbook aims to be practical, most of the suggestions are either too generic (e.g. roofers are advised to "store, measure and cut carefully"), already being done (e.g. "use excess and broken concrete tiles as fill") or marginally practical (e.g. "send old or cut shingles to a recycling facility"). The handbook is not in high demand, and would probably not have been prepared apart from the anticipated C&D waste reduction program.

j. London Home Builders' Association

In 1994, the London Home Builders' Association developed a construction waste management handbook in conjunction with the London Construction Association and the London District Heavy Construction Association. It was distributed to each member of both organizations. A significant portion of the handbook was a list of recycling facilities

k. UMA Engineering Ltd. for Regina Home Builders' Association

This study consists of a set of recommendations prepared for the Regina Home Builders' Association. Perhaps the chief value of the report is that it presents the results of a survey conducted by the Regina Home Builders' Association that determined waste management costs. These results were presented as follows:

Figure 6. Regina Home Builders' Association: Estimated Construction Waste Quantities and Disposal Costs

size of house	volume	weight	bin rental	tipping fee	**total cost**	**cost/100 ft^2**
1200 ft^2	14.5 m^3	2.6 tonnes	$160	$100	$260	$22
1800 ft^2	19.9 m^3	3.6 tonnes	$224	$140	$364	$20
2400 ft^2	22.9 m^3	4.1 tonnes	$256	$160	$416	$17

It was estimated that the average cost for waste disposal was $311 per single family residence in 1993.

The main conclusion of this study was that individual trades should be responsible for their own waste disposal for the following reasons:

• ease of administration
• cost effectiveness
• no liability is incurred by the builder[1]
• reduced problems associated with security for recyclables
• stakeholder consultation and "buy in" is minimal — readily adaptable as a contract condition.

l. Construction and Demolition Waste Reduction Course - Ottawa Construction Association

This course was developed by the Ottawa Construction Association and byDesign Consultants, with support from the Ontario Ministry of Environment and Energy. It is geared to waste reduction issues in the industrial, commercial and institutional sectors. Although some of its contents may be applicable to the residential sector, obtaining detailed information about the course contents was beyond the financial resources of this study.

[1] NAHB (1996) noted that subcontractor agreements do not indemnify a general contractor from statutes governing waste disposal. While this is not necessarily true in Canada, there is reason to exercise caution on this point.

3.3 ONTARIO BUILDERS' PRACTICES

Through discussion with builders and others around the province, we found a wide diversity of ways to handle and dispose of waste. Fig. 2 illustrates some of the different waste management strategies that Ontario builders are practising and how much they are spending on waste management. (Anonymity has been preserved in order to draw out as much uncensored information as possible.)

It is worth noting that the majority of these quoted expenditures (with the exception of system J) do not represent full costs. They represent only the direct costs of disposal (i.e. bin rental and tipping fees), without including time-related costs such as administration, labour, or vehicle expenses. System J appears to be the most expensive system, but is closest to a full cost estimate.

Many builders require subcontractors to remove their own waste from the job site. As discussed earlier, this leads to the impression that waste is being reduced, and indeed for the builder, this system significantly reduces direct costs and responsibility for handling waste. It does not, however, *necessarily* reduce the actual quantity of construction waste generated, nor the full costs of disposal paid by the builder. Materials are often simply landfilled by the subcontractor rather than the builder. We observed only in the case of drywall, where it is banned from landfill and therefore expensive or difficult to get rid of, that less waste (one quarter to one half) is produced when the drywaller is responsible for clean up and disposal. Other trades indicated that the amount of waste generated had little to do with who is responsible for its disposal; they simply landfill the waste and add the cost of disposal to their fees.

Nevertheless, subcontractor disposal has the potential to reduce waste. It creates opportunities for small pieces generated on one site to be moved to and reused at the next. Increased likelihood of direct contact between manufacturer and user presents opportunities for recycling by preventing commingling of waste, and maximizes the potential for reducing, returning or reusing packaging. The temptation to over-estimate the amount by which subcontractor disposal reduces waste, however, should be avoided.

While the trend is moving towards single commingled bins for all waste, larger builders commonly hold separate bins for mixed waste, wood, cardboard, and sometimes drywall, that are used by subtrades. Some larger builders have no waste bins but instead use in-house or hired services devoted exclusively to clean-up. In such cases, bin rental and tipping fees are replaced by costs associated with a pick-up truck and regular collection and delivery. Smaller builders often do their own site clean up, and use the garage for temporary storage of separated or mixed wastes.

One Ontario builder who is a civil engineer, has incorporated value-engineering techniques over the years. Through careful design, he estimates saving in the order of $500 to $600 per house, with $300 to $400 attributed to materials savings and $200 to reduced disposal cost. This builder uses many techniques to support his approach. His first priority is accurate ordering (including keeping inventories of what is left over and adjusting quantities ordered for the next house) and ordering in stages (so that no wood is used for a floor that was intended for the roof, for example). If materials supplied are not used properly, the subcontractor is responsible for

obtaining more supplies. Precise timing of delivery avoids the need to store materials, and therefore potential weather damage and theft. (Another builder commented that there was considerable room for improvement with respect to storage.) This builder spends extra time not only at the design and ordering stages, but also with the framers — an extra half hour spent with the foreman to go over the plan avoids mistakes that lead to wasted time, energy and materials.

Another builder held weekly meetings in the off-season with the whole crew, including designers, supervisors and labourers. Weeks were spent on improving material quantities use alone. Though labourers "may have slept through" these meetings, they developed more respect for materials. A manual was created, and though nobody uses it directly, its development and in particular the discussion process that led to it paid off. This approach may be most appropriate in situations where the trades and the builder have an ongoing, long-term relationship, so that the time spent by all is worth the time invested.

Another builder uses a similar philosophy, believing that the key element to minimize waste is pre-planning. Design technologists are asked to incorporate materials efficiencies into plans. Subcontractors use computer programs to estimate their material requirements. The framer gets only enough lumber ("even slightly less") to compel efficiency. Extra wood is kept in a stock area, which forces the framer to spend extra time fetching more wood if materials are not used efficiently. Furthermore, trades are back-charged if excessive amounts of materials are used. Again, close contact with the workers is felt to be essential to success.

Some builders interviewed are under the impression that nobody is designing for waste minimization. Others think that everybody has always done it. According to some, there was more interest in designs that minimize waste a few years ago. This again supports the view that economic motivation drives waste reduction.

Some builders use trusses all the time, some only once in awhile, and others never. Those who regularly use them say that to stick frame a house would create "a tonne" of waste, and it would be too complicated to design for a weight-bearing load. Others say that trusses are cost-effective on some jobs depending on complexity of roof design. The two to three week wait was cited as one reason for not using them, as was the likelihood that things change during that time. Truss uplift was also cited as a reason why trusses are avoided.

One builder estimates that he regularly saves approximately $200 in building materials by using engineered wall and flooring systems. Many builders reduce waste by using pre-fabricated and engineered products, without even realizing that use of these materials has environmental and economic benefits.

Builders who had conducted an audit for one reason or another reported that the exercise did thereafter alter normal waste generation and management practices.

One builder worked with his hauler for one year (in 1993) to divert as much waste as possible from landfill. Excluding drywall (which was disposed of by the drywaller), 51 percent of the waste generated was diverted from landfill and sold. Wood was sold to landscapers for mulch and compost, to farmers for animal bedding, and to a composite board manufacturer. The sale of

materials reduced disposal costs by approximately $40 per house. Over the one hundred and five houses built that year, the company saved $4,160.

One waste management company services subdivisions with a single 6-yard container in front of each house under construction. The mixed wastes are picked up on a scheduled service. For a fee of $500 to $1,000 per house, builders are finding this service worthwhile. Although this system appears to be the most expensive, one builder who uses both this system (J) where it is available, and system E elsewhere (see Fig. 2), finds that trades are more likely to clean up daily, that safety of the construction site is improved, and that clean sites are appreciated by home buyers. Despite the apparently high direct cost, this system is preferred by the builder. The hauler reports that a lot of work is required to run this system successfully, which might explain why it is not more widely available.

Contamination of construction waste bins with domestic waste is a problem wherever waste bins are found near construction sites. Fencing or locks do not necessarily keep containers from attracting household garbage. An Ontario waste disposal company commented that usually people don't know that such use is inappropriate and believe that the municipality takes this garbage. Letters to area residents and discussions with them have been found to help considerably.

Few generalizations can be made about waste management practices since every builder seems to have his own ways. The *amount* of waste generated does not appear to be related to the size of the building company or geographic region. Builders either aim for waste minimization or they don't, mostly depending on their beliefs and attitudes. Those that have taken steps to minimize waste have done so either because of concern for the environment, to show others that construction waste is not responsible for disproportionately large amounts of society's waste, or because they believe that it makes good economic sense. Those that have done so primarily for environmental reasons enjoy economic benefits, and those that have done it for economic reasons are taking pride in their environmental stewardship.

While size of building company does not appear to be related to level of interest in waste issues, large and small builders take advantage of different approaches to minimize waste. Larger builders are in a better position to invest in their trades' education because the payoff will come in time, since tradespeople occupied on a long-term or full-time basis are highly likely to comply with the general contractor's requests. Builders using the same plan more than once can afford to spend time fine-tuning materials estimates, and to make use of prefabricated or pre-cut components. Smaller builders, on the other hand, may find it easier to keep in close contact with trades in a way that enables them to demonstrate waste management techniques, to explain the intended purpose and impact of the new practice, and to provide needed re-inforcement.

With respect to regional differences, one builder felt that in smaller communities, better communication and fewer employment alternatives led trades to be very receptive to the general contractors' requests. Development of markets that *pay for* scrap may be more likely to develop in highly populated areas where there is higher total construction activity and therefore higher volumes of material, and possibly better access to emerging recycling industries. Currently, low landfill costs and few recycling markets for construction waste mean that this is not a major force in populated areas. An exception is drywall which, in some areas is banned from landfill

sites, forcing the recycling of much of this material. Whereas one might expect densely populated regions to landfill less material than remote regions, landfills in more populated regions are actually competing for volume in order to stay in business. Overall, differences in waste management practices between different regions in the province are smaller than one might expect, because of the combined effect of low landfilling costs and the lack of economically viable alternatives to disposal.

Ontario builders seem to emphasize different methods for achieving waste minimization. Some believe that deterrents (bans) are needed; others believe this approach does not change waste management practices. Only one builder felt that provincial legislation introduced in 1994 had any real impact on awareness or the amount of waste generated. Some swear by accurate materials estimating combined with timely delivery, while others pay little attention to these issues. Highly visible signs are felt to be essential for informing/reminding participants of waste management objectives by some, while many builders see little to no value in signage. Almost all say that good working relationships with subtrades are necessary.

The overriding conclusion, having interviewed twenty two builders, is that there as many ways to deal with waste as there are builders. The wide variety of systems in place suggest that there may be considerable opportunity for builders to learn from each other about how to minimize waste.

4.0 CONCLUSIONS FROM PHASE 1

Based on the information collected above, several conclusions can be drawn about how the OHBA can assist home builders to minimize waste. Two, in particular, emerge as highly relevant to the objectives of this study, i.e. facilitating voluntary acceptance of waste minimization practices and enhancing the reach and impact of the message.

First, minimizing construction waste generation should be emphasized over separation and recycling. Reducing waste saves money by lowering both *disposal* costs and the amount of materials *purchased*. The potential to save money through waste reduction is a message capable of attracting attention, encouraging serious consideration, and permanently changing practices. Reducing materials consumption also has a truly positive environmental impact.

Secondly, builders' practices are very diverse, suggesting that there is considerable opportunity to increase awareness about waste avoidance techniques. Effectively communicating with builders and their workers is challenging, for many reasons. Builders are numerous and a heterogeneous group, their building techniques and waste management practices vary widely because most builders learn on the job, they are loosely-knit as an industry, and the responsibility for waste rests at many levels from the building designer through to the subcontractors. Effectively reaching this audience is not simple, and because of this, or despite it, effort needs to be put in this direction. Significantly reducing waste will involve improving awareness of both the general benefits of waste reduction as well as specific techniques that can reduce waste.

A number of miscellaneous conclusions can also be drawn, which if kept in mind could further enhance the effectiveness of a strategy to be spearheaded by the OHBA.

1. There are impediments to reducing construction waste among home builders. One of the major ones is that many builders do not recognize that waste reduction can significantly affect total costs. Moreover, because recycling is often equated with waste minimization, many builders believe that minimizing waste is costly, time-consuming and inconvenient. Therefore, while some Ontario builders are saving hundreds of dollars per house through efficient materials management, many more never really give the matter much consideration.

2. It is not possible to rank the effectiveness of approaches to minimizing construction waste (for example from good to poor). No single strategy is applicable in all situations. The growing pains and net impact of any of the waste minimization techniques depends on many factors, including practices already in place and the awareness of builders of alternative methods to address waste. Ultimately, each builder requires a unique strategy to effectively minimize waste.

3. Builders need a clear picture of the benefits of addressing waste, financial or otherwise, in order to make a decision to tackle waste and to have the commitment to see changes through.

4. Commitment on the part of the builder and site superintendent is vital to successful waste reduction. Because the amount of material used and wasted in almost every aspect of residential construction is based upon traditional methods rather than carefully considered alternatives,

builders must have a willingness to invest in their own education, as well as the education of their designers and subtrades. A strong commitment will also facilitate clear and consistent communications with personnel.

5. Material-saving construction techniques (e.g. value-engineering, accurate materials estimating) will probably require re-education of many builders, their designers, trades and labourers. The diffuse nature of responsibility for designing, ordering, handling and using materials at a construction site is extremely complex, and at every level there is resistance to change. Everyone with a role to play in waste reduction will need a different type of training, and all will require practice.

6. Manufacturers and suppliers may be willing to alter material sizes and packaging in response to builders' requests. A higher demand for unconventionally sized or packaged materials will make it easier for manufacturers and suppliers to provide these waste-reducing products.

7. Some builders who are using prefabricated and engineered products for reasons not at all to do with waste minimization are reducing waste without even realizing it. Companies providing these products might consider promoting their waste-minimizing benefits.

8. Possibly, the magnitude of savings observed in the various projects reviewed here are lower that they might be for the majority of builders, because builders who have addressed waste have probably always had high awareness of, and interest in, keeping waste to a minimum.

5.0 DIRECTION FOR PHASE 2

There are many ways that the OHBA could lead home builders towards reducing waste. Any strategy should incorporate the following considerations:

• *Time*. Nothing major is likely to happen overnight. Planning a strategy for the long term is almost certainly the most effective approach. Whatever strategies are considered must be committed to a reasonable time frame, and include sufficient follow-up.

• *Reduction* through design and planning is clearly worthwhile, for several reasons. Among them, there is evidence that wood waste, the largest single component of the residential waste stream, can be significantly curtailed. Wood recycling is awkward, expensive, and developing slowly, while designing for minimum waste creates savings at the purchase *and* disposal ends. Reduction is not only the most economically attractive way to minimize waste but the most environmentally sound.

• *Partnerships*. No single interest has the finances to carry out a major waste minimization program, but most can contribute something and can reap rewards. Manufacturers, suppliers, municipal building officials and others may be willing to participate in a joint initiative, but such an approach will require a leader to initiate and coordinate the potential partners and donors.

• *Promotion* and *education* are invariably linked. Certainly builders, architects, trades, and others need information, but as much as they need specific information they need general awareness. Getting to the target audience is essential and challenging, therefore the medium and the message must be carefully chosen. Furthermore, effective education is a two-way street, involving not just top-down but adequate bottom-up communication.

As for potential strategies that can be used by the OHBA, the findings above suggest that the following potential directions should be considered:

1. Tabulating actual cost/benefit data should convince the building community that efforts to minimize construction waste will be cost-effective. Illustrating exactly how much planning and investment is required, how much can be saved, and how long the payback period will be, would spur builders and others to take action to reduce waste. Getting to this stage might take some time, although some builders identified so far could provide aspects of this information. The NAHB Research Center was hoping to find a builder to build two houses, an original plan and a re-designed, value-engineered plan. Actual material and cost savings were to be documented in this NAHB comparison. Their challenge has been to find a builder willing to try advanced techniques but who was not already using them. Unfortunately, they ran out of funding and time, however the approach has merit and should be pursued.

2. Many traditional building practices result in construction waste that could be avoided. It is therefore important to increase awareness about the existence of the alternatives. Providing or facilitating on-the-job or other training opportunities are worth considering. Providing succinct, reliable and practical information is critical, therefore specific programs for each audience may be required. Builders' education needs to be specific about benefits, and persuading builders to

try new techniques will be easier if ways of educating others (e.g. those involved at the design stage and on the construction site) are addressed.

3. Because wood usage and waste can be significantly curtailed, improving framing efficiency is an important opportunity and would be a reasonable focus. This approach could include promotion of material-saving design and framing techniques, as well as use of alternative materials such as pre-cut or partially assembled products and steel framing. Furthermore, because many builders are using engineered products and thus are cutting waste without fully realizing it, this aspect could be promoted by manufacturers, suppliers or builders. This whole area might require education of home buyers as well, in order to accelerate the acceptance of these techniques.

4. Because many new products and techniques inadvertently reduce waste, there may be an opportunity to mention those benefits in established housing outreach programs, such as CMHC's Builders' Series Publications. Documents like the Canadian Wood-Frame House Construction, Building Successful Flooring Systems and Building Envelope Design for Wood Frame Wall Assemblies could incorporate explicit mention of techniques that reduce waste. Likewise, initiatives aimed at minimizing waste could mention other benefits of new technologies and techniques.

5. Any initiative involving the education of designers should involve the Ontario Association of Architects and/or the Association of Architectural Technologists of Ontario. Because some designers believe all house plans are designed to minimize waste, while others observe that emphasis on waste reduction has declined with declining landfill costs, a better understanding of the degree to which waste is actually being addressed would be needed at the outset.

6. Training materials already developed to address waste should be used by organizations who offer training programs to builders, trades and renovators. Waste management education programs could be delivered through suppliers, trade schools, training centres, and industry associations, could be incorporated into existing programs, and could be delivered in any number of formats.

7. Potential partnerships should be identified. Partnership development should address both new types of partnership, and have regard for existing or past partnerships that either have or have not achieved their full potential. Scrutinizing what does and doesn't work, and identifying the necessary ingredients at the planning stage will improve the likelihood that the necessary resources and coordination will be present to succeed. For example, it might be desirable to partner with Environment Canada's National Network on Sustainable Construction. With some initial set-up and a minimal amount of ongoing assistance, this has the potential to be a popular and inexpensive program, and could be a worthwhile service provided jointly by the provincial and local Home Builders Associations.

8. Builders who have achieved significant reductions in waste generation should be an integral part of the development or delivery of educational programs to other builders. They have the most credibility, and can speak from experience on logistics, limitations and real benefits. Depending on the type of outreach program, these builders could deliver the message to their peers or be involved in the development of outreach information.

9. Promoting use of materials with longer expected lifetimes, low embodied energy, or extra high quality could impact the amount of waste produced during renovation or demolition. Incorporating into buildings materials that can be "de-constructed" and reused is only indirectly related to the objectives of this study, but should be addressed where there are practical ways of doing so.

6.0 ALTERNATIVE OUTREACH STRATEGIES

Emerging from the various conclusions of Phase 1 (especially the two key findings, i.e. that minimizing construction waste generation should be emphasized over separation and recycling, and that there is opportunity to increase awareness among builders of waste avoidance techniques), and potential directions for Phase 2, we developed five alternative strategies for implementing a waste minimization strategy to be coordinated by the Ontario Home Builders' Association. These were:

1. Publish articles in the Ontario Home Builder magazine elaborating on specific techniques to reduce waste
2. Develop a kit for local home builders' associations to host waste reduction awareness events, including contacts for appropriate speakers
3. Develop awareness of availability of products that reduce waste
4. Partner with municipalities to co-sponsor waste reduction awareness
5. Increase awareness among home buyers of builders' commitment to waste reduction, including a public awareness campaign and addressing consumers' concerns about material-saving techniques and materials.

The five potential outreach strategies were presented to fifteen home builders and two representatives of home builders' associations. They were asked for their views on which strategies would be most effective. The responses of the ten builders who responded are shown in Fig. 7.

No consensus was apparent among builders surveyed as to the most effective outreach approach. This diversity of opinion has been observed throughout this project. Only options 1, 2 and 3 had no poor rating, but each had an abstention (each from a different builder). Options 4 and 5 have some neutral to negative scores. There is skepticism regarding option 4, probably having to do with some builders' experiences with municipalities as generally uncooperative. *If* municipalities would cooperate in a pro-active, supportive capacity to assist the industry to reduce waste, option 4 could be very fruitful. Though option 5 has some negative scores, it has about as many positive responses as the first three options. Due to the lack of a clear preference for any of the options, the decision about which option to develop could not be based on builder preference. Instead, it was based on other considerations, in particular the experience of the OHBA with respect to the potential effectiveness of each alternative, and on the availability of resources within the OHBA to develop, deliver and follow-up on a chosen program. The decision to choose a modest program that can be assured of sufficient follow-up and that could stimulate and support other initiatives was considered preferable to a more ambitious program that could not be properly executed.

Figure 7. Builders' Ratings of Five Alternative Outreach Methods

The following questionnaire was sent to 15 builders who participated in Phase 1 of this research project. They were asked to rate the effectiveness of five alternative methods of reaching builders about the benefits of waste minimization, according to the following scale: very effective (1), effective (2), don't feel strongly about one way or the other (3), would not likely be effective (4) or definitely not worthwhile (5). Ten builders responded.

Alternative	Rating	# Selections
1. In Ontario Home Builder magazine, publish a series of **articles**. This would both increase awareness of the issues and opportunities, and provide information on specific techniques to reduce waste. Include interviews with builders, material savings costs, state-of-the-art information from CMHC and architects, etc.	1 2 3 4 5	|| ||||| ||
2. Develop a kit for local builders' associations for a waste reduction event or meeting. To include contacts for a **panel** of guests to discuss waste reduction methods and benefits (e.g. truss manufacturers on waste avoidance; steel stud manufacturers on waste avoidance; any manufacturer minimizing manufacturing waste and passing savings on; local municipality on waste objectives or landfill changes; innovative builders; innovative haulers on disposal methods; etc.)	1 2 3 4 5	||| ||| |||
3. Develop awareness of **availability** of products that reduce construction waste (e.g. fibreglass cut to alternative stud spacing). Work with manufacturers to produce displays, information sheets, or other delivery methods.	1 2 3 4 5	|||| ||| ||
4. Partner with **municipalities** to develop strategies and distribute information to builders, possibly at the building permit stage. Municipalities also want to minimize waste, and building inspectors will be exposed to alternative techniques.	1 2 3 4 5	||| | ||| |||
5. Increase awareness among **home buyers** of builders' commitment to waste reduction. Address consumer concerns. Several forms are possible:	1 2 3 4 5	| ||||| | | ||
a) press release at start of and throughout 1, 2, 3, or 4 above, i.e. announcing the commitment on behalf of the building community to minimizing waste;	1 2 3 4 5	|| ||| || | ||
b) camera-ready artwork to be made available to builders to include in their own promotional material, highlighting the merits of material-saving methods, e.g. A-line framing, 2-stud corners, etc.	1 2 3	|| |||| ||

A-line framing, 2-stud corners, etc.	4 5	|

7.0 SELECTED OUTREACH STRATEGY

Based on the experience and resources of the organization, the OHBA chose to develop alternative number two. It is a grassroots method that makes use of local resources and expertise. This approach consists primarily of assisting local home builders' associations (HBAs) with delivering a campaign to increase awareness of the benefits of waste reduction.

Two documents were produced in order to support the delivery of waste reduction awareness through HBAs. The first is a "kit" designed specifically to facilitate a panel discussion on the topic of waste minimization. This kit can be modified, for example into events other than traditional lecture-style talks, and can also be used by related industries and industry associations such as building material product suppliers and manufacturers who wish to increase exposure of waste-saving features of their products. The second document provides practical hints, builders' testimonials and cost-benefit information that can be used as material in presentations or to promote the campaign, and can also be used directly by home builders.

This approach maximizes the opportunity for local builders to address other builders. Builders who have tackled waste are scattered throughout the province, tend to be known to other builders for their initiative, and have the most credibility because they understand the realities of waste minimization. The approach provides leeway for local interpretation, as locally-based initiatives give due regard not only to builders but to local HBAs, some of which have addressed the waste issue to varying degrees. It can be tailored for delivery through trade schools, for on-site demonstrations or workshops. It also welcomes partners such as building material product manufacturers, suppliers and industry associations to promote products or services that reduce waste, and who could contribute organizational, financial or logistical support.

These two documents ("Hosting A Waste Reduction Event: A Kit for Local Home Builders' Associations" and "Lower Costs Through Waste Reduction: Practical Ideas for Ontario Home Builders") are Appendices 2 and 3, respectively.

At the time of publication, the OHBA plans to use these materials in at least three ways. Both documents will be sent directly to the 34 local HBAs across the province. The document containing practical ideas will be provided to the wider audience of home builders through various means, for example it will available to participants at builders' conferences and will be used as the basis for one or more articles in The Ontario Home Builder magazine. The OHBA is also considering sending a letter to buying clubs who represent construction material suppliers, to make them aware of the material. Feedback will be sought from the various users and the documents will be updated over time.

8.0 FUTURE CONSIDERATIONS

Waste is not the most exciting topic, so unless an effort is made to market the interesting aspects of waste reduction, the work contained in the outreach documents (Appendices 2 and 3) may have a tendency to fall flat. A number of considerations can help to maximize the uptake of this material. The suggestions discussed below are intended to benefit both the OHBA and other organizations who may wish to promote waste reduction.

A first step might be to take the outreach documents and re-fashion them into a glossy, colourful format. An unusual shape or tear-out format could be inserted into The Ontario Home Builder. This is not necessary but could help to attract attention. However the documents are printed, paper with high recycled content should be used.

OHBA's regular publication The Ontario Home Builder magazine is an obvious place to increase awareness and expand on the details of waste reduction. Planning for this opportunity can maximize the impact. For example, dedicating an entire issue to waste reduction almost forces readers to look at it. This approach can make the topic colourful because several different articles can re-inforce the message that a variety of approaches, experiences, and results are valid. On the other hand, a series of articles presenting different aspects of waste reduction in consecutive issues provides much-needed reminders that keep the topic on the mind. In this case, momentum and anticipation could be built by having each topic relate to the last. Readers might be stimulated into thinking by recalling what came before and anticipating what might come next. This "series" approach could help to illuminate the relevance of other segments if one particular item catches the eye.

Whatever form the products take, they should ideally be promoted before they are released. By building up expectation, the information is more likely to be recognized once made available, and this sense of recognition or familiarity can increase comfort with the topic and the anticipation of solutions. This is recommended because waste is a subject that many people do not readily warm up to This could involve a simple "Coming Up in Our Next Issue: Profiting by Waste Reduction" announcement or a brief paragraph or two highlighting what is coming and why it is important.

Creating opportunities for two-way communication can fine-tune the message by keeping it relevant and updated. There are several ways of doing this. It is almost mandatory that the final products contain a tear-out sheet or slip of smaller or coloured paper that invites readers to provide comments. If a series of articles is run, they could end with an open invitation to builders to tell the OHBA about *their* experiences addressing waste. A small questionnaire could be put in the membership renewal package or in The Ontario Home Builder in the form of a stamped, addressed tear-out post-card. Important data could be collected that could be used in any number of ways. For example:

1. Do you use any of the following material-saving techniques?

€	€	€	€	€
2-stud corners	A-line framing	16.2" centres	24" centres	etc.

Did you encounter any difficulties introducing these methods?

€ Yes, initially. The challenge was:
- € designer needed time to learn
- € changing framers' habits
- € new measuring tools needed
- € other (please explain)

€ Yes, continuing. (Please explain)

€ No. If not, can you provide advice to ease the transition for other builders?

2. Have you modified house design to reduce waste? If yes, was this done by:
   € in-house designer € your material supplier € other (please specify)

	material	quantity	cost savings
How much less material was purchased?			
How much less waste was produced?			

3. etc.

The excellent line-up of prospective speakers at the back of the kit for HBAs should be a draw, and attests to the validity of the topic. These are some of the most respected builders in the province, and many other builders, trades, etc. will be interested in hearing them speak, and will be curious about what they might say about waste reduction. Interviews with them would help to put a fresh outlook on what might otherwise be considered a stale or marginal topic.

The OHBA should seriously consider contacting related industries or industry associations and inviting them to participate in events that promote waste avoidance or reduction. For example, suppliers who review house designs to conserve materials, manufacturers who are using recycled product or employ reuse or reduction techniques in manufacturing processes, or who manufacture products that minimize waste production on the job site, might want to promote themselves and co-sponsor an awareness-raising event. Although a local HBA might also approach a potential co-sponsor, the OHBA contacting prospective co-sponsors at the provincial level could have a much broader impact. Letting related industries and organizations know of OHBA's interest in construction waste minimization might also encourage companies to put more emphasis on the waste-reducing features of their product or service. These groups can stimulate a local HBA into action, bring enthusiasm to the organizing committee, promote the event through alternative channels, and generally provide needed financial, logistical and organizational support.

The OHBA should consider developing "how to" brochures illustrating efficient framing techniques for general distribution through building supply centres. Many smaller builders use these for information.

Developing an in-house capability to, or seeking partners to, conduct on-site demonstrations or an association talk-circuit might be a long-term approach worth considering. Many of the presentation materials have already been developed. This kind of initiative would be as relevant to professional development and advanced construction practices as to construction waste minimization.

BIBLIOGRAPHY

Canada Mortgage and Housing Corporation

1996 Current Housing Technology Initiatives. Technical Policy and Research

1995 Carlson, Diane, and Williams, Tom for the Regina Home Builders' Association. New Construction Industry Waste Management Plan: A Feasibility Study. Final Report

1994 Kalin Associates Inc. The Residential Construction Waste Management Challenge Follow-Up Survey and Report

1993a Residential Construction Waste Management Audit Report. An Edmonton Case Study

1993b Construction and the Environment

Canadian Construction Association and the National Round Table on the Environment and Economy

1992 A Report of Waste Management for the Construction Industry

Centre for Studies in Construction

1995 Cost Effective Management of Construction & Demolition Waste and Green Building Procurement. Conference Proceedings, Nov. 18 1995, Metro Toronto Convention Centre

City of Edmonton Public Works Department, Greater Edmonton Home Builders' Association, et. al.

1994 Partners in Clean Construction P.I.C.C. Up Waste for a Healthier, Cleaner Community

1996 Partners in Clean Construction. Blueprint for Action for the Residential Construction Industry

Drerup Armstrong Ltd. and the Ottawa-Carleton Home Builders' Association for the Regional Municipality of Ottawa Carleton

1995 Pilot Project for Improved Management of Residential Construction Waste

The Energy Technology Access (ETA) Group Inc.

19-- CMHC Waste Challenge Trainer' Manual

City of Guelph Waste Management Services

1995 A Guide for Institutional, Commercial and Industrial Solid Waste Diversion, Recycling and Disposal

James Keating Construction Ltd.

1995 Ville Lora's Friendly Home Waste Audit Summary

London and District Construction Association, London District Heavy Construction Association, London Home Builders' Association

1994 Construction Waste Management Handbook

Malin, Nadav. Environmental Building News. Nov./Dec.

1995 What's New in Construction Waste Management?

Metropolitan Toronto

1991 The Solid Waste Environmental Assessment Plan (SWEAP)

National Association of Home Builders (U.S.) Research Center

1997 Residential Construction Waste Management. A Builder's Field Guide

1996 Residential Construction Waste Management Demonstration and Evaluation. Task 2 Report

1996 Personal Communication, Lund, Eric, August 21
1996 Personal Communication, Yost, Peter, August 21
1995a Waste Assessment Form (unpublished data) Model 2 story 2200 sq. ft., Largo, Maryland TABCO Somerset "Lexington," November 30 1994
1995b Waste Assessment Form (unpublished data) Production Standard 2 story-2450 sq. ft., Anne Arrundel Cty. Winchester Homes Shipley's Choice, March 28 1995

Office of Federal Environmental Stewardship, Environment Canada
1995 The Environmentally Responsible Construction and Renovation Handbook

Ontario Ministry of Environment and Energy
1995a Proceedings of the Final Meeting of Ontario's C&D Waste Reduction Strategy Team
1995b A Guide to Environmental Legislation Affecting the Ontario Construction Industry
1994a Construction and Demolition (C&D) Material Processing & Reuse Facility Inventory
1994b A Guide to Waste Audits and Reduction Workplans for Construction and Demolition Projects
1994c A Guide to Source Separation of Recyclable Materials for Industrial, Commercial and Institutional Sectors and Multi-Unit Residential Buildings
1993 Keeping C&D Out of Landfills. Conserving Resources and Minimizing Waste in the Construction Industry. A Report by the Ontario Construction and Demolition (C&D) Waste Reduction Strategy Team
19-- What to Do with Home Renovation Waste. Diverting Renovation Material From Disposal (Brochure in English, French and Italian)

Ottawa Construction Association and V.K. Mason Construction Ltd. for the Regional Municipality of Ottawa Carleton
1994 Pilot Project for Management of Construction Waste

Recycling Council of Ontario
1995 Ontario Recycling Markets Directory

Regional Municipality of Waterloo
1996 More than 100 Easy Ways to Cut Costs by Reducing Waste. A Practical Handbook for the Construction and Demolition Industry

Toronto Home Builders' Association
1992 Making a Molehill out of a Mountain II. Technical Report: New Home Pilot Projects
1991 Making a Molehill out of a Mountain II. REIC Consulting Ltd., Renova Consultants, RIS Ltd., Sheltair Scientific, Vilnis
1991 Making a Molehill out of a Mountain II. Technical Report: Renovation Pilot Projects
1990 Making a Molehill out of a Mountain. REIC Consulting Ltd., Renova Consultants, RIS Ltd.
19-- Build Green Program: The Green Dream Home and The Build Green Street

Trueman, Ted. Philip Environmental Inc.
1996 Personal Communication. August 23

Vanderwell, Richard J. Innovative Housing Grants Program, Alberta Municipal Affairs
1988 Optimum Value Engineering

Ward, Cathy. Masters in Environmental Studies, York University
1993 Waste Reduction in Demolition

Waste Reduction Institute for Training & Applications Research, LHB Engineers and Architects, Center for Resourceful Building Technology, Minnesota Office of Environmental Assistance

1995 Resource Efficient Building. Reducing Materials Use, Toxicity and Waste in Design and Construction

1996 Waste Management Update for Watson-Forsberg Co.

19-- Research Report on Source Reduction Options for Flooring, Painting and Plumbing Trades (Joel Schurke)

1996 Personal Communication, Joel Schurke, July 10

APPENDIX 1: PROJECT PROFILES OF SELECTED WASTE MANAGEMENT INITIATIVES

PROFILE A	CMHC'S RESIDENTIAL CONSTRUCTION WASTE MANAGEMENT CHALLENGE AND FOLLOW UP SURVEY - KALIN ASSOCIATES
Objective	In 1991, 32 3-hour interactive seminars were given to builders nationwide to: • raise awareness of the landfill crisis and to provide practical alternatives • demonstrate the federal government's commitment to the environment • promote the 3Rs and stimulate the building industry to participate • transfer design and technical knowledge to the industry • position CMHC as a leader, catalyst and partner in solving environmental issues related to housing Two years after the workshops, a follow-up survey was conducted to determine whether builders were still practicing waste minimization and how it had affected their business
Significant Findings	Shortly after the 32 workshops, the following data was gathered from a questionnaire: • over 60% of workshop participants implemented a Waste Management Action Plan • 56% altered building designs to make them more efficient • 78% improved material storage procedures • 89% improved their material procurement procedures • 90% found uses for excess materials in other parts of building projects • 60% believed that managing construction wastes would increase costs in the short run • 100% believed that managing construction wastes would save money in the long run • 64% felt there were insufficient recycling businesses to handle their construction wastes After two years, the follow-up survey found that: • 73% of those workshop participants who agreed to commit to implementing waste management practices on a current or upcoming project did so • 88% of those who undertook recycling activities maintained them • only 24% found difficulty finding a recycler who would accept reusable material once it had been separated from non-recoverable waste; 63% did not have difficulty • **13% had increased cost, 38% had no effect on their bottom line, and 17% saved money** (five respondents specified an amount of savings per house: $20, $25, $75 and two $100 per house). • job sites were also reported as safer • 25% reported incurring significant capital costs, e.g. signage • 71% reported saving money on tipping fees since implementing recycling • 37% reported incurring significant labour costs (1 to 6 hours). Re: impact on normal daily procedures, responses ranged from little impact after initial set up, maintenance of waste bins, to more time needed to clean up but there is less waste • 17% said recycling added significantly to the time to complete a construction job • 42% reported having difficulty separating and/or storing waste on the construction site; 46% did not have difficulty • 88% did NOT keep track of volumes and/or weights of waste materials • 92% did NOT keep track of volumes and/or weights of recycled materials • 96% did NOT use forms provided by CMHC for keeping track of material quantities • the method of training most often used was lecture style briefings and informal verbal presentation and instruction • 0% used the CMHC waste management challenge video for training • 0% used a prepared brochure or written instructions drafted themselves for training • 92% felt their efforts to recycle were worthwhile • 63% reported their workers felt efforts to recycle were worthwhile

PROFILE B	U.S. NATIONAL HOME BUILDERS' ASSOCIATION RESEARCH CENTER (TASK 2 REPORT)
Objective	• To develop, demonstrate, and disseminate cost-effective, voluntary alternatives to residential construction waste disposal
Strategies	Focussed on reducing materials use at design stage, and jobsite separation of wood and cardboard because recycling markets in the region were well established and because audits revealed the high proportion (60 to 80% by weight or volume) of these wastes. Alternatives to landfilling were explored for: • land application and composting of ground drywall scrap • mulching and composting of construction wood waste (includes discussion of issues relating to glues in manufactured wood products) • recycling of vinyl siding scrap
Education/ Promotion	• developed baseline data through before and after waste audits • developed waste reduction strategies with interdisciplinary teams • waste reduction "tips" for builders identified and published as builder's field guide
Partnerships	• the formation of jobsite recycling committees made up of builders, waste management companies, local recycling and solid waste officials, and recycling companies was recommended to enable parties interested in recycling to work out ideas, collect information/develop a resource guide, develop emerging opportunities, promote award program, offer training seminars • local HBAs can serve as a central source of local information on construction waste management, saving builders from redundant individual research efforts
Design Innovations	• opportunities for more efficient use of framing materials were identified. Two case studies in efficient design and estimation resulted in framing material savings of ~$1200 and ~$600 respectively. Both used CAD-based software: the first involved a premium software program (Argos BDS) which directly updates materials lists as design changes are made, the second was a less sophisticated program (DQ-2000) • not all value-engineering techniques are appropriate for all houses • 78% of the savings from in-line framing techniques occur in the floor frame
Development of Recycling Markets	• availability of recycling outlets, diverse waste management services and fee structures affects success of jobsite recycling • larger builders can achieve economies of scale that make recycling efforts worthwhile, but may take awhile to implement recycling programs; smaller builders can adapt new waste management systems more quickly and efficiently but might experience difficulty handling smaller quantities of materials cost-effectively. Regarding recycled-content building materials: • in order to make use of recycled-content building materials, builders require infor-mation on cost, product availability and performance, and require it from a single source • builders need a single source of information • reasons why builders do not specify recycled-content building materials include higher cost, lower availability, lack of proven performance, and little buyer demand • builders interested in "green" building materials are more concerned with overall resource efficiency than with merely a material's recycled content, so the current focus on recycled content of building materials does not meet the needs of most "green" builders; therefore, NAHB developed a database on recycled-content/resource efficient building materials (REDI 96^{TM}) including comprehensive information, to be updated continually
Other	Volume was a primary factor determining waste management costs; efficient packing of roll-off containers, especially wood and cardboard (approximately 30 minutes per week) could result in volume reductions as high as 35%
Economic Impact	• economic impact ranged from 9% increase to 21% decrease in waste management costs. (Savings of 60% were cited for a Habitat for Humanity project) • two case studies in efficient design and estimation resulted in framing material savings of ~$1200 in one case and ~$600 in the other. Framing material purchases were reduced by 10-15% and wood waste disposal costs were reduced by 65%

PROFILE C	PARTNERS IN CLEAN CONSTRUCTION: CITY OF EDMONTON , CMHC, ENVIRONMENT CANADA, GREATER EDMONTON HOME BUILDERS' ASSOCIATION, CASTLEWOOD, CHALLENGER HOMES, COVENTRY HOMES, ENCORE HOMES, GEORGE WIMPEY CANADA, THE LANDBANK, LANDMARK HOMES, PARKWOOD HOMES, AND TRU WEST HOMES
Objective	To create a *blueprint* for communities everywhere. Sought viable, proactive strategies. Began as a waste audit and industry challenge, included partnership building and evolved into an industry educational forum, pilot test, and evaluation
Strategies	
Education/ Promotion	• A one-year audit measured how much waste was produced, type, and rate, and identified problems associated with waste management • Developed, then introduced to the industry, training materials including video (for convenience and consistency of delivery for new sub-trades) • Manual included data on savings achieved, material estimating and developing a waste program, and individual tip sheets for each subtrade • Educational forum consisted of breakfast session with all partners; discussion groups facilitated presentation of tips relevant to individual sub-trades
Partnerships	Tested central depot system: 5 30-yard bins (for dimensional lumber, plywood/oriented strand board, drywall, cardboard, general waste). Builders were charged a flat $200 fee per house for depot use, coordinated by the land developer. A part-time depot attendant assisted to reduce contamination, monitor bin volumes, call for pick up secure the site, and provide continuing education
Development of Recycling Mkts	Though the project emphasized *reduction* and *reuse*, it did source and contact various companies regarding recycling opportunities
Economic Impact	Builders spent $200 per house for us of the depot system; they would have spent ~$300 per house to have the waste landfilled
Significant Findings	Dimensional lumber was reduced an average of 43% in the first pilot study (1992); wood waste was reduced by an additional 20% after further program development according to a second series of houses audited (1995). Though the depot system was considered successful, its continued operation requires is imperative that paying markets exist for recyclable materials. Education is an effective tool. Incentives and deterrents may also be effective, but involving people in a cooperative way brings about more viable solutions

PROFILE E	WRITAR, LHB ENGINEERS AND ARCHITECTS, CENTER FOR RESOURCEFUL BUILDING TECHNOLOGY, MINNESOTA OFFICE OF ENVIRONMENTAL ASSISTANCE
Objective	To provide an overview and discussion aimed at specific audiences based on the underlying concept of source reduction. In addition to reduction, the project also addresses use of less toxic materials
Recommendations	
for clients	Understand the role of the client, communicate goals clearly, extend the useful life of existing and new buildings, identify and hire experts, avoid toxics, use reused materials, identify locally produced materials and local suppliers, plan for appropriate material storage, meet with building officials
for architects and designers	Build smaller, use less material, consider framing alternatives, use less toxic materials, use standard sizes
for construction practitioners	Accurately estimate materials, use high grade materials, use pre-cut and pre-fabricated components, salvage, prevent damage through proper storage, communicate with subcontractors to reduce toxic materials use, use scraps, use advanced framing techniques, use strong materials and exploit their structural advantages

for plan reviewers, permitters and inspectors	Serve as consumer advocates, understand motivation for resource efficient construction, offer to be involved early in the design process, become familiar with resource efficient building methods and materials, and discuss these with colleagues, garner political support for building officers to encourage resource efficient building
for product suppliers	Offer new products, inform customers, sponsor displays or training seminars, help with accurate materials estimating, reuse packaging materials, ask suppliers to take back packaging ("U turn packaging"), offer just-in-time material deliveries

PROFILE F	PROVINCE OF ONTARIO
Objective	To achieve, for the construction and demolition sectors, the province's waste reduction target of decreasing the amount of waste by at least 50% by the year 2000 compared to 1987 levels
Results	Studies and committee work by the Ontario's C&D Waste Reduction Strategy Team found that information was lacking for how design affects waste production, availability of products, existing techniques and diversion opportunities, and recycling activities
Education/ Promotion	Guides, reports and a facility inventory were produced, including: • Keeping C&D Materials Out of Landfills. Conserving Resources and Minimizing Waste in the Construction Industry • A Guide to Waste Audits and Reduction Workplans for Construction and Demolition Projects • A Guide to Source Separation of Recyclable Materials for Industrial, Commercial and Institutional Sectors and Multi-Unit Residential Buildings • Construction and Demolition Material Processing & Reuse Facility Inventory • Proceedings of the Final Meeting of Ontario's C&D Waste Reduction Strategy Team • A Guide to Environmental Legislation Affecting the Ontario Construction Industry • What to do with home renovation waste (brochure in 3 languages)

PROFILE K	UMA ENGINEERING LTD. FOR REGINA HOME BUILDERS' ASSOCIATION
Objective	To advise the RHBA of the potential benefits of safe, environmentally appropriate waste management practices *direct benefits:* reduce waste produced, reduce cost of purchased materials, reduce haulage and tipping fees for wastes, generate revenue by selling used construction goods and materials *indirect benefits:* learn more efficient construction practices, create goodwill by demonstrating corporate sensitivity to the environment
Strategies	
Education/ Promotion	Downplayed due to diverse mix of RHBA companies, through informal educational opportunities such as newsletters, specific mailings and/or workshops were acknowledged
Partnerships	Recognized but did not develop the idea of an on-site waste management program with bins and separation areas
Design Innovations	Recognized benefits of • designing projects to minimize, within building codes, the amount of materials used • using standard, modular building units which are either pre-cut or partially assembled prior to delivery at the construction site • using more durable building materials, which may initially be more costly • reducing packaging waste through bulk purchasing
Development of Recycling Mkts	A 2-page ***Regina Recyclable Materials Markets*** brochure was developed
Economic Impact	Through a RHBA survey conducted in 1994, wastes types, quantities and disposal costs were estimated (see Fig. 4). Total cost for waste disposal was estimated at $311 per single family residence ($20 per 100 ft^{2})

Source: Vanderwell 1988

Source: City of Edmonton et. al. 1996