RESEARCH REPORT
External Research Program

Ardencraig: Documentation of an Urban Infill and Remodel Project with Sustainability Elements

Canada

CMHC SCHL
HOME TO CANADIANS

CMHC—HOME TO CANADIANS

Canada Mortgage and Housing Corporation (CMHC) has been Canada's national housing agency for more than 60 years.

Together with other housing stakeholders, we help ensure that Canada maintains one of the best housing systems in the world. We are committed to helping Canadians access a wide choice of quality, affordable homes, while making vibrant, healthy communities and cities a reality across the country.

For more information, visit our website at **www.cmhc.ca**

You can also reach us by phone at 1-800-668-2642
or by fax at 1-800-245-9274.

Outside Canada call 613-748-2003 or fax to 613-748-2016.

Canada Mortgage and Housing Corporation supports the Government of Canada policy on access to information for people with disabilities. If you wish to obtain this publication in alternative formats, call 1-800-668-2642.

Ardencraig;

Documentation of a Vancouver Triplex and Infill Project with Sustainability Features.

Produced For:

Canada Mortgage and Housing Corporation
External Research Program
700 Montreal Rd.
Ottawa, Ontario K1A 0P7

Project Officer: Brian Eames

Produced By:

Urban Ecology Design Collaborative
1662 West 75th Ave. Vancouver, B.C.
V6P 6G2 604-261-8910 Fax 604-264-7955

Chesterman Property Group Inc.
Vancouver

Wave Design + Media Inc.
Vancouver

May 10, 2001

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

Table of Contents

Executive Summary

Ardencraig is a heritage-style redevelopment project, that was completed in September 2000 by Chesterman Property Group Inc. in Vancouver. Chesterman converted an existing single family residence built in 1910 into four strata-titled units; three in the converted home and a new coach house in-fill residence on the rear yard. The existing building was a four story, single-family house built in 1910 on a 15.2 x 37.2 m (50 ft. by 122 ft.) lot. The project involved retaining the existing building structure in its present location, expanding the building slightly to the side and rear and adding a two-story coach house unit. The main house was completely upgraded and converted to create three strata-titled units of between 91 and 137 m^2 (975 sq. ft. and 1475 sq. ft).

The project was granted a development permit in May1999 and Allan Diamond Architects were further retained to obtain a Building Permit. Urban Ecology Design Collaborative was retained as consultants on specific environmental issues and Armin Gottschling of Timberland Homes Ltd. was chosen as project manager/general contractor. Heather Tremain of Wave Design was retained to consult on various aspects of design and to co-research the "green" aspects of the project

From the early concept stages of the project, Robert Brown of Chesterman and his design advisor, Heather Tremain, assembled a "Green Team" to set goals and priorities for Ardencraig. At the first Green Team meeting the environmental issues that appeared to be of most concern to the community were discussed. The issues and ideas discussed were as follows:

- Forestry: the continuing use of old growth forests by the building industry is a major concern.
- Land Use and Transportation: continuing urban sprawl and traffic congestion is a major concern.
- The present level of land filling with solid waste is not sustainable.
- Utilities (electricity and gas): the demand for expanded utility capacity and infrastructure is extremely damaging on the environment.
- Water Supply: Logging of watersheds, sale of water out of province, increased population, and replacement cost of obsolete infrastructure is expected to increase demand and cost of water.
- Storm water: Vancouver still has a combined sewer system, though new installations are now separated. Storm water collected from roofs and parking areas mixes with sewage as it enters the city system resulting in overload of sewage treatment capability and poor treatment. In some areas of the city, storm water laden with oil and debris flows into the harbor.
- Air Quality: poor outdoor air quality due to motor vehicles and unhealthy interior air quality caused by moisture problems, dust, poor ventilation and "off gassing" of materials are serious concerns.

The outcome of the Green Team discussions were summarized and a "direction" document created. The main areas of focus were as follows:

- Maximizing the energy efficiency of the building envelope through higher insulation levels, high performance windows and air tightness.
- Minimize use of newly harvested timber. The sources of wood were from the original house and from salvaged timbers from other demolished buildings. Any new wood was to be certified "sustainable".
- Use energy efficient space and domestic water heating systems.
- Incorporation of central heat recovery ventilation systems in each unit.
- Reuse of existing original exterior finishes where possible, where not possible use wood fibre reinforced cement products that duplicate the appearance of the original finishes.
- Prolong building life through the use of rain screen wall assemblies.

There were three months of investigation into the feasibility of the strategies put forward in the Green print. Urban Ecology Design Collaborative compiled a table of possible materials, organized according to the construction specifications index, for the project.

In an attempt to achieve the "no new old growth" goal the project focused on retention of as much of the existing structure as possible. Most additional lumber used was salvaged dimensional framing from other demolished buildings. The final outcome was that approximately 95% of all framing lumber was salvaged wood.

After reviewing the capital and operating costs of high efficiency equipment the developer decided to install a central, gas-fired, medium efficiency boiler (82-84% efficient) with a heat exchanger to supply domestic hot water. The coach house has a separate gas fired boiler (72% efficient) and heat exchanger for both space heating and hot water. In retrospect, the boiler decision could have been more carefully investigated, since the technical issues are quite complex. Furthermore natural gas prices rose quite suddenly after the boiler was chosen, which would alter the payback calculations substantially.

Solar domestic water heating was considered and rejected due to long payback period (25 years). Since the time of the analysis the price of natural gas has doubled.

Central heat recovery ventilation systems were installed in each of the units to exhaust pollutants and provide a constant source of filtered outdoor air while reducing heat losses associated with ventilation. The expense of this equipment was seen as justifiable because of the market's recognition of the health benefits of distributed mechanical ventilation.

A parametric analysis of building envelope insulation levels was performed using the HOT 2000 energy analysis computer program. This resulted in the following options being chosen:

- 38x38mm (2x2in.) interior strapping for the main house, yielding walls of RSI 3.4 (R20)
- 38x89mm (2x6in.) framing on the coach house, yielding walls of RSI 3.4 (R20)
- Use of high performance polyisocyanurate rigid insulation on straw board (Isobord) in the existing roof framing of the main house, yielding a roof of RSI 4.7 (R28).

The decision was based upon the following criteria:

- A commitment to meeting R2000 standards for the renovation.
- The contractors belief in the constructability of the solution.
- The overall room size and height constraints of working within an existing building while still providing livable space which is attractive to purchasers. (Note: in a compact townhouse a few centimeters can make an important difference to a room).

The landscape plan went through many changes as the project progressed and as the developer endeavored to create a green space, which met the following criteria:

- Reduced water consumption.
- Reduced load on the storm sewer.
- Private outdoor space for each resident.
- Shared open space to create a sense of neighborhood.
- Opportunity for "edible" landscaping.
- Attractive appearance that was not the standard "grass/grass/conifer" approach.

To satisfy the criteria listed above the following was adopted:

- Create a small pond fed by rainwater run-off, which could act as a retention pond and a landscape feature.
- Place a perforated sump on site – this is essentially a cistern that fills with rainwater and slowly allows the rainwater to discharge into the soil.
- Make the site as permeable as possible, e.g. use of permeable unit pavers as hard surfaces.
- Collect rainwater in barrels for watering the gardens.
- Use indigenous plants which require less watering.
- Use only a small area of grass in a shared seating area in the front yard.
- Provision of a shared vegetable/herb garden.

In terms of water efficiencies within the building low flow toilets and other fixtures were specified to reduce demands on potable water. "Ultra low flush" toilets were also investigated but their additional cost and the low cost of water in Vancouver meant there was no pay back for them. Composting toilets were abandoned due to low public acceptance and Health Departments reluctance to accept them.

The demolition and construction process was documented with photos and video. In addition, details of the measures taken were kept for incorporation into a project web-site:

http://chestermangroup.com/ardencraig/index.html

The web-site provided people with information on the choices that have been made and the decision making process that was followed. A new TV show focused on "healthy housing" made several trips to the site at various stages.

There was significant amount of media coverage in local newspapers and magazines. In addition the Chesterman Property Group won the 2000 Ethics in Action award primarily for its Ardencraig project.

An open house was held in August 2000 to celebrate completion and introduce friends, potential buyers and people who had been involved in the project or had shown a keen interest, including other local developers. One unit in the project was sold prior to completion a second unit was occupied by Robert Brown the developer and the remaining two units were sold within several months of completion.

Résumé

Achevée en septembre 2000, la propriété à valeur patrimoniale Ardencraig a fait l'objet d'un réaménagement par le Chesterman Property Group Inc., de Vancouver. Chesterman a transformé la maison individuelle, construite en 1910, en quatre logements en copropriété, dont trois à l'intérieur même de la maison transformée et le quatrième comme pavillon d'insertion dans la cour arrière. Il s'agissait à l'origine d'une maison individuelle comportant 4 étages et qui avait été construite sur un terrain de 15,2 m sur 37,2 m (50 pi sur 122 pi). Les travaux consistaient à conserver la structure existante du bâtiment dans son emplacement actuel, et à l'agrandir légèrement sur le côté et à l'arrière, ainsi qu'à ajouter sur le site un pavillon de deux étages. La maison a été entièrement rénovée et transformée en trois logements en copropriété dont l'aire de plancher varie de 91 à 137 m² (975 à 1 475 pi²).

Un permis d'aménagement a été octroyé en mai 1999 et la firme Allan Diamond Architects a été engagée pour préparer la demande de permis de construire. On a retenu les services des consultants Urban Ecology Design Collaborative pour se charger des enjeux environnementaux, et Armin Gottschling de Timberland Homes a été choisi comme gestionnaire de projet et entrepreneur général. Heather Tremain de Wave Design a été mise à contribution pour étudier plus à fond différents aspects de la conception et pour en examiner conjointement les aspects écologiques.

Dès le tout début du projet, Robert Brown de Chesterman et sa conseillère en conception, Heather Tremain, ont rassemblé une équipe « verte » qui s'est chargée d'établir les buts et les priorités devant régir la maison Ardencraig. Lors de la première rencontre de l'équipe, on a abordé les enjeux environnementaux qui inquiétaient le plus la collectivité. Les questions suivantes ont été discutées :

- Foresterie : l'utilisation de bois provenant de forêts anciennes par le secteur du bâtiment est très préoccupante.
- Occupation des sols et transport : on s'inquiète de l'étalement urbain permanent et de la congestion des voies de circulation.
- Enfouissement sanitaire : le niveau actuel d'enfouissement des déchets solides n'est pas durable.
- Services publics (électricité et gaz) : toute augmentation de la capacité des réseaux et des infrastructures est très néfaste pour l'environnement.
- Approvisionnement en eau : à cause de l'exploitation des bassins hydrographiques par les compagnies forestières, du commerce de l'eau hors de la province, de l'accroissement de la population et du coût de remplacement des infrastructures désuètes, on estime que la demande en eau ainsi que son coût iront en augmentant.
- Eaux pluviales : Vancouver possède toujours un réseau unitaire d'assainissement, quoique les nouvelles installations prévoient des réseaux d'égout séparés. Les eaux pluviales recueillies sur les toits et sur les aires de stationnement, ajoutées aux eaux usées du réseau public, créent une surcharge de la capacité d'épuration

des eaux usées et nuisent à l'épuration. Dans certaines parties de la ville, les eaux pluviales transportent de l'huile et des débris jusqu'au port.

- Qualité de l'air : on s'inquiète sérieusement de la mauvaise qualité de l'air causée par les émissions des véhicules ainsi que de l'air intérieur insalubre résultant des problèmes d'humidité et de poussière, d'une ventilation inappropriée et d'émissions de gaz provenant des matériaux.

On a résumé les résultats des discussions de l'équipe verte, puis on a rédigé un document directeur dont voici les éléments saillants :

- Maximiser l'efficacité énergétique de l'enveloppe du bâtiment par l'entremise de niveaux d'isolation plus élevés, de fenêtres à haute performance énergétique et d'une étanchéité à l'air accrue.
- Réduire au minimum l'emploi de bois d'œuvre nouvellement récolté. Le bois utilisé provenait de la maison d'origine ou d'immeubles démolis. Tout nouveau bois d'œuvre devait être certifié écologique.
- Prévoir des installations éconergétiques pour le chauffage des locaux et de l'eau domestique.
- Intégrer des installations centrales de récupération de chaleur dans chacun des logements.
- Dans la mesure du possible, réutiliser les parements existants sinon, employer des panneaux de ciment renforcés de fibres de bois qui simulent l'apparence des parements d'origine.
- Prolonger la durée utile du bâtiment par la mise en place de murs à écran pare-pluie.

La période consacrée à l'étude de faisabilité des mesures écologiques décrites dans le plan vert s'est étalée sur trois mois. La firme Urban Ecology Design Collaborative a compilé un tableau des matériaux acceptables pour le projet, lesquels étaient classés suivant le devis directeur.

Pour réussir à atteindre l'objectif relatif à l'exclusion de bois d'œuvre provenant des forêts anciennes, l'équipe a misé sur la réutilisation maximale des éléments de bois de la charpente existante. Pour la grande majorité du bois d'œuvre additionnel, on s'est approvisionné auprès d'entreprises de récupération de bois d'œuvre. En bout de ligne, environ 95 % du bois utilisé avait été récupéré.

Après avoir évalué le coût initial et le coût d'exploitation des équipements à haut rendement énergétique, le promoteur a porté son choix sur une chaudière centrale fonctionnant au gaz, de moyenne efficacité (82 à 84 %) dotée d'un échangeur de chaleur pour fournir l'eau chaude domestique. Dans le cas du nouveau pavillon, celui-ci a été équipé de sa propre chaudière à gaz (à 72 % d'efficacité) munie d'un échangeur, tant pour le chauffage des locaux que pour la production d'eau chaude domestique. Avec le recul, on aurait dû étudier plus à fond la question de la chaudière, puisque les données techniques sont excessivement complexes. De surcroît, une fois le choix de la chaudière arrêté, le coût du gaz est monté en flèche, ce qui modifie sensiblement le calcul du délai de récupération.

L'option de production d'eau chaude domestique à l'aide de l'énergie solaire a été abandonnée en raison de son délai de récupération trop long (25 ans). Depuis le moment de l'analyse, le prix du gaz naturel a doublé.

On a prévu une installation centrale de ventilation à récupération de chaleur dans chaque logement de manière à évacuer les polluants et à fournir un apport constant d'air frais filtré, tout en amenuisant les pertes de chaleur dues aux installations de ventilation. Les coûts additionnels inhérents à ces équipements sont justifiés, puisque le public reconnaît les avantages pour la santé de la ventilation distribuée.

Une analyse paramétrique des niveaux d'isolation de l'enveloppe a été menée à l'aide du logiciel d'analyse énergétique HOT 2000. Les résultats de cette analyse ont permis d'arrêter les choix suivants :

- Ajout de fourrures de 38 mm x 38 mm (2 po x 2 po) sur les murs existants de la maison, résultant en une valeur RSI totale de 3,4 (R20).
- Utilisation d'une ossature murale de 38 mm x 140 mm (2 po x 6 po) pour le pavillon, ce qui permet d'atteindre une valeur RSI totale de 3,4 (R20).
- Emploi de panneaux isolants rigides de polyisocyanurate à haut rendement énergétique jumelés à des panneaux isolants à base de paille (Isobord) entre les éléments d'ossature du toit de la maison d'origine pour atteindre une valeur RSI de 4,7 (R28).

Ces choix ont été effectués en fonction des critères suivants :

- On s'était engagé à répondre aux exigences du programme R-2000 lors des rénovations.
- L'entrepreneur estimait que les choix arrêtés était constructibles.
- Lors de la rénovation de bâtiments existants, il faut tenir compte des contraintes imposées par la dimension et la hauteur des pièces tout en fournissant un cadre de vie qui est attirant pour les acheteurs (Nota : Dans le cas des maisons en bande compactes, quelques centimètres peuvent faire toute la différence dans une pièce).

Le plan d'aménagement paysager a subi de nombreuses modifications à mesure que les travaux progressaient et que le promoteur s'efforçait de fournir un espace vert conforme aux impératifs suivants :

- Diminuer la consommation d'eau
- Réduire les charges sur l'égout pluvial
- Fournir une aire extérieure privée à chacun des ménages
- Prévoir un espace extérieur communautaire pour créer un sentiment d'appartenance
- Construire des aménagements paysagers avec des végétaux que l'on peut récolter
- Améliorer le coup d'œil à l'extérieur en évitant les aménagements classiques comportant de grandes surfaces de pelouse et des conifères

Pour répondre aux impératifs énoncés ci-dessus, voici comment on a procédé :

- On a créé un petit étang alimenté par les eaux pluviales et qui sert d'étang de rétention ainsi que d'élément paysager.
- Un puisard perforé installé sur le terrain se remplit d'eau comme une citerne et permet à l'eau de s'infiltrer lentement dans le sol.
- On a augmenté la perméabilité de l'emplacement le plus possible, par exemple, par l'emploi de pavés perméables pour les surfaces dures.
- On recueille les eaux pluviales pour arroser les jardins.
- Des plantes indigènes qui demandent moins d'arrosage ont été utilisées.
- L'aire de pelouse a été limitée à celle nécessaire pour aménager un coin repos partagé dans la cour avant.
- On a aménagé un jardin potager communautaire.

En matière d'économies de l'eau dans le bâtiment, on a spécifié des toilettes et d'autres appareils à faible débit de manière à diminuer la demande en eau potable. Par ailleurs, les toilettes à très faible débit ont également été étudiées, mais leur surcoût et le faible coût de l'eau à Vancouver rendaient impossible la récupération des coûts. On a vite abandonné l'idée des toilettes à compostage en raison de leur faible acceptation par le public et du fait que les autorités compétentes sont réticentes à les accepter.

La démolition et la construction ont été documentées à l'aide de photographies et de bandes vidéo. En plus, on a colligé les détails des mesures prises pour les intégrer au site Web du projet :

http://www.chestermangroup.com/ardencraig/index.html

Le site Web renseigne les gens sur les choix qui ont été effectués ainsi que sur le processus décisionnel suivi. Les responsables d'une nouvelle émission de télévision axée sur les principes de la maison saine se sont rendus à plusieurs reprises sur le chantier, à différentes étapes des travaux.

Il y a eu une couverture médiatique marquée dans les revues et les quotidiens locaux. En outre, le Chesterman Property Group Inc. a remporté le prix 2000 *Ethics in Action* principalement à cause de son projet Ardencraig.

On a mis sur pied une journée d'accueil en août 2000 pour fêter l'achèvement de l'ouvrage et permettre aux amis, aux acheteurs potentiels et aux personnes ayant participé à l'initiative ou qui s'y étaient vivement intéressées, y compris les promoteurs locaux, de se rencontrer. Un des logements de l'ensemble a été vendu avant qu'il ne soit achevé. Un deuxième logement était occupé par Robert Brown, le promoteur, tandis que les deux derniers logements ont été vendus durant les mois qui ont suivi l'achèvement des travaux.

CMHC SCHL

National Office
700 Montreal Road
Ottawa ON K1A 0P7
Telephone: (613) 748-2000

Bureau national
700 chemin de Montréal
Ottawa ON K1A 0P7
Téléphone : (613) 748-2000

Puisqu'on prévoit une demande restreinte pour ce document de recherche, seul le résumé a été traduit.

La SCHL fera traduire le document si la demande le justifie.

Pour nous aider à déterminer si la demande justifie que ce rapport soit traduit en français, veuillez remplir la partie ci-dessous et la retourner à l'adresse suivante :

Centre canadien de documentation sur l'habitation
Société canadienne d'hypothèques et de logement
700, chemin Montréal, bureau C1-200
Ottawa (Ontario)
K1A 0P7

Titre du rapport: ______________________________________

____

Je préférerais que ce rapport soit disponible en français.

NOM ______________________________________

ADRESSE______________________________________
rue App.

____
ville province Code postal

No de téléphone (   ) ____________

Part I

The Ardencraig Project

Ardencraig is a heritage-style redevelopment project, that was completed in September 20000 by Chesterman Property Group Inc. in Vancouver. Chesterman converted an existing single family residence built in 1910 into four strata-titled townhouse units; three in the converted home and a new coach house in-fill residence on the rear yard. The property is located at 355 West 11th Avenue in the City Hall area of Vancouver.

Ardencraig was named after the childhood home in Glasgow of Robert Brown, the owner of Chesterman Property Group Inc. Robert Brown's vision was to identify and prioritize a wide range of resource conservation, energy conservation and healthy building measures for inclusion in the project. These are design and construction methods that will minimize the impact of the project on the environment, and are generally referred to as "green building" or "sustainable building" approaches. The project is a market experiment and an example of producing high-quality housing through remodeling and infill (adding floor space to an existing property) in an environmentally sustainable way. There are few, if any, similar examples that have been successfully developed and sold with this emphasis in the market area of Greater Vancouver.

The existing building was a four story, single family house built in 1910 on a 15.2 x 37.2 m (50ft. by 122ft.) lot which is zoned RT-6. The zoning allows for multi-unit dwellings and the addition of a rear-yard dwelling (coach house) where the original building is retained or where a "heritage" style is adopted. This type of zoning produces density bonuses for saving heritage buildings. The project involved retaining the existing building structure in its present location, expanding the building slightly to the side and rear and adding a two-story coach house unit. The coach house is technically one and a half storey – but because of the change in grade on the site the half storey had to be split over each level. The main house was completely upgraded and converted to create three strata-titled townhouse units of between 91 and 137 m^2 (975 sq. ft. and 1475 sq. ft.).

The project was substantially completed in August 2000, and commenced showing for sale in September. One unit was pre-sold and another was retained by the developer as his family residence. The remaining two units (the in-fill coach house and the garden level) were sold in October with closings in November. This report describes the story of Ardencraig from concept to completion, and details many of the specific decisions made about sustainability features. It also reports on a small market survey done during the marketing and post sales stages of the project.

The History of Ardencraig

Robert Brown arrived in Canada from Scotland in 1988. He had worked in Scotland in various aspects of real estate development where many projects are renovations and restorations of 200 to 300 year old buildings. One of his early impressions of Vancouver was surprise that perfectly sound houses only 40 years old were being torn down and sent to landfills to be replaced by new houses made from wood fresh from BC's forests.

In the mid 1990's, when Robert Brown was working in commercial development and leasing in Vancouver, he began spending time on the West Coast of Vancouver Island. In 1996 he built a house in Tofino and began to learn more about the coastal rain forest. In his words:

> " I began to understand the forests better, know the magic of the forests, and see more clearly the impact of losing these forests".

In 1997 Robert Brown quit his commercial real estate work and began an independent company to pursue commercial and residential property re-development. At the early stages however his projects did not specifically have a "green" aspect to them. In November 1998 he agreed to purchase the property at 355 West 11th Avenue, Vancouver with a view to doing a renovation and in-fill project. At the same time he was in contact with some people who were promoting building products such as straw board that are alternatives to wood. He also began to learn about healthy housing. It was not, however until after travelling around North America during early 1999 that the concept to make Ardencraig a test of applying principles of resource efficiency, energy efficiency and healthy housing took shape. Upon his return in July 1999 he set about transforming Ardencraig into such a project. In September 1999, about 3 months prior to the construction start, Robert took a tour flight run by Friends of Clayoquot over southwest Vancouver Island. He was truly shocked at the degree of clear cutting in these private forest lands that are rarely seen by the general public. This was a *"sort of epiphany"* for Brown who resolved to bring this awareness into his development work. In the field of property development, one obvious thing to do is to question where the materials come from to build houses, and to pursue alternatives that save threatened resources, just as we have developed practices and codes for saving energy.

By one measure, Ardencraig is already a success. The public interest and media coverage has been very positive, and Chesterman Properties had already started work on another "green project" even before Ardencraig was complete.

The Development Process

The project was granted a development permit in May1999 and Allan Diamond Architects were further retained to obtain a Building Permit. Urban Ecology Design Collaborative was retained as consultants on specific environmental issues and Armin Gottschling of Timberland Homes Ltd. was chosen as project manager/general contractor. Heather Tremain of Wave Design was retained to consult on various aspects of design and to co-research the "green" aspects of the project.

The production of building permit drawings was slowed somewhat by Robert's revised focus on healthy and sustainable practices. Brown and Tremain took an initial period of approx. 3 months to research and investigate alternative materials and practices. This information was necessary to complete certain aspects of the Building Permit drawings. Part of this time was spent costing materials and locating local suppliers.

Having never done a small multi-family residential project "hands-on" before, and introducing an environmental agenda into the project made the learning curve for Robert Brown quite steep. He found himself constantly doing a great deal of research just to keep up with the pace of construction, in addition to adding the environmental criteria. But, in his words:

> "It was actually an advantage in some ways to be a little naïve about the details of residential construction. For example the framers asked for some plywood to build stairs, and I proposed that they use the salvaged, large dimensional lumber we had on site. They wanted the plywood, so I asked why: 'Because we always do it that way' was the answer. So I prevailed and they used the lumber and the outcome was just fine with everyone."

Part II

Setting Goals; The Green Team/ Environmental "Greenprint" Approach

From the early concept stages of the project, Robert Brown and his design advisor, Heather Tremain, assembled a "Green Team" to set goals and priorities for Ardencraig.

> "For the green team we tried to draw upon people who were working in the environmental arena – but not necessarily in green building. We looked to them to give us a pulse on the most important environmental issues to address with Ardencraig."

Many of the team members had specific ideas and experience and made many specific suggestions. The first greenprint meeting was expected to cover the following areas:

- construction management;
- building envelope;
- wood sources;
- exterior finishes;
- lighting and power;
- heating, cooling and ventilation;
- water use and disposal;
- building material selection;;
- marketing, media and publicity.

At a later meeting there was also a schedule detailing specific products prepared and a selection discussion.

Members of the Green Team were:

- Robert Brown;
- Heather Tremain;
- Bruce Haden, architect;
- Perry Abbey; former contractor, ethical investment advisor;
- Nicole Rycroft, Friends of Clayoquot Sound;
- Gil Yaron; lawyer.
- Armin Gottschling contractor;
- Nancy Bradshaw, socially conscious retailer (and Brown's life partner);

The following is taken from the minutes of the Green Team meeting:

> At the first Green Team meeting the environmental issues that appeared to be of most concern to our community were discussed. The group then brainstormed how the construction of Ardencraig could best contribute to resolving these issues. The issues and ideas discussed were as follows:

1. Forestry: *the continuing use of old growth forests by the building industry is a major concern*. Solutions include:
   - Re-cycling wood from the existing building.
   - Use of salvaged wood from other buildings.
   - Use of "eco-certified"wood.
   - Use of alternative, non-wood products, eg. straw-based building panels, cement fibre siding, vinyl windows, steel framing.

2. Land Use and Transportation: *continuing urban sprawl and traffic congestion is a major concern. Also, the present level of landfilling with solid waste is not sustainable*. Solutions include:
   - Densification of inner city sites decreasing the impact on rural areas.
   - Providing more dwellings near the city core, shopping and services and public transportation reducing vehicle use.
   - Reducing solid waste sent to landfill; effective on-site waste management practices, and providing easy recycling and composting for residents of the units.

3. Utilities (electricity and gas): *the demand for expanded utility capacity and infrastructure is extremely damaging on the environment*. Solutions that focus on energy efficiency and conservation include:
   - Insulation of walls, roof and hot water pipes in excess of code requirements.
   - A central hot water heating system (rather than one system per unit) with individual usage measured by metering.
   - Use of sensors to shut down lights, heating etc. when not in use.
   - Use of energy efficient lamps, focused task lighting such as halogens and energy saving dimmers.
   - Heat exchange unit to extract heat from air .
   - Bright wall, ceiling and floor colours to reduce need for lighting.
   - Clothes drying by clothesline and/or indoor drying areas for racks.
   - Energy efficient appliances.

4. Water Supply: *Logging of watersheds, sale of water out of province, increased population, and replacement cost of obsolete infrastructure is expected to increase demand and cost of water*. Solutions include:
   - Re-cycling "gray" water.
   - Rainwater collection.
   - Increased indigenous landscaping (using well-adapted, drought-tolerant plants).
   - Low flow showers, taps, and toilets (including dry toilets).

5. Stormwater: *Vancouver still has a combined sewer system, though new installations are now separated. Stormwater collected from roofs and parking areas mixes with sewage as it enters the city system resulting in overload of sewage treatment capability and poor treatment. In some areas of the city, storm water laden with oil and debris flows into the harbor.* Solutions include:

- Using more permeable landscaping (minimizing paving) to reduce runoff from the site.
- Using a perforated sump or "dry well" to absorb storm water into the ground before it leaves the site.
- Collecting rainwater run-off for landscape watering.

6. Air Quality: *poor outdoor air quality due to motor vehicles and unhealthy interior air quality caused by moisture problems, dust, poor ventilation and "off gassing" of materials are serious concerns.* Solutions include:
   - Promote use of bicycles (bike storage areas including easy access and accessory storage area).
   - Use non-toxic paints, natural carpets and UF(formaldehyde)-free MDF board.
   - Avoiding/decreasing use of resins, adhesives etc.
   - Minimizing carpet use.
   - Installing reliable ventilation.

7. Other Livability Issues: other ideas/suggestions to improve the livability of Ardencraig included the following:
   - Increasing communal space: amenity room, contact between outdoor open space e.g. French doors/balcony off rear of main floor unit; shared seating area in front yard;
   - Improving access/view of entrance to coach house for security.
   - Shared greenhouse in front yard for flowers/vegetables (solarium in winter).

8. Marketing/Promo Ideas:
   - Use owners' unit as show suite.
   - Focus on visual representation of differences of Ardencraig e.g. photograph of Clayoquot to represent use of old growth in "normal" house construction; stage by stage video/photo history; show volume of waste savings; etc.
   - Be honest! Explain also what measures we investigated but did <u>not</u> use.

The Greenprint Strategies (Summarized from Ardencraig Greenprint)

The outcome of the Green Team discussions were summarized and a "direction" document created. The main areas of focus were as follows:

Building Envelope

Maximizing the energy efficiency of the building envelope by careful design and construction was made a high priority. Airtightness, insulation, rain-screen design and quality doors and windows were emphasized. Insulation materials containing a high proportion of recycled material (>50% target) e.g. cellulose insulation were to be selected. A rigid wall insulation built into the rain-screen system is to be considered. Any insulation will have low emissions of hazardous fibre and VOC's. Vinyl windows will probably be used to improve energy efficiency and save on wood resources.

Wood Sources

During the Greenprint discussions it was emphasized by many participants that only a small fraction of North America's West Coast temperate rain forest still exists, yet the cutting rate is still one acre every 66 seconds! Many who are concerned about the fate of the forests feel that it is a terrible waste to use the lumber from old growth for common building purposes, often in places it can't even be seen and appreciated for its beauty. For Ardencraig therefore a "no new old growth" policy was adopted. The sources of wood were from the original house and from salvaged timbers from other demolished buildings. Any new wood was to be certified "sustainable". The first "certified" lumber sources in BC were just becoming available and Ardencraig was to be one of their first customers. For necessary structural upgrades a source of engineered wood beams which are not from old growth was specified.

Heating, Hot Water, Ventilation And Cooling

Space Heating: the choice of heating system to be used will consider several aspects including:

- method of heat delivery - *forced air, radiant, or convection*;
- energy source - *gas, electric resistance, heat pump (air or ground source), solar (active and passive)*;
- performance requirements of the system - *occupant comfort; energy efficiency; and capital and operating costs.*

It is unlikely that a forced air system will be used due to ducting and fire separation, noise concerns and occupant comfort. Due to operating costs and utility demand concerns it is also very unlikely that electric resistance heating will be used.

Domestic Hot Water: heating of water for bathing etc. can easily be the largest energy use in energy efficient home in the Vancouver climate. Energy simulation and building monitoring show that with a well-insulated envelope and a heat recovery ventilation system, hot water is likely to account for more than 60% of total energy. Therefore energy efficiency of water heating is of utmost importance. Once an investment is made in an efficient system for the main house, it makes sense to use the same boiler for space heating. A separate system is required for the coach house because it is detached. A central system for all units in the main building was considered a good choice for efficiency and energy savings. The ability to separately meter energy use was also considered important. It seems to be necessary for each resident to have an accurate report on their consumption in order to encourage conservation and avoid disputes as do ocurr in many multi-unit buildings where energy is not separately metered but is apportioned in building strata fees.

Solar energy was being considered to provide up to 50% of the hot water requirements. The possible use of a ground source heat pump was also considered.

Ventilation System: After discussing the ventilation options with consultant Chris Mattock the decision was made to adopt a fully ducted heat recovery ventilation system for each unit. Armin, the builder did however voice concerns regarding the problems of ducting such a system within the existing house due to the constraints created by existing and required framing. Also the location of the ventilator unit will not be ideal for servicing access. However the ventilation system is an essential part of the healthy building aspect of Ardencraig so the commitment was made. This turns out to have been a wise marketing decision since the healthy home aspects of the units were rated as very important by both viewers and buyers.

Exterior Finishes

Parts of the existing stucco finish were removed prior to the construction start in order to carry out an inspection of the existing exterior cladding. The city's development permit specified that the appearance of the original finish must be duplicated in this heritage neighborhood. If the existing siding were in good condition it could be removed and later re-fixed to the new rain-screened exterior with whatever extra material is required being provided by salvage in accordance with our "no new old growth" policy. Alternatively, non-wood building products could be used for the exterior cladding, for example a cement/fibre product, if the appearance complied with City requirements.

Under the existing stucco finish there was an asphalt shingle layer on top of fibre-board that was installed over the original horizontal western red cedar siding on the house. Since the wood siding represented the "original character" but was in poor condition due to asphalt shingle being nailed on top, the plan to use the fibre-cement siding was confirmed. Furthermore the fibre-cement product has an expected life of over 50 years with little maintenance.

Prolonged Building Life

In keeping with a requirement of the current Vancouver Building Code, an experienced building envelope professional was part of the design team. He gave specific recommendations regarding materials and construction detailing. The solution to current envelope code requirements using wood or fibre-cement cladding is to build a "rain screen wall". A rain screen wall has an air space behind the cladding that is vented to the outside to provide both a capillary break and air pressure equalization and thus prevent wind forces from driving rain into the wall. The cavity also allows drying of any moisture that enters behind the cladding. This is now common practice in Vancouver for multi-family residential construction.

Rain screen methods and details are sometimes complex and costly. For example wood strapping used to construct the cavity must be treated for rot resistance, and complex layers of flashing details are required for windows and doors.

Kitchens

Ideas which were discussed included:

- Designing kitchen to encourage recycling and composting.
- Use of open wood cupboards (i.e. no doors) thereby saving on wood and cost.
- Cabinets made from reclaimed wood.
- Materials for counter tops: reclaimed slate; cast and coloured concrete; ceramic tile; polyester/mineral solid countertops, recycled glass countertops.
- Appliances: total life cycle to be considered in criteria. Investigate environmental impact of gas vs. electric. Low energy use a priority. (eg European dishwasher and washer; refrigerator designed for solar electric systems etc.).
- Sinks: stainless steel considered the most suitable due to durability and recyclability.
- Water purification is essential. Distillation system and reverse osmosis discussed.
- Use of pedal valves in kitchens was discussed to save water.
- Demand hot water systems (tankless) were investigated.
- In-line kitchen composters were investigated. These are systems that are plumbed to a garbage disposal unit but are designed to capture organic material for composting. Ground food materials are diverted

through the composter which spins it dry and saves it to be composted. (Note: these were not used in the project; nor were any garbage disposal systems.).

Flooring

- Hardwood floors are preferred for health and appearance. Reclaimed wood would be ideal but Maple or Fir plank floors are not suitable due to radiant floor heating which may cause shrinking. Oak is a possibility, or laminated wood products.
- Bamboo flooring to be investigated.
- Recycled rubber flooring to be investigated .
- Only natural fibre carpets with low emission construction were considered.

Bathrooms

- A steel tub is preferable to fibreglass/acrylic from a durability and recyclability perspective. Reclaimed claw foot tubs were considered. Tub taps must be in the middle of the long side of the tub to encourage shared bathing and thus water-savings!
- Urinals were considered.
- Having no shower doors on baths was considered– this saves materials and money.
- Combining the ensuite bath and second bath was considered. This would create one large more luxurious bathroom with "compartments" for toilet, bath and sinks to enable separate use at same time. This would save materials and money and take up less floor space.
- Low flow fixtures are necessary for water savings. The toilet is top priority, the shower head is second and taps are third.

Lighting

- Designing to minimise the number of fixtures, e.g. daylight design.
- Use of low-energy flourescents where appropriate.
- Use of outside floods with motion detectors for security and appearance.
- Timers and energy saving dimmers were emphasized.
- 12 volt halogens were to be used for specific lighting, e.g kitchens.

Paint/Wallcoverings

- Acrylic plaster on drywall lath was considered to minimise the need for detailed taping, sanding, priming, etc
- Rounded outside corners on dry wall were to be specified for aesthetics and improved Feng-Shui. (Note: the Chinese Feng-Shui system warns against sharp corners projecting into a space. They are considered threatening and uncomfortable.).
- Wood wainscoting was considered to improve durability of walls, especially in seating areas.
- Recycled content of wallpapers was to be investigated.
- Low/zero VOC paints, adhesives etc. were to be selected (Note: These have very low emissions of air pollutants while handling and drying).
- Urea formaldehyde-free MDF (medium density fibreboard) was to be selected.

- Water based polyurethane finishes were considered for woodwork.
- Re-cycled paints were considered.
- Reflective, low emissivity paint was considered for comfort and energy savings. (Note: this is a new paint product that insulates by reducing radiant discomfort from cool wall and ceiling surfaces).

Part III
Ardencraig-Greenprint Update – November 1999
Stage – building permit drawings completed

The purpose of the update was to follow up on the strategies proposed in the previous Green Team meetings, to document the decisions that have been made to date and to provide a rationale for those decisions. The update follows the structure of the Greenprint document.

General Comments
There were three months of investigation into the feasibility of the strategies put forward in the Greenprint. A table of possible materials, organized according to the construction specifications index, was compiled for the project by Urban Ecology Design Collaborative. The table listed the sustainability attributes of the materials and their potential use in Ardencraig. An updated version of this table is shown in Appendix 1 listing whether each material was or was not used in the project and why.

Every option that was proposed in the Greenprint was investigated, whether that meant a conversation with the city, obtaining a quote, or undertaking a computer-based energy analysis. Much of the time was spent investigating the ecological aspects of various building products, including their sources and costs. Clearly, not all options/strategies were undertaken. In general any strategy not adopted was discounted if it was either not financially feasible in a project of this scale, likely to be unacceptable to buyers, or was impractical for construction reasons.

Decisions were made in each area to invest in equipment and materials that would add value to the project. It appeared at this stage that the project would be more costly than standard building practice. The extra expenses, and in some cases the savings, had to be calculated as a market risk and it had to be decided whether the market is willing to pay any kind of premium for these alternative processes or materials.

As the Greenprint was reviewed it seemed important to choose particular areas of emphasis. When attempting something unusual, like a market experiment in green building, and particularly when adding novel materials, methods and technologies to typical construction, it seemed overwhelming to "try to do everything". The risk is also there of "doing a little of so many things" that the overall impact is diluted. Robert Brown reports:

> "After the flight over logged areas of southern Vancouver Island, , where we saw the state of the Island's forests and the results of current logging practices, the decision to pursue an 'no old growth' policy was as much emotional, as environmental. Likewise, the focus on water conservation and storm water runoff is an impassioned experiment in the small and simple changes that we might make that will improve the Vancouver environment."

So it was decided that wood recycling, water recycling, and healthy interiors would be the primary emphases for Ardencraig.

Materials Use and Efficiencies During Construction

Demolition salvage and recycling: A demolition sale was held on November 13th, 1999 and certain items were sold/taken away, including kitchen cabinets and kitchen appliances. All Around Demolition which runs the Jack's Used Building Materials operation also paid a small amount to reclaim some salvageable materials that would not be used in the redevelopment. These included useable washroom fixtures, interior doors and oak flooring from the main and second floor. The garage that stood on the rear of the site was deconstructed. Approximately 75 sq.M (800 sq. ft.) of ship-lap sheathing was removed from this building and was stored for use as sheathing to replace plywood on the extension to the house and the coach house. The deconstruction also provided work for graduates of Tradeworks Training Society, a construction trades training program in the Downtown Eastside. Other wood materials, such as salvaged framing lumber, were kept on site and used in new construction. An inventory of all salvaged, recycled and land-filled materials was kept.

A waste bin was filled as a result of the garage demolition, but instead of being land-filled its contents were taken to a recycler where it was sorted and recycled where possible. This same practice of seeking to reduce the amount of waste that ends up in the landfill was continued as deconstruction of the main house progressed. In some cases salvage was not successful. For example a recycling operation could not be found for the asphalt shingles removed from the garage and house.

Building Materials & Selection

Advanced Framing: Advanced framing is a set of steps used to rationalize and minimize each piece of framing and sheathing. Roof trusses or joists are usually placed at 600 mm. (24in.) centers, and aligned with wall studs, which are also placed at 600 mm. (24in.) on center rather than the usual 400 mm (16 in.) thereby eliminating double wall plates. Openings in load bearing walls are also aligned with supporting studs to reduce need for structural headers. Headers are reduced or eliminated in non-load bearing situations and structural sheathing is used only as required for shear strength. Other bracing methods such as steel straps and let-on wood bracing may be used to minimize structural sheathing. Though the existing house at Ardencraig was already framed, so it couln't be easily adapted to advanced framing, an attempt was made to save lumber when framing the coach house. Framing was generally 38x140mm (2"x 6") studs on 600mm (24") centres, but it became evident that advanced framing was very difficult to apply because of the tight and sloping site which created design constraints such as split levels. Also window and door openings had to be located for complex code and design reasons, so couldn't always be aligned with the framing spacing. It seems that advanced framing is best suited to new, larger, spec-built single family dwellings where window openings can be standardised and where there are fewer constraints that those encountered at Ardencraig.

Engineered wood products such as "I" joists and parallel strand lumber were used to minimize the demand for large dimension lumber that can only be cut from large trees. These engineered wood products were used to strengthen and stiffen the old house framing to meet its new use and for seismic upgrading. In place of plywood that is normally used for structural shear strength in wood buildings the fir ship-lap removed from the garage was used, as well as some reclaimed ship-lap from a wood recycling company. It was installed diagonally to produce a shear wall.

Wood Sources

In an attempt to achieve the "no new old growth" goal the project focused on retention of as much of the existing structure as possible. The majority of the south, east and west walls were retained from ground floor level to roof level. The entire roof structure, including trusses and OSB (oriented strand board) roof sheathing from a previous re-roofing was also retained. In addition, Karl Simmerling of Vancouver Timber was contacted to supply salvaged dimensional framing material such as 38x89mm, 38x140mm and 38x240mm (2x4, 2x6, and 2x10) as well as 19mm. (1 in.) ship-lap sheathing. The final outcome was that approximately 95% of all framing lumber was salvaged wood. Final back-framing on the garden level was finger-jointed studs due to lack of supply of enough good salvaged small framing lumber. Finger jointed wood was considered appropriate since it utilizes small pieces of lumber that would otherwise become mill waste. Also, due to the complex roof structure on the coach house, pre-fabricated 38x64mm. (2"x3") manufactured roof trusses were used. The use of certified wood from ecologically managed forests for framing and finishing was investigated but the cost was approximately double that of reclaimed or new wood, primarily due to very limited supply at the time of construction. This option was therefore discounted, though it will be considered for future projects. New wood was used for exterior trim and fascia and MDF was used for the majority of interior trim.

Energy Reduction

Heating: Solace Energy Centre, a ground source heat pump system supplier, was contacted for a quote on a ground source heat pump system to provide space heating and hot water for the four units. The price was approximately $50,000 for the hardware and controls. This option was abandoned due to the very long pay-back on the investment. It was also noted that ground source heat pumps are very difficult to apply on tight urban sites because they require either wells to access groundwater, or a large area of collection field in which to bury heat exchange tubing. This system would be considered for other more appropriate sites, and where electricity is the available fuel option.

A radiant in-floor heating distribution system was chosen primarily for air quality, comfort and space planning reasons. It requires no ducts which interfere with framing, and no convectors which interfere with furniture. The additional benefit of this system, which is bedded in a thin layer of concrete topping, is that the concrete provides improved acoustical separation between the units. Originally a condensing gas boiler and storage tank, the Lennox CompleteHeat, was investigated. This unit is about 94% efficient. However, upon consultation with a mechanical engineer, it was considered that the majority function of the boiler would be the provision of domestic hot water, since the space heating load for the building is quite low. In these circumstances it was suggested that it would be unlikely that the benefits of a condensing boiler would be realized as the water temperature required for the radiant heating system is lower than the optimum operating temperature for full efficiency of a condensing unit. Since the additional cost is quite high, the payback didn't seem to be justified.

The choice was therefore made to install a central, gas-fired, medium efficiency boiler (82-84% efficient) with a heat exchanger to supply domestic hot water. The coach house has a separate gas fired boiler (72% efficient) and heat exchanger for both space heating and hot water.

In retrospect, the boiler decision could have been more carefully investigated, since the technical issues are quite complex. Furthermore natural gas prices rose quite suddenly after the boiler was chosen, which would alter the pay-back calculations substantially.

Solar Energy Innovations: Solar energy for pre-heating hot water for the heating system was also considered. An energy consulting company ran the option through the Retscreen Energy Model, a computer-modeling program produced by Natural Resources Canada. For both of the two scenarios tested, the solar heater did not pay for itself during its own lifetime. In fact, less than 50% of the cost of the system would be paid back by energy savings (using 1999 gas prices) over the 25 year life of the system. It is the relatively high cost of these units, and the relatively low cost of gas that makes these units unfeasible at this time. However, these items can be retrofitted to the house if there is a substantial change to either the cost of the equipment or the cost of heating fuels. However there are some serious roof space limitations and appearance problems for solar water heating on this project. (Note: gas prices have nearly doubled since the analysis was done)

The solar hot water system is a good example of the risks of speculative building, especially in a project emphasizing environmental features. Though solar water heating is preferred for environmental reasons, and would be a highly visible feature of a green building, it cannot be economically justified under current pricing structures, particularly in the Vancouver climate where there are many overcast sky days during the warm season. Therefore the developer would carry a high financial risk if it were included.

Furthermore the question of incompatibility with high efficiency gas equipment is complex and had to be answered. Because solar units are nearly always used in a pre-heat configuration, the inlet water to the domestic hot water system is raised substantially during sunny periods. However a high efficiency boiler (condensing type) relies on a cool inlet water temperature to assist the condensing function. This incompatibility question was never resolved because the solar system option was discarded, and the decision was taken to use a medium efficiency boiler without the condensing feature.

Cooling & Ventilation: Because the building envelope was highly efficient and airtight for energy efficiency reasons (as well as noise control), a mechanical ventilation system was considered desirable for health and building performance reasons. Not only is a healthy ventilation rate assured, approximately 28 l/s (60 cfm) continuously, but the system provides primary filtering of the air that is being brought into the building before it reaches the units so that indoor air quality can be better than outside. In the summer when the windows will often be opened for cooling and natural ventilation, the ventilation system still has a moisture removal function. The ventilation system is designed to remove moisture-laden air from bathrooms, kitchens and laundry with a special variable airflow grill and timer in the bathroom providing a higher rate on demand.

The ventilation system also contains a heat exchanger core that transfers heat from the air that is exhausted from the house into the fresh and filtered incoming air. This process reduces heating needs and heating system sizing, and thus energy consumption and costs.

Building Envelope: A building envelope professional was hired to consult on the weather resistance of the envelope from a technical perspective. Chris Mattock & David Rousseau of Urban Ecology Design Collaborative worked with Peter McGill of Allan Diamond Architects and Armin Gottschling of Timberland Homes on the building envelope from an energy efficiency perspective. The greatest challenge was in providing a highly energy efficient envelope for the main house while still maintaining building integrity and reasonable costs. An initial decision to maintain the 38x89mm (2x4in.) walls of the old house meant that the depth of the wall cavity must be increased in order to achieve an adequate insulating value for the wall (For more information on the choice of insulation type, please review the insulation discussions).

The following options were proposed for the walls to increase the insulation capacity of the existing construction:

- 38x38mm (2x2in.) interior strapping.
- 38x64mm (2x3in.) interior strapping .
- 38x38mm (2x2in.) interior strapping with insulated sheathing (mineral wool or fibreglass).

A initial choice was made to use a high value of insulation in the roof (R40), though the headroom height in the upper floor unit would be reduced to achieve this. However each of the insulation options were then analyzed using the HOT 2000 energy analysis computer program. This resulted in the following options being chosen:

- 38x38mm (2x2in.) interior strapping for the main house, yielding walls of RSI 3.4 (R20).
- 38x89mm (2x6in.) framing on the coach house, yielding walls of RSI 3.4 (R20).
- use of high performance polyisocyanurate rigid insulation on straw board (Isobord) in the existing roof framing of the main house, yielding a roof of RSI 4.7 (R28).

The decision was based upon the following criteria:

- a commitment to meeting R2000 standards for the renovation.
- the contractors belief in the constructability of the solution.
- the overall room size and height constraints of working within an existing building while still providing livable space which is attractive to purchasers (Note: in a compact townhouse a few centimeters can make an important difference to a room).

This particular aspect of the project was quite successful in part because the options were reviewed at a meeting that included the whole of the design team – the architect, the environmental consultants, the structural engineers, the contractor, the building envelope specialist, and the owner/developer. The solution had the input from all of the key players. Though the solution was not an ideal "superinsulated" envelope, it represented an excellent balance of working with the existing building, market acceptability, cost constraints, and construction feasibility.

The addition of an exterior rain-screen, where the fibre-cement cladding is installed over an air space, is virtually a requirement of the new city codes. However, in the view of some, the changes to city code that now require such measures as rain-screen are really an over reaction to the "leaky condo catastrophe". There were so many factors in what caused leaky condos, including no roof overhangs, poor workmanship, lack of flashings, poor flashing details, low quality stucco work, etc. that do not apply to this project that it is arguable whether the rain-screen was really necessary at this location with this traditional roofline.

Landscaping and Water Conservation

The landscape plan went through many changes as the project progressed and as the developer endeavored to create a green space which met the following criteria:

- reduced water consumption.
- reduced load on the storm sewer.
- private outdoor space for each resident.
- shared open space to create a sense of neighborhood.

- opportunity for "edible" landscaping
- attractive appearance that was not the standard "grass/grass/conifer" approach

The initial concept was for a pond/cistern that would store water on the site. This water might then be pumped into the houses through a filter and be used to flush the toilets. When the city's Supervisor of Plumbing was approached with this idea he responded by saying that "*we were 20 years ahead of our time*"! At this time the City will not accept flushing of toilets with anything but potable water.

To satisfy the criteria listed above the following was adopted:

- Create a small pond fed by rainwater run-off, which could act as a retention pond and a landscape feature.
- Place a perforated sump on site – this is essentially a cistern that fills with rainwater and slowly allows the rainwater to discharge into the soil.
- Make the site as permeable as possible, e.g. use of permeable unit pavers as hard surfaces.
- Collect rainwater in barrels for watering the gardens
- Use indigenous plants which require less watering
- Use only a small area of grass in a shared seating area in the front yard
- Provision of a shared vegetable/herb garden

In terms of water efficiencies within the building low flow toilets and other fixtures were specified to reduce demands on potable water. These are now widely available. "Ultra low flush" toilets were also investigated but their additional cost and the low cost of water in Vancouver meant there was no pay back for them. Composting toilets were abandoned for two reasons. One, their public acceptance is quite low, except at a summer cottage where they are more expected. And second, most city Health Departments are quite unwilling to consider them as viable options at this time.

Marketing, Media & Publicity

The demolition and construction process was documented with photos and video. In addition, details of the measures taken were kept for incorporation into a project web-site:

http://chestermangroup.com/ardencraig/index.html

The web-site provides people with information on the choices that have been made and the decision making process that was followed. In addition a new TV show focused on "healthy housing" made several trips to the site at various stages.

There has been a significant amount of media coverage including an article in the March 2000 Shared Vision (a Vancouver healthy lifestyles magazine) and in the Courier (a local weekly newspaper). In addition the project was profiled in Business in Vancouver (a highly circulated weekly business newspaper) and since completion there have been articles in the Vancouver Sun, Georgia Straight and another small piece in Shared Vision. In addition, an article appeared in the VanCity Credit Union newsletter to publicize Chesterman Property Group winning the 2000 Ethics in Action award primarily for its Ardencraig project.

An open house was held in August 2000 to celebrate completion and introduce friends, potential buyers and people who had been involved in the project or had shown a keen interest, including other local developers.

One of the main marketing dilemmas was that there are many design features and technologies that are preferred for environmental reasons, but the current market does not justify the cost of these items. Since it is clear that many of these advanced features do not sell in the mainstream market, where selling price, and in particular price per sq. ft., is the major determinant, the developer must decide which of these features will be valued by more innovative buyers (the early adopters). The construction cost of these items will be borne by the developer and those costs will not be recovered unless they can persuade buyers of the benefits. For example solar water systems were found to be too risky for this project, but individual heat recovery ventilators were included, though they added a substantial cost. The preliminary survey results confirmed the wisdom of this particular choice, since they suggest that buyers value incremental improvements in healthy interiors more than they do energy efficiency, envelope durability, and resource efficiency. (See Appendix II)

The marketing tag line for the project was "Beautiful, Healthy, Sustainable". Chesterman used this tagline to focus potential buyers on what were thought to be the most desirable features of the project. For the August open house and the subsequent real estate open houses Chesterman created display boards that provided some background on the issues related to healthy and sustainable building so that visitors might be able to understand the features and their impact on health or sustainability issues. Visitors were able to do a self-guided tour though the buildings with all of the features of the building being labeled and explained.

In total the number of people who visited all of the open houses was over 300. The real estate agents were overwhelmed by the interest in the project., in comparison to any other similar scale project. According to the agents, over 80% of the visitors were at least somewhat interested in the environmental aspects of the project. Many of them had never heard of some of the sustainable features of the project.

Part IV

Results Achieved in Construction

Armin Gottschling was chosen early as the contractor. He was the previous property owner and had limited experience with environmental construction. Robert Brown and Armin had to experiment and invent as they went, as many of the techniques and materials were unfamiliar. The only problem reported that actually affected the outcome was "novelty overload", i.e. there were so many new things to consider, and some such as lumber salvage would take more time, that some had to be dropped because there just wasn't enough time to pursue them all.

In the case of Ardencraig, the relationship between the builder and developer was very important and many things were worked out on site. Opportunities were seen and special features and materials selected during construction. The developer maintained control of the project budget by working directly with the builder. This is usually called a "project managed or cost plus" type of management because it is not based on a fixed price construction bid. Many of the sub-trades could be fixed-price, but the entire construction budget was fluid. It is very unlikely that an innovative project of this type could be precisely bid and contracted with fixed terms. There are too many items that are unknown in dealing with an old house, salvaged materials etc. for a contractor to accurately anticipate costs.

The initial intent was that:

> "the environmental impact of Ardencraig will ultimately be lessened by adopting the often quoted principles of 'reduce reuse and recycle'. These coupled with 'redesign and rethink' are the strategies to be adopted in the management of all phases of this project and, in particular, the construction phase".

The strategies adopted during construction included:

- Demolition and salvage:
  - The house was surveyed by a salvage expert prior to deconstruction.
  - Items salvaged for re-use in the project included: wood including the structural frame and roof joists, sheathing lumber; granite from the foundation; and a mantle. Items salvaged and sold for re-use in other projects included: window and door trims, interior doors; kitchen cabinets; furnace; bathroom fixtures; appliances; and a pool table!
  - Items recovered and sold for recycling included: piping and wiring containing copper.
- Efficient materials use: close site supervision and education and training of site crews by the project manager ensured the efficient use of materials thereby reducing resource use, waste material requiring disposal, and costs. Also, where possible, materials were reused on site.
- Recycling of waste: In addition to reuse of materials, waste was sorted and either recycled directly or contracted to a waste removal company that recycles.

Wood recycling: Approximately 95 M^3 (40,000 board feet) of existing and salvaged framing material was used in the construction. This represents about 95% of the total framing lumber. Ardencraig did not achieved a completely "*no new old growth*" result due to the use of a small amount of new framing material and the wood used for exterior trim. The developers are pleased however with the measures they took and the resource saving which they achieved.

Fibre cement siding: Due to the fact that the old house was clad with lapped wood siding, it had to be replaced with something similar in appearance under city design requirements for the neighbourhood. At the time of construction, fibre cement siding was approximately the same cost as select grade, stained, red cedar siding including installation. The cedar comes from threatened old-growth forests and is becoming very scarce, so the price has approximately doubled in six years. Cedar also violated the "no new old-growth" policy for Ardencraig. So fibre cement siding was chosen in a profile similar to the original wood. The only complaint about the fibre cement is handling difficulty. It is difficult to cut, i.e. it wears out cutting tools and produces hazardous dust, and cannot be fastened with pneumatic nailers. (Note: since construction was completed there have been some special tools developed for use with fibre cement products, such as a portable circular saw with built-in dust collector.)

Concrete: All concrete work including new foundations, retaining walls, exterior stairs and concrete flooring topping was a special-order mix containing 50% fly ash. The fly ash is waste from coal burning power plants and replaces Portland cement in the mix. There is a solid-waste reduction benefit because fly ash is a waste product (mostly from electric power utilities) that is often land-filled, and there is a major energy and greenhouse gas benefit because Portland cement manufacturing is very energy intensive and emits very high levels of CO_2. The only drawback is that coal ash is not produced locally. Fortunately, one ready-mix supplier had brought a large amount into the area for special projects.

It is routine to replace up to 15% of Portland cement with fly ash, but a 50% mix requires special formulation and handling. The mix tends to cure more slowly than Portland cement concrete, and it is somewhat more plastic (workable) so it can be highly finished achieving a very dense surface. However contractors who have worked with it extensively also report that it is more abrasive than Portland cement mixes and tends to produce more wear on metal trowels.

A report has been written on the use of high volume fly ash in Ardencraig and is avialble at www.ecosmart.ca.

Insulation: Mineral fibre batt ("rock wool") was used between floors for sound and thermal isolation. It is made primarily from mineral processing and smelting waste and has >60% recycled content. Glass fibre batt was used in the walls and ceilings. It contains at least 40% recycled content from glass recycling waste (cullett). Though cellulose cavity insulation was considered for its higher insulation performance and higher recycled content, it was rejected due to concerns about difficulty installing it successfully in the strapped wall cavities and vaulted ceiling cavity. If it is not installed to full density it is likely to settle which would produce cold spots. Chopped, blown glass fibre was also considered but rejected for similar reasons. Polyisocyanurate rigid foam board insulation was used in the roof cavity for its high performance. Though it has no recycled content, it reduced the headroom loss in the upper unit by providing good insulation performance within the existing roof framing cavity. The product is faced with Isobord, a Canadian straw board product.

Ventilation system: Each strata unit has an independent Eneready Heat Recovery Ventilation (HRV) unit. Some creativity was required to minimise the size and number of interior ceiling drops resulting from working around the existing building framing. Units in all but one suite were located in crawl spaces or eaves storage areas. The units must be accessed at least semi-annually for filter servicing.

Heating System: The in-floor radiant, hot water heating system was finally selected for health and comfort preference reasons, for improved sound insulation between suites provided by the concrete topping, and because it provides an excellent match for the fully-ducted ventilation systems. The central heating and hot water system in the main house was fitted with flow meters to apportion energy costs by usage. The coach house is separately metered. The gas for fireplaces and stoves was not metered because it would have been expensive to add the extra monitoring equipment. It is expected that gas usage for fireplaces and stoves will be a very small factor in total energy use, so that initially the estimated cost of gas for the fireplaces and stoves will be apportioned to owners by square footage. However the fireplaces have been pre-wired to accommodate gas clocks if deemed necessary.

Wood Flooring: Wood flooring was chosen for its heritage appearance and dust-free benefits. Salvaged hardwood plank or strip flooring would have been the preferred material, but was not compatible with the in-floor heat. "Floating" floor laminates were the only products that would carry a full warranty over radiant-heated concrete topping. Due to these considerations, and the wood conservation emphasis of Ardencraig, laminated bamboo was chosen. It is made from large bamboo grown in China and manufactured in Indonesia. The bamboo is pressed and glued onto a wood backing. The finish is factory cured polyurethane, so no dusty sanding and toxic finishing is done on-site. The finish and the bamboo are both highly durable. The particular manufacturer was chosen as they do not use urea formaldehyde glues in their process and they also indicated that they provided fair working condition in their factories.

Domestic hot water system: An indirect DHW storage tank with a heat exchanger fed from the same boiler that is used for heating was the final choice. Domestic hot water and heating pipes had to be run individually back to the mechanical room to allow for individual metering for each suite. The piping is a combination of copper and cross-linked polyethylene (PEX).

Solar Hot Water: The poor payback of solar hot water heating was discussed during the greenprint analysis. However it was not used for other reasons. There are very limited south-facing roof slopes on the original house and the south facing roofs on the coach house are very complex and present little appropriate surface for collectors. The typical plate-type collectors are approximately 3.0x1.5M (10 ft x 5 ft) and would not fit the south facing roofs. The tank-type collectors are narrower but much deeper so cannot be easily recessed to appear like a skylight. It would have been esthetically unacceptable to have an exposed collector on this traditional house and it would almost certainly not have met the city's neighbourhood design requirements.

Boiler: A single, central mid-efficiency boiler was used in the main house. It is not as efficient as a condensing unit, and may be replaced even before its full service life is over with a more efficient unit if gas prices justify it. The venting for a more efficient unit should be easily done in the existing boiler room. However compatibility with the heating loops and DHW system will have to be determined.

Low Toxicity Finishes: A locally available "zero VOC's" interior paint line was used throughout the project. A formaldehyde-adhesive-free MDF (Allgreen) was used for kitchen cabinet boxes. The cabinet doors are reclaimed Douglas fir with water-dispersed finish. The wood flooring is pre-finished eliminating sanding dust and emissions from finishing.

Heritage Details: Several new stained glass panels using a design taken form the original house were successfully integrated into three of the four suites. Some interior wood millwork details such as the wood mantel were reused, and the granite block wall was reclaimed from the original house foundation and used for garden retaining walls. Many of the wide base trim and window trim details from old craftsman homes in the area were successfully reproduced using resource-efficient MDF profiles.

Storm water system: The final storm water system was approximately what was planned during the Greenprint phase. The rainwater leaders run to barrels, which overflow through to the collection pond in the back garden. The pond overflow goes to a perforated sump or "dry well" where it is absorbed into the ground for filtration and to recharge local groundwater. Only any excess that cannot be absorbed by the dry well flows to the city storm sewer, which will occur only during an extreme rainfall event. The city did not have any experience with dry wells so had to develop the design. They then assisted in manufacturing a small number of these systems for experimental use free of charge. See regulatory obstacles below.

Landscape design and materials: Permeable surfaces were used for all paths, patios and parking spaces to increase ground absorption of rainwater. Indigenous and drought and pest resistant plants were chosen to minimize water needs and pest controls. Space was reserved for a vegetable garden. Low shrub ground cover was used in place of traditional grass turf to eliminate lawn care.

Other Unique Features:

- Individual water filtration systems for drinking water were installed. This provides treated water instead of buying bottled water as many people do.
- A garden bench was made from BC's first available eco-certified wood.
- The services of a Feng Shui expert were used and interior layouts and landscaping amended to accommodate recommendations where feasible.

- Compost units were installed in the side yard garden.
- Extensive bike storage was provided to promote bike transportation.
- Strata by-laws were adopted that prohibit use of gasoline powered leaf blowers and other equipment that add significantly to noise, air pollution and greenhouse gases.

Part V

Conclusions

Ardencraig is a successful, small-scale market experiment with sustainable building development. It demonstrates that many resource efficiency, energy efficiency and healthy building features that are uncommon in the marketplace can be incorporated into a residential project and that it will sell in the Vancouver market. However there is no doubt that Ardencraig's popularity was due to the successful integration of these sustainability features with a good location, a popular heritage appearance, and with good suite design. The financial risk of Ardencraig was managed successfully by careful evaluation and selection of the features that would add the best value for the cost, and that buyers would respond to. This is not unlike the successful management of a conventional development without the sustainability features, but in the case of Ardencraig the type of features considered and the motivation for the choices were extraordinary.

Not all buyers were equally inspired by the resource efficiency (no new old growth) emphasis, but all considered it at least a "bonus" in a home with other good value. Buyers were impressed by the healthy heating and ventilation systems, which are a very unusual package in Vancouver. The energy efficiency steps in Ardencraig were not extraordinary, largely due to the limitations of working with an old house, and buyers were not overly impressed with these features. Buyers seem to expect energy efficiency, or at least claims of energy efficiency. This may be partly due to the wide exposure of BC Hydro's Power Smart New Home Program which has very modest requirements and has nearly saturated the market in Vancouver.

Lessons Learned

- Only a limited number of sustainability features can be incorporated in one project. It may be best to pick an emphasis or specific targets rather than try to do everything. Where the project was most successful was where there were clear goals.
- Basing new construction almost entirely on recycled wood is feasible and not excessively costly or slow.
- Novelty overload is a real problem in design decisions, materials selection and construction decisions. Each avenue of research turns up possibilities that must be assessed quickly and decisively.
- Novel techniques and materials must be considered for their cost, availability, construction timing, and value added to the project. Some may also raise regulatory obstacles (see below).
- On the energy front it would have been useful to use a measure like R2000, or Powersmart – that was quantifiable and recognizable by the buying public – that would have helped to substantiate claims of efficiency.
- More novel materials such as cellulose insulation, straw board substitutes for MDF etc. could be tried on future projects, now that the overall concept and approach has been successful.
- Additional healthy and energy efficient features and practices could be incorporated with better scheduling and planning next time.
- The envelope energy performance options are limited when remodeling an old house. To have achieved more at Ardencraig would have been costly and probably cost floor area and headroom.

- More efficient heating equipment might have been justified, but the technical complexities of system compatibility have to be solved.
- Active solar features are not feasible in Vancouver with current equipment and fuel prices.
- Next time wood use could be reduced further by using less exterior trim.
- Next time a hydronic convector heating system would resolve the problem of limited options for flooring. It might also make higher efficiency combustion equipment more justifiable.

Regulatory Obstacles

There were relatively few regulatory problems with Ardencraig. The city Planning Dept. did determine what type of exterior materials could be used, but this was expected in this heritage neighbourhood. Only the gray water recycling proposals and the alternative storm-water system really raised any obstacles. The City is not prepared for any radical gray water recycling systems at this time. Their policy is that rainwater can be collected for gardening, but that all piped water must be potable city water, even if it is used only for flushing toilets. The storm-water system and dry-well disposal were not difficult to work out as the city was motivated to see this system tried. However they did require a storm-water connection for the event that the system becomes overloaded.

The only other obstacle noted was that several excellent US-made products that were considered are not CSA approved or do not have CCMC listing, so were unacceptable to the building department, the plumbing department or the electrical department.

Information Sources Used

Web-sites:
Environmental Business News (www.buildinggreen.com)
City of Austin Sustainable Sourcebook (www.greenbuilder.com/sourcebook/)
CMHC (www.cmhc-schl.gc.ca)
US Department of Energy – (www.energy.gov/)
NRCan – energy efficient appliances - (www.nrcan.gc.ca/)
Various Manufacturer's Webstes

Reference books:
Healthy Housing BC Directory, CMHC
Healthy Housing Resource Guide, CMHC
Environmental By Design, David Rousseau & Kim LeClair
Building Materials for the Environmentally Hypersensitive, CMHC
Sol Plan Review, North Vancouver
Vancouver Healthy Housing Project Final Report, CMHC
City of Santa Monica Green Building Guidelines

Consultants:
Urban Ecology Collaborative
Claire Kennedy (Landscape)

Organizations:
CMHC
Greater Vancouver Regional District – Thomas Mueller, Michel Despot
EcoTrust Canada
Waterwise Garden, City of Vancouver

Appendix I

Table of Materials and Technologies Considered for Ardencraig

Division 2 Site Work

Generic Product Description	Sustainability Attributes	Potential Application in Ardencraig	Used or Not in Ardencraig and Why
Recycled content landscape construction products: • plastic lumber • landscaping ties, edging, benches, grates, turf, construction fence, reinforcement mesh. • pavers • geotextile fabric	Highly durable and rot-resistant products made with waste plastic, tire rubber, waste wood fibre and cement. Uses consumer waste. Eliminates hazardous chemical treatments used in rot-resistant wood construction. Saves wood.	Site development and landscaping.	• Plastic lumber- not used for aesthetic reasons • Landscaping ties not used – investigated use of recycled hydro poles but rejected. • Bench made from BC's first available eco-certified wood. • Granite salvaged from original house foundation used in front wall and retaining walls
Salvaged landscape materials: • turf, trees and shrubs • soil and compost, etc.	Saves production of new materials. Reduces organic waste. Provides mature plantings.	Landscaping	• Existing turf reclaimed for other projects

Division 3 Concrete

Generic Product Description	Sustainability Attributes	Application in Ardencraig Project	Used or Not in Ardencraig and Why
Rental or recycled lumber forms	Saves new material. Minimizes waste	Concrete wall forming	Salvaged wood used for forms and then re-used. Rental forms also used.
Fly ash as an additive to replace >15% of the Portland cement in concrete.	Reduces use of Portland cement which is energy intensive in its manufacturer, diverts fly ash from the waste stream	All concrete.	50% fly ash concrete used for all foundations, floor toppings, porches and stairs
Form release agents based on vegetable oil.	Eliminates odours, release of VOC's and is nontoxic as well as reducing demand for petroleum based form release oils.	Concrete form work	No form release agent used
Low emission concrete additives, curing compounds, accelerators, bonding agents and sealers.	Reduces VOC emissions into the atmosphere and building interior	All concrete work	Not used – no interior finished concrete
Concrete colorants, inorganic, mineral-based pigments for coloring finished concrete	Eliminates tile and setting.	Interior finished concrete work	Not used – no interior finished concrete
Sodium silicate (water glass) for sealing and hardening concrete and masonry surfaces.	Increases durability of concrete surfaces, reduces concrete dust enhancing indoor air quality	All exposed interior concrete work	Not used – no interior finished concrete

Insulated concrete forms (providing both form work and permanent building insulation)	Provides integral foundation insulation and drainage. Reduces condensation formation and mold growth.	Ground level and below grade foundations.	Not used – limited below ground foundations. Rental forms used.
Fabric foundation forming systems	Very resource efficient, small amount of lumber used and all recovered, eliminates concrete wastage during pour	All foundation footings	Not used – cost and time restrictive
Paper fibre tube forming using recycled paper fibre	Almost entirely made of recycled paper	Concrete columns	Used for small footings
Rebar supports (cradles, chairs, wheels etc.) made from recycled plastics	Manufactured from post consumer waste, diverting it from the land fill	All reinforced concrete work	Not used – not needed

Division 4 Masonry

Generic Product Description	**Sustainability Attributes**	**Application in Ardencraig**	**Used or Not in Ardencraig and Why**
Concrete block with expanded polystyrene bead aggregate, wood fibre aggregate or other lightweight, recycled materials	Improved insulation. Reduces condensation formation and mold growth enhancing indoor air quality.	Exterior masonry wall use.	No exterior masonry used in this project
Salvaged brick, stone etc.	Saves new production. Reduces waste.	Interior and exterior wall and floor use.	Salvaged stone used for garden walls

Division 5 Metals

Generic Product Description	**Sustainability Attributes**	**Application in Ardencraig**	**Used or Not in Ardencraig and Why**
Lightweight steel framing	Saves wood resources, durable, easily salvaged. Non-combustible.	Non-structural partitions.	Investigated use of steel studs for partition walls and bracing but did not use due to higher cost and decision to use salvaged framing lumber
Salvaged architectural metals	Saves new production. Reduces waste.	Stair and balcony rails.	Not used in project

Division 6 Wood and Plastics

Generic Product Description	**Sustainability Attributes**	**Application in Ardencraig**	**Used or Not in Ardencraig and Why**
Salvaged wood framing materials.	Saves virgin wood, reduces waste.	Framing and sheathing.	• Over 95% of framing lumber (approx 40,000 bd ft) was salvaged lumber including shiplap for sheathing.
Wood finishing materials.	Saves virgin wood, reduces waste.	Millwork, stairs, cabinets etc..	• Reclaimed Douglas fir used for kitchen cabinet doors • Reclaimed fireplace mantel

Engineered wood products: • finger jointed lumber • veneered lumber • dyed and figured simulated hardwoods • molded MDF trim	Uses resources efficiently. Adds value to low quality resources. Medium Density Fibreboard (MDF) can use sawmill waste.	Framing, interior finishing, casework, millwork, cabinets and furniture.	• FJ studs used for small section of framing where salvaged lumber not available • MDF used for all interior trim
Engineered panel products: • MDF (particle board) • low density fibreboard • OSB (wafer board)	Uses resources efficiently. Adds value to low quality resources, e.g. wood waste and fast growing hardwoods.	Interior wall and floor finishing. Cabinets and furniture frames etc.	• "All Green" MDF used for kitchen cabinet boxes • Fibreboard sound insulation used between concrete floor topping and floating floor • Floating floor with bamboo top veneer used for floors (1800 sf)
Low-toxicity manufacturing resins and wood glues: • polyurea resins (MDI products) • powdered resins (phenolics). • acrylic and vinyl adhesives (PVA products)	Low emissions and improved worker safety. Non-toxic cleanup and waste. Powdered resins reduce waste.	All engineered wood products above. Veneer and panel application. Furniture construction.	• Formaldehyde free (MDI resin) MDF and straw board.
Recycled paper board. Agricultural waste board (straw and grass).	Uses low grade waste paper or agricultural fibre. Low-toxicity, safe handling.	Door panels, shelving, furniture, cabinet panels	• Isobord insulation panels used
Honeycomb panels	Uses waste paper and wood fibre	Door panels, shelving, cabinets, closets	• Not used
Fibre cement board	Uses waste cellulose fibre for reinforcement, highly durable, resistant to moisture and fire.	Ceramic tile backer board. Fire rated partitions.	• Not used.
Mineral composite products: • mineral filled cement/ plastic resin panels	Uses waste materials. Highly durable and moisture resistant.	Countertops, bath enclosures, floor tile, decorative trim, furniture.	• Not used

Division 7 Thermal and Moisture Protection

Generic Product Description	Sustainability Attributes	Application in Ardencraig	Used or Not in Ardencraig and Why
Cementitious (crystallizing) concrete sealers	Replaces asphalt products, reduces risk of mold formation	Sealing below grade foundations and for pond water containment.	• Not used – unaware of product
Aluminum foil and plastic laminated foil	Used as a radiant barrier can reduce heating and cooling loads. Can be manufactured from recycled aluminum.	Radiant barrier in roofs, walls (with air-space).	• Not required in this project
Recycled plastic batt insulation	Made from recycled plastic waste reducing land fill and conserving energy	Wall and roof insulation	• Not used – alternative material selected

Cellulose insulation	Typically 80% recycled content, low energy of manufacture, reduces air leakage, fills voids effectively.	Cavity insulation material in roofs and walls (blown in batt).	• Not used – concern with settling post installation, and increased cost.
Mineral Wool Batt Insulation	Utilizes waste products manufactured from mining and industrial slag, highly durable and insect resistant.	Cavity insulation material in roofs and walls.	• Rockwool batts used for sound insulation between floors
Mineral Wool Board Insulation	Utilizes waste products manufactured from mining and industrial slag, highly durable and insect resistant. Used in rain screen applications.	Roof, wall and vertical below grade insulation. Exterior wall insulation upgrade.	• Not used
Rigid glass-fibre insulation board	Can use recycled glass, highly durable and insect resistant. Used in rain screen applications.	Roof, wall and vertical below grade insulation. Exterior wall insulation upgrade.	• Not used – alternative product used
Fibre-cement siding	Uses recycled cellulose fibre for reinforcement, highly durable, resistant to decay, fire and termites.	Exterior cladding	• "Hardiplank" siding used for majority of exterior
Fibre-cement shingles	Uses recycled cellulose fibre for reinforcement, highly durable, resistant to decay, fire and termites	Sloped roofing (greater than 4/12 pitch)	• "Hardishingles" used for exterior siding features. Considered too costly for roof.
Rubber roofing (slate like shingles)	Manufactured from 100% recycled tires. Very durable	Sloped roofing	• "FlexShake" considered. Discounted due to cost (2-3 times more expensive than asphalt shingle) Also not CSA approved and concerns re energy of transportation from US.
Water based low toxicity caulkings for interior application	Enhances indoor air quality by reducing pollutant loading , maybe used as part of air barrier system	Apartment interiors as part of the air barrier system	• Acrylic caulkings used.
Low emission, water dispersed adhesives	Enhances indoor air quality by reducing pollutant loading	Cabinets, flooring, carpet installation	• Used for assembling of kitchen cabinets
Rain screen cladding systems	Increases building durability by reducing rain entry	All exterior wall applications	• Used on main house but not in-fill dwelling due to considerable overhangs and sheltered location.

Division 8 Doors and Windows

Generic Product Description	Sustainability Attributes	Application in Ardencraig	Used or Not in Ardencraig and Why
Insulated entry door	Reduces heating and cooling requirements .Reduces condensation formation and mold growth.	Entry doors	• Solid wood doors with double glazed lites used for front entrances.
Wood composite doors (e.g. parallel strand lumber core, quality wood veneer)	Resource efficient and durable.	Interior solid doors	• Used for all internal doors

Windows with plastic frames and sashes and low E argon filled glazing units	Reduces heating and cooling requirements. Reduces condensation formation and mold growth. Can have high recycled content.	Windows	• Vinyl window frames used with double Low E finish and argon filled.
Salvaged doors.	Replaces new production, reduces waste	Interior and exterior doors	• Not used due to labour intensive refinishing
Salvaged, heritage windows	Replaces new production, reduces waste	Interior windows	• One stained glass window per unit made from reclaimed glass for interior. • Salvaged windows not suitable for exterior for energy performance reasons.

Division 9 Finishes

Generic Product Description	**Sustainability Attributes**	**Application in Ardencraig**	**Used or Not in Ardencraig and Why**
Recycled content gypsum board	Contains construction and demolition gypsum waste. Uses recycled paper.	Interior walls and ceilings, fire-rated insulated partitions, sound-rated walls and ceilings.	• All drywall from supplier which utilises recycled gypsum waste
Fibre-gypsum board	Uses waste wood and paper fibre. Can use recycled gypsum. Highly durable and scratch resistant.	High wear corridors, durable bathroom and kitchen walls and ceilings, acoustic and fire-rated flooring underlayment.	• Not manufactured in Western Canada
Molded recycled fibre-gypsum interior trims	Can use recycled gypsum. Uses recycled mineral fibre.	Coves, crowns casings etc.	• Not used – MDF used instead
Agricultural waste board (straw and grass).	Uses low grade agricultural fibre. Low-toxicity, safe handling.	Base for veneered, decorative panels. Cabinet panels, flooring underlayment.	• Isobord used
Plant-fibre fabrics	Jute, hemp, coir, bamboo, rice and wheat straw fibre.	Wall coverings, furniture, drapery, blinds, carpet.	• Not used. Purchasers responsible for interior decoration
Recycled plastic textiles	Uses waste PET plastic from food containers to make a durable polyester fibre	Wall coverings, furniture, drapery, blinds, carpet fibre, upholstery filling.	• Not used – Purchasers responsible for interior decoration
Recycled content ceramic tile	Uses mineral waste from mining, manufacturing, and consumer glass.	Wall and floor tile.	• Not used – unaware of supplier
Recycled content acoustic panels	Uses low grade wood fibre, agricultural and paper waste and clay and gypsum.	Acoustic ceilings.	• Not relevant to this project
Veneered wood flooring, MDF or LVL core	Uses valuable wood more efficiently.	Floors, esp. over radiant heat	• Bamboo veneer flooring used
Recycled rubber flooring	Uses waste tire rubber	Common areas, corridors, outdoor mats.	• Not required for this project
Linseed oil linoleum flooring	Uses renewable vegetable oil. Highly durable and healthy. Anti-bacterial.	Kitchen and bath floors, entries and desk tops (show unit).	• Not required for this project
Low toxicity paints, adhesives and coatings- zero VOC standard.	Occupant and worker safety. Reduced toxic waste.	All uses	• All interior paints were zero VOC

Salvaged wood floors	Saves new production, reduces waste.	Wood floors	• Not suitable for use over radiant heating
Local, underutilized hardwoods, e.g. Alder, Birch and Big Leaf Maple	Uses woods that are often wasted. Saves highly valued wood, e.g. Oak	Stairs, trims, floors, window stools.	• Not used – salvaged wood and MDF used instead
Salvaged finishing woods, e.g. interior millwork and flooring.	Saves virgin wood, reduces waste.	Stairs, trims, floors, window stools	• Not used
Salvaged hardware and accessories	Saves new production, reduces waste.	Door and window hardware, bathroom accessories etc.	• Not used

Division 15 Mechanical Systems

Generic Product Description	Sustainability Attributes	Application in Ardencraig	Used or Not in Ardencraig and Why
Radiant or convective heating	Energy efficient and has health benefits over forced air.	Suites	• Radiant system selected for comfort and marketability
Very-low-flow plumbing fixtures	Reduces water consumption (unheated and heated) reducing fuel use. Reduces load on sewers.	All fixtures	• Low flow (6L) toilets used throughout. Low flow showers. Ultra lpw were investigated but not used due to cost.
Rain water collection and storage systems	Reduces demand on city utilities.	Landscape irrigation, toilet flushing. (requires separated supply plumbing)	• Rainwater run-off collected in barrels for landscape watering. City would not consider re-use for toilet flushing.
Small-scale biological gray water treatment system	Reduces load on sewers. Reduces water demand.	Irrigation (requires separate drain plumbing)	• Not used due to time, space and cost constraints and regulatory obstacles.
Groundwater recharge absorption (dry-well and swale)	Reduces load on sewers, recharges groundwater.	Overflow from rainwater systems.	• Overflows run to perforated sump (dry well)
Gray water heat recovery	Recover heat from waste water to preheat incoming water, reducing fuel consumption.	Kitchen, laundry and bath grey-water. (requires separate drain plumbing).	• Not used – unaware of local supplier
Potable water treatment systems	Through filtration to remove sediment, minerals, chemicals and by products of chlorination. Reduces transportation and cost of bottled water.	Fittings provided in individual apartments. System in show unit.	• Filter system at kitchen sinks. Larger scale system not used due to cost.
Central exhaust only ventilation systems	Enhances indoor air quality and helps to control indoor humidity levels in winter.	Fan for whole building. Intakes in individual apartments.	• Not relevant to this project
Individual heat recovery ventilation systems	Enhances indoor air quality and helps to control indoor humidity levels in winter by continuously exhausting moisture and air pollutants while continuously supplying outdoor air. Heat recovery reduces energy use.	Individual supply and exhaust heat recovery units in apartments.	• Individual HRV for each suite installed.
Individual filtration / gas adsorption systems	Enhances indoor air quality by reducing levels of volatile organic compounds.	Individual apartments. Combined with ventilation system.	• Not used. HRV has basic filtration included. VOC removal not needed.

Solar domestic water heating systems	Substitutes renewable energy for fossil fuels reducing greenhouse gas emissions.	Water pre-heating for living units.	• Not used – considered but discounted due to high cost / unlikely payback
Low chemical emission ductwork mastic	Enhances indoor air quality by reducing pollutant loading, reduces ductwork losses	Ventilation ducts	• Not used – unaware of product

Division 16 Electrical

Generic Product Description	Sustainability Attributes	Application in Ardencraig	Used or Not in Ardencraig and Why
High efficiency indoor lighting and controls • compact fluorescent • LED exit lights • metal halides • occupancy sensors	Reduced electrical consumption. Longer life, less maintenance and waste.	Common areas, stairs, fire exits, corridors, kitchens and baths,	• Compact flourescents used in certain locations • Dimmers utilised on most interior fixtures
High efficiency outdoor lighting and controls • sodium lamps • metal halides • sensor controls	Reduced electrical consumption. Longer life, less maintenance and waste, better security.	Paths, gardens, entries..	• Compact flourescents used in certain locations • Motion sensors used in certain locations
Local communications systems and networks, e.g. Smart Home systems	Improved energy and water use management, at-home work, security and community information.	Pre-wire all units.	• Not used due to cost
Building integrated photovoltaic (PV) solar electric systems: • PV cells • PV glass and roofing tile • controllers	Replaces fossil fuel generated electricity reducing greenhouse gas emissions. Replaces some electrical distribution wiring.	Provide for future retrofit.	• Not used – considered but discounted due to cost and lack of south facing roofs.
Electric vehicle charging stations.	Zero or low emission vehicles reduce urban pollution and greenhouse gases.	Provide electrical capacity and conduit for chargers.	• Cable run to parking spaces

Appendix II

Market Response

A survey form was developed for use primarily during open houses. It was administered to purchasers if they had not attended an open house. A copy of the survey form and compiler results is below.

The environmental aspects of Ardencraig can be distilled into three main categories, Energy, Resources and Health. Of these three, people seem to be most responsive to the *health* aspects. People perceived direct benefit from healthy interiors and it seems that their self-interest and health consciousness was aroused. The resource efficiency and other broad environmental responses are something people appreciated, but very few would go out of their way to find, and even fewer would pay extra for it.

Energy efficiency is something people expect to get now, and any claims of extraordinary efficiency are viewed with skepticism. Everyone claims energy efficiency, everyone has to meet the code, and many go a little further and attain utility standards like BC Hydro Power Smart. However, though survey respondents may have been skeptical in their comments about energy efficiency claims, they did rank energy efficiency high, after health, location and heritage character.

A notable exception is the buyer who purchased the first unit. She was highly motivated by the resource efficiency aspects of Ardencraig. She seemed to indicate in her survey that there was a personal moral value to her in the resource efficiency features.

It seems that the special sustainability features of Ardencraig were very attractive to a small group of sophisticated buyers. These are probably the "early adopter" segment, and if interviewed further would probably be found to have higher education, a good deal of life experience, strong ideals, and known as leaders among their peers.

Ardencraig Visitor Survey Form

. Identification

1) Age group

- under 25
- 25 to 35
- 35 to 50
- over 50

2) Gender: M F

3) Household type:

- Single
- Couple
- Child or parent in home
- Cat or dog in home
- Other household factors ____________________ (e.g. physical handicaps)

4) Household gross income, 1999 (before taxes):

- Up to $60,000
- $60,000 to $90,000
- Over $90,000

5) **Previous home ownership:**

- None
- Owned apartment
- Owned detached home

6) **Transportation A**:

Do you commute to work? If so, how far and by what means?

____

7) **Transportation B:**

How many cars do you use in your household? ____________

8) **Work at home:**

Does someone in your household work primarily at home? ____________

I. Information sources:

9) How you learned of this project:

- Real Estate Weekly
- Newspaper article
- Television or radio item
- From a friend
- Other ______________________________

10) How long have you been looking for a home? _____________

11) Where have you been looking? ____________________________________

II. Response to this project:

12) Please rank each factor about this home as: 0) not important 1) somewhat important 2) important 3) extremely important to you

- Location 0 1 2 3
- Envelope durability (weather resistance and low maintenance) 0 1 2 3
- Energy efficiency 0 1 2 3
- Incorporation of salvaged and recycled materials 0 1 2 3
- Water conservation and consumer waste recycling features 0 1 2 3
- Healthy indoor environment (indoor air) 0 1 2 3
- Aesthetics / heritage character 0 1 2 3

13) Price and value overall

- How do you rate the value you would get for the price of this home
  0) unacceptable 1) just o.k. 2) good 3) excellent

14) Favourite features. Please name your most favoured features of this home.

____

15) Least favourite features. Please name your least favoured features of this home:

____

16) Other comments and suggestions:

____

____

ARDENCRAIG SURVEY RESULTS
Total Surveys Completed, 31

Part 1

AGE	under 25	25 - 35	35 - 50	50+
	1	9	19	2

SEX	male	female
	14	19

HOUSHOLD TYPE	Single	Couple	Child or Parent	Cat or Dog	Other	No answer
	11	16	5	5		1

INCOME	under $60,000	60-90,000	90,000 +	No answer
	8	13	7	3

PREV. HOME OWNERSHIP	None	Apartment	Detached Home	No answer
	12	6	12	1

	COMMUTE		HOW				
TRANSPORTATION	Yes	No	Car	Transit	Bike	Walk	No answer
	24	3	8	6	3	6	5

NO. of CARS	0	1	2	No answer
	3	19	4	5

WORK AT HOME	Yes	No	Part Time	No answer
	13	11	4	3

INFORMATION SOURCE	Real Estate W	Newspaper	TV/Radio	Friend	Other
	3	6	0	5	17

LENGTH OF SEARCH	1month	3 mos	6 mos	I yr	I yr +	Not looking	No answer
	5	4	4	6	3	4	5

WHERE HAVE YOU BEEN LOOKING	Eastside	Westside	Mt Pleasant	Near Downtown	Vancouver	Oustide Van.	No answer
	2	7	7	3	2	6	8

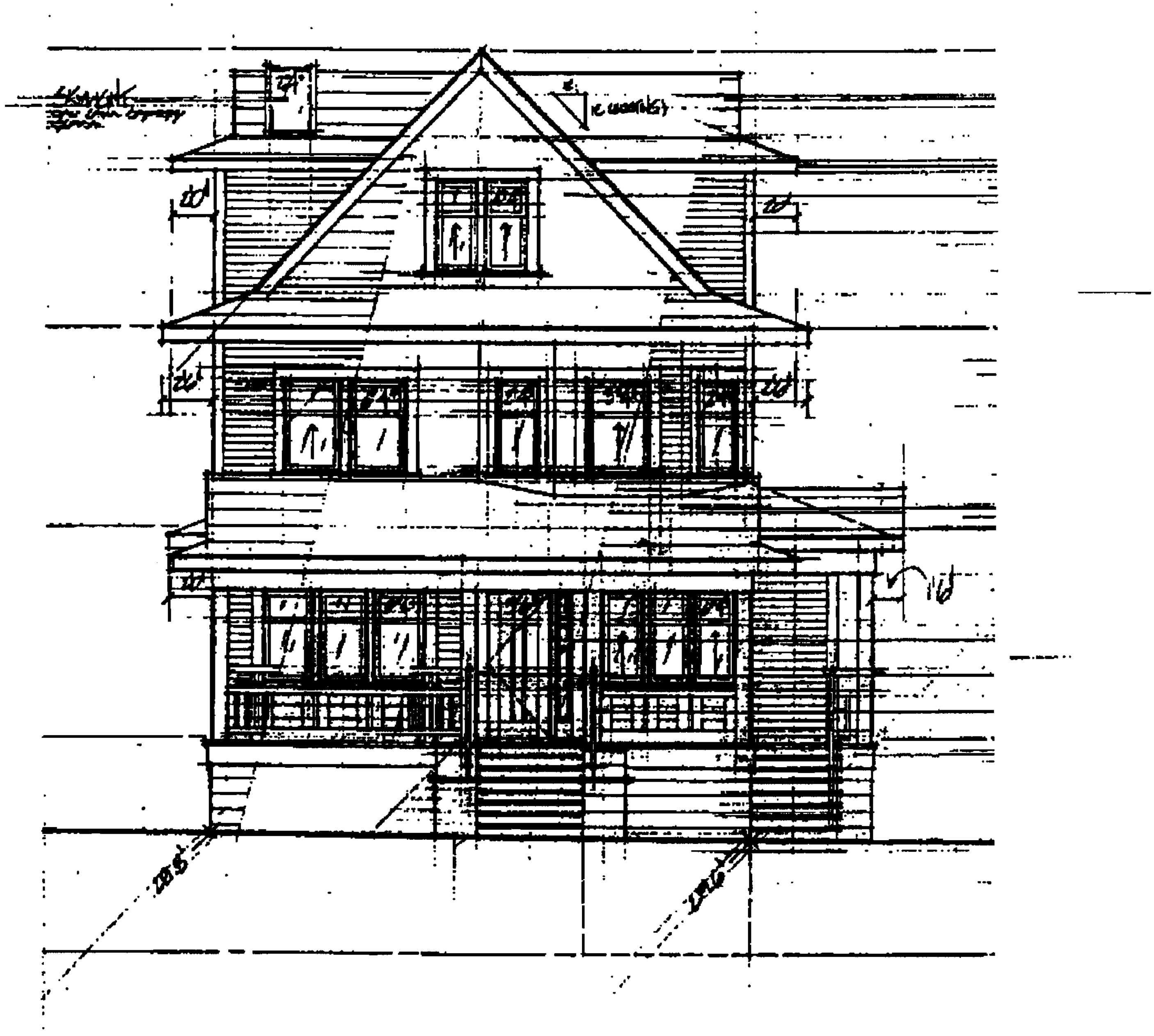
* RANKED IN ORDER OF IMPORTANCE	0	1	2	3	No answer
LOCATION	O	1	8	19	2
ENVELOPE DURABILITY	0	3	10	16	1
ENERGY EFFICIENCY	0	1	10	18	1
SALVAGED & RECYCLED MATERIALS	1	9	10	9	1
WATER CONSERVATION & RECYCLING	0	4	15	11	1
HEALTHY INDOOR ENVIRONMENT	1	1	3	25	1
AESTHETICS / HERITAGE CHARACTER	0	0	6	22	2

** PRICE & VALUE	0	1	2	3	No answer
	0	7	12	6	4

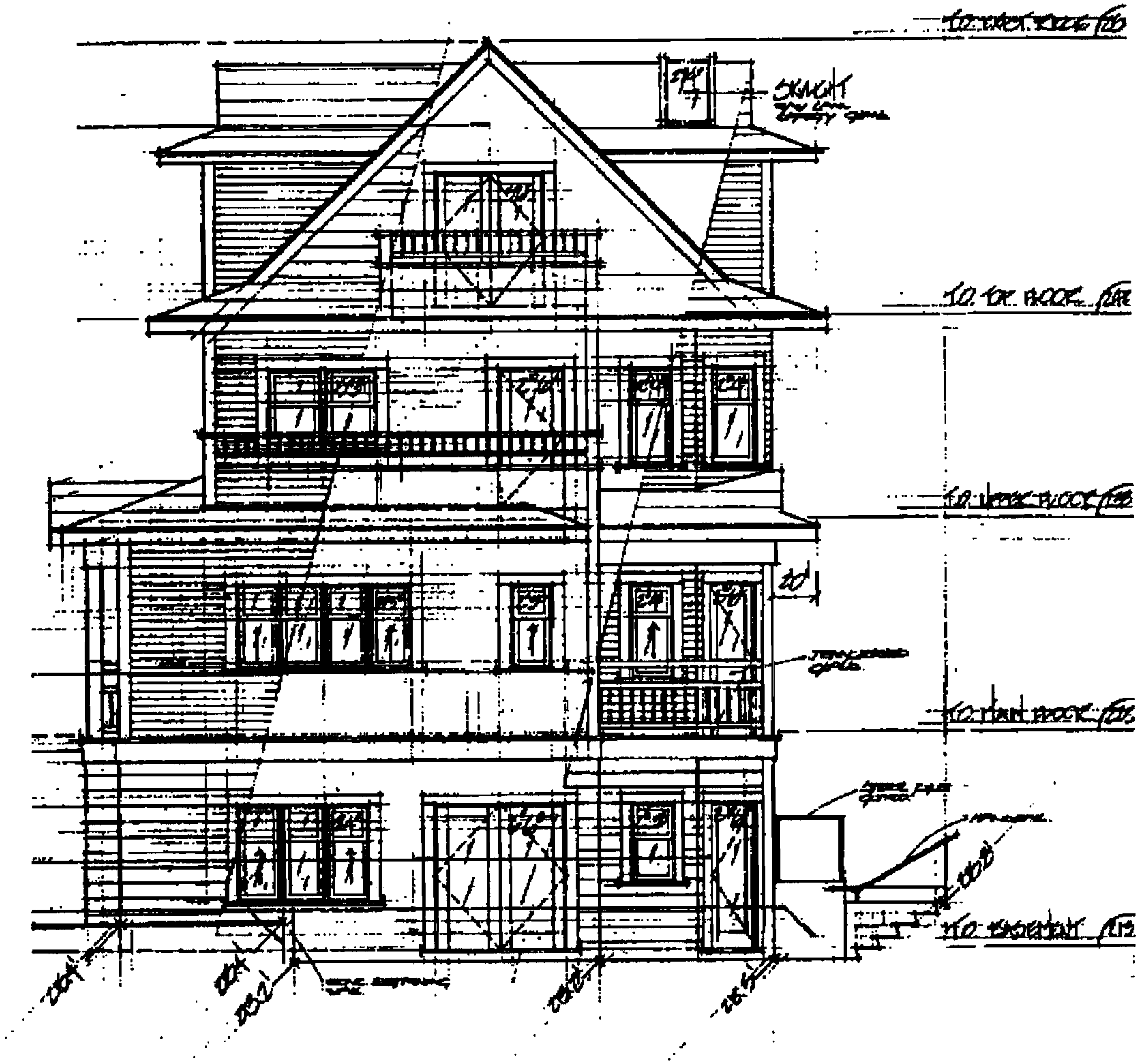
* 0) not important
1) somewhat important
2) important
3) extremely important to you

** 0) unacceptable
1) just o.k.
2) good
3) excellent

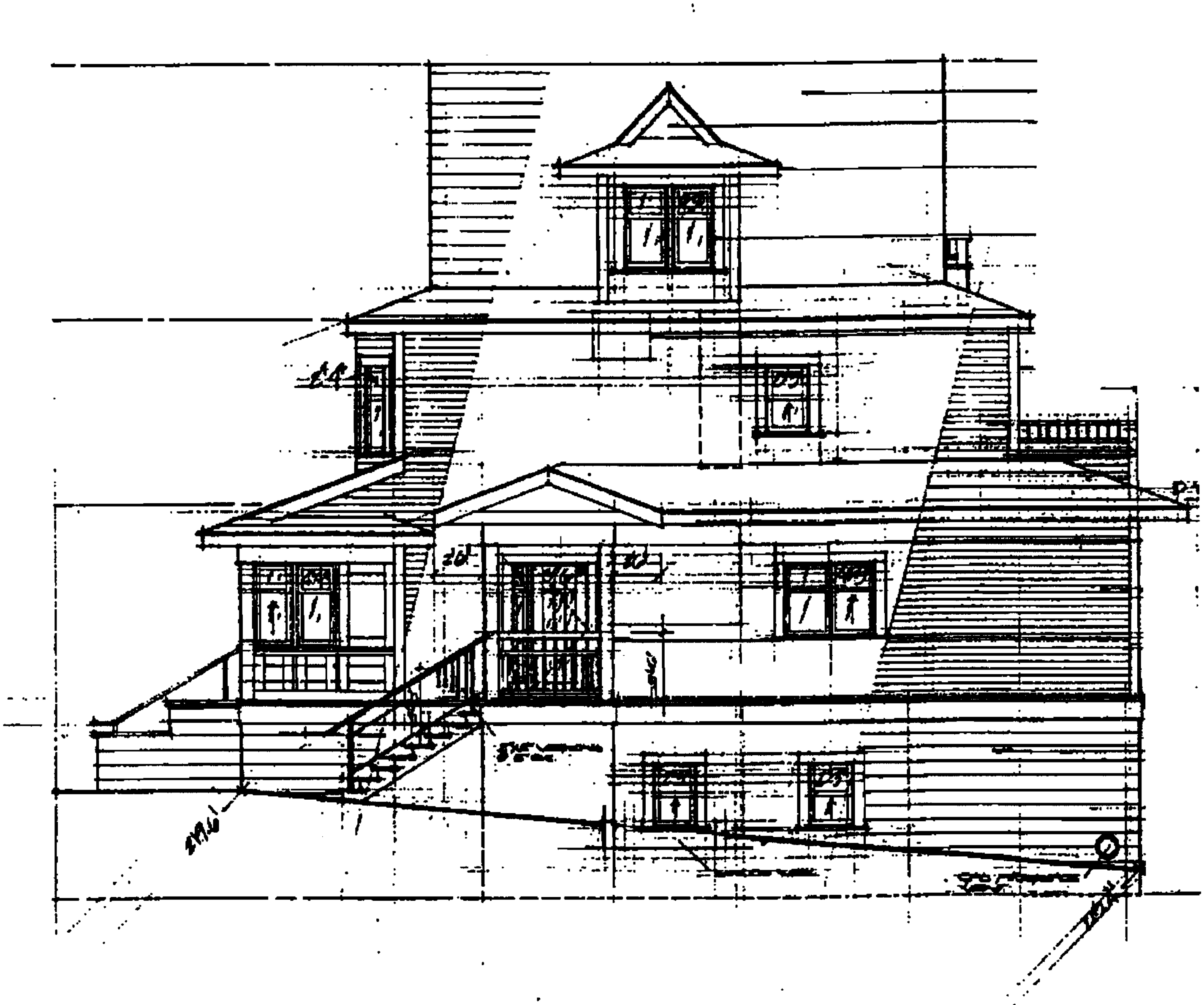
Appendix III
Drawings and Photographic Record



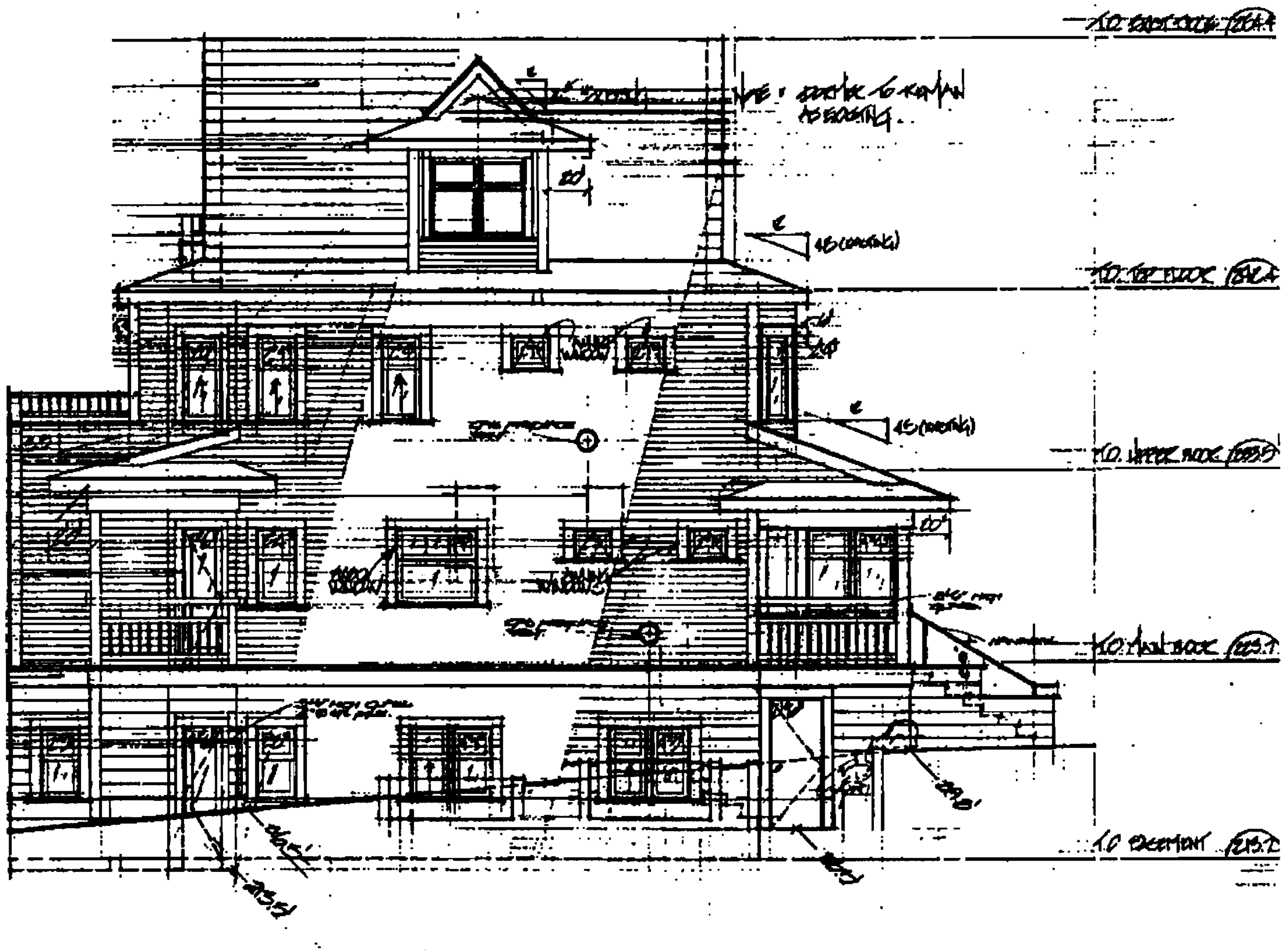
SOUTH ELEVATION ARDENCRAIG TRIPLEX
ALAN DIAMOND ARCHITECTS



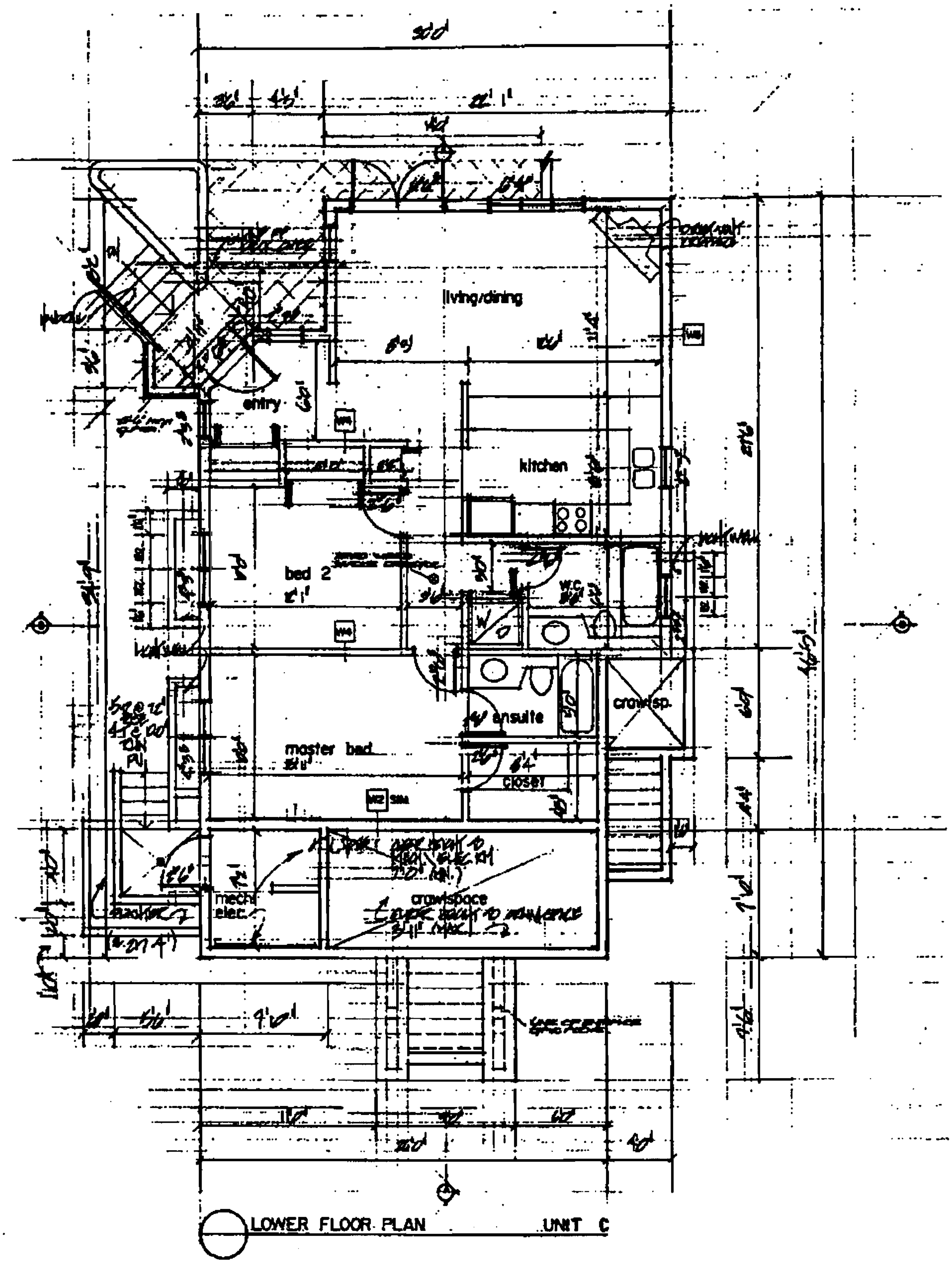
NORTH ELEVATION ARDENCRAIG TRIPLEX
ALAN DIAMOND ARCHITECTS



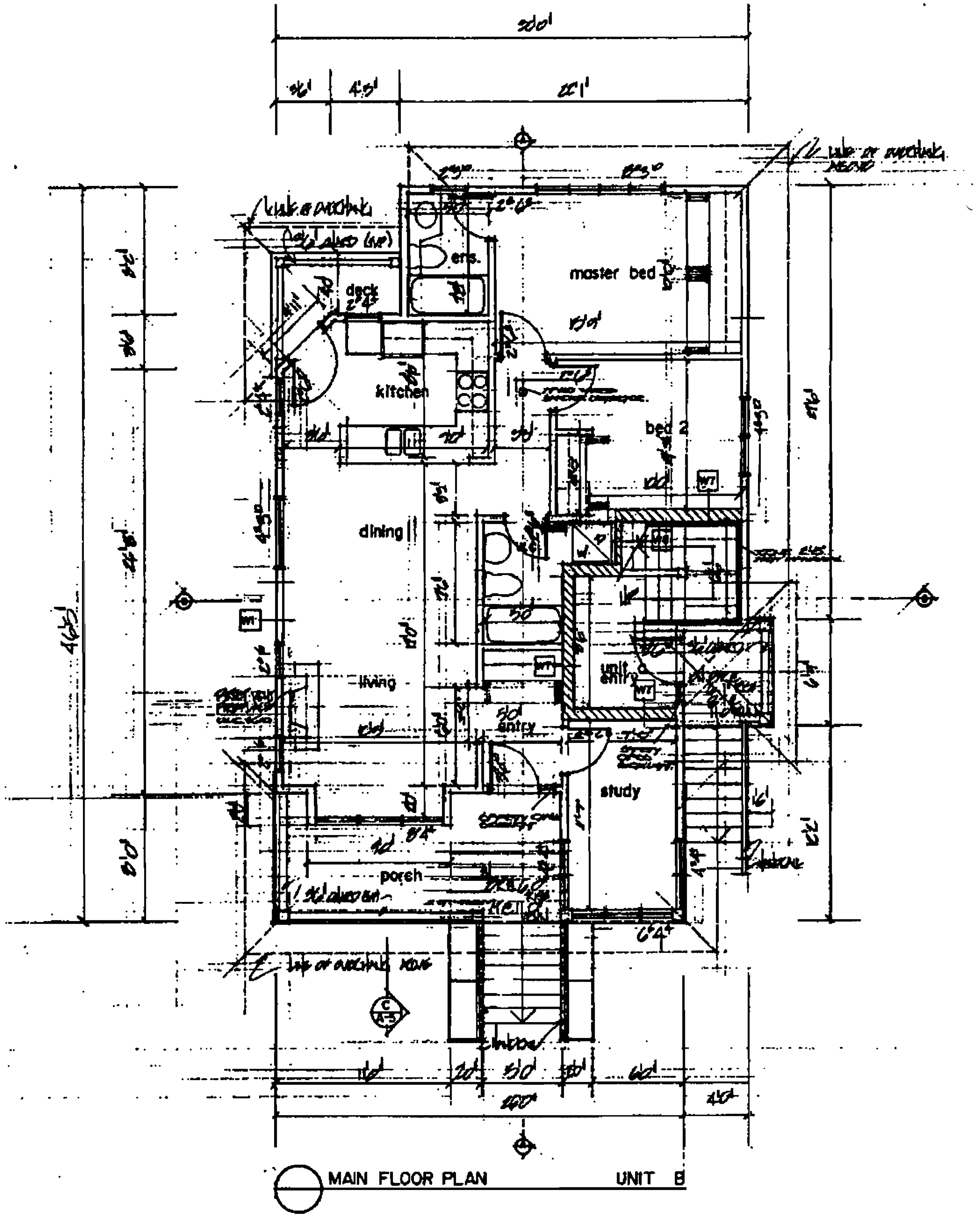
EAST ELEVATION ARDENCRAIG TRIPLEX
ALAN DIAMOND ARCHITECTS



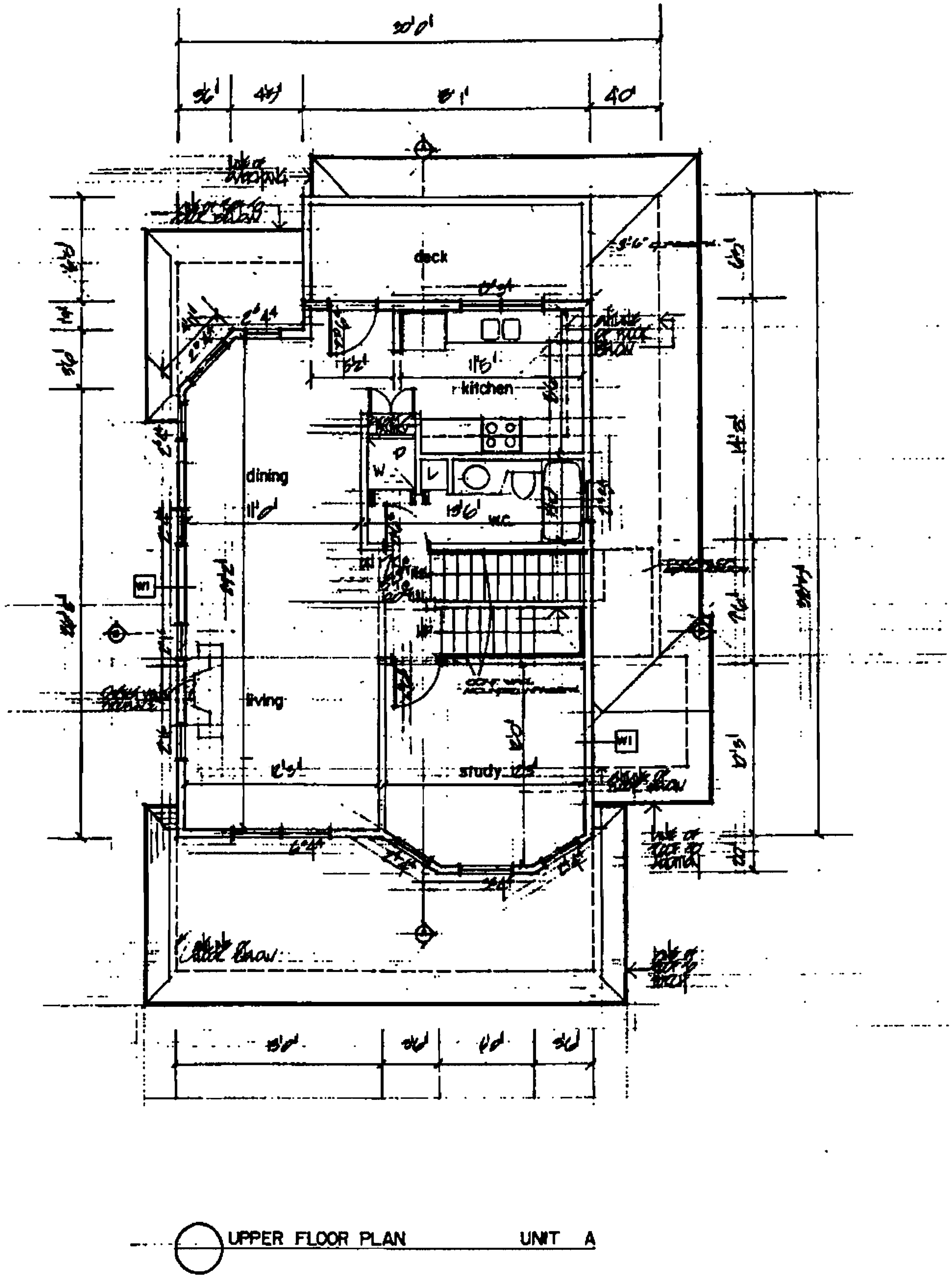
WEST ELEVATION ARDENCRAIG TRIPLEX
ALAN DIAMOND ARCHITECTS



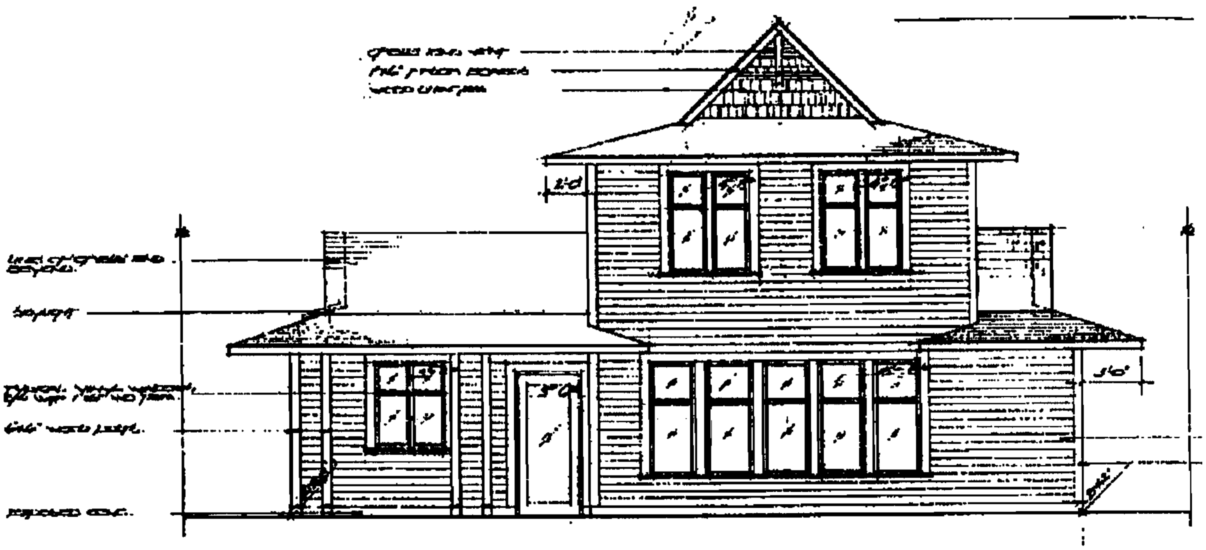
ARDENGRAIG PROJECT TRIPLEX
ALAN DIAMOND ARCHITECTS



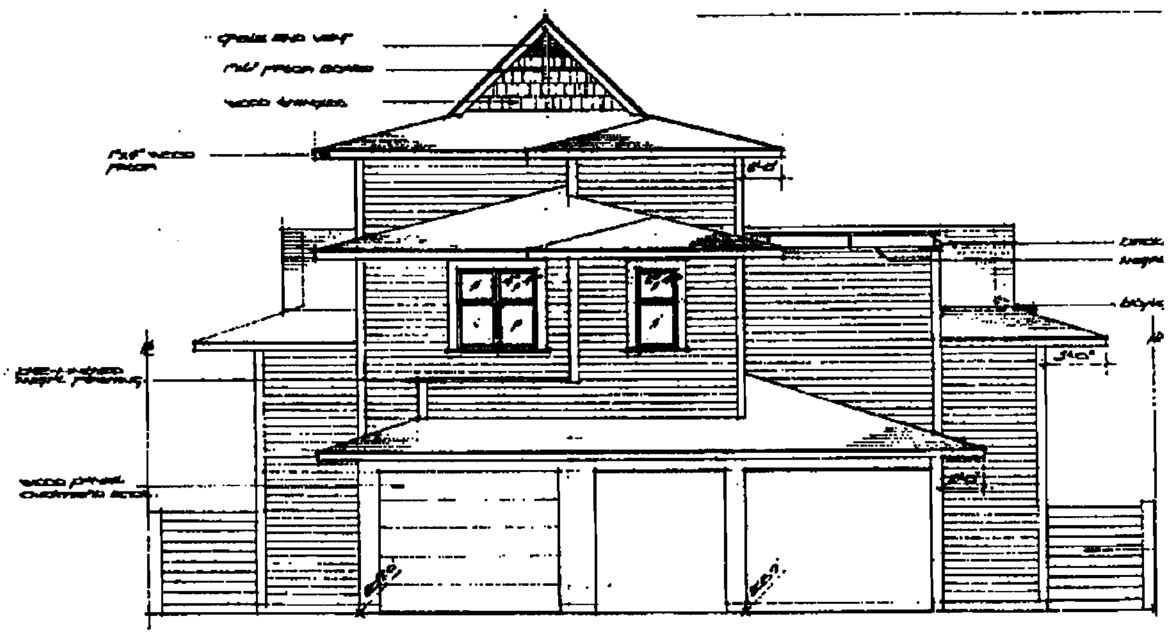
ARDENCRAIG PROJECT TRIPLEX
ALAN DIAMOND ARCHITECTS



ARDENCRAIG PROJECT TRIPLEX
ALAN DIAMOND ARCHITECTS

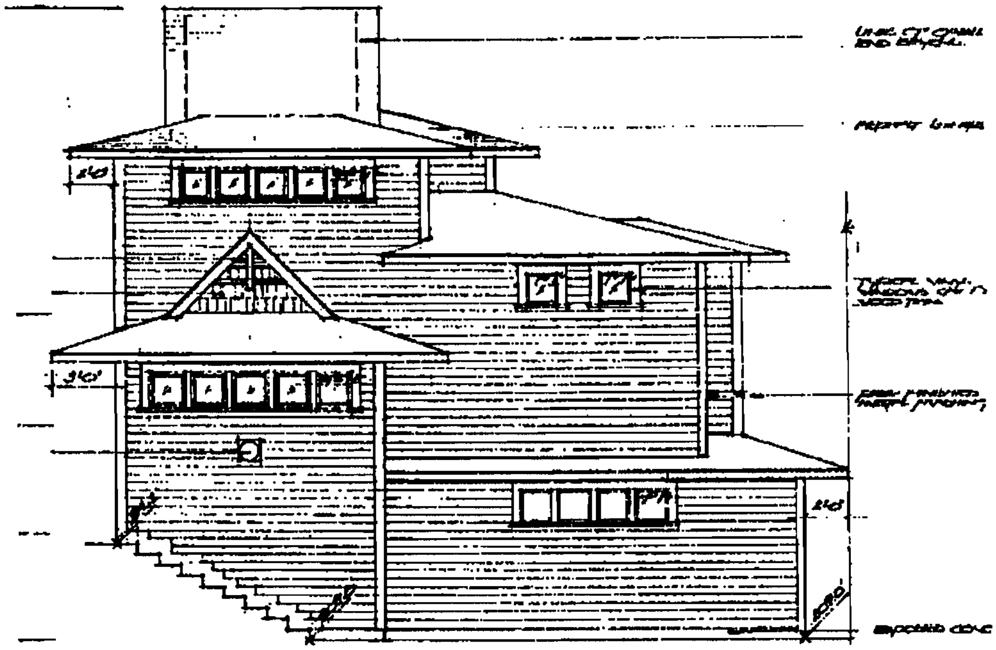


SOUTH ELEVATION

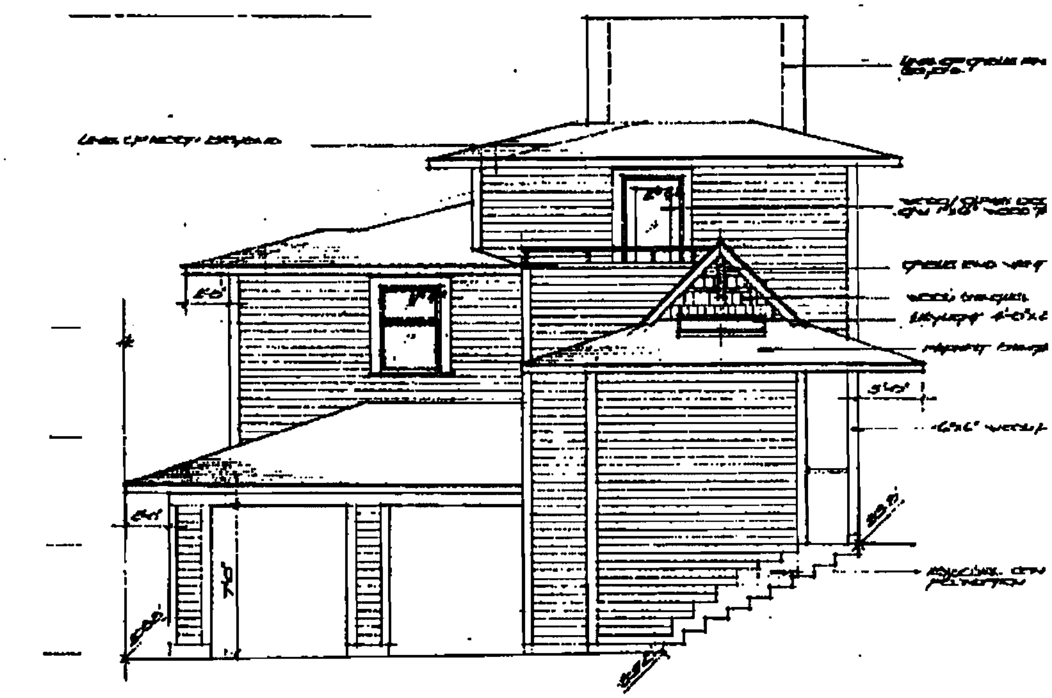


NORTH ELEVATION

ARDENCRAIG PROJECT COACH HOUSE
ALAN DIAMOND ARCHITECTS



EAST ELEVATION



WEST ELEVATION

ARDENCRAIG PROJECT COACH HOUSE
ALAN DIAMOND ARCHITECTS

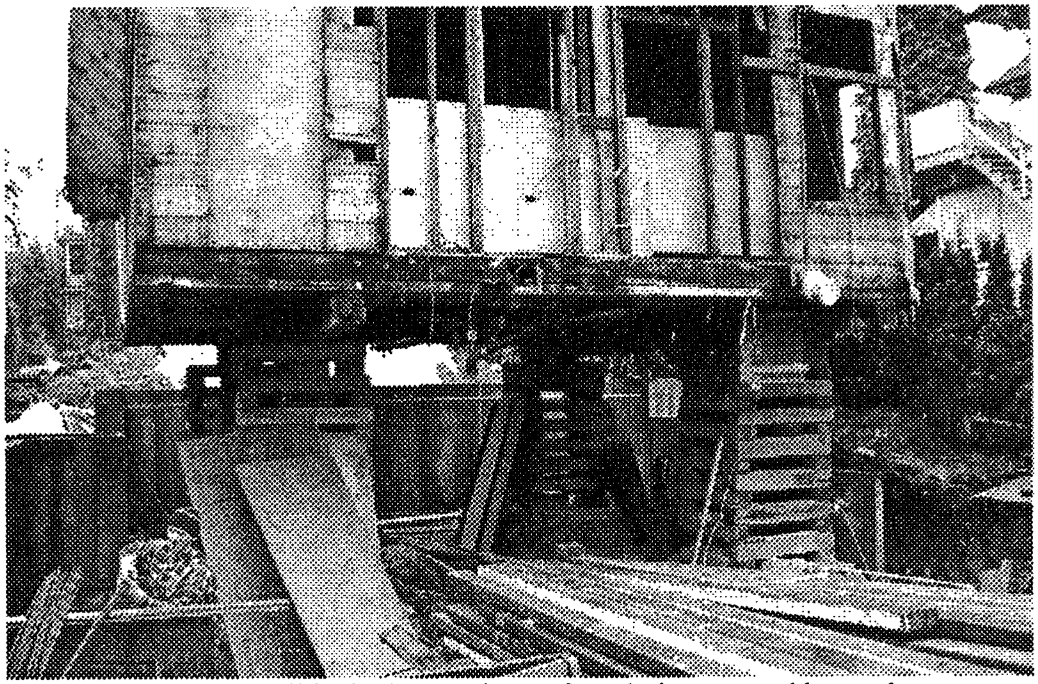
South elevation Ardencraig project prior to development

Interior main floor living room prior to development

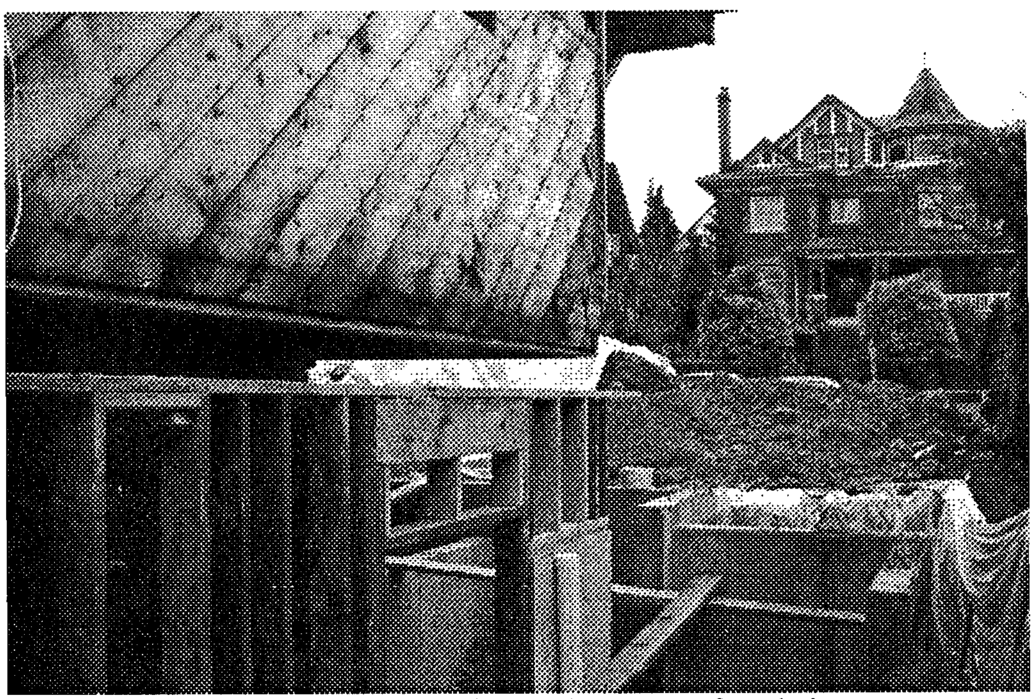
Stucco being stripped from triplex south elevation


Original siding being stripped from triplex south and north elevations

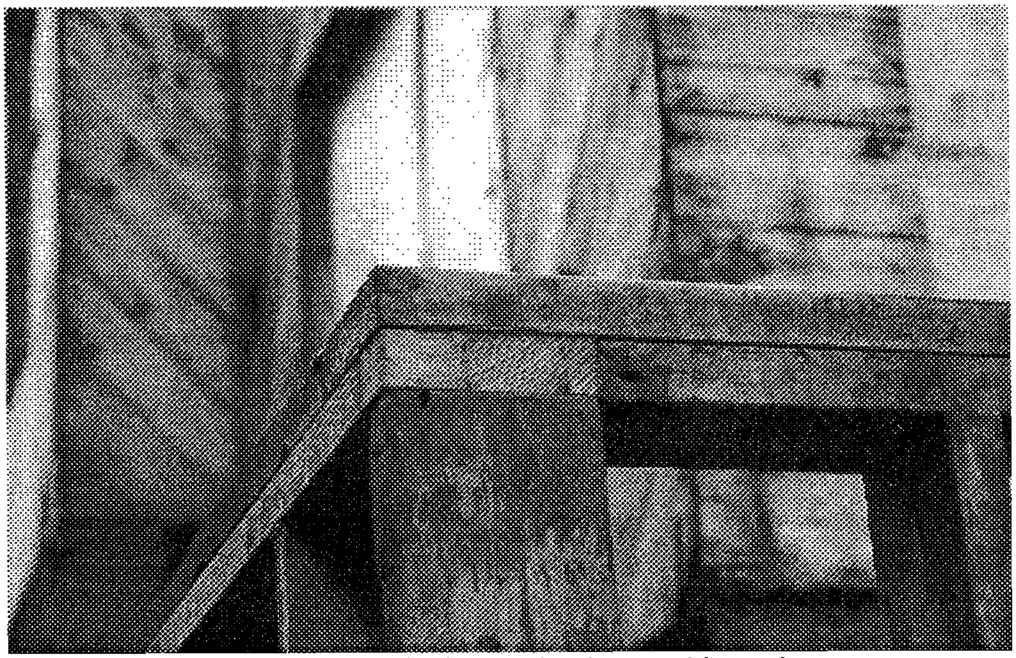
Triplex north elevation stripped to sheathing and framing,
original stone foundation



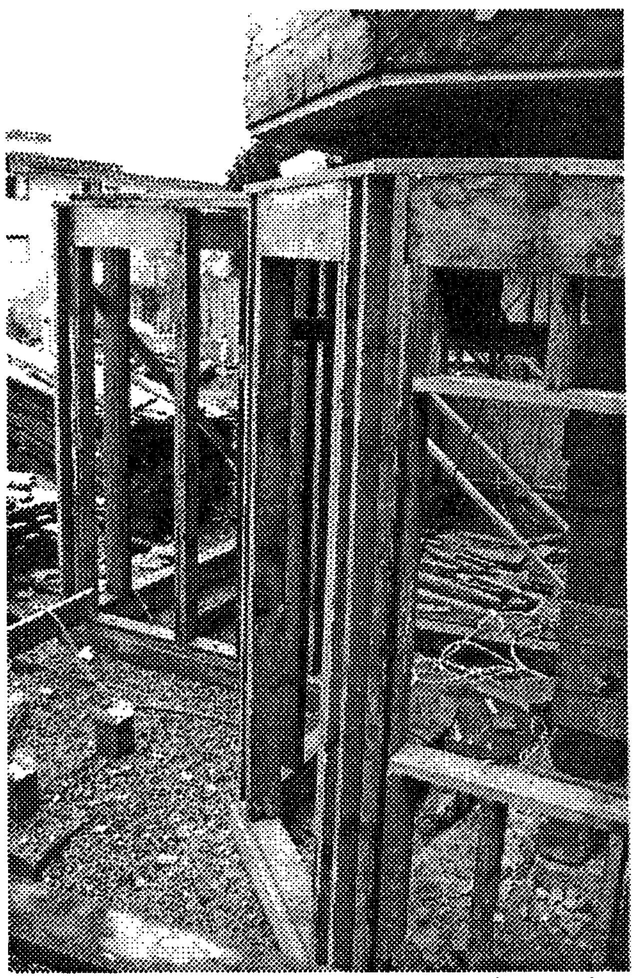
Triplex shell jacked up and new foundation poured beneath



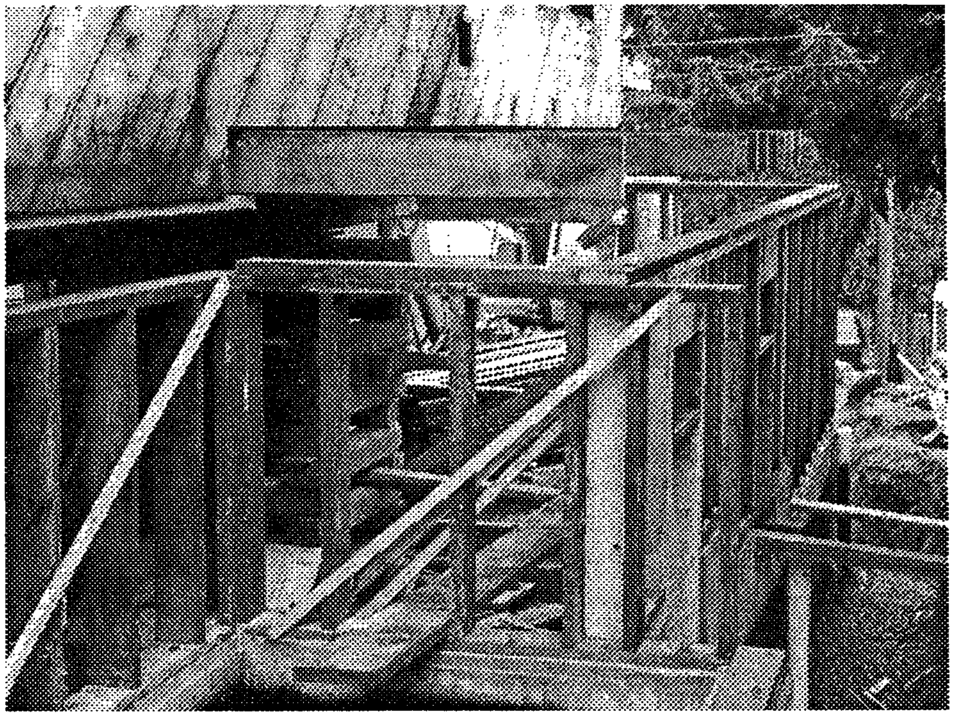
Triplex building shell lowered onto new foundation
and lower floor framing



Close up view of salvaged lumber used in project

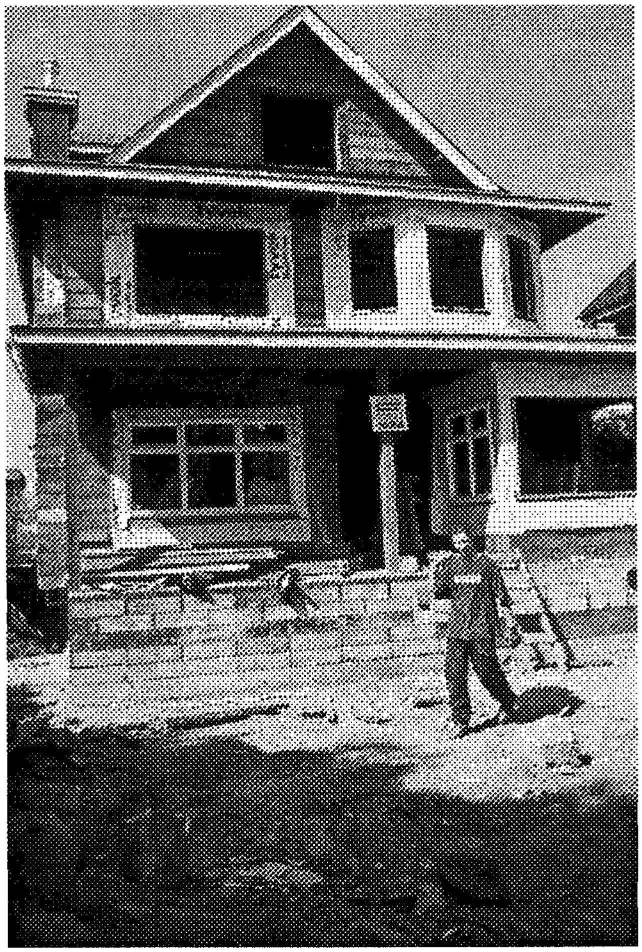


Triplex lower floor walls framed from salvaged lumber



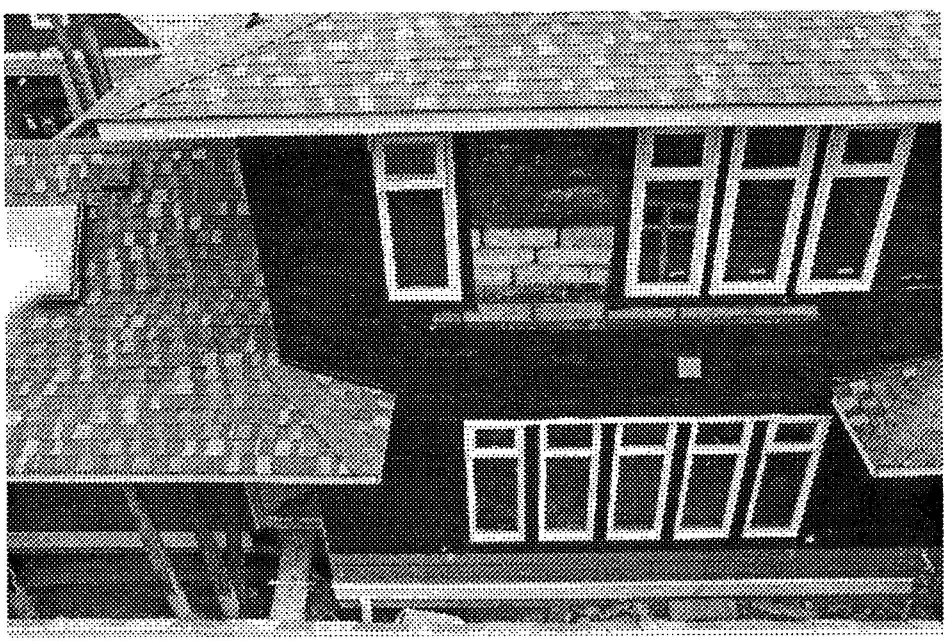
Triplex lower floor framed from salvaged lumber

Coach house showing roof trusses and walls framed
with salvaged lumber


Triplex units showing sheathing and house wrap
during window installation


Coach house and rear of triplex shown from alley during framing

South elevation coach house with salvaged shiplap sheathing

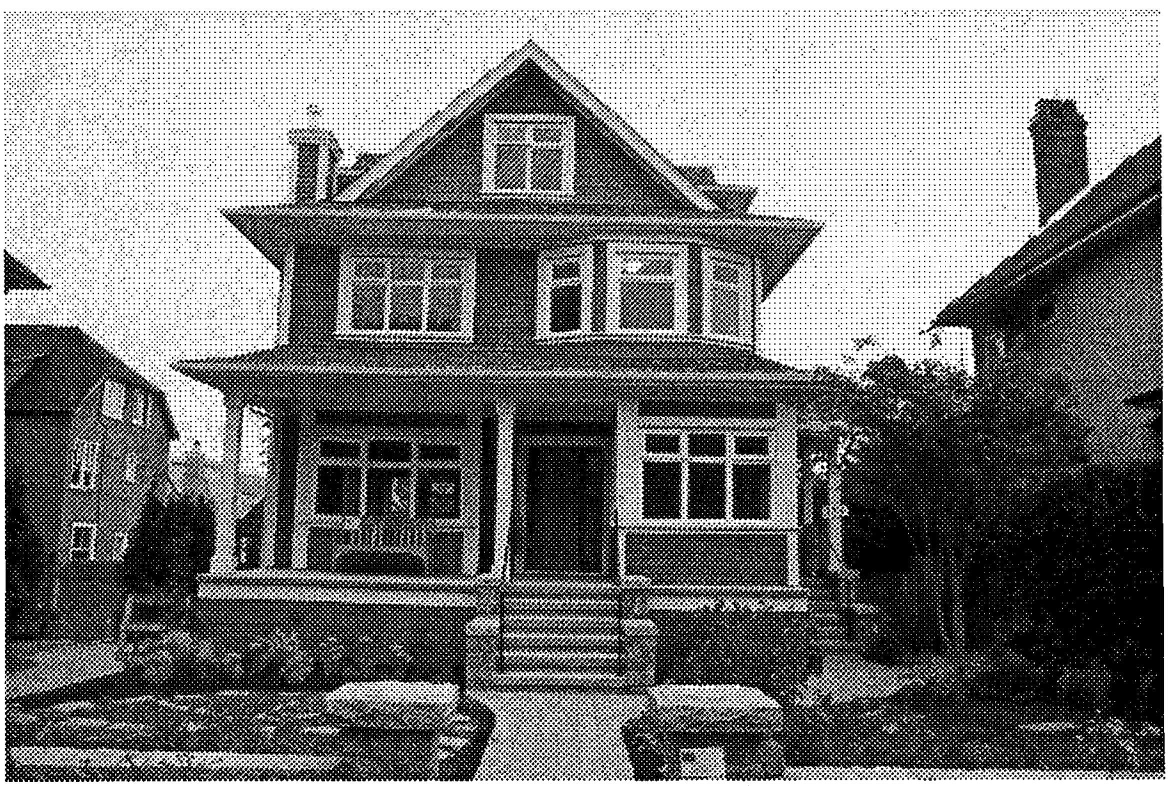


South elevation coach house with building paper

South elevation triplex showing building paper and vertical strapping for rain screen wall cavity

North elevation showing building paper and vertical strapping for rain screen wall cavity

Triplex south elevation showing close up of vertical strapping around windows



Finished triplex south elevation

Appendix III
Selected Costing Information

Component	Notes	Costing
Bamboo Flooring		Approx. \$8.25 ft^2 plus \$1.85 for install compared to approx \$6-\$8 per ft^2 for good quality hardwood
Eco certified wood	Iinvestigated this for framing lumber (from BC's first FSC certified source) but didn't use any as the cost was approx. double that of regular supply and we had also decided that reclaimed was the preferred material	
Salvaged framing lumber (studs and sheathing):	Costs vary depending on lengths and dimensions	Examples 2x4's (9' and 11' lengths) were \$440 per 1000 bd. ft. 2x6 (12 ft lengths) were \$450 per 1000 bd. ft. 1"x8" shiplap was used instead of plywood/OSB sheathing at a cost of \$0.33 per lineal ft. (i.e. \$495 per 1000 bd. ft or \$15.84 to cover the same area as a 4'x8' sheet) In addition we negotiated no delivery charges which totaled approx. \$1250
	Comparable costs for framing lumber and sheathing at the time were	2"x4" FJ studs were \$393 per 1000 bd. ft. (-12%); 2x6 fir was \$449 per 1000 bd. ft.(same cost) 4'x8' sheet of ½" fir plywood was \$17.89 (+13%);
Ventilation systems, Eneready 1000 HRV fully ducted to all rooms		Total cost including install was \$11,000 for four units.
Fly ash concrete		\$91.00 per m^3
	Comparable cost for conventional concrete	\$85 per cu m^3
Wood fibre reinforced siding (Hardi plank):		51/4" x 12' \$5.95 (covers 4 sq. ft. ie \$1.49 per sq. ft.) Install was \$1.40 per sq. ft. for total of \$2.89 per sq. ft.
	Compared to 4" exposure horizontal beveled cedar siding	\$1.75 per sq. ft. plus \$1.10 per sq. ft. for install for a total of \$2.85 per sq. ft.

Appendix III
Selected Costing Information con't

Component	Notes	Costing
Wood fibre reinforced shingles (Hardi shingles):		Bundles $295.00 ea (covers approx. 100 sq. ft. ie $2.95 psf) $1.40 per sq. ft installation Total: $4.35 per sq. ft.
	Compared to cedar shingles	$2.10 per sq. ft. plus $1.10 installation for a total of $3.20 per sq. ft.
Windows: upgrade with double low E and argon fill		Approx. $4 per sq. ft. of glass area totaling approx. $1950 for the project
Zero VOC paint		Additional cost of approx. $1500.

: