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A Green Building Materials Assessment Tool For The Toronto Renovations Marketplace

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A GREEN BUILDING MATERIALS ASSESSMENT TOOL

FOR THE TORONTO RENOVATIONS MARKETPLACE

By

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A Green Building Assessment Tool for the Toronto Renovations Marketplace

Christopher Phillips, Master of Building Science (Ryerson University, 2013)

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Abstract

This research paper addresses the marketplace confusion and barriers that can prevent easy and well informed environmentally preferable material selections from being integrated into residential renovation projects in the Toronto region. It establishes a template for an easy-to-use material assessment toolbox that considers environmental impact categories that reveal variation between products of similar type and that are often considered together as "eco-friendly" options. The material assessment tool developed as a result of this research provides a resource that satisfies the Toronto-based needs of both client and contractor to assess and source environmentally preferable material choices common to most residential renovations work and to understand the up-front cost implications of these choices.

Acknowledgements

I would like to thank Dr. Russell Richman for his patience and support as my supervisor for the last 5 years.

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1. Introduction

The building industry is evolving: consumer awareness of green building is increasing and savvy manufacturers are creating products that are marketed as "environmentally friendly", yet these claims can be based only on a single attribute environmental appeal and other detrimental elements in the same product may outweigh the benefits of the "green" component. Where, in the past, green building materials were only available in specialty stores or by special order, there is now a large range of material options marketed as "green" that are available in mainstream big-box building outlets. The environmentally preferable claims of these products can be dubious. Media reports on the false "green-washing" claims of manufacturers, such as presented by the CBC-produced series *Marketplace* (Johnson and Vasil, 2011), are not uncommon. Products can also contain potentially toxic trade secret ingredients that can add to the difficulty of comparatively assessing materials (Baker-Laporte et al, 2008).

For the Toronto homeowner, choosing the "greenest" materials for a residential renovation is an often sought after ideal that can be filled with confusion, uncertainty, and exasperation. Homeowners who seek to minimise the environmental impact of their renovations project often find themselves acting the part of materials researcher, but are confronted with manufacturer green-washing claims and engaging contractors who are unfamiliar with material alternatives and who have an apprehension of incorporating new materials that may affect costs and can take time to source. Committed homeowners with a budget to spare find themselves faced with trying to engage the services of a design or green building professional to consult with their chosen contractor in the "greening" of their project.

Financial constraints, however, often result in projects that do not have a budget for added green building consultation costs and renovations are completed without incorporating options that are easily obtainable, environmentally preferable, and have little to no added impact on cost. Other material alternatives may be selected as a "green" material option for a single environmentally preferable attribute, but the choice may not be fully informed. An example of this is the selection of bamboo flooring as an "eco-friendly" alternative based on bamboo's rapid renewability. It would not be unexpected for a residential contractor to suggest this alternative to a homeowner seeking a "green" flooring material, and base this suggestion on the familiarity of a single product sold at the building box store that he or she frequents and a general sense that bamboo is "eco-friendly". In this exchange, the complexities of green building material selection are missed and both the contractor and client may be selecting a product with a larger environmental impact than other, more conventional (and possibly less expensive) options. A more holistic assessment of the "eco-friendliness" of a bamboo flooring product would consider the origin of the material, the potential toxicity and off-gassing of the binders used, the energy input in the product's manufacture, and whether endangered rainforests were cleared in order to grow bamboo as a cash crop. These deeper considerations are often omitted in literature touting the environmentally friendly nature of a product and can mislead and exasperate the committed consumer.

It is clear that marketplace confusion and misinformation exists. Building material assessment tools are available, but they have not been effective in educating the Toronto renovation market. This research paper was undertaken to understand the limitations of current building material assessment tools and to form the basis of a new, easy to use, green building materials toolbox specific to the Toronto region. The objective of this assessment tool was to provide homeowners and residential contractors the means to easily and knowledgably integrate environmentally preferable materials into their projects. In order to achieve this goal, this toolbox was designed to both provide an understanding of the complexities of green building material choices and address the missing cost, sourcing, and product relevance issues often found in other resources. The toolbox was also developed such that it is accessible to the non-design or green building professional.

In sum, this research paper seeks to address the following questions:

A) What are the limitations of existing building material assessment tools? Where do these tool succeed?

B) What are useful criteria in the development of a building assessment tool specific to the Toronto renovations marketplace?

C) How can materials available to the Toronto renovations marketplace be comparatively evaluated and how does one create a format for a relevant and simplified product-specific assessment criteria?

2. Methodology

There were several stages to the research process that led to the development of an effective Toronto-based green building material assessment tool.

A review of existing green building material assessment tools was conducted. Both free and paid subscriber-based on-line resources and published works were examined to determine the unique approaches used to assess material options, as well as to critique their utility to the Toronto-based residential renovations consumer.

The challenges and important considerations inherent in the development of a green building material toolbox was outlined in a review of critical research and observations of product assessment tools. These considerations were used to establish a framework for the creation of the Toronto-based green building materials assessment tool.

Addressing the weaknesses that were observed in other assessment tools and building upon the framework that was established, the toolbox was developed. Material categories for the toolbox were selected particular to the needs of the Toronto-based residential renovations contractor and client. Environmental impact categories and assessment criteria for each material category were established through reviews of other tools and material environmental impact research and made geographically relevant to Toronto. Product marketplace data for each material category was then obtained and used to populate the assessment tool across the established impact categories. Product unit pricing was then obtained from retailers. Pricing was established across products for each material category such that pricing reflected a similar amount or design of product, thus countertops were priced using the same design template and trim pricing was based on the same size and profile. This resulted in the creation of a multi-attribute environmental building material assessment tool that addresses the limitations observed in other assessment resources.

A review of the Toolbox limitations was then conducted and improvements and potential future developments were suggested.

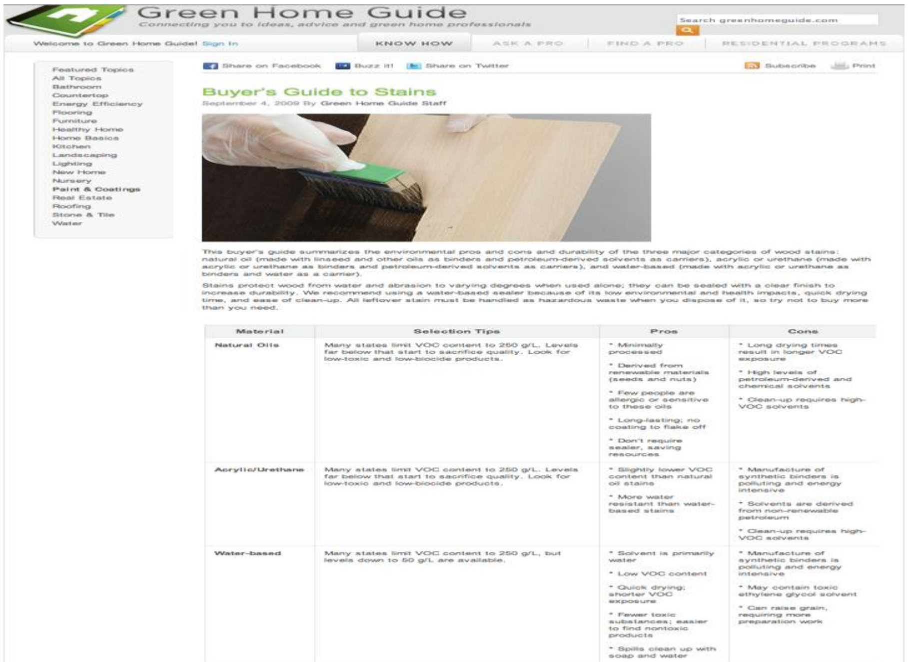
3. Existing Market-oriented Green Building Material Assessment Resources: A Review

There are several resources available for consumers and contractors who seek information about environmentally preferable material choices. Many of these resources were used to create the material assessment methodology that is outlined later in this research. A review of these tools illustrates that no single assessment database, website, or printed work satisfactorily achieves the particular needs of a consumer or residential contractor seeking an environmental assessment of readily obtainable material options in the Toronto marketplace. Existing tools suffer from being too complex and difficult to use for the average non-building professional or, conversely, are not detailed enough or do not offer comparative product assessments. Where specific products are reviewed, most are not available without placing a special order to the United States or elsewhere.

The following is a review of major websites and published works that provide green building material assessment information, as well as examples of lesser-known local resources that also serve as guides for consumers seeking environmentally preferable material choices. Desirable elements and approaches from some of these books and websites helped to shape the look and scope of the Toronto toolbox developed in this research, and this is discussed after the review.

3.1 Green Home Guide

Figure 3.1
Green Home Guide: Buyer's Guide to Stains (www.greenhomeguide.com).



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Paint & Coatings
Real Estate
Roofing
Stone & Tile
Water

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Buyer's Guide to Stains
September 4, 2009 By Green Home Guide Staff

This buyer's guide summarizes the environmental pros and cons and durability of the three major categories of wood stains: natural oil (made with linseed and other oils as binders and petroleum-derived solvents as carriers), acrylic or urethane (made with acrylic or urethane as binders and petroleum-derived solvents as carriers), and water-based (made with acrylic or urethane as binders and water as a carrier).

Stains protect wood from water and abrasion to varying degrees when used alone; they can be sealed with a clear finish to increase durability. We recommend using a water-based sealer because of its low environmental and health impacts, quick drying time, and ease of clean-up. All leftover stain must be handled as hazardous waste when you dispose of it, so try not to buy more than you need.

Material	Selection Tips	Pros	Cons
Natural Oils	Many states limit VOC content to 250 g/L. Levels far below that start to sacrifice quality. Look for low-toxic and low-biocide products.	* Minimally processed * Derived from renewable materials (seeds and nuts) * Few people are allergic or sensitive to these oils * Long-lasting; no coating to flake off * Don't require sealer, saving resources	* Long drying times result in longer VOC exposure * High levels of petroleum-derived and chemical solvents * Clean-up requires high-VOC solvents
Acrylic/Urethane	Many states limit VOC content to 250 g/L. Levels far below that start to sacrifice quality. Look for low-toxic and low-biocide products.	* Slightly lower VOC content than natural oil stains * More water resistant than water-based stains	* Manufacture of synthetic binders is polluting and energy intensive * Solvents are derived from non-renewable petroleum * Clean-up requires high-VOC solvents
Water-based	Many states limit VOC content to 250 g/L, but levels down to 50 g/L are available.	* Solvent is primarily water * Low VOC content * Quick drying; shorter VOC exposure * Fewer toxic substances; easier to find nontoxic products * Spills clean up with soap and water	* Manufacture of synthetic binders is polluting and energy intensive * May contain toxic ethylene glycol solvent * Can raise grain, requiring more preparation work

Retrieved from http://greenhomeguide.com/know-how/article/buyers-guide-to-stains on Aug 13, 2013

The Green Home Guide (USGBC, 2009), established by the United States Green Building Council (USGBC), is an on-line green building resource specifically aimed at the homeowner. Its Buyer's Guides, a screenshot of which is displayed in the Figure 3.1 above, contain information on finish products, such as flooring and countertops, and a list of material options within each product category. A short list of environmental pros and cons for each material option is provided, along with general tips about product selection. Certain materials have an added cost category, but the website does not provide product-specific information.

The material categories examined in the Buyer's Guides are narrow in breadth, with a primary focus on wet-applied products, but also covering countertops and tile selection. The Buyer's Guides are presented in the form of web articles and are not linked in one location or differentiated from the rest of the *Green Home Guide* website. The website offers general information about environmentally preferable material options, but these options are not comparatively rated against each other and specific products are not mentioned. As a result, *Green Home Guide* is both limited in its use as an assessment tool for users seeking the environmentally preferable material option within a certain category, and in its usefulness to the contractor, who must do further research on identifying and locating specific products for each category.

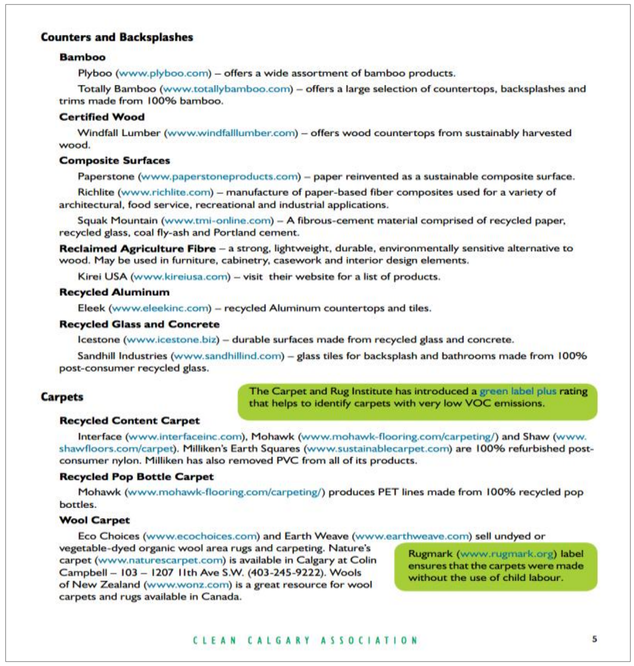
Table 3.1 summarizes the pros and cons of this tool from the point of view of its usability as an assessment tool for evaluating locally available green building materials for the Toronto homeowner or contractor:

Table 3.1
Summary of Pros and Cons: Green Home Guide.

Pros	Cons
Online information in form of Buyers Guides by product categories	Buyers Guides in form of web articles, not grouped or easily found on website
Created by USGBC	Narrow breadth of material categories (mostly finishes i.e. stains, flooring & countertops).
Specifically for homeowners	Limited usefulness for contractor/builder
Short list of environmental pros and cons	Limited cost information for some materials
General tips on product selection provided	No product specific information
	Environmentally preferable options not rated comparatively

3.2 Clean Calgary Association Green Building and Renovation Guide

Figure 3.2
Clean Calgary Association: Green Building and Renovation Guide (www.greencalgary.org).



Counters and Backsplashes

Bamboo

Plyboo (www.plyboo.com) – offers a wide assortment of bamboo products.

Totally Bamboo (www.totallybamboo.com) – offers a large selection of countertops, backsplashes and trims made from 100% bamboo.

Certified Wood

Windfall Lumber (www.windfalllumber.com) – offers wood countertops from sustainably harvested wood.

Composite Surfaces

Paperstone (www.paperstoneproducts.com) – paper reinvented as a sustainable composite surface.

Richlite (www.richlite.com) – manufacture of paper-based fiber composites used for a variety of architectural, food service, recreational and industrial applications.

Squak Mountain (www.tmi-online.com) – A fibrous-cement material comprised of recycled paper, recycled glass, coal fly-ash and Portland cement.

Reclaimed Agriculture Fibre – a strong, lightweight, durable, environmentally sensitive alternative to wood. May be used in furniture, cabinetry, casework and interior design elements.

Kirei USA (www.kireiusa.com) – visit their website for a list of products.

Recycled Aluminum

Eleek (www.eleekinc.com) – recycled Aluminum countertops and tiles.

Recycled Glass and Concrete

Icestone (www.icestone.biz) – durable surfaces made from recycled glass and concrete.

Sandhill Industries (www.sandhillind.com) – glass tiles for backsplash and bathrooms made from 100% post-consumer recycled glass.

Carpets

The Carpet and Rug Institute has introduced a green label plus rating that helps to identify carpets with very low VOC emissions.

Recycled Content Carpet

Interface (www.interfaceinc.com), Mohawk (www.mohawk-flooring.com/carpeting/) and Shaw (www.shawfloors.com/carpet). Milliken's Earth Squares (www.sustainablecarpet.com) are 100% refurbished post-consumer nylon. Milliken has also removed PVC from all of its products.

Recycled Pop Bottle Carpet

Mohawk (www.mohawk-flooring.com/carpeting/) produces PET lines made from 100% recycled pop bottles.

Wool Carpet

Eco Choices (www.ecochoices.com) and Earth Weave (www.earthweave.com) sell undyed or vegetable-dyed organic wool area rugs and carpeting. Nature's carpet (www.naturescarpet.com) is available in Calgary at Colin Campbell – 103 – 1207 11th Ave S.W. (403-245-9222). Wools of New Zealand (www.wonz.com) is a great resource for wool carpets and rugs available in Canada.

Rugmark (www.rugmark.org) label ensures that the carpets were made without the use of child labour.

CLEAN CALGARY ASSOCIATION 5

Retrieved from http://www.greencalgary.org/images/uploads/File/GreenBuildingGuide.pdf on Aug. 13, 2013

The Clean Calgary Association has created a *Green Building and Renovation Guide* (Clean Calgary Association, n.d.) to help consumers in southern Alberta make educated decisions about the products that they chose to integrate into their homes. There are fourteen material categories in the *Guide*, a screen shot of which is displayed in Figure 3.2 above, each with several suggested alternative material options considered to be broadly more "environmentally friendly" than what would be conventionally used. The *Guide* provides some insight into green building assessment issues, however these mostly involve broadly identifying a relevant third-party single attribute certification.

Although a useful introduction into green materials for a homeowner or renovations contractor, the *Guide* does not include any cost information for the listed material alternatives and materials are included equally as generally "environmentally friendly" options, with no comparative assessment information provided. Materials are also generally promoted according to one single environmentally preferable attribute. Thus bamboo flooring, with four product/retailer listings, is justified for inclusion in the *Guide* on the basis of its quick regenerative ability alone. Other environmental concerns for bamboo as an alternative flooring material, such as distance from manufacture and the potential for off-gassing of formaldehyde binders are not addressed.

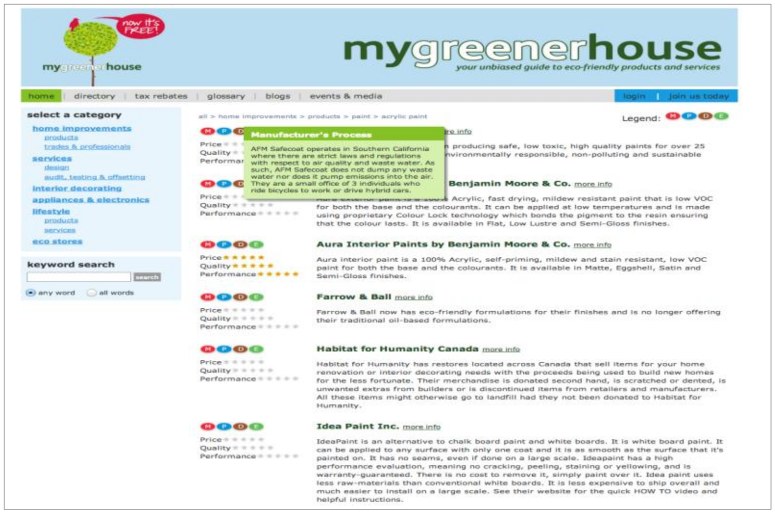
Table 3.2 summarizes the pros and cons of this tool from the point of view of its usability as an assessment tool for evaluating locally available green building materials for the Toronto homeowner or contractor:

Table 3.2
Summary of Pros and Cons: Clean Calgary Association Green Building and Renovation Guide

Pros	Cons
Location specific green building material resource (Calgary)	No cost information provided
Online PDF Guide for consumers with some broad introductory insight into green building assessment issues	Broadly identifies “environmentally friendly” materials through ID of relevant 3rd party single attribute certification.
14 material categories, each with suggested alternative “environmentally friendly materials”	No comparative assessment between materials.
	Materials generally assessed on one single environmentally preferable attribute.
	Potential negative attributes of “environmentally friendly” options not addressed.

3.3 My Greener House

Figure 3.3
My Greener House: Acrylic Paints (www.mygreenerhouse.ca).



Retrieved from http://www.mygreenerhouse.ca/members/subcategory/9/3/summary/acrylic-paint.htm on Aug 13, 2013

A more thorough market-friendly approach to green building materials assessment is the free Toronto-based online directory *My Greener House* (www.mygreenerhouse.ca), a screen shot of which is shown above in Figure 3.3. Developed by designer Jennifer Harris, *My Greener House* is an easy-to-use and well-researched resource aimed primarily at homeowners. It does not require any specialised training to use and understand. The website includes professional services and furniture in its directory, and the materials listing is fairly comprehensive across a wide variety of building products that lists everything from adhesives and caulks to countertops and wood products. Each material category contains several products and manufacturers. Each review contains a brief product overview, contact information for the manufacturer, and a discussion of the product across four categories: materials rating, manufacturer's process, distance to market, and eco-certification. In some cases, PDF documents of product MSDS and technical data sheets are provided. The materials rating does not comparatively rate materials, but rather gives a brief overview of the composition of each product. The manufacturer's process category is not clearly defined, as this category includes emissions information for the manufacturing of some products (e.g. PaperStone) and general, and sometimes questionable, manufacturer eco-initiatives for others (e.g. encouraging client website use for information gathering over the printing of paper for WoodPlus Coatings Ltd. of Pickering, Ontario). The distance to market category lists the location of manufacture for most products and, in some cases, includes information about the transportation used to deliver the product to market. Conventional products are not included in this directory.

The *My Greener House* directory has fields for rating each product by price, quality, and performance based on a 5-star scale. Ratings are supplied by the users of the directory, but justifications for these ratings and how these ratings compare to each other is not defined. The rating system is also limited in that the majority of the products are devoid of any star rating whatsoever across these three ratings areas, suggesting the resource is still incomplete. Although the manufacturer information and contact details are useful, this directory's utility for the contractor would increase exponentially if distributor and/or retailer information was provided, along with unit prices for each product. In comparison to the Calgary-based guide, *My Greener House* delves much deeper and more broadly into the various issues that surround green materials selection, yet the resource remains weak in regards to comparative assessment and pricing information.

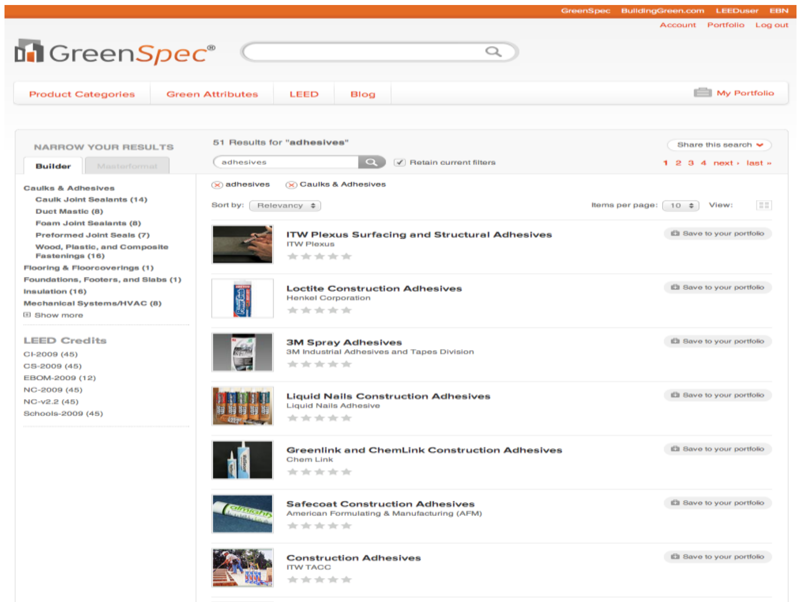
Table 3.3 summarizes the pros and cons of this tool from the point of view of its usability as an assessment tool for evaluating locally available green building materials for the Toronto homeowner or contractor:

Table 3.3
Summary of Pros and Cons: My Greener House

Pros	Cons
Free, Toronto-based online directory primarily for homeowners	Materials rating does not comparatively rate materials
Easy to use, well researched, requires no specialized training or knowledge	Manufacturer's process category not clearly defined
Fairly comprehensive materials listing across a wide variety of building products, furniture and professional services	General and sometimes questionable manufacturer eco-initiatives listed.
Each materials category contains several products and manufacturers and in some cases links to pdf's of MSDS or product information	Does not include distributor/retail information.
Product info across 4 categories: materials rating, manufacturer's process, distance to market, and eco-certification	Star rating system for price, quality and performance not clearly defined and based on user feedback; majority of ratings are empty.

3.4 GreenSpec Product Guide

Figure 3.4
GreenSpec Product Guide: Adhesives (greenspec.buildinggreen.com).



Retrieved from
http://greenspec.buildinggreen.com/search/apachesolr_search/adhesives?filters=tid%3A52 on Aug 13, 2013

Perhaps the most widely known green building materials directory in North America, the *GreenSpec Product Guide* is available both for a fee on-line (www.buildinggreen.com) and in a book format that follows a similar organisation (Piepkorn & Wilson, 2006). The *Product Guide* (a screenshot of which is displayed above) was created specifically for building contractors and homeowners in the late 1990s. Products are listed in the directory only when they meet the broad criteria outlined by GreenSpec's "Green Attributes", which cover operational impacts, occupant health, responsible sourcing and manufacture, and local well-being. The tool is extensive, with information on over 2,200 specific alternative products across almost every building material category. Each category (e.g. paints and coatings, interior finish and trim, insulation and vapour retarders, etc.) contains a short, but detailed overview of the predominant environmental concerns associated within it. Specific products and their images can be scrolled through or found using a keyword search. Individual product listings start with a point-form response to the question “what makes this product green?” Each product is succinctly described and matched with links to additional information, MSDS, technical data sheets and other manufacturer-provided literature. GreenSpec indicates product attributes of note, including VOC or recycled content amounts, and lists any relevant green certifications or standards that are met. Manufacturer contact information is also provided.

Although an excellent and easy to use resource, the GreenSpec Product Guide does not provide comparative environmental assessment information between products or include pricing information. Many of the products that are listed in the directory are available in Canada only by special order from the United States, which can make the website somewhat frustrating to use for a Toronto-based contractor seeking easy-to-find alternatives for his/her renovation project.

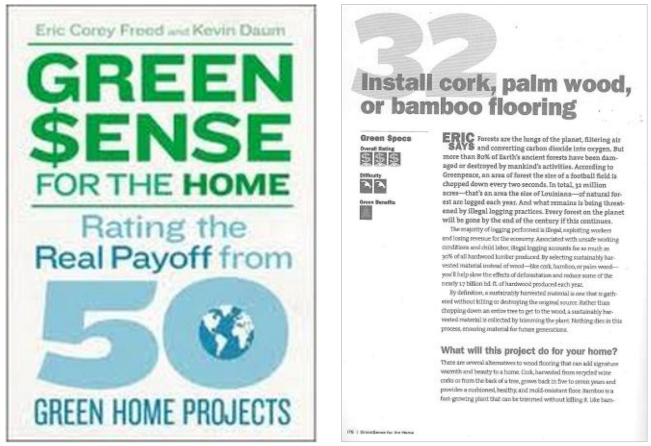
Table 3.4 summarizes the pros and cons of this tool from the point of view of its usability as an assessment tool for evaluating locally available green building materials for the Toronto homeowner or contractor:

Table 3.4
Summary of Pros and Cons: GreenSpec Product Guide

Pros	Cons
Online green building materials directory for North America specifically for homeowners and contractors.	Fee based (~$20/month)
Extensive: 2,200 specific alternative products across almost every building category	Products only listed if meet GreenSpec’s “green attributes”
Covers operational impacts, occupant health, responsible sourcing and manufacture, and local well-being.	No comparative environmental assessment between products.
Each category contains short, detailed overview of predominant environmental concerns.	No pricing information.
Each product is described and matched with additional information (MSDS, technical data, certifications, etc.)	Many products listed only available in Canada by special order from US.
Manufacturer contact info provided	

3.5 GreenSense for the Home: Rating the Real Payoff from 50 Green Home Projects

Figure 3.5
GreenSense for the Home: Rating the Real Payoff from 50 Green Home Projects



Daum & Freed, 2010 (front cover; p. 178)

GreenSense for the Home is a residential and homeowner-oriented green building assessment tool that was published in 2010 (Daum & Freed, 2010). Written by Eric Corey Freed, principal architect of the green building firm organicARCHITECT and Kevin Daum, *GreenSense* is aimed specifically at homeowners and residential contractors. *GreenSense,* an excerpt of which is displayed in Figure 3.5 above, is a direct and well-informed response to the most often asked-query regarding green building: that of cost. The book examines fifty common and easy to implement residential renovation and new build projects and approaches, with several of these specifically related to alternative choices in building materials. Healthy wall finishes, green countertops, high recycled content drywall, certified wood use, and Portland cement-reduced concrete are some examples of the building materials that are discussed. Each material is assessed both from an environmental and practical/financial perspective. Similar to *GreenSpec*, a short but detailed overview of the environmental impact of each material option is provided. Unlike *GreenSpec*, *GreenSense for the Home* couches the information it provides in terms and a format that is meant to resonate with the homeowner. Possible material sourcing and application issues are identified, along with the role of the contractor, potential maintenance and durability concerns, and impacts (if any) implementation would make on traditional building timelines. The second part of each assessment is a financial overview of the green building approach. This "practical" discussion examines capital costs, potential tax credits and rebates, potential savings, and any potential impact on re-sale value of the home. Depending on the material being examined, costs are given in dollars per square foot or as a percentage premium over a given conventional alternative. This marrying of quality information about a broad range of residential green building alternatives with cost data for marketplace consumption is unique. Each approach is given a rating from one to five for both "difficulty" (to implement) and for "overall rating", an attempt to balance the green and financial elements to indicate worthiness. A list of material supplier names and website addresses is also provided.

GreenSense for the Home is an excellent starting point for a homeowner or contractor who is looking to implement a greener approach to a renovation project and who is searching for answers to questions about initial costs, potential payback, and the environmental impact of the decisions being made. From a strict materials perspective, however, the range of products that are assessed in this publication is limited to less than ten categories and the benefits and drawbacks between individual brands are not discussed. The overall rating out of five for each material/green building approach is a broad subjective assessment made by the authors and is given without a methodology. Providing a single rating that promises to balance both the complex aspects of "green" material selection and all financial considerations for a single material category is a bold endeavour that is likely only to satisfy homeowners with a passing interest in building green. In practice, homeowners often base material selections on their own subjective hierarchy of important characteristics and a single over-all rating, as used in *GreenSense*, may prove too simplistic in its approach. *GreenSense's* lack of any comparison between specific brands or types within a material category (e.g. countertops) can also mislead users into believing that all the alternative options within a material category can be equally weighed from an environmental perspective. Products and costs examined in *GreenSense* are also written for the American residential renovations marketplace and are not necessarily transferrable to the Toronto market.

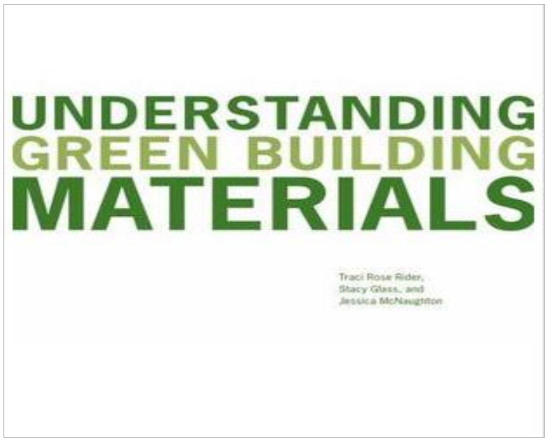
Table 3.5 summarizes the pros and cons of this tool from the point of view of its usability as an assessment tool for evaluating locally available green building materials for the Toronto homeowner or contractor:

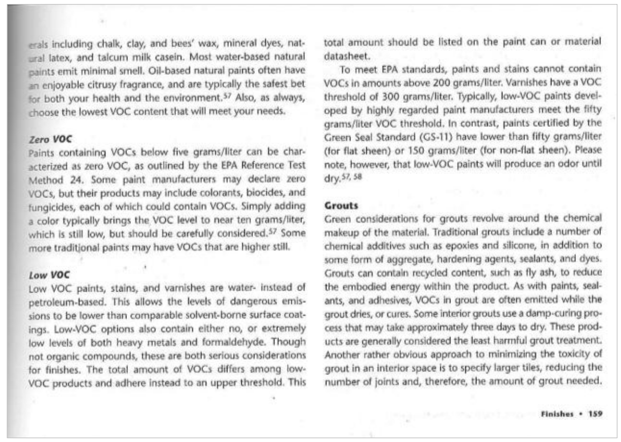
Table 3.5
Summary of Pros and Cons: GreenSense for the Home

Pros	Cons
Easily obtainable and accessible residential green building assessment tool specifically for homeowners	Data included only as up-to-date as last publication date (2010)
Includes 50 common, easy to implement renovation or new build projects	Overall rating is broad subjective assessment made by authors with no methodology given
Provides short, detailed overview of environmental impact of each material option	Single rating too simplistic and can be misleading
Includes costs (capital, rebates, potential savings, etc.) as dollar/sq ft or as percentage premium over conventional	No comparison between brands or types within a material category
Includes other issues (sourcing, maintenance & durability, impact on traditional timeline, etc.)	Non-Canadian pricing and products
Green approaches rated from 1-5 on both difficulty to implement and overall rating	
Material supplier names and website address provided	

3.6 Understanding Green Building Materials

Figure 3.6
Understanding Green Building Materials





erals including chalk, clay, and bees' wax, mineral dyes, natural latex, and talcum milk casein. Most water-based natural paints emit minimal smell. Oil-based natural paints often have an enjoyable citrusy fragrance, and are typically the safest bet for both your health and the environment.[57] Also, as always, choose the lowest VOC content that will meet your needs.

Zero VOC

Paints containing VOCs below five grams/liter can be characterized as zero VOC, as outlined by the EPA Reference Test Method 24. Some paint manufacturers may declare zero VOCs, but their products may include colorants, biocides, and fungicides, each of which could contain VOCs. Simply adding a color typically brings the VOC level to near ten grams/liter, which is still low, but should be carefully considered.[57] Some more traditional paints may have VOCs that are higher still.

Low VOC

Low VOC paints, stains, and varnishes are water- instead of petroleum-based. This allows the levels of dangerous emissions to be lower than comparable solvent-borne surface coatings. Low-VOC options also contain either no, or extremely low levels of both heavy metals and formaldehyde. Though not organic compounds, these are both serious considerations for finishes. The total amount of VOCs differs among low-VOC products and adhere instead to an upper threshold. This total amount should be listed on the paint can or material datasheet.

To meet EPA standards, paints and stains cannot contain VOCs in amounts above 200 grams/liter. Varnishes have a VOC threshold of 300 grams/liter. Typically, low-VOC paints developed by highly regarded paint manufacturers meet the fifty grams/liter VOC threshold. In contrast, paints certified by the Green Seal Standard (GS-11) have lower than fifty grams/liter (for flat sheen) or 150 grams/liter (for non-flat sheen). Please note, however, that low-VOC paints will produce an odor until dry.[57, 58]

Grouts

Green considerations for grouts revolve around the chemical makeup of the material. Traditional grouts include a number of chemical additives such as epoxies and silicone, in addition to some form of aggregate, hardening agents, sealants, and dyes. Grouts can contain recycled content, such as fly ash, to reduce the embodied energy within the product. As with paints, sealants, and adhesives, VOCs in grout are often emitted while the grout dries, or cures. Some interior grouts use a damp-curing process that may take approximately three days to dry. These products are generally considered the least harmful grout treatment. Another rather obvious approach to minimizing the toxicity of grout in an interior space is to specify larger tiles, reducing the number of joints and, therefore, the amount of grout needed.

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Rider et al, 2011 (front cover; p. 159)

Understanding Green Building Materials (Rider et al, 2011), an excerpt of which is displayed in Figure 3.6 above, is written by architect and sustainability consultant Traci Rider with Stacy Glass, president of the American sustainable building product distributor, CaraGreen. Aimed at architects, designers, and contractors, it is meant as a companion volume to an earlier guidebook on general green building principles. About half the book is devoted to placing material selection into the greater context of green building design. Various whole building rating systems are discussed, along with general considerations in green material selection. An overview of material labels and certifications is provided and a chapter is devoted to the role of life cycle assessment (LCA) in material evaluation, its methodology, and its current limitations due to a dearth of comprehensive data. An LCA analysis assessment evaluates the total environmental burden of a product, from its origin and resource acquisition, through to its production and installation, to its disposal. A full LCA analysis of any one product is extremely complicated and time-intensive and the product data needed to do a proper assessment is not available for most materials (Rider et al, 2011). The authors also warn of the subjective nature of LCA material assessment tools that attempt to combine findings into a single score. The second half of the book is a review of the various environmental issues and options available for specific material categories, including wall systems, flooring, countertops, millwork, and finishes. Each material category is examined in terms of composition, primary environmental concerns, alternatives and best choices, and evolving trends.

Understanding Green Building Materials achieves the promise of its title, however its utility as a marketplace material assessment tool is limited. Specific products and manufacturers of material alternatives are rarely mentioned leaving the client or contractor to do this research, and costs of the various options are not discussed at any point. Although several green alternatives within a material category (e.g. flooring) are discussed, there is no comparative assessment between these alternatives. The book is text-heavy, with information on the materials provided only in paragraph form. The lack of tables or graphic inhibits simple comparisons of material options and, again, limits its use as a go-to tool for the marketplace.

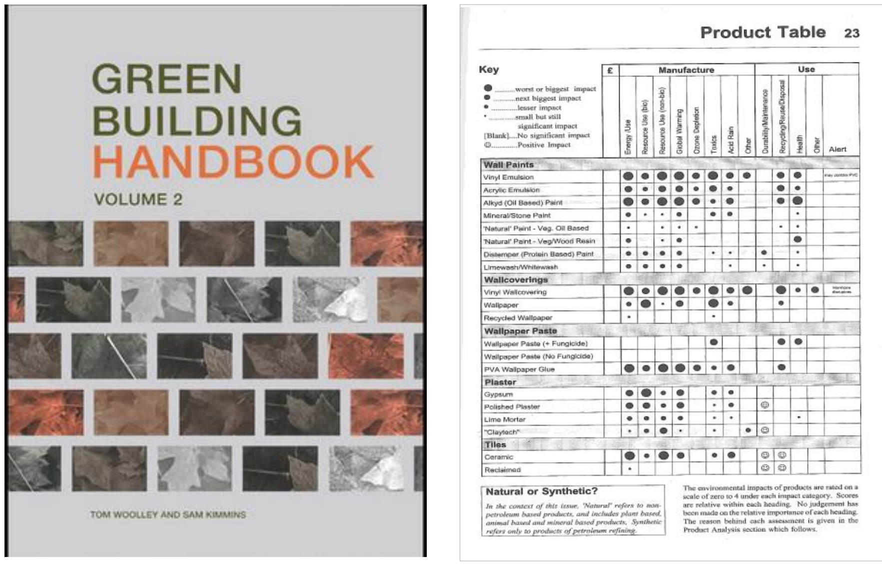
Table 3.6 summarizes the pros and cons of this tool from the point of view of its usability as an assessment tool for evaluating locally available green building materials for the Toronto homeowner or contractor:

Table 3.6
Summary of Pros and Cons: Understanding Green Building Materials

Pros	Cons
½ of book places material selection into the greater context of green building design	Little specific mention of products or manufacturers of alternative materials.
Includes overview of material labels, certifications and Life Cycle Analysis	No comparative assessment between alternative materials.
Remaining ½ of book reviews environmental issues and options available for a few material categories (flooring, countertops, finishes, etc.)	Text heavy book without tables or graphs.
	Utility as marketplace material assessment tool limited.
	Data included only as up-to-date as last publication date (2011)

3.7 Green Building Handbook: A Guide to Building Products and Their Impact on the Environment

Figure 3.7
Green Building Handbook: A Guide to Building Products and Their Impact on the Environment, Vol 1 & 2



Woolley, 2000 (Vol. 2, p.23)

Written primarily for a UK audience eleven years before *Understanding Green Building Materials*, Queen's University, Belfast Professor of Architecture Tom Woolley's *Green Building Handbooks Vol. 1 and Vol. 2* (Woolley 1997, 2000) are detailed building material assessment guides, a sample of which is displayed in Figure 3.7 above. The range of product areas covered between both volumes includes interior decorations (mostly wall coverings), adhesives, electrical wiring, glazing, floor coverings, insulation materials, composite boards, and roofing materials. Woolley's approach combines a short summary of the main areas of environmental concern for each product category with recommended "best buys" and a more detailed table showing the relative environmental impacts across up to eleven assessment categories for the various product types. The assessment categories are separated into manufacture (including energy use, resource use, global warming, toxics, etc.) and use (including durability/maintenance, recycling/reuse/disposal, and health). Woolley's simplified relative rating system is illustrated in an easy to read graphic format that uses differently sized dots to represent the severity of environmental impacts. Based on a four-point scale, the largest dot has the biggest general impact and the smallest dot represents the least amount of impact in relation to other materials in that category. A missing dot represents no significant impact. Unlike most other assessment tools, there is no attempt to provide an over-all rating for any one product and Woolley addresses this directly, stating that the quantification of environmental impacts is such a complex issue that this kind of decision-making is more "a political rather than scientific matter" (Woolley, 2000). A product analysis section follows the table graphic and it is here that Woolley provides justification for his environmental assessments, as each product is briefly discussed against the various impact categories.

Several individual manufacturers of alternative products are listed in the *Green Building Handbooks*, some with estimated unit pricing, however almost all of these are UK-based and not easily obtainable in the Greater Toronto Area. Woolley does not use defined thresholds when selecting the size of impact for each category, but rather relies on a well-informed, yet subjective approach to making these judgements. The result is a simplified and broad approach to material impact assessment, but also one that is accessible and "good enough" for the purposes of most clients and their builders.

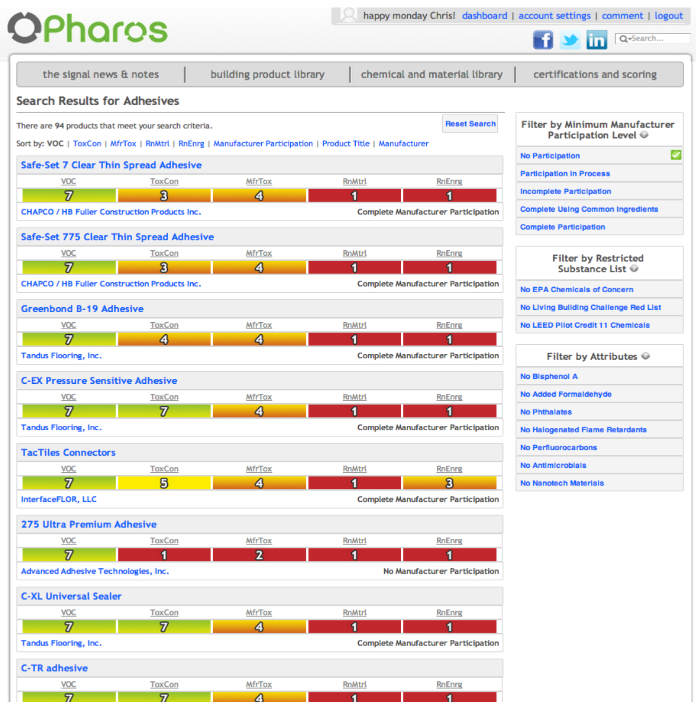
Table 3.7 summarizes the pros and cons of this tool from the point of view of its usability as an assessment tool for evaluating locally available green building materials for the Toronto homeowner or contractor:

Table 3.7
Summary of Pros and Cons: Green Building Handbooks

Pros	Cons
Easily accessible, well detailed building product assessment guides	Data included only as up-to-date as last publication date (1997/2000)
Includes range of product areas such as interior finishing products (paints, floor covering), adhesives, wiring, glazing, insulation, composite boards, and roofing materials.	Written primarily for UK audience with UK-based materials
Includes short summary of main areas of environmental concern in each product category and names "best buy"	Impact ratings not based on defined thresholds
Includes detailed table with relative environmental impacts across up to 11 assessment categories for different product types.	
Uses easy to read different sized dots (based on size of relative environmental impact) to compare products	
No overall product rating – instead graphic table provides justification for each product assessment	

3.8 The Pharos Project

Figure 3.8
The Pharos Project (www.pharosproject.net)



Retrieved from http://www.pharosproject.net/product_search/results/cat/9 on Aug 13, 2013

The Pharos Project (www.pharosproject.net), which was publicly launched in 2009, is a web-based environmental impact assessment tool and database for building materials created by The Healthy Building Network, an American NGO. Assessments, as displayed in the screenshot in Figure 3.8 above , are not based on in-house testing, but largely rely on 2nd and 3rd party certifications. There is a fee to access the product database (under 20 USD/month), however manufacturers are not charged to have their products listed. With just over 100 rated materials in 2011, the *Pharos Project's* building product library is rapidly expanding and now numbers over 1180 products across 12 product categories. In table form, individual products are given a rating out of 10 across five impact categories: volatile organic compounds, toxic content, manufacturing toxics, renewable materials, and renewable energy. The user has the option to sort products according to the given score in any impact category. A deeper analysis of the product and the justification behind each impact rating is also available on a separate product page for every material. Here, the broad pros and cons of the product are highlighted and the individual ingredients of the product (as far as they are known) are listed in a table with their percentage of content and assessed according to toxic content, toxics released in manufacture, and renewable content. Issues for each individual ingredient are highlighted and, when the mouse cursor is dragged overtop these issues, a reference box provides information about the applicable agency or study responsible for the hazard declaration. Unknown elements of potential concern are also listed. Any relevant certifications for the product are listed, along with links to the manufacturer website and literature. An area for notes from the "Pharos Team" is also provided.

The Pharos Project is becoming the authoritative source for green building material assessment results in North America. The depth and breadth of its building product library is unmatched, with an ease of use that satisfies the casual user's need for a simple numbered rating for products that is combined with the opportunity to read a deep review of the material across each impact category. However, as a tool for homeowner and residential contractor use in Toronto, there are some critical weaknesses. A United States-based undertaking, *The Pharos Project* database is currently heavily populated by products that are not yet readily available without special order in Canada. As such, a large proportion of the reviews have a limited use to a contractor trying to source material alternatives that s/he can offer a client. Even with over a thousand listed products, the vast majority of often-used and easily accessible building materials are not yet listed in *The Pharos Project* database, including several well-recognized brands. The database also does not offer cost or distributor details for listed products, two key areas to achieve real utility from a contractor perspective. *The Pharos Project*, as with most of product-specific tools examined in this research, relies on the participation and transparency of manufacturers to provide an accurate rating across its impact categories. In instances where transparency lacks, products can receive a very low ranking in this tool that may or may not be an appropriate indication of actual impact.

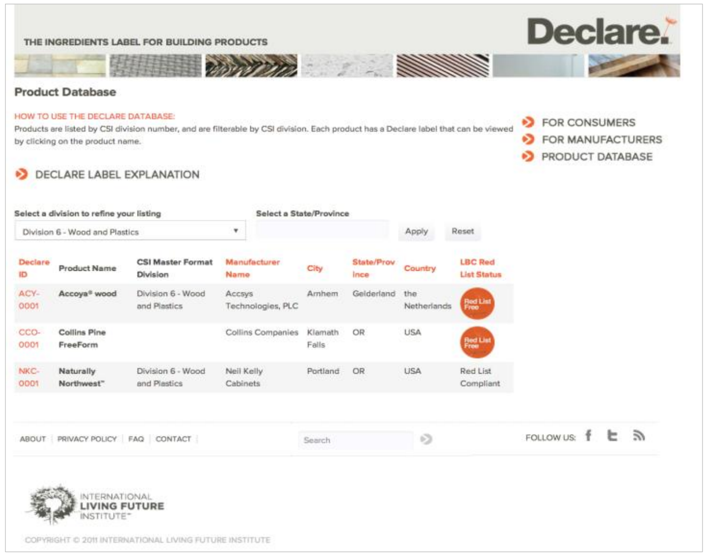
Table 3.8 summarizes the pros and cons of this tool from the point of view of its usability as an assessment tool for evaluating locally available green building materials for the Toronto homeowner or contractor:

Table 3.8
Summary of Pros and Cons: The Pharos Project

Pros	Cons
Web-based environmental assessment tool and database for building materials	Assessments largely rely on 2nd and 3rd party certifications
Nearly 1,200 products rated across 12 product categories	Fee based (~$20/month)
Ratings can be sorted across 5 impact categories (VOC, toxic content, manufacturing toxics, renewable materials, renewable energy)	Most rated products US based and not yet readily available in Canada without special order
Deeper analysis of product and justification behind rating available for every material	Commonly used, easily accessible, main stream green building materials not yet rated
Includes broad pros/cons of products as well as ingredients and issues associated with ingredients	No cost or distributor information
Includes as yet unknown elements of potential concern	Lack of manufacturer participation or transparency can potentially lead to a negative over-correction within the rating system
Includes references and certifications as well as links to manufacturer website and literature	
Unmatched depth and breadth of green building material assessment results in North America	

3.9 Declare Product Database

Figure 3.9
Delcare Product Database: Wood and Plastic (www.declareproducts.com)



Retrieved from http://www.declareproducts.com/product-database?field_csi_master_format_division_tid=6&field_manufacturer_state_provinc_value= on Aug 13, 2013

The *Declare Product Database* (www.declareproducts.com) is a free on-line materials database developed by International Living Future Institute, a non-profit organization responsible for the Living Building Challenge sustainable building certification programme (International Living Future Institute, 2010). *Declare* has been developed primarily to help enable building professionals to source and provide documentation for materials that conform to the requirements of the Living Building Challenge. To be listed on the database, as per the screenshot example above in Figure 3.9, *Declare* requires full ingredient disclosure of a product. Products that are free or, with some small component exceptions, nearly free from "Red List" chemicals -- materials universally understood to be either seriously harmful to human health or the environment and listed on the *Declare* website -- are indicated as "Red List Free" or "Red List Compliant" and therefore qualify for inclusion into a building project seeking Living Building Challenge certification (Living Building Challenge, 2013). Products can be searched according to CSI Master Format Divisions and place of final manufacture. Each product contained in the database has its own "Declare Label", showing assembly details, the life expectancy of the product, end of life options, the product's Red List status, and a full ingredient list. Companies that provide the required ingredient documentation pay an annual fee of between $600-$800 per product to be listed on the database, and an annual 50% renewal fee is charged for products whose composition is unchanged year after year. No renewal fee is charged if a Red Listed ingredient has been removed from a product's composition in the previous year.

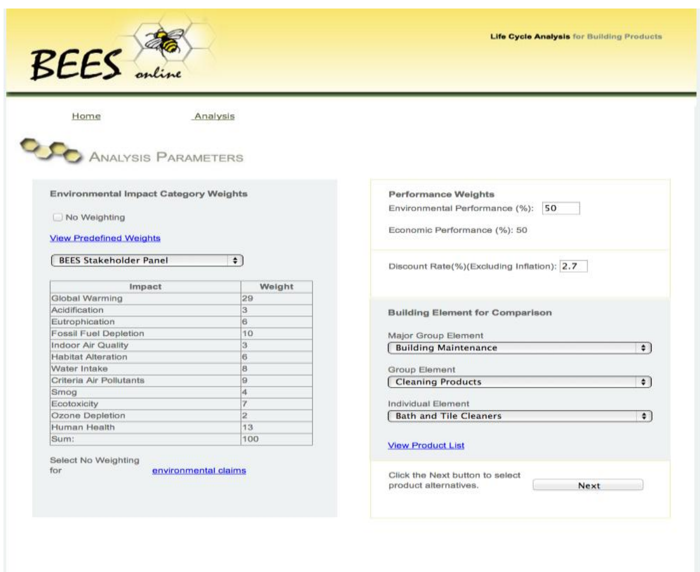
Declare currently has extremely limited utility for the average homeowner or residential contractor. Very few of the products listed in the *Declare* database are readily available in Toronto and the entire database includes less than 50 products, eleven of which are furnishings that are not usually the purvey of a residential contractor. *Declare* is primarily a support tool for achieving Living Building Challenge Certification, an ideal condition that requires building materials used on projects to be Red List free or compliant. Very few products available in the marketplace make such claims. *Declare's* database provides an either/or Red List ingredient scenario that, while straightforward and simple to understand, offers no comparative insight between building products that do not achieve Red List free or compliant status. The emphasis of *Declare's* database is on material ingredients and health impacts, with reference to Red List status. Manufacturing location, life expectancy, and end of life information is provided, but the database does not provide an assessment of energy inputs in manufacture between various products: there is no way to distinguish between an energy-intensive product and one that is less so. There is also no product cost information in the *Declare* database, which limits its usefulness by a contractor or client not completely devoted to achieving the requirements Living Building Challenge.

Table 3.9 summarizes the pros and cons of this tool from the point of view of its usability as an assessment tool for evaluating locally available green building materials for the Toronto homeowner or contractor:

Table 3.9 Summary of Pros and Cons: Declare Product Database	
Pros	Cons
Provides sourcing and documentation for materials that conform to requirements of Living Building Challenge	Extremely limited utility for average homeowner/residential builder
On line tool where products can be searched by CSI Master Format Divisions and final place of manufacture	Very few products listed are available in Toronto
Each product listing includes assembly details, life expectancy of the product, end of life options, Red List status and full ingredient list.	Emphasis on material ingredients and health impacts and no reference to energy inputs
	No product cost information

3.10 BEES Online

Figure 3.10
BEES Online (www.ws680.nist.gov/Bees)



Retrieved from
http://ws680.nist.gov/Bees/(A(bD4joGLOzgEkAAAAZjE2NmQ5M2YtNGIyNi00NWVmLWFhMWQtMjcyYmRiOTc2ZGM42-HVH_Q34lILNm5NRYdPe-7Z1W01))/AnalysisParametersBuildingProds.aspx
on Aug 13, 2013

Launched as a free on-line software programme in 2007 by the National Institute for Standards and Technology and the United States Environmental Protection Agency, *BEES* (Building for Environmental and Economic Sustainability) is a material assessment tool designed for professionals in the building industry (http://www.nist.gov/el/economics/BEESSoftware.cfm). The aim of the tool is to aid in material selection that balances environmental performance with economic performance, and to provide the user with an ability to weigh assessments according to his or her own particular values as shown by the screenshot in Figure 3.10 of the input menu. Environmental performance is measured according to the LCA standard outlined in ISO 14040 and economic performance is measured using life cycle costing that follows the ASTM International standard. The software has comprehensive data for 230 (mostly generic) building materials. Users have the ability to choose various building elements, then weight environmental impacts by either pre-set EPA advisory board or BEES stakeholder definitions, or choose the weighting of each impact using a user-defined setting. The importance of economic considerations of material choices is defined by the user, who chooses how to balance environmental impact with economic performance using a relative percentage weighting. Once all variables have been entered, the performance of chosen materials is then calculated by the software and expressed using bar graphs for comparison: over-all impacts of materials can thus be easily compared to each other, as well between impact categories for each material, which are expressed as different colours within the over-all bar graph.

The *BEES* software provides a comprehensive analysis of a broad range of building materials, with the added strength of being able to compare, in a detailed fashion, the performance of materials against each other. The added ability for the user to define environmental and economic weightings makes this a particularly powerful tool. These benefits aside, as a market-based tool *BEES* suffers for its complexity. The user has the ability to control almost every aspect of the assessment parameters, but the choices can be overwhelming and unfamiliar: one is asked to comparatively weigh the importance of an impact on eutrophication versus ecotoxicity and ten other categories. The ability to weigh future replacement and repair costs between materials is an excellent option, but not intuitive for most people: users must set a “Discount Rate” of up to 20% to convert future building costs to their current value. Users must also enter the transportation distance from the material’s place of manufacture to point of use so that this can be factored into the LCA calculations. This level of detail achieves rigorous and meaningful outputs, but is likely to push beyond the comfort level of the average user in the marketplace. As most of the products listed in *BEES* are for generic materials, it is not possible to weigh the performance of different products of the same material. Thus a cork floor tile is only assessed as an example of its type, without mention of product differences that might be of importance to a consumer: potential off-gassing and type of adhesives used, type of backing material, and wear layer coating, for example. From a residential contractor perspective, the dearth of information on product names, manufacturers, and retail costs severely limits the utility of *BEES* as a tool.

Table 3.10 summarizes the pros and cons of this tool from the point of view of its usability as an assessment tool for evaluating locally available green building materials for the Toronto homeowner or contractor:

Table 3.10
Summary of Pros and Cons: BEES online

Pros	Cons
Online materials assessment tool	Designed for building professionals
Aids in material selection balancing environmental performance (via life cycle analysis) with economic performance (via life cycle costing)	Rating choices can be overwhelming and unfamiliar
Allows user to weigh assessment according to own values	Ratings options are not intuitive and require detailed information to be input by user
Performance is calculated by the software and expressed using easily comparable bar graphs	Products listed are generic materials, so performance difference of different products not possible
Provides comprehensive analysis of broad range of building materials	No product names, manufacturers or retail costs
Level of detail achieves meaningful and rigorous output	

3.11 Conclusions from the Review of Existing Resources

A review of various building product assessment tools illustrates that several sources of information exist, but all are found wanting in some significant way for a consumer or contractor seeking to do environmentally preferable conventional renovations in the Toronto area.

On-line tools that offer a rigorous and holistic comparative environmental assessment of material options, such as *The Pharos Project* or *BEES Online*, are limited in product scope and local availability and offer little useful information for a Toronto consumer/contractor trying to make the best material choice with the options s/he has on hand. *My Greener House* is Toronto-based and lists locally-available building products and brands, but this database while comprehensive in its materials content, has mostly incomplete user-based ratings and lacks the rigour of other on-line tools, and does not provide the means for a comparative assessment within various material categories. *The Clean Calgary Association Green Building and Renovation Guide* suffers from the same drawbacks as *My Greener House*. The USGBC-produced *Green Home Guide* broadly lists the various environmental "pros" and "cons" of materials (e.g. bamboo) within various broad material categories (e.g. flooring), but the concerns are not comparatively rated and specific products are not listed, leaving the consumer/contractor to make uninformed decisions between brands (e.g. without knowledge of FSC-certification or adhesive types within bamboo flooring). *The Declare Product Database* and its ingredient lists are valuable to those seeking Living Building Challenge Certification, but its emphasis on full content declaration by manufacturers and focus on Red List compliance filters out the vast majority of building products that a consumer/contractor must choose from in the Toronto market.

Books such as *GreenSense for the Home* and *Understanding Green Building Materials* provide good starting points for making broadly environmentally preferable material choices backed up by some academic rigour, but these offer little to no brand-specific assessments and no comparative assessment within each material category: thus the relative merits and drawbacks of alternative countertops and flooring are discussed, but the options within these categories are not compared to each other. Tom Wooley's *Green Building Handbooks* provide academically rigorous and comprehensive comparative assessments across eighteen broad material categories, however these were written almost 15 years ago and have a strong UK focus. Specific products mentioned in the *Green Building Handbooks* are not readily available in the North American market, several new materials marketed as "green" alternatives have since been developed and are therefore not assessed in the books, and cost implications of choices in our marketplace are not addressed. *The GreenSpec Product Guide* lists specific products that conform to its "green attributes" filter, but it does not provide comparative assessment information between these products or pricing information. The products listed in *GreenSpec* are also largely produced in the United States and are not all readily available in the Toronto marketplace, which limits its utility to the Toronto consumer/contractor. A disadvantage of the book format itself is that updates to information and the inclusion of new products are limited to the publication of each new edition.

In sum, no one tool was found that satisfies all of the following: a) provides an academically rigorous building materials assessment that goes beyond broad platitudes for what is "environmentally preferable"; b) offers a comparative assessment within material categories; c) lists specific products readily available in the Toronto marketplace; d) provides costing and distributor information to ensure simple sourcing of materials at the consumer/contractor level; e) includes materials such as framing lumber, structural wood panel products, and drywall that are often used in the residential renovations sector but are not often subject to brand recognition; and f) is simple enough to be understood and used by a typical consumer/residential contractor to make environmentally preferable material purchasing decisions.

4. Review of Difficulties Inherent in the Creation of Environmental Assessment Tools

Prior to creating a Toronto-based green materials assessment tool, a critical review of limitations inherent in creating such a tool was conducted. What follows is a summary of these findings.

Hertwich et al (1996) comment on some of the difficulties inherent in the creation of an environmental assessment tool for products in their critical review of six product evaluation methods for determining environmental impacts. Their research illustrates how various methodologies can be engaged for the same purpose, but often result in vastly different outcomes due to the internal weightings and priorities of each approach. The calculation of the total environmental impact of a product can include health hazards and a hierarchy of importance, total pollutant emissions and scarcity calculations, resource creation and derogation, environmental damage estimating based on economic considerations, and other elements. The internal prioritization of each approach bears a certain degree of subjectivity and prejudice that cannot be avoided in any attempt to determine the over-all environmental impact of one particular product.

As a result of their research, Hertwich et al comment on the need to avoid "analytical paralysis" in the development of an assessment tool and provide recommendations for the design of an environmental impact methodology. Analytical paralysis is defined by the authors as a state where useful impact evaluation becomes unfeasible if realistic limitations are not placed on the required inputs for the assessment. Products are understood to be complex compounds of ingredients, with composition ratios that are rarely available and made with materials that are often undeclared and considered "trade secrets". A detailed analysis of every component of a single product would require significant amounts of research and capital expenditure. An assessment tool with a limited budget and scope, such as the one developed in this research, must recognize these limitations and develop an approach that is suitable to its goals: an analysis can omit environmental impacts that are reasonably comparable and be flexible enough to allow some uncertainty and subjectivity into the assessment to avoid analytical paralysis. The observations outlined in the Hertwich et al paper informed the development of the methodology for this research.

Harris (1999) identifies other issues in environmental impact assessment tools that must be noted and accepted as part of the development process. Harris illustrates that no single list of indicators is universally accepted as identifying the environmental impact of a material. He lists embodied energy, scarcity, recycling potential, energy consumption, health impacts and other indicators as commonly used in the development of an assessment tool, but demonstrates that few criteria or set targets have been established for any of these impacts, and that there is no agreement about how these impacts are relatively weighted. Harris concludes that the objective weighting of various environmental impacts is, by definition, impossible. Tom Woolley, in his *Green Building Handbooks* (Woolley, 1997 and 2000), comes to the same conclusion in his assessment tool, calling the attempt to weigh impacts against each other "a political rather than scientific matter". Harris explains that geographical location can be key in assessing the importance of an impact and that this becomes most important when heavy, relatively low value items are evaluated and the embodied energy in transportation is a significant part of the total environmental impact.

Haapio and Viitaniemi (2008) find, in their critical review of building environmental assessment tools, several issues that affect utility. Their criticisms are applicable to material assessment tools and can be seen in the review of the material assessment tools below. Haapio and Viitaniemi argue that it is difficult to compare the results of various tools against each other and that it is not clear how and when certain tools are best to be utilised and by whom. Significant amounts of information are available, but how to take this information and apply it is a common problem. The authors indicate that, in building environmental assessment tools, only "high quality buildings" are commonly assessed. The same can be said of most green material assessment tools, where assessed products have already been filtered for achieving certain criteria before being included in a database. By only focusing on the elite material options, many habitual choices in material selection that a contractor must make are not addressed. The authors conclude that the most effective assessment tool is one that is developed specifically to the particular needs of the user, and that weakness of many tools is that they attempt to satisfy too many interests. These findings illustrate the value and need of developing a material assessment tool that is Toronto-centric and accessible to a non-design or non-green building professional.

Alyami and Rezgui (2012) suggest how best to develop a sustainable building assessment tool. In any materials assessment that forms part of a greater building tool, they identify resource consumption as the prime target for analysis. Alyami and Rezgui suggest that any material evaluation should give a value preference to products that a) avoid the use of virgin materials, b) require a minimal amount of extraction, production, and transportation energy, c) are processed with water efficiency in mind; d) are non-polluting; e) are sourced locally and f) can be recycled easily after use. These characteristics, with the exception of difficult to assess water resource use, have been identified across the material categories considered for the market-based toolbox. Impact categories for this assessment tool value recycled material over virgin material in resource use, but also recognise the impact of energy use in the manufacturing process. Thus a less energy intensive process is given a higher rating in the toolbox compared to processes that are more energy intensive and locally produced products are given a preference over products that have been produced and transported from afar. In the Toronto-based assessment tool, preference is given to products that have the lowest impact on indoor health, minimise global carbon emissions, and minimise the use of non-renewable resources.

5. Determination of Criteria for Toolbox

The accessibility of *The Pharos Project* database and its success in concentrating its assessments into only five easily understandable impact categories played a significant role in the development of the Toronto market-based product assessment tool. This, combined with the broad, yet meaningful, scoring parameters used in Tom Woolley's *Green Building Handbook* formed the basis of the approach used in this research.

Woolley, in his *Green Building Handbooks*, achieved a useful medium between what is typically offered by material guides and assessment tools. Woolley provided academically rigorous comparative information between materials, which are often omitted in market-oriented guides, and did so without the complexities that could make the tool difficult to use for a user not educated in the field of green building and design. The simple table format that Woolley used, where dots of varying sizes convey degrees of environmental impact, was a concept and look that helped to guide the approach of the assessment tool developed as part of this research.

This Toronto-based tool was developed to take into account Alyami and Rezgui's recommendations of assessing the importance of resource consumption in material impacts, articulated in a way most relevant and particular to the material category being assessed. Material resource use was the single impact category held in common across every material category in this research.

Informed by these observations, the development of a successful green building material assessment tool for the Toronto marketplace was designed according to a methodology based on the following elements:

5.1 Use of multiple impact attributes specific to each material category

In order to evaluate products, impact categories were chosen to evaluate material categories. The simplified broad environmental impact approach used in *The Pharos Project* was used as a model for the toolbox to avoid the complications of attempting to assess individual products across several impacts, as done in LCA-based tools such as *BEES* or in Tom Woolley's *Handbooks*. The environmental impacts assessed in the Toronto tool are adaptations of the categories used in *The Pharos Project*. Impact categories that were deemed relatively similar between products of a material category were not included in the assessment tool due to insufficient product information being available to assign meaningful differences between these products. Further research was then conducted for each material impact category to create a rating system across products that was meaningful and appropriate to the Toronto marketplace. A detailed description and justification for each impact category is provided in Section 7.

5.2 Inputs omitted for environmental impacts between products that are reasonably comparable

If products of the same material type were deemed broadly alike in any particular impact category, this impact category was omitted from the toolbox. The assessment tool developed here chooses only to examine the impacts that differentiate similar material types from each other. Where differentiation exists, it is explained in the impact category methodology of the research. This approach does not provide a user with a full understanding of the total environmental impact of a material choice, but the limitations in time and budget for this research did not allow a complete life cycle analysis of each individual product. Although the toolbox has this inherent limitation, it is also not intended to be a full LCA tool. Its simplicity allows a user to differentiate between similar products that are currently available in the Toronto marketplace and to make environmentally preferable selections from amongst these products.

5.3 Relative impacts of products examined in lieu of single scores

Products assessed in this toolbox are examined in relation to each other within each impact category. Following Tom Woolley's approach (Woolley 1997, 2000), the assessments that are provided illustrate only generally expected degrees of environmental consequence and preference. There is no defined degree of difference between a score of "1" and "2" in this assessment, only that a higher score is considered environmentally preferable within a certain impact category. Given the inherent difficulties of weighing environmental impacts against each other, this tool does not attempt to prescribe a value between the impact categories to determine a single "best product in class". The graphic nature of the toolbox and the simplification of environmental impacts into a small number of categories does, however, allow a user to easily distinguish a product that scores preferably across several criteria. The subjective nature of any material selection that results from the use of this tool is a reflection of the reality of the residential renovations process, where attributes such as health may be considered of greater importance than renewable material content, and where up-front cost plays a significant part in decision-making.

5.4 Geographical relevance and impact of transportation energy for heavier materials are noted

The impact categories developed for each material type in this assessment tool have been designed specifically for the Toronto marketplace and are discussed in detail in the methodology of that section. Products assessed in the toolbox are all readily available in the Toronto marketplace. As recommended by Harris (1999), an emphasis on the environmental impact of material sourcing for heavy, generally low value materials is provided and is detailed in the impact category methodology.

5.5 Recognition of inherent subjectivity

This assessment tool is designed to be used as a general guide for residential contractors and their clients to identify available opportunities to minimise environmental impacts associated with typical material purchases in an informed and multi-attributive manner. The environmental impact categories that are highlighted for each material type often represent a synthesis of several building material studies, assessments, and evaluations and it is understood that a certain amount of subjectivity in the valuation of impacts exists. The challenges inherent in creating simplified assessment categories, particularly for complex products made of combinations of renewable and non-renewable resources, and which often include associated third-party certifications, is significant and necessarily requires some subjective input. It is also recognized that the users of this toolbox bring their own internal valuation of environmental impacts to the material selection process, with the added caveat of cost. As a result, the assessment tool developed from this research seeks to address the complexities of green building material selection and to be nothing more than an actionable guide to the user. It does not purport to offer the final statement on the "greenest" material in any particular category.

5.6 Flexibility to withstand uncertainty of undeclared ingredients and exact compositions

The material assessment toolbox established as a result of this research was constructed within a limited time and budget. It was understood that most products reviewed for this tool likely contain undeclared materials with exact compositions that cannot be ascertained. Where some material assessment tools, such the *Pharos Project*, regularly assign low values in environmental impact categories for products where manufacturing and ingredient data is not fully known, the Toronto market-based tool was developed to create useable and simplified assessments broad enough to differentiate products in each material category without succumbing to the "analytical paralysis" described by Hertwich et al (1996). The toolbox includes a summary section of widely recognized environmental impacts for each material category. The impact categories developed for the Toronto assessment tool address these impacts for each type of material based on the ingredient information available at this time. The development of new products that address these impacts in a novel way could, in a future revision, lead to the re-work of existing impact category assessment criteria or result in the creation of an entirely new impact category for a particular material.

5.7 An emphasis on resource consumption

This assessment tool has been developed such that resource consumption, articulated in a way that is most relevant and particular to the material type being assessed, is the single element held in common across every material category. Evaluations on resource consumption for each material category are explained in the impact category methodology described in a later section of this research paper, but broadly follow the general guidelines suggested by Alyami and Rezgui (2012).

6. Determination of Material Categories to be Included in the Toolbox

The intended users of the toolbox developed as a result of this research are homeowners and residential contractors in the Toronto area. The toolbox is designed to be used as a general guide for residential contractors and their clients to identify available opportunities to minimise environmental impacts associated with typical material purchases in an informed manner. Although more categories of materials can still be added to this resource in a larger document, those that were selected for assessment represent materials that are commonly purchased by contractors in the residential renovations industry. The specific products that were included in the toolbox are readily obtainable in and around Toronto and unit prices were included, where applicable, so that cost repercussions of material selections are easily understood. Sourcing alternative building products can be time intensive and expensive, which can result in products being overlooked if the information to acquire them is not close at hand.

This toolbox contains assessments across eight material categories representing products that are amongst the most frequently purchased by a contractor in interior residential renovations projects. The work produced in this research represents an approach that can easily be expanded to include a greater breadth of materials. An exhaustive list of material categories for residential use would be a much more significant undertaking and beyond the scope of this research. Without time and space constraints, material categories representing roofing, insulation, exterior cladding, window frames, adhesives and caulks, and piping for plumbing would be amongst the first to be considered in an expanded version of this tool. With some exceptions, these excluded material categories were considered second tier items largely because they are purchases that would more often be made by a specialised licensed sub-trade, such as an electrician, plumber or, increasingly, insulation installer.

The materials included for evaluation in this initial version of the toolbox are listed below in Table 6.1:

Table 6.1 Materials to be included in Toolbox
Ready Mix Concrete
Framing Lumber
Composite Boards – Structural
Drywall
Casework and Trim
Countertops
Flooring
Wall Finishes

For each material category, specific criteria were developed to evaluate environmental impacts for each category. This process is described in detail in the following Section 7.

7. Material Categories and Associated Impact Category Assessment Methodology

Described below is the methodology applied in determining the impact categories particular to each of the eight material categories listed previously in Table 6.1.

7.1 Ready Mix Concrete

7.1.1 Overview

Concrete is usually ordered by a residential contractor when lowering a basement floor (underpinning), pouring a foundation slab for a new addition, or using insulated concrete forms (ICFs). Concrete mainly comprises aggregate, sand, water, Portland cement, and additives that can provide colour, delay curing, and affect flow. Portland Cement, which typically comprises about 10% to 15% by weight of concrete, binds the material together and provides its strength (Foster et al, 2007). Up to 10% of all global carbon emissions is a direct result of high embodied energy cement creation, and the material is considered to be the single largest contributor to global warming in the industrialized world (Daum & Freed, 2010). Up to 50% of the total Portland cement content in concrete can be replaced with other materials that also have the advantage of being waste products produced by other industrial processes. In Canada, these supplementary cementitious materials (SCMs) are commonly fly ash, a by-product of coal-burning electric power plants, and slag, the non-metallic leftovers from steel production (Concrete Construction, 2007). Both of these materials are typically land-filled (Bouzoubaa & Fournier, 2005). Using SCM-enhanced concrete in renovations work thus decreases the environmental implications of cement, while also finding a practical use for waste products that would generally be landfilled.

Up to 15% of total Portland cement content in general concrete mixes has been replaced by SCMs over the last several years, mostly as a cost-saving measure (Daum & Freed, 2010). Most green building literature for the marketplace is produced in the United States and tends to focus mainly on using fly ash as a supplement to cement. Finding locally-produced fly ash as an SCM in the Toronto area has recently become very difficult, however, as Ontario has moved away from coal generated electricity: from being the source of 25% of all power produced in the province in 2003 to just under 3% of all power produced in 2013, with all coal plants expected to close by the end of 2014 (Spears, 2013). Even when coal generated electricity had a larger role in Ontario, fly ash for use in southern Ontario-made concrete has historically been imported in significant amounts from the northern United States. This is largely because the fly ash produced in Ontario is typically too high in alkali content and free carbon for use as a SCM. Blast furnace slag for use as an SCM, however, is locally produced in southern Ontario (Bouzoubaa and Fournier, 2005).

7.1.2 Impact Categories

The following is the identification and rationale for the impact categories chosen for ready mix concrete. A table summarizing these findings is provided at the end of this section (Table 7.1).

7.1.2.1 SCM Sourcing and Use

When supplementary cementitious materials are used to displace the Portland cement content in concrete, industrial waste products are diverted from landfill and the total embodied energy required to produce new cement for that pour is decreased. Small concrete suppliers who do not already keep a "green" concrete mix generally lack the facilities to accommodate SCM storage. Small builders and renovators also tend to gravitate toward smaller concrete suppliers. Toronto concrete providers contacted for this research paper who are able to add SCM content at a builder's request or who provide pre-prepared SCM-enhanced mixes only use slag, but some companies import their SCM fly ash from the United States. For the purposes of this assessment tool, concrete that contains locally produced slag is given a higher rating than concrete that contains supplementary cementitious materials that have been imported from elsewhere. Companies that do not accommodate added SCM use are given the lowest rating. When ordering concrete, contractors should specify the highest amount of SCM suitable for their application. Current concrete regulations place upper limits on SCM use that can make mixes with very high SCM content harder to specify, but these regulations will be reviewed in 2014 and are, according to a representative at concrete supplier Holicim, expected to change (P. Trunk, personal communication, July 25, 2013). According to a representative of Innocon, a Toronto ready-mix concrete provider, their UltraGreen slag-enhanced ready mix contains between 40%-45% supplementary cementitious material and it can be used without engineering approval for most regular concrete work in residential construction (R. Lucci, personal communication, August 8, 2013).

In order of preference for this category:

SCM requests accommodated – slag used

SCM requests accommodated – fly ash used

SCM requests not accommodated

7.1.2.2 Aggregate

The aggregate used by most concrete providers is clean stone, new material that is often taken from pits and quarries, and comprises the largest percentage of concrete by weight. Recycled aggregate can be used in new concrete mixes, however, and is usually sourced from infrastructure demolition activities. The use of recycled aggregate finds a use for demolition waste, generally reduces aggregate costs, and is much less energy-intensive than virgin aggregate (OHMPA, 2010). Regulations exist in some regions that limit the amount of recycled aggregate used in new concrete mixes, particularly when used for structural purposes, but at least 20% of clean stone can be replaced in any new concrete application (World Business Council for Sustainable Development, 2009). Again, as with SCM use, recycled aggregate is more easily used by larger concrete providers that have the facilities to store these materials and operations that can ensure that the quality of recycled material is uncontaminated and will not affect new mixes (Construction Materials Recycling Association, n.d.). One example of this is Holcim, a concrete provider that pours any leftover concrete that returns from jobsites into forms, which are then crushed at their facility for use in future mixes (P. Trunk, personal communication, July 25, 2013).

Providers are ranked in order of preference for this category:

Facility uses recycled aggregate

Facility only uses non-recycled (clean) aggregate

Table 7.1 Summary of Material Impact Categories: Concrete			
CONCRETE		Major issues associated with impact category	Suggested methods to reduce impact
SCM Sourcing and Use (total points: 3)		- high embodied energy of Portland Cement large cause of global carbon emissions	- replace Portland with SCM industrial waste product such as slag
3	SCM requests accommodated – slag used		
2	SCM requests accommodated – fly ash used		
1	SCM requests not accommodated		
Aggregate (total points: 2)		- aggregate is the largest % material by weight in concrete - usually sourced from quarried clean stone	- replace clean aggregate with recycled aggregate
2	Facility uses recycled aggregate		
1	Facility only uses non-recycled (clean) aggregate		

7.2 Framing Lumber

7.2.1 Overview

In the residential renovations industry, wood wall framing remains the most common type of construction and is often employed in the energy retrofitting of double-brick masonry homes in order to add insulation to interior walls, as well as the framing of new partition walls and some structural elements. When taking into account all wood products, a typical home can be expected to use about 4,000 square meters of forest space (Daum & Freed, 2010). Deforestation is a significant environmental issue, negatively affecting soil quality, climate, and biodiversity (CaGBC, 2010).

7.2.2 Impact Category

The following is the identification and rationale for the impact categories chosen for Framing Lumber. A table summarizing these findings is provided at the end of this section (Table 7.2).

7.2.2.1 Resource Use

Choosing framing lumber and other wood products that have been sourced from responsibly-managed forests ensures that trees have been sustainably harvested and processed to minimise the environmental impact of the forest industry. Wood that has been certified by the Forest Stewardship Council (FSC), a non-profit 3rd party organisation, ensures that sustainable guidelines have been met (CaGBC, 2010) and is the most recognized international certification standard for wood products in green building. Another prevalent certification in North America is the Sustainable Forestry Initiative (SFI) standard, which was founded within the American timber industry itself. Although SFI now operates as an independent entity and has increased its standards such that it meets many of the same criteria of FSC, these standards are often perceived as less defined and more open to interpretation (Rider et al, 2011). As non-industry stakeholders and environmental groups are largely the source of criticism of SFI standards, in this assessment tool FSC-certification has been chosen as the preferred standard and SFI is weighted less than FSC-certified lumber, as it is in the Pharos Project (Pharos Project, n.d.) and by the Canada Green Building Council's LEED building assessment certification system (CaGBC, 2010).

In recent years, big box stores have begun to carry FSC-certified framing lumber at an equivalent price to non-certified products. Contractors should choose FSC-certified lumber for their project needs and this tool provides sourcing information to help locate common framing material in the Toronto area. It should be noted that there is also a preference within FSC-certification itself. Wood products with an FSC Pure label are ensured to be 100% sourced from fully FSC-certified forests. Wood products labelled FSC Mixed contain a minimum of 70% FSC certified wood combined with FSC Controlled Wood. FSC Controlled Wood comes from approved and independently verified “non-controversial” sources, but does not yet meet all of FSC's standards to achieve full certification status (FSC, n.d.).

Framing lumber is thus ranked in this tool in order of the following preference:

FSC-certified Pure/100%

FSC-certified Mixed

SFI-certified

Non-certified

7.2.2.2 Sourcing

Ensuring that lumber is harvested sustainably through 3rd-party certification is important but, in addition, lumber should be harvested as locally as possible to avoid the carbon emissions associated with transporting material from across the country. Canada is a major softwood lumber producer and most framing lumber is homegrown and simply labelled as a product of Canada. Tracing the provincial origin of lumber available in big box stores is not always feasible, but it is possible to purchase sustainably-harvested 3rd-party certified material direct from the Ontario mill. If possible, use of locally reclaimed or re-used lumber is the environmentally preferable option. Thus sourcing, in order of preference is as follows:

Reclaimed, salvaged, or re-used

Of Ontario origin

Of North American origin

Other

Table 7.2 Summary of Material Impact Categories: Framing Lumber			
FRAMING LUMBER		Major issues associated with impact category	Suggested methods to reduce impact
Resource Use (Total points: 4)		- Deforestation negatively affects soil quality, climate and biodiversity	- use lumber sourced primarily from responsibly managed forests (preferably 3rd party certified)
4	FSC-certified Pure/100%		
3	FSC-certified Mixed		
2	SFI certified		
1	Non-certified		
Sourcing (Total points: 4)		- transporting lumber causes carbon emissions	- use lumber grown as locally as possible
4	Reclaimed, salvaged or re-used		
3	Of Ontario origin		
2	Of North American origin		
1	Other		

7.3 Composite Boards – Structural

7.3.1 Overview

This material category provides an assessment of wood composite panel materials that are often used in residential renovations work to sheath roof and wall framing and create subfloors. Typically plywood and oriented strand board (OSB) are used for these construction-grade applications and most of this material is sourced and manufactured in North America.

7.3.2 Impact Categories

The following is the identification and rationale for the impact categories chosen for Composite Boards. A table summarizing these findings is provided at the end of this section (Table 7.3).

7.3.2.1 Resource Use and Manufacture

This impact category reflects a summation and extension of the findings outlined in the Green Building Handbook and in life cycle assessment reports for Canadian plywood sheathing and OSB as produced by the Athena Institute. The Handbook assesses production impacts across eight categories and ranks plywood marginally ahead of OSB. The lack of wasted wood in OSB is seen as a benefit over plywood in regards to renewable resource depletion, however the larger amount of petrochemical-based resin binders found in OSB contribute to higher impacts for non-renewable resource use, as well as higher impacts in categories associated with its production, such as in global warming, toxics, and acid rain (Woolley, 1997). A material comparison using Athena's LCA reports for plywood and OSB, with impacts quantified in terms of total energy used in production, greenhouse gas emissions, and four other categories, also shows plywood manufacture has consistently less over-all environmental impact compared to OSB manufacture (Athena Sustainable Materials Institute 2008a, 2008b). For the purposes of this tool, the environmental preference for plywood over OSB is augmented by incorporating wood sourcing information into the assessment. Plywood is rated higher than OSB, and plywood containing third party sustainably sourced wood is considered to have the lowest impact. It is now possible to purchase certified sustainably-harvested construction-grade plywood panels in Toronto, however third party certified OSB panels have yet to be located. Thus, in order of preference from least to most impact:

FSC-certified plywood

SFI-certified plywood

Non-certified plywood

Oriented Strand Board (OSB)

7.3.2.2 Health

The primary health concern for this material category is related to the binders that hold composite wood sheathing together. These binders have traditionally been based on polymers that contain formaldehyde, a widely recognized carcinogen and a trigger chemical for respiratory and dermatological issues (Healthy Building Network, 2008b). Formaldehyde-based adhesives in wood panel products have generally been of two types: urea- and phenol-formaldehyde (UF and PF). The chemical bond in UF-based resins is less stable than PF-based resins, and this leads to greater amounts of formaldehyde emissions in these products (Pharos Project, n.d.). PF-resins are more expensive to manufacture than UF-binders, but they are also more resistant to moisture and have generally been used for board products that are labelled for exterior use (Canadian Plywood Association, n.d.). The chemical bond in PF-based adhesives is stronger than that found in UF-based resins and, although board products using PF binders continue to off-gas formaldehyde, emissions are a tenth of that found in board products using UF binders (Pharos Project, n.d.).

There are two formaldehyde-free resins used in board products, but only one is currently available for non-millwork applications: methylene diphenyl diisocyanate (MDI). Although MDI-based resins do not emit formaldehyde, several toxic chemicals are used in its production, including formaldehyde, and health concerns are more related to its point of manufacture (Healthy Building Network, 2008b). For the purposes of this assessment, binders that do not contain formaldehyde are preferred over PF-based binders. UF-based adhesives are recognized as having the largest negative impact on health. Woolley, in his *Green Building Handbook*, gives OSB a greater negative rating than plywood in his comparison of health impacts on the basis that OSB simply has more potential formaldehyde content that could get concentrated in a home (Woolley, 1997). For this reason, PF-based OSB is considered less preferable to PF-based plywood.

Thus, in order of preference from least to most impact:

No added formaldehyde binders used (NAF)

Phenol formaldehyde binders used – plywood (NAUF)

Phenol formaldehyde binders used – OSB (NAUF)

Urea formaldehyde binders used

7.3.2.3 Sourcing

Ensuring that panel products are harvested sustainably through 3rd-party certification is important, but manufacture should be sourced as locally as possible to avoid unnecessary carbon emissions associated with transporting the material. Use of locally reclaimed or re-used panel products is the environmentally preferable option. The source of manufactured panel products, in order of preference, is as follows:

Reclaimed, salvaged, or re-used

Of Ontario origin

Of North American origin

Other

Table 7.3 Summary of Material Impact Categories: Composite Boards - Structural			
COMPOSITE BOARDS – Structural		Major issues associated with impact category	Suggested methods to reduce impact
Resource Use and Manufacture (Total points: 4)		- depletion of renewable resource in manufacture (wood and petro-chemical binders) - energy/environmental impact of production	- use wood harvested sustainably - use waste wood - reduce amount of binders
4	FSC-certified plywood		
3	SFI-certified plywood		
2	Non-certified plywood		
1	Oriented Strand Board (OSB)		
Health (Total points: 4)		- binders that hold wood together contain formaldehyde (carcinogen, health hazard)	- minimize or eliminate formaldehyde (esp. urea)
4	No added formaldehyde binders used (NAF)		
3	Phenol formaldehyde binders used – plywood (NAUF)		
2	Phenol formaldehyde binders used – OSB (NAUF)		
1	Urea formaldehyde binders used		
Sourcing (Total points: 4)		- Manufacture and transportation of board products causes carbon emissions	- minimize transportation
4	Reclaimed, salvaged or re-used		
3	Of Ontario origin		
2	Of North American origin		
1	Other		

7.4 Drywall

7.4.1 Overview

Drywall, or gypsum board, is by far the most common wall surface material used in North American residential renovations, present in almost 100% of all projects (Foster et al, 2007). In a complete remodel, an average home will use over 7 tons of drywall (Foster et al, 2007). There are several categories of drywall that contain additional chemical additives or material reinforcements. These are designed for use in wet locations, to achieve a certain fire rating, or for other specialized purposes (Gesimondo & Postell, 2011). This assessment tool examines only the most widely used type of drywall in residential work: paper-faced ½ inch wallboard. National Gypsum has developed new "ultra-light" drywall and Certainteed is marketing a new "aircleansing" drywall product, both of which warrant future impact category assessment, but for now these materials are not easily available for the Canadian small-residential market and the unique composition of the products is a not disclosed, making their evaluation difficult for purposes of this tool.

Ninety-five percent of drywall by weight is comprised of the gypsum core, and five percent of the product by weight is the paper sheathing that encapsulates it (Rider et al, 2011). In North America, almost all of the paper used by every major manufacturer contains 100% recycled post-consumer content, mainly from newspaper and cardboard (Pharos Project, n.d.). Thus, although recycled paper use is promoted by manufacturers as an "eco-friendly" component of their product, this alone does not differentiate one specific product from another. Post-consumer recycled content in drywall, reported by weight, is therefore referring only to the presence of recycled paper content when reported as 5% of the total. Post-consumer recycled content that is greater than 5% by weight can be assumed to originate from drywall recycling. The gypsum used in drywall is either newly mined or from recycled sources. Post-consumer recycled content is derived from drywall scraps and pre-consumer recycled content is synthetic gypsum sourced mainly from fly ash, a by-product of the coal industry (Rider et al, 2011).

New drywall production and gypsum recovery are both energy-intensive processes (Gesimondo & Postell, 2011), with the majority of energy at manufacture used in the drying process to harden slurry into solid boards (Pharos Project, n.d.). Comparatively speaking, and given the lack of data for the manufacturing process across products and companies, the energy input towards manufacture can be considered equivalent and is thus not included as a comparative assessment priority. Drywall is also known to include chemical additives, which assist in the manufacture of the product, and these can embody up to 2.5% of the entire material by weight (Pharos Project, n.d.). As these additives are not usually declared by manufacturers, and as they are likely present in somewhat similar amounts for every product, potential toxic material content between brands is not included as a comparative assessment priority. Durability between various drywall products of this type is also considered close enough to not warrant a comparative assessment in this tool.

7.4.2 Impact Categories

The following is the identification and rationale for the impact categories chosen for Drywall. A table summarizing these findings is provided at the end of this section (Table 7.4).

7.4.2.1 Materials – Recycled Content

Raw gypsum ore is a non-renewable resource and thus the use of new gypsum in drywall is of greater environmental impact than the use of recycled gypsum. The use of recycled gypsum in the manufacture of drywall is also likely less energy-intensive than the mining and transportation of virgin material (Foster et al, 2007). For these reasons, drywall with a higher over-all recycled content scores higher in this impact category. Where over-all recycled content is somewhat similar, a higher assessment is given to the drywall brand with the greater post-consumer recycled content. This indicates a preference for material that can be easily recovered in drywall demolition and new use over the waste products resulting in the burning of coal. This valuation also reflects some recent concerns that heavy metals, including mercury, from the coal burning process may transfer in small amounts to synthetic gypsum (Solomon & Roberts, 2012). Drywall recycled content (total, as well as pre- and post-consumer) varies widely depending on the point of manufacture (Pharos Project, n.d.). This assessment tool bases ratings on the recycled content and pre- and post-consumer ratios as reported by the manufacturer for plants located closest to the Greater Toronto Area. The 5% recycled post-consumer content threshold has been chosen as a key differentiator as it represents the use of post-consumer recycled paper content by weight in every drywall product. Products that report higher than 5% post-consumer recycled content are indicating the use of post-consumer recycled gypsum in addition to recycled wood fibre used in the paper face of the drywall, and this is valued more highly. For this tool, assessment of Materials – Recycled Content is as follows, from least to most impact:

90% or greater total recycled gypsum content, >5% recycled post-consumer content

90% or greater total recycled gypsum content, < or = 5% recycled post-consumer content

50%-89% total recycled gypsum content, >5% recycled post-consumer content

50%-89% total recycled gypsum content, < or = 5% recycled post-consumer content

0%-49% total recycled gypsum content, >5% recycled post-consumer content

0%-49% total recycled gypsum content, < or = 5% recycled post-consumer content

7.4.2.2 Materials – New

For the virgin gypsum content used in drywall, a preference is made for sources that are locally mined, as per the following order of preference:

Regional – southern Ontario or north-eastern United States

Sourced from outside southern Ontario and region

7.4.2.3 VOCs

The testing of six drywall brands in the United States by the US Environmental Protection Agency in 2009 indicated that five tested positive for formaldehyde content. In 2003, fifty percent of the drywall samples tested by the government of California did not pass the Section 01350 standards for formaldehyde emissions (Pharos Project, n.d.). Although the off-gassing of formaldehyde and other VOCs in drywall is not usually considered a concern for drywall produced in North America, several companies have undergone voluntary third-party certification of their brands to reassure purchasers that their products meet stringent indoor air quality standards. For the purposes of this assessment tool, and based on the precautionary principle, drywall products that have passed California Section 01350 testing or that have been certified to the Greenguard standard are rated one level higher than drywall products from manufacturers that have not shown independent proof of emissions compliance.

Therefore points are awarded as follows:

Meets California Section 01350 testing/Greenguard Certified

Not independently tested

7.4.2.4 Sourcing

Drywall is produced in several locations across North America, with some manufacturing facilities in Ontario and even the Greater Toronto area. The most sustainable sourcing option for drywall is to choose material that is manufactured as close to the jobsite as possible (Rider et al, 2011). As a reflection of the carbon impact on the transportation of drywall to the retailer, the highest value in this impact category is awarded to products manufactured in the Greater Toronto Area. Products receive an incrementally lesser value as they are located further from the city.

For this assessment, preference is given as follows:

Manufactured in GTA

Manufactured in Southern Ontario/not GTA

Manufactured beyond Southern Ontario

Table 7.4
Summary of Material Impact Categories: Drywall

DRYWALL	Major issues associated with impact category	Suggested methods to reduce impact
Materials – recycled content (Total points: 6)	- raw gypsum is non-renewable resource - pre-consumer recycled drywall uses by product of coal industry	- maximize amount of recycled gypsum content - maximize post consumer content - use of post-consumer recycled gypsum preferable to waste from coal
6	90% or greater total recycled gypsum content, >5% recycled post-consumer content	
5	90% or greater total recycled gypsum content, < or = 5% recycled post-consumer content	
4	50%-89% total recycled gypsum content, >5% recycled post-consumer content	
3	50%-89% total recycled gypsum content, < or = 5% recycled post-consumer content	
2	0%-49% total recycled gypsum content, >5% recycled post-consumer content	
1	0%-49% total recycled gypsum content, < or = 5% recycled post-consumer content	
Materials – new (Total points: 2)	- raw gypsum is non-renewable resource	- use locally mined gypsum
2	Regional – southern Ontario or north-eastern United States	
1	Sourced from outside southern Ontario and region	
VOC's (Total points: 2)	- some drywall tests positive for formaldehyde and other VOCs	- use drywall that is 3rd party certified to contain no formaldehyde/VOCs
2	Meets California Section 01350 testing/Greenguard Certified	
1	Not independently tested	
Sourcing (Total points: 3)	- transportation of drywall causes carbon impact	- choose drywall manufactured closest to jobsite
3	Manufactured in GTA	
2	Manufactured in Southern Ontario/not GTA	
1	Manufactured beyond Southern Ontario	

7.5 Casework and Trim

7.5.1 Overview

Up until the 2000s, solid wood was used almost exclusively for trim work such as baseboards, window casements, and chair rails (Coleman & Piland, 2005). Today, medium density fibreboard (MDF) is the most common material chosen for trim work. MDF is usually made of wood fibre, often held together with a urea-formaldehyde-based binder (Baker-Laporte et al, 2008). Builders tend to select MDF trim products because they are a) inexpensive compared to solid wood, b) more malleable than solid wood, which allows trim to hug wall imperfections, and c) often sold pre-finished with primer, which can save on time and painting costs. However, in recent years, the urea-formaldehyde content of the binders commonly used in MDF has become a health concern, and the formaldehyde it contains is classified as a known carcinogen by the State of California and the World Health Organization (Healthy Building Network # 2 2008b). Sick building syndrome, respiratory diseases, and skin diseases have also been linked to formaldehyde (Woolley, 1997). Manufacturers are now examining the use of new binders for MDF products and marketing the recycled content of the product, claiming MDF as an environmentally responsible choice. This material category assesses the common trim options typically used by contractors in Toronto: Solid wood, finger-jointed wood, and MDF. Plaster mouldings, which are mostly a niche product in the Toronto renovations market, are not part of this assessment tool. It is worth noting, however, that plaster mouldings are generally manufactured with an extruded polystyrene core and an acrylic plaster veneer. The dearth of renewable materials, the high non-renewable petrochemical content, and the inability to recycle the polystyrene when in this form would likely result in a very low over-all environmental assessment.

7.5.2 Impact categories

The following is the identification and rationale for the impact categories chosen for Casework and Trim. A table summarizing these findings is provided at the end of this section (Table 7.5).

7.5.2.1 Health

In this material category, urea-formaldehyde (UF) binders have largely represented the biggest health concern. Formaldehyde itself is the chemical known to cause health issues, but when it is contained in UF it is particularly unstable within the resin and has a tendency to off-gas and affect the indoor environment for some time after installation (Woolley, 1997). Phenol formaldehyde, which is resistant to water and often used as a binder for exterior-grade products, also contains the carcinogenic formaldehyde, but the bond within the resin is much more stable. As a result, phenol formaldehyde emits only 10% of the formaldehyde that urea formaldehyde does (Healthy Building Network, 2008a), and as such is often considered to be a “healthier” choice than UF. However, dermatological and respiratory issues may be present with phenol formaldehyde (Woolley, 1997) and it is also recognized as a suspected immunotoxicant by the United States’ National Institutes of Health (Healthy Building Network, 2008b).

A new soy-based binder, called PureBond and manufactured by Columbia Forest Products, was developed in 2006 and was the first resin to not use formaldehyde at any point in its production (Columbia Forest Products, 2011). Although PureBond has mostly satisfied concerns for negative health impacts on the user, as it emits no formaldehydes, there have been criticisms about the toxicity of one of the feedstock components that is part of its manufacture, specifically epichlorohydrin, which is used to create kymene, a large component of the PureBond resin. Epichlorohydrin is recognized as a carcinogen, a reproductive toxin, and is toxic to humans. The health concern with epichlorohydrin is primarily for those involved at the point of manufacture (Healthy Building Network, 2008a). Another, more common, MDF binder advertised as “formaldehyde free” in some products marketed as “green” is methylene diphynyl diisocyanate, or MDI. MDI is produced from a type of formaldehyde (unlike PureBond) and several other toxic chemicals but, like Purebond, emissions at the installation stage are of less concern that at the production stage (Healthy Building Network, 2008a). In Canada, the adhesives most commonly used for finger-jointed wood products are phenol-formaldehyde based (Chui et al, 2009). Beyond the turpenes naturally found in wood products, with aromatics such as pine or cedar containing more than other species, the VOCs emitted from solid wood are generally benign (Genser, 2007).

This assessment tool ranks health impacts of trim products as follows, from least to most impact:

Solid wood product

Formaldehyde-free binders used

Phenol formaldehyde binders used

Urea formaldehyde binders used

7.5.2.2 Renewable Resources

It is difficult to provide an over-all resource weighting for this material category, as products that may contain high recycled content (e.g. MDF) also contain significant amounts of non-renewable petrochemical-based adhesives. There are several high-recycled wood fibre content MDF products available today that focus on this single attribute and are marketed as “green” products. For this reason, this material category is assessed for both renewable and non-renewable resources and an impact category for end-use disposal has also been added to provide a more holistic assessment of the trim options commonly available in the Toronto area.

In Canada, studies have shown that about 25% of manufacturers use new wood in their MDF products, with products that contain up to 80% virgin materials, and average 34% new wood content (Green Seal, 2001). Most MDF, however, is produced with waste wood from lumber and plywood manufacture. A simple survey of MDF manufacturing locations, provided in some big box store websites as part of the product listing, also indicates that facilities are often located in South America. With concerns for rainforest deforestation in tropical regions, MDF containing third party certified origins for the wood fibre used is given a preferential rating in this tool as a guard against the inclusion of new or waste wood from these areas. Non-third party certified MDF has been given preference over finger-jointed products in this assessment in recognition that most MDF is manufactured from low-grade feedstock (Green Seal, 2001). Finger-jointed trim is produced from low-quality, knotted woods that would normally be discarded but have been cut into short lengths and re-assembled with tight joins and adhesive to create a useful product (Chui et al, 2009). As the feedstock of finger-jointed trim can be considered of a higher quality compared to that of MDF, and given that third-party certification of these products is hard to find, finger-jointed trim is ranked as having a greater impact on renewable resource use. New solid wood trim is recognized as having the greatest impact on renewable resource use, with a preference given to sustainably-sourced feedstock.

In order of preference, renewable resource use for trim products is ranked as follows:

Reclaimed solid wood

MDF – third party certified recycled content

MDF

Finger-jointed solid wood

FSC- and SFI-certified solid wood

Non-certified solid wood

7.5.2.3 Non-renewable Resources

Although MDF is often marketed as a "green" product – mainly due to its use of pre-consumer recycled content from wood waste left over from lumber and plywood processing – about 10% of MDF by weight is comprised of binders from non-renewable petrochemical sources (Ayrilmis & Kara, 2013). Furthermore, the manufacture of these adhesives is generally toxic and requires a high level of embodied energy (Woolley, 1997). This impact category ranks trim products according to the amount of non-renewable resources used in manufacture, with a preference given to solid wood. Finger-jointed wood, which uses a relatively small amount of adhesive compared to MDF, is ranked second.

Thus, in order of preference:

Solid wood

Finger-jointed solid wood

MDF

7.5.2.4 Sourcing

It is important to include sourcing as an impact category for trim materials in order to provide a sound basis for assessment. Non-certified MDF or finger-jointed products that are easily available in some big box stores may appear to have less impact on renewable resource use, but are often manufactured in South American countries where rainforest deforestation is a concern. Energy use in transportation from these countries can negatively contribute to the over-all carbon footprint of the material. In this assessment, preference is given to products with origins as follows:

North America

South America

Overseas

7.5.2.5 Disposal

This impact category has been added to achieve a more holistic assessment of trim materials available in the Toronto marketplace and to help counterbalance environmental claims of manufacturers that tend to focus and market only on one environmentally preferable aspect of their products. The rise in popularity of MDF trim has introduced material into homes that will likely end up in landfill once removed. The resin contained in MDF prevents easy recycling or further chipping, and it cannot be safely burned in biomass for energy programmes (Woolley, 1997). New technologies are being developed to try to recover wood pulp from MDF for manufacture into new MDF products, but these are still being scaled and assessed for cost effectiveness (Bartlett et al, 2012). MDF is also more fragile than solid wood, which can make relocation and re-use difficult. Solid wood trim products can be easily removed and re-used, can be chipped and recycled into new products, and can be burned in waste-to-energy initiatives. Even if land-filled, solid wood trim will not introduce significant amounts of petrochemical-based resins into the environment that may leach out over time. Solid wood products are thus recognized as having a lesser impact at time of disposal than MDF products. Thus, the order of preference for this category is as follows:

Solid Wood Products (including finger-jointed products)

MDF Products

Table 7.5 Summary of Material Impact Categories: Casework and Trim			
CASEWORK & TRIM		Major issues associated with impact category	Suggested methods to reduce impact
Health (Total points: 4)		- Urea formaldehyde binders pose health concern	- minimize or eliminate formaldehyde (esp. urea)
4	Solid wood product		
3	Formaldehyde-free binders used		
2	Phenol formaldehyde binders used		
1	Urea formaldehyde binders used		
Renewable Resources (Total points: 6)		- Depletion of renewable resource (wood)	- Minimize use of renewable resource (wood)
6	Reclaimed solid wood		
5	MDF – third party certified recycled content		
4	MDF		
3	Finger-jointed solid wood		
2	FSC- and SFI-certified solid wood		
1	Non-certified solid wood		
Non-renewable Resources (Total points: 3)		- Petrochemical binders are toxic and have high embodied energy	- minimize or eliminate use of petrochemical binders
3	Solid wood		
2	Finger-jointed solid wood		
1	MDF		
Sourcing (Total points: 3)		- Manufacture and transportation have environmental impact	- reduce transportation by buying as locally produced as possible
3	North America		
2	South America		
1	Overseas		
Disposal (Total points: 2)		- Fragility of MDF makes reuse difficult - MDF resins prevent easy recycling or chipping for fuel	- choose wood over MDF
2	Solid Wood Products		
1	MDF Products		

7.6 Countertops

7.6.1 Overview

Most residential renovations work in Canada involves the remodelling of single rooms (CMHC, 2012), and the rooms that are most often renovated are kitchens and bathrooms. Countertop selection is often a major design component in these rooms and decision that homeowners tend to be actively engaged in. As in flooring, countertops come in a variety of options and manufacturers tend to market according to a single "green" attribute. Stone has, for example, been touted as an environmentally responsible countertop option because it is "natural" and VOC-free (Ehrlich, 2013). In order to provide a holistic assessment of countertop options it is necessary to consider material resource use, impact in manufacture, health impacts, and resultant carbon emissions due to transportation.

7.6.2 Impact categories

The following is the identification and rationale for the impact categories chosen for Countertops. A table summarizing these findings is provided at the end of this section (Table 7.6).

7.6.2.1 Material Resource Use

Countertops can be made of one material or composites of materials, with composites sometimes containing recycled elements bound within non-renewable resources. Recycled content is one area that is often marketed by manufacturers to showcase the "greenness" of a particular product. This impact category examines material resource use with a preference for salvaged or reclaimed content couched within a greater preference for renewable resources over non-renewable resources.

Refinished, salvaged, or reclaimed countertops thus achieve the highest rating using this filter and new products that are entirely formed of non-renewable resources are considered most impactful. Some countertop products are highly manufactured, but use almost no additional material resources in their production. These countertops are generally made of recycled plastic or glass and are given the second highest level of preference in this category. Composite products with a very high recycled content are ranked third in preference. A threshold of 70% or greater of total recycled content is applied so that products of note across a wide variety can be included, such as paper/resin composites and terrazzo-type surfaces that incorporate large amounts of glass. Products whose recycled content falls below this threshold are often highly manufactured laminates that incorporate high-embodied energy petrochemical-based adhesives. While recycled content in countertops is to be lauded, the inclusion of comparatively small amounts is not recognized here and these materials are categorized as having mostly new content from an environmental impact point of view. These "mostly new" content countertops are ranked in order of preference, from those that are minimally processed and made of a single, solid renewable material, to highly manufactured renewable/non-renewable composites, to countertops made almost entirely of new, non-renewable material. For sake of simplicity, a preference between certified and non-third party certified renewable materials is not noted here, but is certainly relevant in the weighing of two otherwise similar options.

Countertop impacts on material resource use have been ranked in order of the following preference, from least to most impact:

Refinished, salvaged or reclaimed

Almost 100% recycled content, highly processed

High recycled content (=/> 70%) – composite products

Mostly new content – single material, renewable

Mostly new content – composite

Mostly new content – non-renewable material

7.6.2.2 Impact in Manufacture

This impact category represents an assessment of the general repercussions of resource extraction and manufacturing of countertop products. Hard data for manufacturing impacts of the various countertop options is not available and the BEES LCA tool does not include countertops amongst its material categories. Green building material guides speak broadly about the benefits and drawbacks of countertop options and the Pharos Project currently only lists countertops that are made of solid polymer (such as Corian) or traditional laminates. The relative assessment of manufacturing impacts is thus a significant challenge but is also vitally important to address, as the material components of countertop options taken alone can lead to a skewed over-all product assessment. For the purposes of this tool and material type, the degree of manufacturing impact can be understood in broad, yet relevant, strokes.

A preference is given to products that do not require a significant amount of processing and a lower rating is provided to products whose manufacture is energy intensive. Re-use of salvaged or minimally processed reclaimed wood is ranked highest in this category. Most countertops are either a result of energy-intensive quarrying or are manufactured composites that use binders that are the result of petrochemical processing. Quarrying operations for stone used in countertops can create soil erosion, contaminate groundwater, and are generally loosely regulated in the countries where most slab material is sourced (Rider et al, 2011). Engineered stone countertop products are generally made of quartz and are often marketed as a more environmentally friendly quarried product, as quartz is mined not as large slabs, but in small pieces that are later ground. The ability to use small pieces of stone creates less waste during the manufacturing process and this appears to be the largest environmental advantage for engineered stone countertops (USGBC, 2009d). This advantage is likely lost, however, once the raw material is processed. Stone taken from the quarry is ground and mixed with synthetic, usually non-renewable petrochemical-based resins and then baked at extremely high temperatures (Foster et al, 2007). Due to this energy-intensive process, this assessment tool ranks the environmental impact of manufacture for engineered stone countertops as being greater than that for non-engineered stone products. Energy intensive laminates and manufactured solid surfaces are still assessed more favourably than commercial-scale quarried stone countertops in regard to environmental impacts during manufacture.

Environmental impacts due to manufacturing of countertops have been ranked in the following order, from least to most impact:

Re-use of salvaged countertop material or reclaimed, minimally processed material

Minimally processed renewable material

Laminates and manufactured solid surfaces

Product a result of quarrying, no resins used

Product a result of quarrying, highly manufactured with resins

7.6.2.3 Health

The potential health impact of countertop materials has come primarily as a result of formaldehyde-based binders (within the particleboard substrate) and glues (adhering the decorative top player) used in laminate countertops (Hodgson et al, 2002). Formaldehyde is a known carcinogen and a trigger chemical for respiratory and dermatological issues (Healthy Building Network, 2008b). Urea-formaldehyde (UF) based resins release formaldehyde into the environment at a much greater rate than phenol-formaldehyde (PF) based resins. For this reason, products that contain PF binders are preferred over those that contain UF-based adhesives (Woolley, 1997). Cashew nut shell liquid resin (CNSLR) is a non-petroleum-based polymer that is used in some paper composite countertops, including PaperStone. CNSLR is sourced from the husk of the cashew nut and then often linked with formaldehyde to create a cordonal-formaldehyde resin (Peek, 2010). This bond is strong enough to manufacture countertops that meet third-party VOC-free requirements, however formaldehyde is still part of the chemical make-up of the resin.

Almost every major green building resource consulted for this paper that references stone countertops indicates that this material may be a source of unwanted radioactivity in the home. Research into countertop radioactivity testing indicates that small amounts of radon emissions can indeed be observed in some types of granite and that quartz was found to generally have negligible emissions. Radon emissions in granite, when rarely present, were found to be less than 7% of levels considered actionable or unsafe in a home by the Unites States EPA. Radon emissions were found to originate mainly from biotite, a uranium-containing black/brown mineral found in some types of granite (Chyi, 2008). For the purposes of this assessment tool, potential radon emissions from stone cannot be included as a blanket health risk factor, however purchasers of granite countertops are encouraged to consider sourcing their material from regions where biotite may not be present.

Apart from the emissions of natural terpenes that are benign to all except the most chemically sensitive (Genser, 2007), un-finished solid wood or butcher block countertops made with food-safe wood glues have little to no impact on health and can be easily installed mechanically and without adhesives. The addition of petrochemical-based sealers or finishes, however, can quickly add large amounts of VOCs to a home and can negatively impact on the health rating of wood as a countertop option – especially if finishes are not applied away from the building site. To maintain wood as a countertop option with little health impact, the use of natural finishes such as walnut, tung, or linseed oil is required (Baker-Laporte et al, 2008). If wood is reclaimed, care must be taken to understand its origins to ensure the surface is food safe and free of toxic products that may have been added in its previous life. Generally, unfinished solid wood products can be expected to rate very highly in this assessment, but are labelled N/A here as third-party VOC certification is not available for this type of countertop.

As in flooring, countertops can contain several materials that can negatively impact indoor air quality, most often due to adhesives and finish coats. Assessing each of these for potential health impacts is not feasible. For this reason, well-recognized industry benchmark standards have been used to establish an order of preference for this impact category. The rating levels suggested here correspond to a simplified version of the Pharos Project criteria for composite wood products.

VOC emission concerns are primarily related to off-gassing of adhesives and finishes. As has been discussed previously, limiting formaldehyde emissions from adhesives is a baseline approach to minimising health impacts from many manufactured products. Compliance with The California Environmental Protection Agency (CARB) Phase 1 and Phase 2 standards are often cited in Countertop product literature. These standards are meant to specifically refer to formaldehyde emissions in composite wood products and must necessarily be met in order for products to be sold or supplied to the State of California. The CARB Phase 1 standard, which came into effect in California during the summer of 2009, permits products to have formaldehyde emissions ranging from .08 to .21 PPM. The CARB Phase 2 standard, effective in California from the summer of 2012, is more stringent with allowable formaldehyde emission ranges of between .05 to .13 PPM (CARB, 2007). Although these regulations are only active in the State of California, they are widely referenced in various rating systems, including the Pharos Project. CARB compliance limits, but does not ban, the presence of formaldehydes in products. CARB compliance likely indicates the use of phenol formaldehyde in place of traditional urea-formaldehyde and products marked NAUF, or no-added-urea-formaldehyde, and without any further certification are assessed as equivalent to CARB Phase 1. Products that are formaldehyde-free or claim NAF (no added formaldehyde) status are thus rated one level higher than those that achieve CARB compliance. These products likely use adhesives based on methylene diphenyl diisocyanate (MDI) or soy binders, such as Pure Bond.

The highest rating for this health impact category, and echoed by most green building standards, is provided to products that achieve third party recognition, normally Greenguard certification, for meeting the California 01350 standard. CA 01350 requirements became slightly more stringent in 2012, and Greenguard's top certification (Greenguard Gold) corresponds to this adjustment. For the purpose of this simplified assessment, a countertop that achieves either CA 01350 standard or Greenguard certification is rewarded an equivalent “best in class” rating. The CA 01350 standard tests for VOC emission rates of eighty chemicals known to have negative health effects, including formaldehyde. CA 01350 does not address every building product-related health impact, its limitations have been noted (Lent 2009), however it remains the North American benchmark for improving material indoor air quality performance.

Countertop impacts on health have been ranked in order of the following preference, from least to most impact:

Meets California 01350 VOC emissions criteria

Formaldehyde free/NAF

Meets CARB Phase 2 standard

Meets CARB Phase 1 standard /NAUF

No certification

7.6.2.4 Sourcing

Countertops tend to be heavy by nature and the transportation of these products can play a significant part in their over-all environmental impact. Products that are quarried and transported as complete slabs are responsible for the largest amount of carbon emissions in this material category (Rider et al, 2011), and most materials transported in this fully intact state, inexpensive granite in particular, are sourced from abroad. In North America, the granite used for countertops originates mostly from Brazil, India, Africa, and China (Kincaid et al, 2010).

Many countertops marketed as “green” may contain high recycled elements and meet stringent VOC regulations, but are shipped as pre-fabricated pieces from the United States’ west coast or overseas. The high carbon impact of transporting heavy materials, even if these materials have certain environmentally friendly attributes, warrants recognition. For the purposes of this assessment, the highest rating for material sourcing has been provided to countertops that meet the stringent requirements of the Living Building Challenge and its appropriate sourcing criteria for heavy or high density materials (International Living Future Institute 2013). The 500 km zone restriction criterion, representing a radius from the point of installation (Toronto), is understood to broadly qualify the northeastern United States and Ontario. European sources are preferred over Asian origins to reflect the closer proximity to Toronto. Preference is given to products with origins as follows, from least to most impact:

Meets Living Building Challenge sourcing criteria for heavy or high density materials

North American, outside of the Living Building Challenge 500km zone restriction

Of European origin

Of South American origin

Of Asian or African origin

Table 7.6 Summary of Material Impact Categories: Countertops			
COUNTERTOPS		Major issues associated with impact category	Suggested methods to reduce impact
Material Resource Use (Total points: 6)		- Depletion of renewable and non-renewable resources is harmful to environment	- Minimize use of renewable and non-renewable resources - Prioritize high recycled content (esp. of non-renewable)
6	Refinished, salvaged or reclaimed		
5	Almost 100% recycled content, highly processed		
4	High recycled content (=/> 70%) – composite products		
3	Mostly new content – single material, renewable		
2	Mostly new content – composite		
1	Mostly new content – non-renewable material		
Impact of Manufacture (Total points: 5)		- Extraction & processing of materials is energy intensive and harmful to environment - manufacture process is harmful to environment	- Prioritize minimally processed materials - Prioritize renewable materials
5	Re-use of salvaged countertop material or reclaimed, minimally processed material		
4	Minimally processed renewable material		
3	Laminates and manufactured solid surfaces		
2	Product a result of quarrying, no resins used		
1	Product a result of quarrying, highly manufactured with resins		
Health (Total points: 5)		- Urea formaldehyde binders and VOC finishes pose a health concern	- minimize or eliminate formaldehyde (esp. urea) and other VOCs
5	Meets California 01350 VOC emissions criteria		
4	Formaldehyde free/NAF		
3	Meets CARB Phase 2 standard		
2	Meets CARB Phase 1 standard /NAUF		
1	No certification		
Sourcing (Total points: 5)		- Transportation of heavy countertops create large carbon emissions	- Source countertop materials as locally as possible
5	Meets Living Building Challenge sourcing criteria for heavy or high density materials		
4	North American, outside of the Living Building Challenge 500km zone restriction		
3	Of European origin		
2	Of South American origin		
1	Of Asian or African origin		

7.7 Flooring

7.7.1 Overview

This assessment category examines various types of new solid flooring products, although it should be noted that, where possible, re-finishing existing wood floors is the environmentally preferable over-all approach. In Toronto, there exists a significant stock of pre-1960s homes due for remodelling that maintain original hard wood flooring, often hidden and well-protected over the years by wall-to-wall carpeting that became a later fashion. The re-use of existing floors limits the impact in manufacture to new finish coats, reduces the carbon impact on transportation for large amounts of flooring materials, prevents the creation of waste materials to landfill, and significantly lessens the general resources involved in this aspect of a renovation. The re-finishing of floors usually requires sanding, followed by the application of stain and then a wear layer. Although natural, less environmentally impactful options exist including tea and coffee staining, and beeswax, tung oil, and linseed oil finishing, these don't meet the durability or familiarity of use of synthetics and the average renovations contractor and client will almost always tend toward more conventional off-the-shelf options. In this case, VOC emissions are of primary concern and floor finishes should be water-based and chosen such that they comply to South Coast Air Quality Management District Rule 1113, Architectural Coatings: 250 g/L for stains and 100 g/L for floor coatings, a minimum standard referenced by LEED Canada for Homes (CaGBC, 2010), GreenSpec, and other green building standards and directories.

The flooring products assessed here are representative of the most common, readily available formats of each type. To allow for the most accurate comparative assessment, most of the products in this category can be installed without the need for adhesives. Although cork flooring is available in natural, unfinished squares, and in this uninstalled format would receive a favourable assessment in most impact categories, the cork flooring assessed here is that which is most commonly available in the Toronto marketplace: a tongue-and-groove product comprised mainly of high density fiberboard (HDF), with a thin cork veneer and polyurethane wear layer (Building Green, 1996). Research into suggested installation of non-tongue-and-groove natural cork tiles indicates that the process is fairly specialized and complicated, involving the addition of sub-floor, adhesives, and various finish coats (Jelinek Cork Group, n.d.). This process effectively transforms the unfinished cork tile into a new compound of materials not too dissimilar from tongue-and-groove products. Similarly, natural linoleum products are mostly sold in the Toronto market with a petrochemical-based wear layer, require additional adhesives to install, and require absolutely flat surfaces for application. In the residential market, these products are mostly considered in the engineered floating floor form. Thus for this tool exclusively readily available cork plank and natural linoleum products are assessed. It should be noted again that, as with most flooring products, the surface of natural cork can be treated with a non-toxic and natural carnauba wax (Daum & Freed, 2010), but the decrease in durability and need for regular re-application does not make this an option that the general Toronto marketplace is willing to bear.

Although carpeting is not included in this assessment tool, it is worth noting that various life cycle analyses indicate that this type of flooring is consistently one of the worst performing of any option (Boyer, 2009). Surprisingly, natural wool carpeting is shown to be the worst environmental offender of this category, with over five times the environmental impact of synthetic, nylon alternatives (NIST, n.d.). This is due to the total carbon emissions produced during the lifecycle of raised sheep for this purpose.

7.7.2 Impact Categories

The following is the identification and rationale for the impact categories chosen for Flooring. A table summarizing these findings is provided at the end of this section (Table 7.7).

7.7.2.1 Impact of Manufacture

This impact category, representing an assessment of the general repercussions of resource extraction and manufacturing of flooring products, is underpinned on a simplification of environmental performance results for a variety of general floor options as discussed in Jim Bowyer's Life Cycle Assessment of Flooring Materials: A Guide to Intelligent Selection (Boyer, 2009) and illustrated using the BEES Online LCA comparative analysis software (NIST, n.d.). Here, the type of manufactured flooring product and not the base material itself is assessed. It is necessary to do this as the products available in the marketplace may be based upon the same foundation, but can range from highly processed to relatively low processed end goods. Although some small variation may exist in the relative impact of manufacture in similar flooring types (e.g. solid single material products, floating floors, etc.), these can be categorized into five distinct classes that broadly indicate over-all environmental impact due to manufacturing.

Boyer's LCA research into various flooring options suggests that bio-based solid flooring consistently performs better environmentally than synthetic materials and highly processed products. Boyer also indicates that common petrochemical-based coatings on pre-finished flooring is the other factor that significantly adds to the environmental impact of these products. As an example, Boyer illustrates how BEES LCA data can be used to show that natural cork tile performs better environmentally than almost any other floor surface material. However, once processed into a floating floor plank, the manufacture and added weight of the HDF core, combined with the synthetic wear layer coating, is shown to more than double this material's over-all environmental impact (Boyer, 2009).

This assessment tool simplifies Boyer's LCA findings to rank flooring manufacturing impacts in broad terms. Simply manufactured flooring is ranked ahead of products that require significant production energy inputs and the addition of what are normally petrochemical-based adhesives. Following arguments expressed in earlier material categories, composite products containing plywood cores are considered slightly less impactful from a manufacturing perspective as compared to HDF/MDF cores. Only bio-based flooring products are considered here.

Materials are thus assessed in order of least to most environmental impact as follows:

Solid single material, minimally processed

Simple composite

Composite – plywood core

Composite – HDF/MDF core

HDF/MDF core, synthetic veneer

It is necessary to note that this assessment category treats all floors as if they are finished, including wood products that are sold unfinished. The on-site addition of a wear layer to unfinished flooring has the potential to make a significant negative impact on the over-all environmental performance of an installed floor. The choice of conventional stains and sealers to finish flooring in situ not only negates the environmental benefits of the unfinished product in this impact category, but is likely to have a much more deleterious effect on indoor air quality as compared to pre-finished products (Baker-Laporte et al, 2008). In sum, the environmental benefit of unfinished flooring in this impact category can only be truly realised if it is finished using a non-petrochemical natural oil or similar product, even if the natural alternative requires regular reapplication (Boyer, 2009). For this reason, this assessment tool includes a separate column that indicates whether or not a particular product is manufactured as a finished or unfinished floor. Unfinished floors are, perhaps, unfairly graded in this impact assessment of flooring products and an assumption has been made for the sake of comparative simplicity that the application of most commonly used finishes will result in a similar over-all assessment to pre-finished products. That said, an unfinished product represents a significant opportunity to reduce the over-all impact of a new floor. The presence of a finished/unfinished column in this material category draws attention to this potential.

7.7.2.2 Resources

This impact category represents a simplified ranking of resource use in primarily bio-based floor systems. The use of renewable materials and recycled products is combined and balanced with relevant 3rd party certifications for sustainable sourcing. As with other material categories, flooring that is salvaged or re-used with minimal processing is considered to have the least amount of impact on resource use. Flooring products that contain significantly large amounts of recycled material, usually present in the MDF/HDF core of engineered flooring, is assessed as having less of an impact on resources compared to floors manufactured entirely from new material. Floors made of rapidly renewable virgin resources (e.g. bamboo) are deemed less impactful than slower-growing virgin wood-based products. Third-party certification for the sustainable harvest of new materials is given preference within each category.

For the purposes of this assessment, resource use in flooring from least to most environmental impact is assessed as follows:

Refinished, salvaged, and reclaimed

Primarily waste or recycled fibres (engineered products)

Primarily rapidly renewable content – 3rd party certified

Primarily rapidly renewable content – Non-certified

Primarily renewable content – 3rd party certified

Primarily renewable content – Non-certified

7.7.2.3 Health

Health impact concerns of flooring products closely mirrors that of laminate countertops. Similar third-party certifications are thus commonly used by industry for both material categories and the assessment methodology for this tool is the same. Both Greenguard and Floor Score are third party certifications that independently verify adherence to the CA

01350 standard. As outlined in the countertop health impact category, products that meet this multiple VOC emissions standard are considered preferable to those that reference only compliance to formaldehyde emissions at various levels.

Flooring impacts on health have been ranked in order of the following preference, from least to most impact:

Meets California 01350 VOC emissions criteria

Formaldehyde free/NAF

Meets CARB Phase 2 standard

Meets CARB Phase 1 standard /NAUF

No certification

7.7.2.4 Sourcing

Individual product options of the same flooring material can have widely different origins. Environmentally preferable flooring materials can also be sourced thousands of kilometres away from their point of purchase, thus making the carbon impact of their transportation a factor in any environmental assessment (Foster et al, 2007). This impact category highlights the value of considering the origin of a material, prompting a pause for thought when weighing options, such as comparing third-party FSC-certified new Canadian hardwood floors to (for example) reclaimed, but exotically sourced alternatives. In this impact category, the highest rating is provided to existing floors that are refinished in the home. After re-use of in-situ materials, ratings are reduced by a factor of one, starting from “regional” materials that satisfy the flooring sourcing requirements of the stringent Living Building Challenge (International Living Future Institute, 2013) to products comprised primarily of non-North American or overseas content.

From “best” to “worst”, the following indicators have been used in this impact category:

Re-finished existing floor (in-situ);

Meets Living Building Challenge sourcing requirements (within 2,000km of project);

Primarily of North American content;

Mix of North American and non-North American/overseas content;

Primarily of non-North American or overseas content;

Table 7.7 Summary of Material Impact Categories: Flooring			
FLOORING		Major issues associated with impact category	Suggested methods to reduce impact
Impact of Manufacture (Total points: 5)		- Highly processed manufacturing is energy intensive - Petrochemical adhesives and coatings impact environment	- Prioritize minimally processed materials - Prioritize materials that are bio based over synthetics
5	Solid single material, minimally processed		
4	Simple composite		
3	Composite – plywood core		
2	Composite – HDF/MDF core		
1	HDF/MDF core, synthetic veneer		
Resources (Total points: 6)		- Depletion of renewable and non-renewable resources impacts environment	- Minimize use of renewable and non-renewable resources - Prioritize high recycled content (esp. of non-renewable)
6	Refinished, salvaged, and reclaimed		
5	Primarily waste or recycled fibres (engineered products)		
4	Primarily rapidly renewable content – 3rd party certified		
3	Primarily rapidly renewable content – Non-certified		
2	Primarily renewable content – 3rd party certified		
1	Primarily renewable content – Non-certified		
Health (Total points: 5)		- Urea formaldehyde binders and VOC finishes pose a health concern	- minimize or eliminate formaldehyde (esp. urea) and other VOCs
5	Meets California 01350 VOC emissions criteria		
4	Formaldehyde free/NAF		
3	Meets CARB Phase 2 standard		
2	Meets CARB Phase 1 standard /NAUF		
1	No certification		
Sourcing (Total points: 5)		- Transportation of materials in flooring create large carbon emissions	- Prioritize flooring made of locally sourced materials
5	Re-finished existing floor (in-situ);		
4	Meets Living Building Challenge sourcing requirements (within 2,000km of project);		
3	Primarily of North American content;		
2	Mix of North American and non-North American/overseas content;		
1	Primarily of non-North American or overseas content;		

7.8 Interior Wall Finishes

7.8.1 Overview

Given this assessment tool is specifically focused toward the residential sector of the GTA, the range of products in this category are limited to those that can be applied to a drywall or lath and plaster substrate. Products in this assessment are also limited to those that are appropriate to areas that are not expected to experience regular wetting. Impact categories for interior wall finishes have been chosen according to environmental considerations for this material type that are held in common across the green building material resources listed in the literature review of this paper. These considerations have been distilled into the following categories: health, material resources, and disposal.

7.8.2 Impact Categories

The following is the identification and rationale for the impact categories chosen for Interior Wall Finishes. A table summarizing these findings is provided at the end of this section (Table 7.8).

7.8.2.1 Health

VOCs are carbon-containing compounds that evaporate at normal room temperatures. Although not all VOCs are harmful to humans, most of those that are created from petrochemical sources are known to contribute to a variety of human health ailments (Baker-Laporte et al, 2008). The majority of paint used in residential renovations is now water-based acrylic latex and the lack of petroleum-based solvent in these products provides a much-reduced level of over-all VOC emissions (USGBC, 2009c). Minimum emissions allowances for paints in Canada has decreased substantially in recent years as a response to health concerns related to VOCs. Currently, flat coatings must not exceed 100g/L and semi-gloss must not exceed 150g/L of VOCs before the addition of colourant (Canadian Environmental Protection Act, 2009). Although VOC emissions are only a small part of the over-all environmental and potential health impacts of paints, it is an attribute that is intensely marketed in the industry and often of primary concern for homeowners.

Products in this category that market themselves as low-VOC often claim compliance to the California Section 1350 standard for VOC emissions (up to 50g/L of VOCs before the addition of colourant), which is also referenced in the Canada Green Building Council's LEED rating system (CaGBC, 2010). This test protocol, which is an accepted green building standard, is an imperfect benchmark as it was established to minimise VOC emissions that lead to ozone and smog creation and does not directly address health impacts. As a result, VOCs that are hazardous to human health may be exempt from the CA 1350 standard because they do not directly contribute to pollution at the atmospheric level (Pharos Project, n.d.). Most conventional acrylic latex paints also gain VOCs when colourant is added, typically increasing the VOC content of the base white product by about 10g/L (Rider et al, 2011). Some paint companies now provide tints that are VOC free however, for the purposes of this tool, only white paint was compared.

Determining the toxic nature of wet-applied wall finishes beyond VOC emissions is difficult to achieve. Ingredients present in small amounts or considered trade secrets do not need to be declared on a product's MSDS and paint companies are generally unwilling to fully disclose their material content. As a response, the Pharos Project product directory assigns its lowest rank to most paint products in its Manufacturing Toxicity impact category (Pharos Project, n.d.). The only means to achieve a more holistic understanding of the potential toxic nature of paints beyond VOC emissions is to use 3rd party certification standards. Green Seal, an independent non-profit organization, is the most widely acclaimed certifier of wet applied products. Products that achieve Green Seal certification must not only contain less than 50g/L of VOCs, but also be free of several known toxic elements, including heavy metals, phthalates, and formaldehyde (Green Seal, 2011). Green Seal certification provides a more complete assurance of less toxic finishes beyond simple VOC levels and, for the purpose of this assessment tool, products that have achieved this certification are ranked as preferable to those that do not. Natural dry mixed products that are assessed in this tool may not have Green Seal certification, but would qualify and are ranked as most environmentally preferable.

This impact category is ranked according to commonly understood industry thresholds for VOC content.

Truly VOC and resin free, 0g/L

Technically zero-VOC, up to 5g/L, Green Seal certified

Low VOC content, no more than 50g/L, Green Seal certified

Technically zero-VOC, up to 5g/L

Low VOC content, no more than 50g/L

Conforms to Canadian VOC regulations for architectural coatings, less than 100g/L (flat)

7.8.2.2 Material Resources

This category broadly ranks environmental impacts related to the manufacture of various interior paint products available in the Toronto market. Given the limited amount of publicly available information on industry "secret" ingredients and product-specific manufacturing processes, this assessment relies on products grouped by type and overlooks what are likely relatively minor variances between brands and their impact on resources. In the Green Building Handbook Vol. 2 (Woolley 2000), Tom Woolley provides an environmental assessment of a variety of wall finishes. Woolley broadly rates materials according to five comparative levels of impact. Production impacts are assessed across eight categories. For the purposes of this simplified tool, Woolley's findings for individual manufacture-associated impacts are condensed into one single impact category and form the basis this assessment.

In residential renovations work water borne acrylic, often called latex, paints are most commonly used. Acrylic paints are usually petrochemical-based, create large amounts non-biodegradable waste during manufacture, and often contain biocides and fungicides that are not declared on product MSDS (USGBC, 2009c). Of synthetic petrochemical-based paints, acrylic latex products perform slightly better environmentally than alkyd (or oil based) products that also tend to have a large amount of hydrocarbon solvents and therefore more non-renewable content (Woolley 2000). Alkyd paints, which tend to release much higher amounts of VOCs than acrylics, are becoming increasingly rare in the renovations industry as homeowners become more concerned about VOC emissions in paint products. Some older paint contractors, however, prefer the coverage and the ease of using alkyds and have been known, in this author's professional experience, to try to introduce these products to their jobsites.

Performing better than new petrochemical-based paints from a resource perspective are alternative, "natural" wall paints. Natural oil paint binders are derived from plants and pigments are not from synthetically manufactured petrochemical derivatives. Natural paints of this type available in the Toronto marketplace use mineral-based pigments, which are products of mining. These plant-based alkyd emulsions are generally modified plant oils that have undergone a level of processing that is not normally disclosed in product literature. Research into bio-based epoxy resins indicates that there are several ways to formulate these products and it is not easy to define the over-all environmental impact of bio-based resin manufacture with publicly-available information (Balart et al, 2012). A drawback of most ready-to-use wet products, including "natural" paints, is the need for preservatives, biocides and defoamers. These typically appear in amounts that are less than 1% by volume and are not declared on product MSDS' (Baker-Laporte et al, 2008). These drawbacks aside, the higher level of renewable resources in natural oil paints is responsible for a preferred rating in this category, as compared to conventional acrylics (Woolley 2000).

Non-oil-based wall finishes are assessed marginally better than vegetable oil resin-based paints and are purchased as a dry mix and re-hydrated with water. Both clay plaster mix and milk paints can be sourced locally in Toronto, although most clay plaster is purchased as a refined product called American Clay, from the southwestern United States. In the Green Building Handbook, Woolley assigns these alternatives a larger impact in his category of non-bio-based resources as compared to vegetable oil based resin paints.

Woolley's reasoning is that both natural clay products and milk paints contain fairly significant non-renewable resources such as clay and limestone, the extraction of which can be damaging to the region it is sourced from. Woolley's comparative assessment, however, takes into account less processed versions of vegetable oil resin based paint products and the unknown additives present in North American ready-for-use "natural" paints are considered industry secrets and do not need to be declared. Both clay plasters and milk paints are sold as dry mixes and do not require potentially impact-heavy biocides and de-foaming agents.

As this impact category is separated from VOC emissions and toxicity concerns, the wall finish that receives the highest material resource rating is recycled acrylic emulsion paint. Boomerang Paints, which recovers leftover paint from Eastern Canada, is made of 99% recycled content and 1% of new materials that include biocides, dryers, and other unspecified quality control additives (Piepkorn & Wilson, 2006). Although these additives are not declared, this is not unusual for the paint industry and these materials are largely present in most paint products. From a purely resource and waste-based perspective, recycled acrylic paints directly remove (or at least delay the introduction of) highly toxic materials from the waste stream and thereby perform better in this impact category than even the most natural of wall finishes that still require non-renewable resource inputs.

In order of preference, resource and material use is ranked as follows:

Synthetic petrochemical-based (Acrylic emulsion paint) – recycled

Non-resin containing, non-petroleum-based paints and plaster (milk paint, clay)

Non-petroleum-based (soy-based resin)

Synthetic petrochemical-based (Acrylic emulsion paint)

Synthetic petrochemical-based (alkyds)

7.8.2.3 Disposal

Most wet-applied wall finishes are essentially petrochemical plastic products that are not biodegradable and will potentially persist in the environment, even if as microscopic particulate, for hundreds of years (Foster et al, 2007). This environmental impact category has been included in this material assessment to draw attention to the long-term impact of coating our walls in liquid plastic. Wall finishes are assessed simply as ecological, indicating minimal disruption to the environment, or persistent after end of useful life.

Table 7.8
Summary of Material Impact Categories: Wall Finishes

WALL FINISHES		Major issues associated with impact category	Suggested methods to reduce impact
Health (Total points: 6)		- VOC emissions in finishes pose a health concern	- minimize or eliminate VOCs
6	Truly VOC and resin free, 0g/L		
5	Technically zero-VOC, up to 5g/L, Green Seal certified		
4	Low VOC content, no more than 50g/L, Green Seal certified		
3	Technically zero-VOC, up to 5g/L		
2	Low VOC content, no more than 50g/L		
1	Conforms to Canadian VOC regulations for architectural coatings, less than 100g/L (flat)		
Material Resources (Total points: 5)		- Synthetic Petrochemicals in paints create non-biodegradable waste during manufacture - Wall coverings contain biocides, fungicides or preservatives - Synthetic petrochemicals in paints contain high non-renewable content	- Prioritize recycled content - Prioritize materials that are natural bio based - Choose materials that do not require biocides - Reduce or eliminate synthetic resins
5	Synthetic petrochemical-based (Acrylic emulsion paint) – recycled		
4	Non-resin containing, non-petroleum-based paints and plaster (milk paint, clay)		
3	Non-petroleum-based (soy-based resin)		
2	Synthetic petrochemical-based (Acrylic emulsion paint)		
1	Synthetic petrochemical-based (alkyds)		
Disposal (Total points: 2)		- Petrochemical wall coverings are not biodegradable	- Prioritize wall finishes that will cause minimal disruption to environment at disposal
2	Ecological		
1	Persistent		

8. Population and use of the Green Building Materials Assessment Tool

Material categories in the assessment tool were populated with market data from products chosen as representative of materials readily available in the Toronto market as of July 2013. These products included both conventional and "green" options so that price comparisons can be made and concerns regarding the potential added cost of "green" materials can be addressed. Research on product availability and pricing was made over several phone calls to Toronto distributors and retail outlets and additional product information, including material safety and technical data sheets and corporate sustainability/environmental policies, was researched from manufacturer websites. This data was used to populate the toolbox and, where applicable, hyperlinks were added to ensure this information was easily accessible to the user. An expanded version of the toolbox, containing detailed information that forms the justification of the given ratings, can be seen in Appendix A. However, for ease of use, many of these columns are hidden from print views in order to provide a more simplified look, such as that shown below in Figure 8.1.

Figure 8.1
Drywall Section of Green Building Materials Assessment Tool: Condensed version

DRYWALL	Brand	Cost/4'x8'x1/2" Standard SHT	Manufacturer	Where to buy	Sourcing	1. outside Southern Ont; 2. Southern Ont/not GTA; 3. GTA	Materials Use: recycled	1. 0-49% Total, 5≤ post; 2. 0-49% total, >5 post; 3. 50-89% Total, 5≤ post; 4. 50-89% total, >5 post; 5. ≥90% Total, 5≤ post; 6. ≥90% total, >5 post	Materials Use: New materials	1. South ON or NE USA; 2. Outside the region	VOC	1. No 3rd party; 2. Greenguard/CA-01350	MAJOR ENVIRONMENTAL CONCERNS ASSOCIATED WITH THIS CATEGORY
	Certainteed Regular	$7.47/SHT	Certainteed	Rona	Mississauga, ON		95% total recycled content -13% post cons. & 82% pre cons. (Miss, ON Plant)		270km - Sarnia, On		GreenGuard Gold		* Raw gypsum is non-renewable resource * Pre-consumer recycled drywall uses by product of coal industry * Some drywall tests positive for formaldehyde and other VOCs * Transportation of drywall causes carbon emissions
	CGC Regular	$7.96/SHT	CGC	HomeDepot Stockyards	Hagersville, ON		26.1% total recycled content - 4.8% post cons. & 21.2% pre-cons. (Hagersville Plant)		76% from 10km - Hagersville, ON & 21% from 290km - Tomkins, NY		Not certified		
	Georgia Pacific Regular	$12.19/SHT	Georgia Pacific	HomeDepot Stockyards	Caledonia, ON		55% total recycled content -4% post cons. & 51% pre-cons. (Caledonia Plant)		370km - Munroe, MI		GreenGuard Gold		
	LaFarge Regular	$12.19/SHT	LaFarge	Builders Supplies Ltd.	Buchanan, NY		99% total recycled content -5% post cons. & 94% pre-cons. (Buchanan Plant)		400km - 50% - Aquasco, MD & 50% - Newburg, MD		GreenGuard Certified		

This assessment tool was expressed in a spreadsheet database that was formatted such that additional material categories and product brands can be added at a later date. The tool was separated into eight material categories. Impact categories for each material category were listed across the top of the page and specific products for each material category were listed on the left hand side of the page. Impact categories and their total achievable scores (or points) specific to each material category, as outlined in the research, appear as a numbered total point indicator die next to the heading of each impact category. The total score achievable in an impact category ranged from two to six points (or dots on the die) and was dependent on how many impact categories were deemed appropriate for the material. Each available point in an impact category was listed vertically with a brief description next to the total point indicator die. Products were given a separate rating for each impact category, expressed both as a total number on a die and as a coloured bar graph that corresponded to the vertically listed available points for each impact category. The higher the number of points the more environmentally preferable the product. In order to aid in the comprehension of the points scored, colours were assigned to the bar graphs. Universally, a score of one was assigned a red colour as it was always considered to be the least environmentally preferable option. Universally, the highest point achievable was assigned a dark green colour. Any points scored between these extremes were assigned increasingly lighter shades of red or darker shades of green.

In this tool, the greater the number of points, the better the environmental performance of a product in that impact category. Given the inherent complications of environmental material assessment and weightings, products were not assessed a single comprehensive environmental score. Points contain equal value only within each impact category and are not necessarily equivalent across impact categories. Thus a simple tally of total points awarded for a product across impact categories does not necessarily imply the better product. This material assessment tool only indicates relative performance of products within established impact categories for each material type to assist the user in achieving a general understanding of how the choice performs under the simplified criteria outlined in this research. The weighting of impact categories within each material type, and how this affects decision making, is thus open to the subjective assessment of the user.

Individual products listed in the database appear as hyper-links and, when clicked, bring the user to the manufacturer's most appropriate product page for that item. This allows the user to easily browse product specifications and options. The assessment tool was also designed so that it can be comfortably sized to print on letter-sized pages and, when presented in colour, can be used as an on-site reference when a computer or internet connection is not available.

A "Price" column was included that provides a current unit price (as of July 2013), where applicable, for each product listed in the database.

The "Where to buy" section was hyper-linked. A click on the notation for each product directs the user to the most relevant page showing distributor contact information.

Each material category was also given a summary section of major environmental impacts associated with the category.

9. Review of Limitations and Improvements of the Populated Toolbox

There are some key limitations to the assessment tool that should be noted, as well as some areas that could be further developed to increase the utility of the resource for marketplace use.

The tool is not an exhaustive assessment of every material available for the residential market. This toolbox is representative of some of the major purchases that a residential renovator might make in a typical interior remodelling project. A more expansive list of material categories lies beyond the time limitations for this research paper. The format and design of this resource is, however, a model that satisfies the needs of the residential renovations marketplace and is easily replicable and expandable with the addition of further research.

Cost data for products included in the toolbox was obtained as retail pricing over the phone or retrieved from retailer or manufacturer prices posted on-line. However, retrieving accurate costing for some products is complex due to differences in prices for design variations (i.e. certain models are more or less expensive than others). In addition, pricing of some products is variable across different distributors or retailers. For instance, the pricing of countertop options proved exceptionally difficult as even a countertop built of the same material can vary widely depending on total linear footage, thickness, shape of the counter, type of edging, the size and number of cut-outs required, the support materials used, and the difficulty of installation. Many countertop purchases are bundled with installation, which made isolating unit material costs difficult. Over time, prices of the products assessed in this toolbox would need to be refreshed in order to keep the database current.

In order to provide a reasonable cost comparison between products within material categories, products of similar unit size were researched. As a result, the various flooring products that appear in the toolbox are planks of the same width, countertops were assessed using the same template, and paint costs were all considered with the same finish. A direct purchase cost comparison between products was thus achieved, however this data is limited to the product varieties included in the toolbox. Where exact costing for a material variety is not present, the impact categories contained in the toolbox remain relevant and can continue to be used to help guide a homeowner or contractor to evaluate and select products.

New building products are being introduced to the market on a regular basis and environmentally preferable materials are increasingly readily available. FSC-certified lumber, low or zero-VOC paints, and NAUF wood panel products can now be purchased at many big box building stores and no longer need to be specially ordered. Product information is highly subject to change. The long-term utility of the material assessment toolbox that has been developed is dependent on regular active inputs to remain relevant.

The toolbox is useable as a paper-based resource, but its full functionality is gained as a web-enabled spreadsheet. The hyperlinks currently embedded in the design allow instantaneous access to most significant product information. These links could be expanded to include retailer maps, store representative information, and job purchase calendar dates to increase its utility as a purchasing tool. Its development and resizing into a tool for mobile applications would ensure that assessment information during purchase runs is close at hand. An expansion of the tool could also allow the uploading of project plan drawings and material take-offs. Some contractors use cloud computing programmes, such as Google Drive or BuilderTrend, to store project information. This assessment tool could be uploaded to these cloud applications and accessed anywhere an internet connection is available, including a client's home during a review of possible material purchase options.

10. Conclusion

10.1 Observations and challenges

There is a significant amount of confusion, misinformation, and lack of information in the residential renovations marketplace that prevents environmentally preferable materials from being integrated into home remodelling projects. A variety of material assessment tools, databases, and guidebooks are available to aid in decision-making, however a review of these resources found these lacking in utility for the average Toronto-based homeowner and contractor. Existing tools were found to be too complicated for the non-design or non-green building professional, or lacking in sufficient academic rigour to provide a useful comparative assessment. Material databases were found to be extremely limited in scope and populated with products unavailable in the Toronto marketplace. Key data, such as cost and retailer information, was rarely observed. It was concluded that informed purchasing of building materials by residential renovations contractors and their clients required a green building material assessment tool designed specifically for the needs of the Toronto marketplace.

The assessment tool created as a result of this research borrowed from some of the elements found to be especially successful in other tools. The product-specific nature of *The Pharos Project* was a large influence on the design of the toolbox. The simplification of environmental impacts into five broad categories in *The Pharos Project* was deemed a user-friendly way to represent complicated information. The impact categories developed for use in the Toronto-based assessment tool were influenced by those used in *The Pharos Project*, and were further simplified to represent broad relative impacts. Impact categories that were deemed relatively similar between products of a material category were not included in the assessment tool due to insufficient product information being available to assign meaningful differences between these products. The user-friendly graphic representation used by Tom Woolley in his *Handbooks* influenced the design of the Toronto assessment tool, as did his use of a simplified rating system of relative impacts as response to the difficulties inherent in LCA work.

The end result of this research was the development of a green building materials assessment tool that satisfies the particular needs of a Toronto-based homeowner or residential contractor who seeks to integrate environmentally preferable material into his/her projects in an informed manner. The tool provides a greater depth of comparative assessment over other residential market-based resources, and its utility is derived from being geographically relevant in both its impact assessments and its inclusion of often-purchased renovation products available in the Toronto area. Barriers in design and accessibility that could discourage the average homeowner or contractor from using other assessment tools were overcome by simplifying the product ratings and assessment criteria used in the toolbox and incorporating actual pricing and retailer information.

Although the Toronto assessment tool achieves the goal of providing the Toronto-based user with a way to comparatively assess materials for environmental preference, it is not perfect. The comparative assessment of complex products made of numerous, and often very different, ingredients presented a challenge in some material categories. This was particularly true for countertops and flooring. Products in these categories are often composites of several materials and the materials themselves, especially between countertops, can differ considerably. These products are often marketed as "green" by manufacturers based on a single environmentally preferable attribute, such as containing no VOCs, incorporating high recycled content, or using a rapidly renewable resource. However, when placed within a composite, these environmentally beneficial attributes may be outweighed by other aspects of the product. Impact categories for these complex products weigh impacts on health, resource use, manufacture, and material sourcing in order to provide the user with a more balanced perspective of the environmental footprint of each product. This multi-attribute approach is an advantage of the Toolbox over the single attribute certifications that are often applied to these products, however the lack of a weighting between environmental impacts is a limitation. The assessment tool, for example, does not provide a final answer as to whether a locally quarried countertop is environmentally preferable over a highly processed, but 100% recycled, countertop manufactured along the

American West coast. Also, without a full life cycle analysis of each individual component of composite materials, the ranking of preference within some impact categories necessarily required a certain degree of subjective analysis in order to avoid analytical paralysis. This need was felt less at the extremes of an assessment, where the dichotomy between "bad" and "better" are clear. In the case of countertop material resource use, the re-use or refurbishment of a countertop, or a countertop made entirely of 100% recycled material, is a clear preference over products made entirely of new and non-renewable materials. But what of products made of smaller percentages of recycled material, usually combined with non-renewable resources? At what point does the use of recycled material in a product begin to get outweighed by the non-renewable resources that are also part of the composite? How does a new countertop made entirely of solid, uncertified wood compare to a similar product made of a combination of 20% certified recycled content, new uncertified wood, and petrochemical-based binders? The thresholds established in the impact category rankings of some material categories that contain composite products necessarily required subjective input. Although unavoidable given the scope of this research, the result is an imperfect assessment tool.

The potential for misuse of the Toronto material assessment tool also needs to be addressed. The tool is limited to the comparative assessment of readily available material options and it does not provide a full LCA approach to these products. There is a danger that a user may select a more environmentally preferable product using the toolbox without understanding the full environmental implications of that decision. The assessment tool could be used to rationalise purchases that, although preferable to other options, may still have a great over-all environmental impact. The addition of a summary column of recognized issues associated with each material category in the spreadsheet is intended to keep the user aware of the broader environmental concerns, but this may not avoid user complacency from developing. The tool achieves its goal of a simplified and relevant format to help aid in environmentally preferable purchasing, but it does so by focusing on the details between products, avoiding "big picture" implications of these decisions, and limiting its reach to established product lines. Another potential area for misinterpretation of the Toronto toolbox exists in that users may be inclined to add up total "scores" between products of a material category and use this aggregate to determine the "best in class" of a particular material. Although a product that consistently scores best across all categories could safely be considered environmentally preferable to another product that scores less well, products that contain a mix of favourable reviews across impact categories cannot simply be scored in aggregate to determine the most environmentally sound choice. The toolbox, given the scope of this research and the lack of any universally defined approach, avoids weighting impact categories within a material category. This approach is similar to that used in the *Pharos Project* and is necessary to create a simplified assessment system, but the potential for an inaccurate material selection due to the lack of a full LCA weighted approach exists with the Toronto-based assessment tool.

10.2 Potential for continued research

The research begun in this MRP can be expanded to include additional material categories, such as roofing, insulation, exterior cladding, window frames, adhesives and caulks, piping for plumbing, and others. The revision of this assessment tool to include new material categories would require a further review of green building material resources to determine a list of notable environmental impacts commonly attributed to each category. Impact categories for each new material category in the toolbox would be developed by adapting recognized material-specific environmental impacts and concerns to fit the simplified impact categories used in the assessment tool. The impact categories used in the Toronto toolbox are similar to those used in the *Pharos Project* and reflect impacts on health and non-renewable and renewable resource use. Energy use and carbon impacts in the transportation of heavier materials is also considered in the assessment, with Toronto considered as the end use site for any calculations of distance from manufacture. The assessment of products such as window frames or various types of insulation in a subsequent version of this tool may warrant an additional assessment category based on thermal performance, however such a revision would continue to broadly reflect the tool's assessment of a product's impact on resource and energy use.

Further research into the environmental impacts of a material category would then need to be conducted to create a rating system within each impact category that is relevant to the Toronto marketplace. In very similar products, this research would involve separating out the known components of a material category to make the assessment relevant to the Toronto region. This is a key stage in the development of the toolbox, as a Toronto-centric assessment of material options is one of the primary ways the assessment tool differentiates itself from other resources. Two examples of injecting geographic relevance to the existing toolbox included research into the availability of different supplementary cementitious materials in Toronto to indicate a preference for local slag use over imported fly ash in Toronto-produced concrete and research into the post- and pre-consumer content ratios of various drywall manufacturing facilities supplying the Toronto market. This depth of research, which can be replicated for new material categories, created geographically relevant differentiation in environmental impacts between similar products and this information was used to define a rating scale for impact categories for comparative assessment between products. Ratings for future material impact categories that are not affected by geographic location can be determined by adapting research and rankings of other resources to fit the template developed in the toolbox. Examples of this in the current version of the assessment tool include adaptations of Tom Wooley's assessment of various board products, which was also used to help define impact categories in flooring and trim, and the *Pharos Project* health ranking, which was adapted to provide a simplified health assessment in the Toronto toolbox.

Products chosen for inclusion in any future version of the toolbox should be readily available for purchase in Toronto to ensure marketplace relevance. Cost and sourcing data for these products can be acquired through manufacturer websites and by contacting suppliers by email or over the phone. The toolbox is then populated by adding the relevant data to the spreadsheet and assessing each product across the impact categories that have been determined for each type of material.

The potential for a groundbreaking product development or a fundamental change in the composition of a product in a material category, and how this would affect the assessment tool, needs to be addressed. What if a new type of paint, for example, is developed such that the environmentally-damaging whitener titanium dioxide, ubiquitous throughout the industry, is somehow removed from a paint product and replaced with an environmentally benign substitute? Or if a concrete product was developed that made the need for Portland cement obsolete? These types of developments would expose the limitations of the assessment tool as it is currently formed. In wall finishes, the assessment tool assumes that titanium dioxide is necessarily found in commercially available products, just as it assumes that concrete products will contain Portland cement. The environmentally beneficial impact of removing these critical components from these respective material categories would not be expressed in the product ratings as currently devised. However, the assessment tool developed in this research has been designed to be flexible enough to accommodate changes in the marketplace, with the understanding that new products are regularly developed, just as prices also fluctuate. Information can easily be changed and adapted as it exists in the form of an electronic database and the long-term relevancy of the toolbox is contingent on user upkeep. Truly groundbreaking product developments that impact the environmental footprint of a material can be addressed in the toolbox by adding new impact categories to a material category or adapting the impact categories that already exist. The total absence of Portland cement in a concrete mix, for example, could be incorporated into the toolbox with a small revision of the supplementary cementitious material impact category, and the presence of titanium dioxide, or theoretical lack thereof, in paints could be addressed by adding a new binary impact assessment category.

Although the toolbox developed in this research has several inherent limitations, this resource provides its users with the means to assess, select, and purchase environmentally preferable renovation building products in the Toronto marketplace. By expanding the tool to include more material categories and increasing the number of products being assessed, the potential of this resource can be realised.

Appendix A: Toronto-based Green Building Materials Assessment Tool

CONCRETE	Brand	Cost/Cubic M.	Manufacturer	Where to buy	SCM Sourcing & Use	3	1. No SCM 2. SCM Fly Ash 3.SCM Slag	Aggregate Use	2	1. Only clean 2. Recycled agg	MAJOR ENVIRONMENTAL CONCERNS ASSOCIATED WITH THIS CATEGORY
	Holcim/Dufferin Concrete	$135.00/m3	Dufferin Concrete	Holcim/Dufferin Concrete		3			2		* High embodied energy of Portland Cement is a large cause of global carbon emissions * Aggregate is the largest % material by weight in concrete * Aggregate is typically sourced from quarried clean stone
	Innocon	$135.00/m3	Innocon	Innocon		3			1		
	Kreitmaker	$135.00/m3	Kreitmaker	Kreitmaker		1			1		

FRAMING LUMBER		Cost/2"x4"x8' Standard piece	Manufacturer	Where to buy	Resource Use & Sourcing	4	1. Not certified 2. SFI certified 3. FSC certified 4. FSC	Sourcing	4	1. Other 2. North 3. Ontario 4. [illegible]	MAJOR ENVIRONMENTAL CONCERNS ASSOCIATED WITH THIS CATEGORY
	ECO-White Spruce	$2.65/piece	Tembec	Rona	FSC	3		Ontario/Quebec	3		* Deforestation negatively affects soil quality, climate and biodiversity * Transporting lumber causes carbon emissions
	Kiln-Dried Spruce	$2.65/piece	Various	Rona	not certified	1		Ontario/Quebec	3		
	Economy Grade Spruce	$2.42/piece	Various	Rona	not certified	1		Ontario/Quebec	3		

COMPOSITE BOARD	Brand	Cost/sq. ft.	Manufacturer	Where to buy	Resource Use & Manufacture	4	1. OSB 2. Not cert. Plywood 3. SFI cert. plywood 4. FSC cert. plywood	Sourcing	4	1. other/outside NA 2. North America 3. Ontario 4. Halcim, ashegs, rana	Health & VOC	4	1. Urea formaldehyde 2. Phend formald OSB 3. Phend formald plywood 4. No added Formald	MAJOR ENVIRONMENTAL CONCERNS ASSOCIATED WITH THIS CATEGORY
	PureKor Plywood	$1.34/sq. ft.	McKillican	Eco Building Resource	FSC	4		Oregon, USA	2		NAUF	3		* Depletion of renewable resource in manufacture (wood and petro-chemical binders) * Energy/environmental impact of production * Binders that hold wood together contain formaldehyde (carcinogen, health hazard) * Manufacture and transportation of board products causes carbon emissions
	Std Spr Sheathing	$0.77/sq. ft.	Various	Rona	Non-certified	2		Ontario & Quebec	3		NAUF	3		
	Stable Edge OSB	$1.00/sq. ft.	Norbord	Rona	FSC & SFI	1		Quebec & USA	2		NAUF	2		
	OSB Panel	$0.50/sq. ft.	Various	Rona	Non-certified	1		North America	2		NAUF	2		

DRYWALL	Brand	Cost/4'x8'x1/2" Standard SHT	Manufacturer	Where to buy	Sourcing	3	1. outside Southern Ont 2. Southern Ont/not GTA 3. GTA	Materials Use: recycled	6	1. 0-49% Total, 5≤ post 2. 0-49% total, >5 post 3. 50-89% Total, 5≤ post 4. 50-89% total, >5 post 5. ≥90% Total, 5≤ post 6. ≥90% total, >5 post	Materials Use: New materials	2	1. South ON or NE USA 2. Outside the region	VOC	2	1. No 3rd party 2. Greenguard/CA-01350	MAJOR ENVIRONMENTAL CONCERNS ASSOCIATED WITH THIS CATEGORY
	Certainteed Regular	$7.47/SHT	Certainteed	Rona	Mississauga, ON	3		95% total recycled content -13% post cons. & 82% pre cons. (Miss, ON Plant)	6		270km - Sarnia, On	2		GreenGuard Gold	2		* Raw gypsum is non-renewable resource * Pre-consumer recycled drywall uses by product of coal industry * Some drywall tests positive for formaldehyde and other VOCs * Transportation of drywall causes carbon emissions
	CGC Regular	$7.96/SHT	CGC	HomeDepot Stockyards	Hagersville, ON	2		26.1% total recycled content - 4.8% post cons. & 21.2% pre-cons. (Hagersville Plant)	1		76% from 10km - Hagersville, ON & 21% from 290km - Tomkins, NY	2		Not certified	1		
	Georgia Pacific Regular	$12.19/SHT	Georgia Pacific	HomeDepot Stockyards	Caledonia, ON	2		55% total recycled content -4% post cons. & 51% pre-cons. (Caledonia Plant)	2		370km - Munroe, MI	1		GreenGuard Gold	2		
	LaFarge Regular	$12.19/SHT	LaFarge	Builders Supplies Ltd.	Buchanan, NY	1		99% total recycled content -5% post cons. & 94% pre-cons. (Buchanan Plant)	5		400km - 50% - Aquasco, MD & 50% - Newburg, MD	1		GreenGuard Certified	2		

CASEWORK & TRIM	Brand	Cost/Linear Foot Std. 5/16" x 3 1/2"	Manufacturer	Where to buy	Health	Health score (1. Urea Form. 2. Phenol Form. 3. 4. Solid wood)	Sourcing	Sourcing score (1. Overseas 2. South 3. North)	Non-renewable Resources	Non-renewable score (1. MDF 2. Fingerjointed 3. Solid wood)	Renewable Resources	Renewable score (1. non cert solid 2. FSC/SFI 3. fingerjointed 4. MDF (certified) 6. reclaimed)	Disposal	Disposal score (1. MDF 2. Solid Wood)
	Alexandria Solid Clear Pine	$2.10/ln. ft.	Alexandria Pine	HD Locator	Solid Wood (non-FSC)	4	Canada	3	solid wood	3		1		2
	Poplar FSC by special order	n/a	Brenlo	Brenlo	Solid wood (FSC)	4	Canada	3	solid wood	3		2		2
	Alexandria Fingerjointed Pine	$0.89/ln. ft.	Alexandria Fingerjointed	HD Locator	Finger jointed	2	Canada	3	finger jointed	2		3		2
	Timeless Materials Reclaimed soft wood	$2.75/ln. ft.	Timeless Materials	Timeless Materials	Reclaimed Solid Wood	4	Canada	3	solid wood	3		6		2
	Timeless Materials Reclaimed hard wood	$5.00/ln. ft.	Timeless Materials	Timeless Materials	Reclaimed Solid Wood	4	Canada	3	solid wood	3		6		2
	Moulding & Millwork Colonial Baseboard	$4.43/ln. ft.	Moulding & Millwork	Rona Locator	MDF - regular	1	USA	3		1		4		1
	Alexandria Deco Smart Primed MDF Colonial base	$0.59/ln. ft.	Alexandria Deco Smart	HD Locator	MDF 'eco' (not FSC)	2	Argentina	2		1		4		1
	Spero MFSP8910-08 NAUF MDF Colonial	$0.82/ln. ft.	Moulding & Millwork Spero	Rona Locator	MDF - NAUF	2	US/Canada	3		1		4		1
	Plyboo Natural Edge Bamboo baseboard (prefinished)	$4.50/ln. ft.	Smith & Fong	Plyboo Direct	Bamboo NAUF/FSC	2	China	1		2		2		1

MAJOR ENVIRONMENTAL CONCERNS ASSOCIATED WITH THIS CATEGORY

- Urea formaldehyde binders pose health concern
- Depletion of renewable resource (wood)
- Petrochemical binders are toxic and have high embodied energy
- Manufacture and transportation have environmental impact
- Fragility of MDF makes reuse difficult
- MDF resins prevent easy recycling or chipping for fuel

COUNTERTOP	Brand	Cost/sq. ft. (material cost before install)	Manufacturer	Where to buy	Health & VOCs	Health score (1. No certification 2. Carb 1 Formald/NAUF 3. Carb II Formald 4. Formaldehyde 5. CA1350/GreenGuard)	Materials Resource Use	Materials score (1. New mats, non renew 2. Composite, new mats 3. Mostly new, single, 4. Comp. >70% recycle 5. 100% recycled, highly 6. Salvaged, reclaimed, reuse)	Sourcing	Sourcing score (1. Asia/Africa 2. South America 3. Europe 4. NA > 500 km LBC 5. NA ≤ 500 km (LBC))	Impact of Manufacture	Impact score (1. Quarrying/highly Mfr 2. Quarrying/no resins 3. Laminates/Mfr Solid 4. Minimally processed 5. Salvaged/reclaimed)
	Corian Terra Collection 20% recycled content	$21.25/sq. ft.	Dupont	UPPER CANADA MARBLE & GRANITE	GreenGuard GreenGuard Gold	5	20% recycled pre-cons. recycled resin content	1	Manufacturing sites are in Ontario & Quebec	5		3
	Paperstone Countertop	$47.50/sq. ft.	Paperstone	Eco Building Store	VOC free	4		5	Hoquiam WA	4		3
	Icestone Countertop	$55.50/sq. Ft.	Icestone	Eco Building Store	VOC Free	4		4	Brooklyn, NY	4		3
	Corian	$19.50/sq. ft.	Dupont	UPPER CANADA MARBLE & GRANITE	GreenGuard	5	100% new material	1	Manufacturing sites are in Ontario & Quebec	5		3
	3 Form 100% recycled	$35-45.00/sq. ft.	3-form	3-form	Greenguard ISO 14001:2004 certified	5	100% post cons. recycled material	5	Manufactured in Salt Lake City. Imported by truck.	4		3
	Granite	$50-125.00/sq. ft.	Various	Various	Potential radon off gas	1	100% new material	1	Imported from China, Turkey, distrib. from Pensilvania	1		2
	Cambria	$18.25/sq. ft.	Cambria Canada	Cambria Dealers	Greenguard Greenguard Gold Radon Free NSF Certified	5	93% quartz, 7% resin and pigment	2	Quartz is mined in North America, Manufactured Leseur in Minesota	4		1
	CeasarStone	$20.50/sq. ft.	CeasarStone	Ceaserstone Dealers	Greenguard	5	93% quartz, 7% resin and pigment (42% reclaimed post-cons.)	3	Mined all over the world, including Canada, USA, Israel, Manufactured in Israel	3		1
	Stainless Steel	$40-$180.00/sq. ft.	Various	ATH Stainless	no VOC's	5	100% Steel	4	n/a			3
	Ikea Butcher Block	$13.00/sq. ft.	IKEA	IKEA	* Only in the stain	1	100% Beech wood	3	Europe	3		4
	FSC wood countertop	$47.00/sq. ft	Various	Eco Building Store	Not tested, fungicide added	1	FSC Maple from Quebec	3	FSC Maple from Quebec	5		4
	Formica Laminate	$17.50/sq. ft.	Formica	Rona	Greenguard GreenGuard Gold	5		2	Cincinnati, OH	4		3

MAJOR ENVIRONMENTAL CONCERNS ASSOCIATED WITH THIS CATEGORY

- Depletion of renewable and non-renewable resources is harmful to environment
- Extraction & processing of materials is energy intensive and harmful to environment
- Manufacture process is harmful to environment
- Urea formaldehyde binders and VOC finishes pose a health concern
- Transportation of heavy countertops create large carbon emissions

FLOORING	Product	Cost/sq. ft.	Manufacturer	Where to buy	Impact in Manufacture	1. HDF/MDF 2. Composite 3. Comp. Ply 4. Simple composite 5. Solid Product	Health/VOC	1. No certification 2. Carb 1 3. Carb II Formald 4. Formaldehyde 5.	Sourcing	1. Primarily Overseas 2. Mix of NA/other 3. Primarily NA 4. LBC within 2000km 5. Refinish existing	Resources	1. renewable, not 2. renewable, 3rd 3. Rapidly renew, not 4. Rapidly renew, 3rd 5. Primarily waste 6. Refin, reclaim,	Finished	1. Finished 2. Unfinished	MAJOR ENVIRONMENTAL CONCERNS ASSOCIATED WITH THIS CATEGORY
Bamboo Hardwood floating click	Trillium Natural Color Strandwoven	$3.29/sq. ft.	Trillium	Home Depot	100% Bamboo,	4	E1 & Carb II	3	China	1	Not certified	3	UV polyurethane, alum oxide	1	* Highly processed flooring requires manufacturing that is energy intensive * Petrochemical adhesives and coatings impact environment (avoid if possible) * Depletion of renewable and non-renewable resources impacts environment * Urea formaldehyde binders and VOC finishes pose a health concern
	Smith & Fong Natural Unfinished NAUF/FSC	$4.85/sq. ft.	Smith & Fong Plyboo	Taproot Distributor	100% bamboo	4	NAF, FloorScore, CARB II	4	China	1	FSC Pure/100%	4	Unfinished	2	
	Smith & Fong Amber prefinished NAUF/FSC	$5.82/sq. ft.	Smith & Fong Plyboo	Taproot Distributor	100% bamboo	4	NAF, FloorScore, CARB II	4	China	1	FSC Pure/100%	4	Alum Oxide	1	
Bamboo Engineered	Nadurra Bamboo Lock N Float	$4.84/sq. ft.	Nadurra	Nadurra	100% bamboo	4	Formaldehyde Free	4	China	1	FSC	4	UV-cured, water-based, 0-solvent finish	1	
Reclaimed	Timeless Materials reclaimed hardwood floor	$5-8.00/sq. ft.	Timeless Materials	Timeless Materials	Remilled barnboard	5	n/a		Ontario	4	Not certified	6	Unfinished	2	
	Timeless Materials reclaimed softwood floor	$4-6.00/sq. ft.	Timeless Materials	Timeless Materials	Reclaimed softwood	5	n/a		Ontario	4	Not certified	6	Unfinished	2	
Hardwood - non-fsc, imported	White Oak "HNK"	$4.59/sq. ft.	Various	Canfloor	Chinese White Oak	5	n/a		China	1	n/a	1	Alum Oxide	1	
Hardwood - non-fsc, Canadian	Maple Panache	$3.99/sq. ft.	Various	Canfloor	Canadian Maple	5	n/a		Canada	3	n/a	1	finished	1	
Hardwood - fsc, local	Hemlock not prefinished	$2.95/sq. ft.	Haliburton Forest Sawmill	Haliburton Forest Sawmill	Reclaimed Hemlock	5	n/a		Ontario	4	FSC Pure/100%	2	unfinished	2	
Hardwood - fsc, local	DuroDesign hardwood FSC Canadian maple - finished	$5.50/sq. ft.	Duro Design	Duro Dealers	Canadian Maple	5	n/a		Quebec	4	FSC	2	low VOC polyurethane (200g/l)	1	
Hardwood - fsc, local	DuroDesign hardwood FSC Canadian maple - unfinished	$4.50/sq. ft.	Duro Design	Duro Dealers	Canadian Maple	5	n/a		Quebec	4	FSC	2	unfinished	2	
Engineered - fsc	Nadurra Lower Canada Engineered Maple	$7.90/sq. ft.	Nadurra	Nadurra	Canadian maple top, birch plywood core	3		1	Canada	3	FSC	5	polyurethane finish	1	
Engineered - FSC, NAUF	Ecotimber Natural White Oak engineered	$5-7.00/sq. ft.	EcoTimber	ZeroPoint	Recycled post industrial wood fibre (3rd party certified), American White Oak	2	NAUF	2	USA	3	FSC	5	unfinished	2	
Cork	Torlys Florence Designer	$5-7.00/sq. ft.	Torlys	Torlys Dealers	composite HDF, cork, polyurethane binder, solvent free PVA glue	2	CarbII, NAF	4	Quebec	4	FSC	5	acrylic finish	1	
Marmoleum	Forbo Click Square flooring	$6-7.50/sq. ft.	Forbo	Forbo Dealers	Linoleum, formaldehyde free HDF board, cork sheet (cork+polymerized resin)	2	CA1350/CarbII	5	Germany	1	USDA Biobased	5	UV "TopShield" finish	1	

WALL COVERING	Brand	Cost/sq. ft. Based on coverage	Manufacturer	Where to buy	Materials Resource Use	1. Synthetic 2. Synthetic 3. non-petro 4. non-resin, 5. recycled	Health	1. VOC 2. Low <50 3. technically 4. GreenSeal + 5. GreenSeal resin free	Disposal	1. Persistent 2. Ecological	MAJOR ENVIRONMENTAL CONCERNS ASSOCIATED WITH THIS CATEGORY
Paints	Benjamin Moore Natura	$0.16/sq. ft.	Benjamin Moore	Across Toronto	Acrylic pigment - waterborne colourants		< 5.0 g/L VOC's		persistent		* VOC emissions in finishes pose a health concern * Synthetic Petrochemicals in paints create non-biodegradable waste during manufacture * Wall coverings contain biocides, fungicides or preservatives * Synthetic petrochemicals in paints contain high non-renewable content * Petrochemical wall coverings are not biodegradable
	Benjamin Moore Aura	$0.16/sq. ft.	Benjamin Moore	Across Toronto	Acrylic pigment		< 50.0 g/L VOCs		persistent		
	Benjamin Moore EcoSpec	$0.10/sq. ft.	Benjamin Moore	Across Toronto	Acrylic pigment - waterborne colourants		< 50.0 g/L VOCs		persistent		
	BEHR Premium Plus	$0.09/sq. ft.	Behr	HomeDepot Stockyards	Acrylic latex		47.0 g/L VOCs		persistent		
	Boomerang /Rona Recycled	$0.05/sq. ft.	Boomerang recycled Paint	Rona	Acrylic latex		43.0 g/L VOCs		persistent		
	Mythic Paint Classic	$0.13/sq. ft.	Mythic Paint	Sustain Eco Store	Acrylic latex		< 5.0 g/L VOCs		persistent		
	Sherwin Williams Harmony	$0.15/sq. ft.	Sherwin-Williams	Sherwin-Williams	Acrylic latex - colourants do not add to VOC's		< 50.0 g/L VOCs		persistent		
	YoLo Interior	$0.09/sq. ft.	YOLO Colourhouse	HomeDepot Stockyards	Acrylic latex		< 5.0 g/L VOCs		persistent		
Other	American Clay Loma	$0.36/sq. ft.	American Clay	Zero Point	Clay Plaster		0 g/L VOCs		ecological		
	Homestead House Milk Paint	$0.19/sq. ft.	Homestead House Milk Paint Co.	Homestead	Milk Paint		0 g/L VOCs		ecological		
	Green Planet Paints Premium	$0.13/sq. ft.	Green Planet Paints	SIP - Etobicoke	Clay paint		0 g/L VOCs		ecological		

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