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HOUSING FOR THE ENVIRONMENTALLY HYPERSENSITIVE

(Survey and Examples of Clean Air Housing in Canada)

Prepared for the

Research Division of

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by

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DISCLAIMER

The material contained in this report *does not* constitute medical advice. The authors and the Canada Mortgage and Housing Corporation do not endorse any method, material or product whatsoever as safe for individual human health or the environment, or for purposes of alleviating health problems or reducing health risk. All health problems should be referred to a physician.

Individuals who, for health reasons, wish to make alterations to their homes, to design and construct new homes or to relocate are advised that the methods, materials and examples described in this report may not be appropriate for everyone. Each individual is advised to seek medical advice and design consultation in order to determine if such methods and materials are safe and appropriate in their case.

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INTRODUCTION...PROJECT SCOPE

We live in an age of growing environmental awareness when every area of life is being reexamined in the light of what we now know or suspect about the impact of our actions on both individual human health and on the global environment. The housing industry is no exception.

There are a number of Canadians who, due to health disorders, are apparently affected, to an unusual degree, by airborne agents commonly found inside homes. Among them are a small number of people who react at subtoxic levels to indoor air pollution. Their condition, commonly described as "environmental allergy", "environmental hypersensitivity" or "environmental illness" may cause them to suffer discomfort or, in some cases, severe reactions to low levels of air pollution caused by molds, dust, pollens or chemical vapors from building materials, heating systems, paints, carpets, furniture and cleaning and maintenance products. The levels of air pollution which affect these people may have no noticeable effect on healthy individuals and may indeed even be undetectable by them.

Some people who have identified health problems which are associated with common air pollutants have chosen to make alterations to their homes in order to reduce their exposure to these agents. Some have even built new homes to rigorous clean air standards. Others have found that carefuly selecting their home when they rent or buy can help to reduce their exposure. The range of adaptations undertaken includes everything from removing one or more sources of air pollution such as a carpet from the home and adding an air cleaner, to building a specially designed home with rigorous attention paid to details appropriate to their health needs.To some the home truly becomes a health refuge.

This report summarizes research undertaken across Canada in the winter of 1989-90 in which nearly a hundred people with environmental health problems were contacted and asked about their homes and their health. Information about individual actions to reduce exposure in homes was collected along with comments about the effectiveness of these measures. The report constitutes a partial picture of the nature and extent of "clean air" housing in Canada, what resources people have found useful in producing these houses or renovations, and the building materials and methods, heating and ventilation systems found in ten of the houses which were investigated in detail.

This report does not represent an exhaustive survey of the nature or scope of environmental health problems in Canada, nor does it represent a complete picture of the "clean air " housing phenomenon. It is instead a selected summary of the features of the houses which were investigated and the reported experiences of those who participated in the research. This report is intended as a resource for those who are planning, building, renovating or moving due to special environmental health concerns. It may also have broader significance for those who are interested in indoor air quality with regard to the healthy population and in building materials and systems which are more "environmentally friendly" in global terms.

Several important questions are raised by this research which cannot be readily answered at this time. Some of these are:

-Is the number of environmentally ill people increasing, and if so, is this an advance warning of a public health problem of greater proportions?

-Are the people affected by this disorder useful guides for the healthy population in terms of what can be done for prevention?

-Are there useful lessons to be learned from these examples about building methods and materials which are more environmentally appropriate in terms of sustainable resource and energy use and reduced industrial pollution as well as other global concerns?

-How Many are Affected? This study was not designed to provide statistical evidence of the number of people in Canada with enviromental health problems or their characteristics, nor was it designed to accurately assess the number or degree of recognized indoor air quality problems in Canadian homes. The study identied *a sample* of Canadians with recognized environmental health problems related to their homes. It also received reports on steps which some had taken to alter their homes in order to reduce exposure to airborne allergens and chemical incitants.

CHAPTER 1. ENVIRONMENTAL HYPERSENSITIVITY: AN OVERVIEW

DEFINITION

In 1984 The Ad Hoc Committee on Environmental Hypersensitivity Disorders was set up by the Ontario Ministry of Health to investigate the nature of this health condition. The working definition arrived at by the Committee is:

"Environmental hypersensitivity is a chronic (i.e. continuing for more than three months) multisystem disorder, usually involving symptoms of the central nervous system and at least one other system. Affected persons are frequently intolerant to some foods and they react adversely to some chemicals and to environmental agents, singly or in combination, at levels generally tolerated by the majority. Affected persons have varying degrees of morbidity, from mild discomfort to total disability. Upon physical examination, the patient is normally free from any abnormal, objective findings. Although abnormalities of complement and lymphocytes have been recorded, no single laboratory test, including serum IgE [1], is consistently altered. Improvement is associated with avoidance of suspected agents and symptoms recur with re-exposure." [2]

Environmental hypersensitivity has also been called environmental allergy, environmental illness, ecologic illness, 20th century disease, total allergy syndrome and multiple chemical sensitivity.

CHARACTERISTICS OF THE ENVIRONMENTALLY HYPERSENSITIVE

An environmentally hypersensitive person reacts to one or more substances in the environment at levels which do not appear to affect the rest of the population to the same extent. All individuals are sensitive to their surroundings; environmentally hypersensitive persons, however, not only react to various internal and external factors, they also react more intensely. Often such people will also react more dramatically to such conditions as chilling, fatigue or infection[3].

Symptoms may vary considerably from one person to another. In general multiple symptoms are reported. It is not unusual for a hypersensitive person to present only one symptom. The most frequently reported are those affecting the central nervous system - tension, fatigue, headaches, depression and the inability to concentrate. Various other physical systems may be involved such as gastrointestinal, respiratory, musculoskeletal, genitourinary, EENT (eyes, ears, nose and throat), skin and cardiovascular [2].

Often, the symptoms are severe enough to interfere with a person's daily activities, life and career.

A MEDICAL PERSPECTIVE

Several branches of clinical ecology and research medicine deal regularly with the effects of environment on health. Physicians who practice "clinical ecology", for example, believe that there are specific components of the environment which make people ill. These can be found in food, clothing, drugs, air, and water as well as in the home, work, and play environment [4]. Allergy specialists, toxologists, occupational health specialists, cancer researchers, and many others are also determining which environmental agents are capable of causing or aggravating illness.There are currently very divergent views within the medical profession both as to the legitimacy of environmental sickness and to the diagnosis and treatment administered by clinical ecologists.

Reactions to natural inhalants (dusts, moulds, pollens and animal dander) and to some foods (milk, eggs, nuts) are mediated by Immunoglobulin E (IgE), a type of antibody produced by the body in allergic responses. These are regarded as true allergic reactions and most often manifest in serum IgE measurements. Clinical ecologists and allergists are in agreement on this issue.

Controversy arises, however, when other foods or chemical contaminants such as pesticides, chlorine, vehicle exhausts, paints, etc. are cited as incitants, since these have not largely been recognized by allergy specialists in the past. In addition the symptoms environmentally hypersensitive patients report often cannot be verified by testing methods.

It is misleading to describe the condition of environmental hypersensitivity as an allergy, since the causative mechanisms may be quite different from those that cause allergies.

CAUSES

Three factors are commonly cited which may contribute to an individual's chances of developing a hypersensitivity disorder [5]:

- Biochemical Individuality: A person's unique makeup is mainly a product of genetics and his or her mother's health and nutritional state during pregnancy;

- Total Body Burden: All human beings are subject to biological stress including illness, psychological state and all forms of irritants and toxic contaminants carried by the body; and

- Nutritional State: Nutritional health plays an important role in the activity of the immune system as well as other body systems.

Several common factors related to the onset of hypersensitivity also occur in reports from those affected:

- Illness, infection or traumatic injury as well as periods of severe stress;

- Chronic exposure to low level contamination such as moulds or formaldehyde in homes, industrial emissions, or chemicals in food and water; and

- Acute exposure to toxic agents during episodes such as pesticide applications or industrial accidents

In its final report, The Ad Hoc Committee on Environmental Hypersensitivity [3] made 30 recommendations on policies, clinical recognition, services and insurance benefit coverage for people diagnosed with this condition. In the preface to its conclusions, the committee stated that:

"... our study of one disorder, environmental hypersensitivity, raised our collective concern about the role of environmental factors as a cause of human illness ...". It seems clear that we are inexorably increasing the toxicity of our environment. Some of those chemicals may not be hazardous. However, it is clear that some are and that, for many, we have no way as yet of knowing whether they are or are not harmful; nor do we have adequate information on the effects of low dose exposure over long periods or the possible synergistic effects of long term exposure to many chemicals."

CLEAN AIR HOUSING

In response to these concerns and in an effort to create tolerable environments for themselves, some affected individuals have built new homes or taken special measures in older homes to address health problems. These people, in conjunction with the medical, design and construction professionals whom they consult, are in the process of defining clean air housing in Canada.

The housing needs of people with environmental hypersensitivity are variable and dependent on many factors, including the severity of the illness and sensitivity to different pollutants or substances found in the indoor environment. The capacity to make alterations in housing is also dependent on financial ability and the existence of support from family and others.

Historically, there have been many movements that have, through the promulgation of holistic philosophies, attempted to address the creation of clean wholesome surroundings for human habitation. These practitioners have generally adopted an approach which equates natural materials - those occurring in nature - with better indoor air quality and better health.

To a large degree, and in the absence of more comprehensive information, this approach continues to be employed. Although many of the materials found to be benign are natural, it is counter-productive to assume that all which is natural is good while all that is not is bad. At present there are two major schools of thought on the matter of housing and healthy environments. The first, typified by the German studies in Bau-Biologie, use a biological model. The house is conceived as an organism, and should therefore be built of natural materials in order to "breathe". The manner in which air and moisture transpire, as well as the way in which background radiation, sunlight and electromagnetic fields penetrate the structure are matters of study and debate. It is, however, assumed that all these things must be in a balance approaching the natural state for the dwelling to be truly - "healthy". The second approach also asserts that buildings should breathe because mould growth, structural degradation, and many forms of moisture damage result from the uncontrolled breathing of buildings. This school of thought holds that buildings are interrelated sys-

tems, not organisms, which should be constructed as airtight as possible and should contain an engineered ventilation system which ensures indoor air quality. In this way moisture is prevented from entering the structure, thereby eliminating potential degradation while pollutants are excluded from the living space. Only those products which do not introduce airborne contamination are enclosed within the draft free envelope.

The term "clean air housing", as used in this document, refers to varying degrees of improvement of the air quality of homes which correspond to varying degrees of exclusion or elimination of indoor air pollutants.

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(1) IgE is a complex protein found in the human body which belongs to a group of proteins known as the immunoglobulins. It has antibody activity, i.e. it attacks antigens, (such as pollens) which the body recognizes as foreign. IgE is associated with certain types of allergic reactions such as hayfever, asthma, or hives in which it induces the release of several substances, including histamine, which cause tissue inflammation and damage. IgE does not play any distinct role in chemical sensitivity, however some individuals with chemical sensitivities also have IgE mediated allergies.

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CHAPTER 2...INDOOR AIR QUALITY

The air inside residential buildings contains not only naturally occurring gases but a vast range of man-made gases and particles. Some of these contaminants come from outdoors, but many come from biological activity, combustion, and the "outgassing" of volatile chemicals used in building construction , furnishings and the maintenance of homes.

AIR QUALITY CONTROL IN HOMES

Houses, particularly in colder climates, are enclosed environments. Indoor air pollution from both "building-related", "furnishing" and "occupant-related" sources necessitates regular air change to prevent an unhealthy buildup. In the past, air change in homes was primarily due to accidental leakage, but most older homes have now been weatherized to reduce energy costs resulting in a reduction of uncontrolled ventilation. New houses are designed to reduce drafts, to improve comfort and energy efficiency and to ensure their durability. Some homes use fan operated heat recovery ventilation which can offer very good air quality if it is designed and operated with care, and if the pollution sources in the home are minimized.

High technology approaches are one means of achieving good air quality in homes. However, conventionally constructed or well maintained older homes and apartments can also be "clean air homes" if air quality control measures are employed.

INDOOR AIR POLLUTANTS: SOURCES AND HEALTH EFFECTS

There are four major categories of indoor air pollutants which are responsible for the majority of air quality problems in residences.

MOULDS

Fungus or mildew grows in damp places, such as in bathrooms and basements, especially on surfaces where moisture condenses, such as cold, uninsulated walls. Mildew is also found in areas of poor air circulation e.g. in closets, and under sinks. Mould problems generally occur after prolonged or repeated water damage or excessive dampness on materials such as carpets, ceiling, walls, woodwork, clothes, paper or books.

Excess moisture inside the house can arise from inadequate ventilation in areas where moisture is continuously produced. The use of a humidifier can lead to condensation of the moisture in colder parts of the house. Excess moisture can also result from improper drainage of the foundation, and from infiltration of soil gasses into the building. Damage can occur on windows and woodwork and in insulated wall cavities when warm, moist air comes in contact with cooler surfaces and condenses.

Mould growths release spores which are very complex packets of chemicals that contain a variety of enzymes and toxins [1]. The mycotoxins inside the spores can also produce secondary metabolites [2]. Inhalation of mould spores can cause allergic reactions, impairment of lung function and irreversible lung damage. If the immune system fails to prevent the invasion, other body organs and tissues can be affected [2].

"Mouldy smells" are due to volatile chemicals produced by fungi. These are complex mixtures of organic chemicals consisting of alcohols, esters, aldehydes, various hydrocarbons and aromatics. Although many of these volatile chemicals have been identified, it is not clear how they affect humans [2].

CHEMICAL POLLUTANTS

The chemical pollutants can be divided into two groups: the inorganic gaseous pollutants; and the volatile organic compounds (VOC's).

The inorganic gaseous pollutants include combustion gases (carbon monoxide, carbon dioxide, nitrogen oxide, nitrogen dioxide), chlorine, ammonia and ozone.

Smoking, unvented cooking, unvented heaters and leaking chimneys introduce combustion gases indoors. Exhaust equipment such as furnaces dryers, kitchen and bathroom fans, and central vacuum systems, can cause the houses in which they are installed to operate under a negative pressure. This can cause fluegases to spill from combustion appliances indoors if sufficient combustion make up air is not supplied to combustion devices such as furnaces.[3].

Carbon monoxide is a known health hazard since it competes with oxygen in binding with hemoglobin. The other gases are intoxicants or respiratory irritants. Nitrogen oxides can reduce immunity to respiratory illness [4]. Ozone, produced by electrical equipment, is an irritant and a mutagen [5].

Carbon dioxide produced by human metabolism, is usually not a problem in homes unless the ventilation is exceptionally poor or spillage is frequent.

The volatile organic compounds comprise a wide range of chemical compounds which vary from simple to complex, and contain carbon and hydrogen in their molecular structures. Hydrocarbons, aldehydes, alcohols, phenols and ketones are examples of classes of organic compounds.

The sources are many and include building materials, furniture, carpets and synthetic floor coverings, wallpapers, plastics, household products, beddings, toiletries, etc. The odors from cooking, paints, new clothes and perfumes are due to volatile organic compounds. Many materials found inside homes are sources of VOC's [6,7,8,]. In a recent study of forty homes, from 20 up 150 VOC's were observed [9].

The most widely studied of the VOCs has been formaldehyde. Sources of formaldehyde emissions include urea-formaldehyde insulation, particle board and pressed board products as well as home furnishings, carpeting and a number of other household sources. New homes with poor ventilation, mobile homes and recently renovated homes are susceptible to problems from formaldehyde and other organic chemicals [10]. Formaldehyde is an irritant to the eyes and respiratory system. Several studies also indicate that it is a central nervous system depressant and produces numerous adverse effects.[11] Repeated exposure can also cause certain individuals to become sensitized. Studies to determine its long-term effects on humans are incomplete; however, animal studies suggest that it is a potential human carcinogen.[11, 12]

The toxicities of some volatile organic compounds are known. Benzene, which is commonly present in gasoline, is a recognized carcinogen. Xylene and toluene, solvents emitted by many household products, affect the central nervous system. Styrene, which is a component of plastics, is a narcotic [13]. Many are mild intoxicants [14], which affect everyone even at low levels. The health effects of many other VOC's are not clearly understood. For example, a compound called 4-phenyl-cyclohexene which is part of the characteristic odor of new latex backed carpets was recently isolated though no health effects or exposure standards have been established [15].

The overall effects of these organic chemicals has not been quantified, but considering that over 350 different organic compounds have been identified at concentrations over 1ppb in indoor air [8], their potential importance can not be ignored.

PARTICULATES

House dust is made up of small particles and fibres which come from both outdoor and indoor sources. The largest of these tend to fall to the floor and collect into dust balls or become imbedded in carpets and furniture. These are easy to capture when housecleaning and are not generally inhaled. The smaller particles (less than 10 microns or 10 thousandths of a millimeter in diameter) remain airborne and easily enter the lungs. The particles in house dust come mainly from two basic classes of material; those which are *biological*, and those which are *non-biological* These two categories include the following:

Biological particles:

- Dust mites. These are microscopic spiderlike insects which live in all house dust.
- Mould spores from mildew and other fungus types.
- Pollens and plant fragments from grasses, flowers, trees and shrubs.
- Animal dander. These are fragments of skin, hair from humans and skin, hairs and feathers from pets and may be covered with sputum.
- Bacteria and viruses exhaled by people carrying illness.

Some of these particles are allergenic and trigger an immune response in people who are sensitive to that agent. Others such as bacteria are pathogenic and cause disease directly. The major allergenic agents in house dust are dust mites, mold spores, pollens and animal dander. Some biological particles are also known to incite allergic responses in sensitive people though their health effects are not well understood. Sawdust from softwoods such as cedar and pine are known

to be allergenic to some people due to the volatile wood resins called *terpenes* and organic acids which they release.

Non-biological particles:

- Asbestos from old building materials and other sources.
- Glass fibre from insulation.
- Lead from automobile emissions; other heavy metals from industry and incineration.
- Natural and Synthetic fibres.
- Dust from soils.
- Dust from agriculture, mining or other industry.
- Combustion particles from automobiles, smokers, industry, furnaces, stoves and fireplaces.
- Other dusts, such as plaster from construction etc.

Dust particles actually trap volatile organic compounds which are readily adsorbed by their surfaces. When these laden particles come into contact with heated surfaces, (for example when they are circulated through a furnace), the gases are released, as well as the break down products from the various synthetic and natural materials which comprise the dust.

Probably the most toxic particulates in house dust include mineral materials such as asbestos which are well known carcinogens as well as soot from combustion. Inhaled asbestos fibre becomes embedded in the lung wall and, unlike most other fibres, stays for a lifetime. The fibres may eventually penetrate the lung and enter the lining of the chest cavity where they abrade and puncture delicate cells increasing the risk of lung and chest cancers. The lung cancers resulting from asbestos exposure may not appear for twenty to thirty years or more.

Soot from any form of combustion including auto exhaust, tobacco and wood smoke, oil burners, incinerators and industrial emissions contains small amounts of a family of chemicals called polycyclic aromatic hydrocarbons (PAH's). The best known of these is benzo-a-pyrene (BaP), a potent carcinogen. PAH's are responsible for many of the cancers caused by smoking, and for elevated levels of cancers downwind from some smelters and other polluting industries.

The long term effects of glass fibre from building insulation, a well-known irritant particle found indoors, are still under investigation.

Numerous other hazardous particles such as lead, mercury and cadmium compounds (the heavy metals) are found in dust as well as in thousands of man-made chemicals used in industry, agriculture and construction. Most of these are not commonly found in homes but do occur near industry, although lead based paint is an exception.

Other particles such as sawdust, shed upholstery and bedding fibre etc. are also present in house dust. These are too numerous to characterize. Most are merely nuisances.

RADON (natural soil radiation)

Soil radiation from natural sources enters homes in some affected regions and increases lung cancer risk. Radon gas from the natural breakdown of radium in soil, rock and groundwater decays indoors into products called radon progeny (or radon daughters) which easily attach themselves to dust particles and are inhaled. In the lungs the radon progeny emit hazardous alpha radiation which can cause lung cancer. Radon is not a problem specific to the environmentally sensitive, but rather a concern for the general population and will not be discussed further here. Other CMHC and Provincial Health Dept. publications are available on this topic. Much of the work on radon entry into the home is relevant to the environmentally hypersensitive, since radon is accompanied by a mixture of soil gases , including mildew odor and moisture, all of which can cause air quality problems in the home of sufficient magnitude to trigger symptoms or aggravate hypersensitivity.

SYNERGY

Synergy is an important principle to understand when assessing the health effects of air pollutants. Synergy means that two or more air pollutants may have a combined effect that is greater than the sum of their individual effects. For example the cancer risk of smokers who are exposed to asbestos is much higher than the combined risks of smoking and asbestos exposure.

AIRTIGHTNESS AND CLEAN AIR HOMES

Draft free or airtight construction insures lower energy costs and improved longevity for buildings. While draft free construction alone does not guarantee better indoor air quality, a well designed ventilation system in an energy efficient home can insure that fresh air is delivered to the occupied space, so long as the ducting remains clean and that exhaust is extracted from the most appropriate points. Airtight walls, ceilings and floors are highly appropriate features for a "clean air" home.

The common perception that houses must be leaky to have good air quality is a myth. In most buildings, air which leaks through walls, floor, and ceilings carries with it various gases from insulation, glues, asphalt treated products and dusts contained in the cavities of the building structure. The draft sealing methods used in energy efficient homes not only improve comfort, save energy and help prevent concealed moisture damage to the structure, but they also prevent the flushing of pollutants from the cavities into the living space.

Energy efficient homes with ducted ventilation systems and heat recovery ventilators can be designed so that they can draw intake air from the safest point outside the home, away from the streets, garages, and other polluting sources. They can also provide filtration of outside air not possible with natural ventilation. Those with non-ducted ventilation systems, with heat pump energy recovery at a central exhaust point, can allow distributed air intake, including openable windows, which can sometimes be an advantage for hypersensitives since it allows separation of the air in different parts of the house. Such central exhaust systems lend themselves well to the inclusion of heat-pump heat recovery, and thus more energy efficient operation. Other energy efficient features such as passive solar heat retention reduce the reliance on central heat sources, and consequently reduce the potential for indoor pollution from such sources.

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CHAPTER 3...THE SURVEY

In the winter of 1989-90 a cross-Canada survey was undertaken to identify people with environmental health problems who had modified their homes in order to reduce their exposure to indoor air pollution. The survey consisted of two parts: a preliminary survey to collect basic information on the nature of clean air housing in Canada; and a selection of ten in-depth case studies drawn from the preliminary group. The case studies represent a range of special housing renovations and new construction, and are presented in a following section.

PUBLICIZING THE SURVEY

The survey was advertised in several newspapers, through the Allergy and Environmental Health Association Quarterly, some provincial newsletters of the Allergy Information Association and in Habitabec and other newsletters and journals. Several physicians who see patients with this condition and some allergy specialty shops displayed posters which announced the survey. The presidents of environmental health associations as well as members who are actively involved with the national association (AEHA) were contacted.

The request for participants clearly specified that the researchers wished to hear from those who not only suffered from unusual sensitivities to environmental agents, but who had also made significant changes to their homes to reduce their exposure.

In total over 200 responses were received in the twelve week period of the survey from which 92 were selected for participation in the preliminary survey.

CONDUCTING THE SURVEY

Respondents in the initial survey fell into three categories: those who renovated homes; those who moved to another home seeking conditions which were better for their health; and those who built new homes. Separate questionnaire segments were developed for each category and both homeowners and renters were surveyed. The questionnaire was administered by telephone and included several questions about the respondent's health and home, with particular emphasis on what ventilation, heating and floor coverings were used, as well as other finishes, cleaning practices, etc.. The respondents were also asked to estimate how much had been spent on adapting their houses to their health requirements.

Because the time allotted to complete the study was limited it was not possible to comprehensively contact all those who had altered their homes, moved households or built homes to accomodate their environmental hypersensitivity.

SUMMARY OF RESULTS OF THE PRELIMINARY SURVEY

TYPES OF HOUSING INCLUDED IN THE SURVEY

Forty-eight renovations, twenty-seven new constructions and seventeen moved households were surveyed, for a total of ninety two dwellings. Because emphasis was placed on reaching those who had built new houses, the actual proportion of renovations is probably much larger than represented here.

Table 3.1
Age, Number and Location of Houses

Age of building		Building location	
Renovations-			
less than 25 yrs.	19	urban 29	rural 19
25-50 yrs.	16		
over 50 yrs.	11		
not known	2		
	48		
New construction-			
less than 2 yrs.	20	urban 8	rural 19
2-5 yrs.	6		
5-10 yrs.	1		
	27		
Moved household-			
	N/A	urban 9	rural 8
	17		
Totals:	**92**	**urban 46**	**rural 46**

The majority of the renovations had been done in the past ten years.Most of the new construction had been done in the past five years, or was still in progress.

About half of those surveyed felt that their location had good ambient air quality (these were mostly the rural locations) while half cited problems with pollution from traffic, industry, landfill sites, agricultural spraying or lawn care and wood smoke from neighbours.

HEALTH CONDITION OF THE RESPONDENTS

The respondents were asked to briefly discuss their health condition (or the condition of the dependent(s) for whom they were reporting), with emphasis on those environmental agents to which they were sensitive and which had prompted their housing changes. Respondents were also asked to discuss their symptoms. A follow-up study of medical histories was done by a consulting physician.That study does not form part of this document.

Agents cited:

The survey asked respondents to list the environmental agents to which they were sensitive. Many reported multiple chemical sensitivities and sensitivities to molds, dusts etc. Most also offered information on food allergies.

Table 3.2
Agents associated with environmental sensitivities (total number of citations):

Sample size: 92

- Moulds, dusts, pollens, animal dander	11
- Volatile organic compounds (from pressed wood products, carpets, paints, household cleaners, fabrics, inks, etc.).	102
- Smoke, perfumes, odors from cooking.	59
- Petroleum (oil and gas vapours).	49
- Vehicle exhaust (urban air pollution).	17
- Woods (natural resins from pine, cedar etc.).	9
- Other.	3
- Don't know.	2
Average number of agents cited by respondents:	3.8

The way in which "chemical" pollutants were reported makes them difficult to categorize. For example, most of the chemicals cited are volatile organic compounds but no attempt was made to isolate them from their sources (i.e. from particle board, carpet, petroleum etc.). In some cases volatile organic compounds were referred to generally as formaldehyde. Several inorganic agents such as chlorine from bleach or tap water, were also mentioned.

The majority of respondents cited both chemical sensitivities and sensitivities to moulds, dusts, etc. Generally the responses to chemical agents were more detailed than those to moulds and dusts. If all of the reported chemical agents are compiled (i.e. household chemicals, smoke, petroleum products etc.) they total over twice as many citations as moulds and dusts. Very few respondents cited chemical sensitivities with little or no significant parallel sensitivities to moulds and dust.

Symptoms cited:

The survey offered no categories for symptoms. However the project medical advisor later categorized the symptoms reported by respondents. See Table 3.3

Table 3.3
Symptoms produced by exposure (total number of citations):

Sample size: 92

- **Central Nervous System** (headaches, migraines, loss of coordination, dizziness, seizures, trembling, blurred vision or light sensitivity, depression, anxiety, disorientation, memory loss, incoherence, irritability,poor sleep, hyperactivity).	47
- **General** (exhaustion, fatigue, sleepiness, lethargy, flu-like symptoms).	43
- **Lower Respiratory** (asthma, bronchitis, breathing difficulty, chest tightness).	41
- **Upper Respiratory** (congestion, sneezing, burning eyes, sinus inflammation, nose bleeds, sore throat, ear pain).	37
- **Dermatological** (itching, burning skin, hives, eczema, sweating).	13
- **Cardiovascular** (heart palpitations, low blood pressure).	10
- **Gastrointestinal** (nausea, stomach cramps, diarrhea).	7
- **Musculoskeletal** (joint inflammation, back pain, muscle and joint stiffness).	7
- **Genitourinary** (bed-wetting, urinary pain, menstrual cramps).	3

Clinical tests:

The respondents were asked about clinical testing for allergies and sensitivities, though the specific discussion of testing methods and results was left for the follow-up medical history survey. Most of those who volunteered their test results cited several positive results to both conventional allergy tests and to clinical ecology tests.

Have been tested	84	(91%)
Have not been tested	5	(5%)
Severe reactions halted testing	2	
No response	1	

Food Sensitivities

Thirty-six respondents (39%) reported severe food sensitivities to common allergenic foods such as wheat, corn and dairy products. Food intolerance is associated with most cases of environmental hypersensitivity, and most survey respondents who reported having both also reported a relationship between them. In most cases, avoidance of environmental incitants reduced food sensitivity to some extent.

This result is consistent with the literature.

Age and gender distribution of respondents and affected family members:

More adult women reported environmental hypersensitivity than adult men, which is consistent with the literature. The small sample of children in this survey was not adequate to determine a correlation among children in the general population.

Adults-	Women	62	Men	19
Children-	Girls	8	Boys	13

SUMMARY OF HOUSING ALTERATIONS

RENOVATIONS

Renovations ranged from changing only the heating system to complete gutting and rebuilding of every component of the house except the frame.

Table 3.4
Specific changes to homes for renovations:

Sample size:

- Changed heating system.	34	(71%)
- Changed flooring.	32	(67%)
- Use a portable or central air cleaner.	25	(52%)
- Changed cabinets and furniture.	22	(46%)
- Use a central ventilation system.	8	(17%)

The most common reason cited for changing the heating system was to switch to electricity in order to avoid fossil fuel in the home. The second most common reason was to replace a forced air furnace with a low temperature system which would reduce odors from heated dust. Common flooring changes were consistently the removal of carpets and the installation of hard finishes such as ceramic tile or hardwood which are more chemically stable than carpet. Many renovators did both.

The most common air cleaners were electronic particle filters, either the portable or the furnace-mounted type. A preference for the "passive electrostatic" type filter which cannot produce ozone was indicated, although charcoal or other adsorption devices were also used. Those who changed furnishings and cabinets usually did so to avoid particleboard and odors from treated fabrics and plastic foams.

NEW CONSTRUCTION

Respondents who had built new homes typically reported more severe initial sensitivities than those who renovated and, in general, the newly- constructed homes approached air quality more rigorously. The preference for all-electric or isolated combustion heating, and the preference for hardwood and ceramic floor finishes without carpets are also evident in those who built new houses.

Table 3.5
Specific features of new construction:

Sample size: 27

- Heating system.-		
-all electric or electric/wood	20	{74%}
-isolated combustion boiler	5	(19%)
-conventional forced air	2	
- Flooring, all ceramic and /or hardwood floors.	23	{85%}
- Custom cabinets and furniture without particleboard.	17	{63%}
- Avoidance of both plywood and composition board.	13	{48%}
- Ventilation and air filtration system.	12	{44%}
- Air filtration system only.	9	{33%}
- Use of plaster or solid wood interior finish	6	{22%}

Central ventilation systems and air filtration, custom cabinets without particleboard and furnishings with chemically untreated and natural fabrics and fillings are more common in new construction than in renovations.

MOVED HOUSEHOLD

Those who moved their households for health reasons generally found the indoor air of the previous homes unacceptable, and half reported poor ambient air quality at their previous locations.

Table 3.6
Reasons for choosing another house:

Good local air quality
Electric or hot water/steam heating
Electric range and hot water heater
Hardwood and tile floors
Plaster walls and ceilings
Clean, dry interior. No mould
Dry basement or crawlspace
Furnace mounted air cleaner
Well-aged paint and floor covering
Plywood or solid wood cabinets
No carpet, or clean older carpet

PARTICIPANTS' ASSESSMENT OF EFFECTIVENESS OF HOUSING CHANGES

Survey participants were asked to assess the extent to which they were affected by their home before renovating, building or moving. Table 3.7 below shows their assessment which is subjective and based on recognized symptoms (see Table 3.3). Those who reported "slightly affected" usually suffered irritation from air pollution but were able to function reasonably well; those who reported "seriously affected" suffered impairment which interfered significantly with work, family life, etc.; those who reported "disabled" suffered impairment which made work, travel or other normal functions impossible. A few who reported a disabled condition occasional needed oxygen or

life, etc.; those who reported "disabled" suffered impairment which made work, travel or other normal functions impossible. A few who reported a disabled condition occasional needed oxygen or other emergency treatment after exposure to the agents listed in Table 3.1

Table 3.7
Participants' assessment of the extent to which they were affected by previous house:

DEGREE HEALTH WAS AFFECTED IN PREVIOUS HOME	Renovation	New Construction	Moved Household	Subtotals
Slightly affected	2	2	2	6 {7%}
Seriously affected	29 {60%}	10 {37%}	8 {47%}	47 {51%}
Disabled	17 {35%}	15 {56%}	7 {41%}	39 {42%}
DEGREE OF RELIEF AFTER CHANGE				
Great deal of relief	15 {31%}	13 {48%)	5 {29%}	33
Considerable relief	19 {40%}	6 {22%}	7 {41%}	32
Slight relief	9 {19%}	0	5 {29%}	14
No relief	3	1	0	4
Unsure	2	3	0	5
Don't know yet (1)	4			4
TOTALS	48	27	17	92

(1) 4 subjects had not occupied new houses long enough to assess relief.

PARTICIPANTS' ASSESSMENT OF COSTS FOR SPECIAL FEATURES

Participants were asked to evaluate how much they had spent on special air quality features. Though most had kept accurate records, a large proportion of those who built new or moved household were unable to estimate incremental costs.

Those who did, typically separated the cost of air cleaning systems as well as the extra cost of their heating systems and floor coverings. Some also included the cost of replacing or re-upholstering furniture or changing bedding for health reasons in their estimates.

Table 3.8
Participants Estimate of incremental cost of special features.

- Renovations-

No extra cost	1
Less than $5,000	8
$5,000 to $20,000	
$20,000 to $50,000	
Over $50,000	2
Don't know	13

- New Construction-

No extra cost	1
Less than $5,000	2
$5,000 to $20,000	
$20,000 to $50,000	

COMMENTARY ON THE SURVEY RESULTS

THE RESPONDENTS

Most respondents reported as an affected individual, though several reported for a child, or for themselves and one or more children. Typically there was one affected individual per household though a few cases of family groupings were found. In these cases both parents often reported a family history of allergies which is consistent with the observation that a tendency to hypersensitivity is often apparently inherited.

HOUSE TENURE

Most of the respondents owned their homes though some were renters who had chosen a particular location and rental unit for health reasons. Some renters made alterations to their homes to improve conditions for their individual health needs. At least one made a substantial investment in a rented home.

HEALTH CONDITION

Most who reported extreme hypersensitivity had developed the condition in mid-life, though some indicated that childhood allergies had persisted, or were early warnings of a problem. Many who discussed the onset of their hypersensitivity associated it with a serious injury or illness, often requiring surgery or prolonged drug therapy. Some also associated their illness with environmental exposure at work or in a neighbourhood polluted by industry or traffic. Fifteen percent felt that exposure to UFFI in their homes, or gases from new building and finishing products associated with remodeling and renovation, had precipitated their illness.

TYPE OF HOUSING CHANGES

Floor coverings and heating systems were the first items modified in renovations. The preferred floor coverings were hardwood and ceramic tile, with small area rugs of acceptable material. Some respondents used small amounts of vinyl tile, or sheet vinyl material and/or fixed carpet of acceptable material. The preferred heating systems were hot water, electric radiant heat or low temperature electric baseboard heaters. In some cases a recirculating forced air unit was used, with a low temperature fan coil heat exchanger operated by hot water or a heat pump, which also provides air filtration.

The second priority, in most cases, was the use of low emission building and finishing materials, as well as furnishings. The most common materials avoided were particle board, interior plywoods, carpets, soft plastics and plastic foams. Several respondents avoided conventional paints, varnishes and glues and a few avoided gypsum wallboard. Many substituted solid wood, cotton and wool fabrics, and special low emission paints for more conventional materials. A few built largely with masonry, concrete and plaster to avoid woods, manufactured woods and gypsum wallboard.

The third item of priority among most respondents was the outdoor air quality in their region or neighbourhood. Many reported that highway traffic and industry in urban areas, and agricultural spraying in rural areas, caused moderate to severe health problems for them. In most of the homes there was no equipment which could fully and reliably remove such chemical contaminants from incoming air. Several moved to lower-density neighborhoods or even to remote rural areas to avoid these problems.

Though several respondents used heat recovery ventilators ducted to all rooms, the most common ventilation systems relied on conventional local exhaust fans in bathrooms and kitchens with building leakage and open windows providing the makeup air. Some also added exhaust fans directly to laundry rooms, storage rooms and closets to remove moisture and odors from those spaces. Many had portable air cleaners, some with charcoal adsorption capability, though few used them regularly or relied on them heavily. Several reported disappointing results with using portable air cleaners to improve air quality in unmodified homes. A few respondents had air cleaning units custom-built into a central air handling system. Some of these had charcoal adsorption and other chemical scrubbing capabilities.

Most respondents avoided commercial cleaners, bleaches, waxes, polishes etc., and substituted borax, baking soda, washing soda, vinegar and mild soap flakes for cleaning purposes. Several installed central vacuums, with exhaust ducted to the outside and a few used commercial mould inhibitors.

COSTS AND FINANCING

It appears from the data that the incremental costs of special features are less for new construction than for renovations and that the incremental cost of implementing clean-air housing features correlates with the extent and type of the features. A few of the respondents reported financing their renovations in whole or in part through the Residential Rehabilitation Assistance Programme(RRAP). Some used Ontario Housing loans and disability grants. A few received disability pensions from insurance plans which helped with financing. Several received tax deductions from Revenue Canada for the costs of special heating and ventilation/filtration systems if claims were substantiated by a physician's letter.

THE LIMITS OF THE DATA

It is difficult to determine the actual numbers of individuals with recognized environmental health problems related to exposure in homes from this survey. The reason for this is that the survey was not completely exhaustive in it's national scope nor was there enough time allotted to reach the largest possible sample through advertising. Furthermore there was a good deal of "self selecting" requested in the call for participants (i.e. those with environmental health problems who had made "significant" changes to their home were solicited). It is therefore impossible to predict either how many people were reached or what proportion of those affected who were reached chose to respond.

The allergy literature usually places about fifteen percent of the population in the "allergic" category, though there seems little concrete evidence to support this figure. This includes hay fever, asthma, food allergy with serious symptoms and several other conditions. This number does not take into account more subtle sensitivities which may not manifest themselves with obvious clinical symptoms but which may nonetheless affect the health and well being of many Canadians.

It is fair to say from the results of this limited survey that awareness among Canadians of environmental health problems which can be connected to exposure in their homes is probably growing. It is also apparent that there is a small group whose sensitivities are so acute that they require special clean air provisions in their homes in order to remain functional. It is also probable that awareness among the general public of indoor air quality problems in homes due to poor ventilation and emissions from building materials, finishes, furnishings and other sources is growing and will begin to affect a larger portion of the housing market in the future.

CONCLUSIONS TO THE SURVEY

Based on the results of the survey, the following features are common in clean-air housing:

- the heating system utilizes an electric source rather than petroleum fuels; a low temperature heating system is preferable.
- hard-finish flooring such as ceramic tiles or hardwood is used; tiles are laid with cement mortars rather than adhesives; concrete without admixtures, water reduction oils, and curing agents is used for foundation.
- building materials with no formaldehyde or minimum emission of volatile organic compounds are used; Woods used are not treated with wood preservatives.
- wall and ceiling surfaces that do not require paints (such as plaster) are used, or if painted, non-toxic paints are used.
- draft free building techniques are used to reduce the infiltration of contaminants from the outdoors or from materials in the building envelope.
- good outdoor ambient air quality and location away from heavy traffic, industrial pollution, or power lines is emphasized.
- a ventilation system to bring in fresh air and exhaust stale air from local sources of pollution within the house is used.
- an air purification system to remove airborne contaminants such as dusts, mould spores, pollens, and chemical pollutants, is used.
- a central vacuum system which exhausts to the outside, or other suitable means of removing dust from the home.
- furniture, furnishings, household products selected for minimum emission of volatile chemical contaminants.
- a sufficient amount of natural lighting.

CONCLUSIONS

The measures undertaken by an individual are dependent on the severity of the illness, financial resources, accessibility of information and support from family members. Those who built with rigorous controls reported a greater degree of relief.

CHAPTER 4..CASE STUDIES

CASE STUDY #1

LOCATION: RURAL S.W. ALBERTA

SITE AMBIENT AIR QUALITY: EXCELLENT

INTRODUCTION

Sarah is a librarian and the mother of adult children. Four years ago, her sensitivities to indoor air pollution became noticeable at work where renovations had been done and indoor carpeting installed. Shortly after entering the building, Sarah would experience faintness, shortness of breath, blurred vision, headaches, slurred speech and flushed face. She took time off work, but got no relief by staying home where new carpeting had recently been installed. In fact, Sarah became more ill. After several attempts to get medical help she finally found a doctor who diagnosed several environmental sensitivities as well as related food allergies. The main agents which triggered her symptoms were identified as urban and industrial air pollution, natural gas, building material odors, paints, new carpets, soft plastics, household cleaning products, alcohols and inks.

Though Sarah had a history of mild allergies to house dust, pollen, feathers, mildew, wood resins and other plant materials, the sensitivities to petroleum products, alcohols, formaldehyde and other air pollutants were not apparent until her health crisis. As a result of this experience the family decided to look for a rural property with very clean air and to build a new house to meet Sarah's clean air needs.

They moved out of their house and rented an electrically-heated townhouse which was slightly better tolerated than the previous home. In the meantime they found a two-acre lot in a rural subdivision, where the air quality was very good, and hired an architect to design a clean-air home. The architect had no previous experience with the special requirements of a hypersensitive client, but did some research on building materials and methods and agreed to act as project manager.

BUILDING RATIONALE

The site was chosen for its excellent ambient air quality and distance from major roads. Occasional wood smoke from neighboring homes enters the site but is not a serious problem. There is no agricultural spraying in the immediate area.

The house is a 260 m^2 (2800 ft^2) single family detached home with basement and separate garage. The house was designed to take advantage of the site's ambient air quality through the use of a stepped plan which allows natural cross-ventilation of all rooms. An apartment for guests is located over the attached garage but is not built to the same chemical sensitivity standards as the rest of the house. Construction was kept as conventional as possible in the interests of controlling costs and using local materials. Most of the rooms are fitted with glass pocket doors to make it possible to isolate areas of the house from cooking odours, etc. A large enclosed storage room is located in the basement to reduce exposure to dust and emissions from stored materials. The rooms over the garage are used for hobbies to reduce exposure to chemical agents in the house. The house contains a separate utility room for water treatment equipment, etc.

CONSTRUCTION SUMMARY

The house basement consists of a conventional concrete slab and wall. A frame wall with fiberglass insulation and a polyethylene air/vapour barrier is located inside the foundation The house uses conventional 38x140 (2x6) framing with RSI 3.5 (R 20) and a continuous 150 micrometer (6 mil) polyethylene air/vapour barrier. Interior finishes are primarily drywall on walls and ceilings and ceramic tile floors. All drywall was painted with a white latex paint containing a passive formaldehyde absorbing agent (F-Sorb) to reduce emissions. All wood trim and interior doors were sealed with a clear hypoallergenic sealer (Crystal Aire). Electric ceiling radiant panels and an airtight wood burning stove were installed. Natural gas was specifically excluded from the home to prevent exposure to gas leaks or flue gases. Mechanical ventilation consists of exhaust fans in the kitchen, laundry, bathrooms, library, master bedroom closet and wall oven.

ANECDOTAL NOTES

The desired results were obtained with few significant problems, due in large part to the close construction management provided by the architect who enforced a no-smoking policy on the site during construction. The owners wanted to use interior plaster in place of drywall for wall and ceiling finishes, but costs were too high and tradespeople hard to find. The acoustical sealant used for sealing the joints in the polyethylene air/vapour barrier caused Sarah some discomfort for about 4 months after moving in, but the sealant has now dissipated and the discomfort has disappeared.

COSTS

Total Construction Costs (excluding land): $180,000

Approximate Cost per m2: $860, per ft2: $80

Costs of Special Features
Electric radiant heat: $5,000
Ceramic tile floors: $14,000
Sealing of particle board in cabinets: $500
Formaldehyde absorbing agent and hypoallergenic sealer: $500
Direct vent wall oven: $1200
Flush element cook top: $700
Extra exhaust fans: $600
Extra pocket doors: $1500

Estimated total incremental cost of special features (above what would have been normally incorporated into this house) $14,000 or 8%.

OCCUPANT ASSESSMENT

The excellent ambient and indoor air quality of the new house have provided Sarah with very good relief from chemical sensitivity symptoms. Though she is still not able to work, the relief available at home enables her to travel occasionally (with a portable air cleaner in the car) and live a relatively normal life.

COMMENTARY

This architecturally-based solution for attaining good indoor air quality uses conventional construction methods and simple exhaust fans effectively. More rigorous draft sealing methods such as "airtight drywall" or use of a low emission caulking could have reduced the problem with the odour from acoustical sealant. Fuel consumption is higher than if a heat recovery ventilation system had been used, but the owners find the operating costs acceptable. Sarah's particular tolerances permitted the use of cedar shingles and asphalt-impregnated sheathing paper, but these materials would not be tolerated well by all chemically sensitive individuals.

CASE STUDY #1

CONSTRUCTION MATERIALS /PRODUCTS TABLE

MATERIALS/PRODUCTS	LOCATIONS USED	COMMENTS
1.0 SITE WORK		
2.0 CONCRETE		
2.1 Poured concrete	Perimeter foundation wall Basement floor slab	Standard redimix
3.0 MASONRY		
4.0 METALS		
5.0 WOOD AND PLASTICS		
5.1 Conventional wood framing	Walls, floors , roof and inside basement walls	38x140 (2x6) Spruce
5.2 16 mm (5/8") exterior grade plywood	Subflooring and tile underlayment	
5.3 10 mm (3/8") exterior grade plywood	Exterior wall sheathing	
5.4 Solid pine	MoUldings and trim	All sealed with hypoallergenic sealer
6.0 THERMAL AND MOISTURE PROTECTION		
6.1 Fiberglass batts	All exterior walls and ceiling	RSI 3.5 (R 20) walls, RSI 7 (R 40) ceilings
6.2 Cedar shingles	Roofing and exterior finish of outside walls	Occupant has no sensitivity to cedar but others may
6.3 150 micrometer (6 mil) polyethylene	Continuous air vapour barrier	
6.4 Acoustical sealant (non curing butyl caulking)	Continuous air vapour barrier	Acoustical sealant used, to join poly took prolonged period to stop out gassing
7.0 WINDOWS AND DOORS		
7.1 Douglas fir	Window frames	Painted inside and metal clad outside
7.2 Insulated steel	Exterior doors	
7.3 Hollow core hard board	Interior doors	Sealed with oil base coat and two coats of latex paint with 'F-Sorb' passive formaldehyde absorbing agent
8.0 FINISHES		
8.1 Ceramic tile flooring	All floors except basement	Thin set mortar
8.2 Silicone grout sealer	All grout	Allowed to off gas before occupancy
8.2 Painted concrete (enamel)	Basement floor (storage room only)	Standard enamel floor paint
8.3 Gypsum board	All interior walls and ceilings	Screwed to framing, standard fillers, where back of g.b. exposed 'Crystal Aire' hypo allergenic sealer used
8.4 Paint	All interior walls and ceilings	Latex paint with 'F-Sorb' passive formaldehyde agent
9.0 SPECIALTIES		

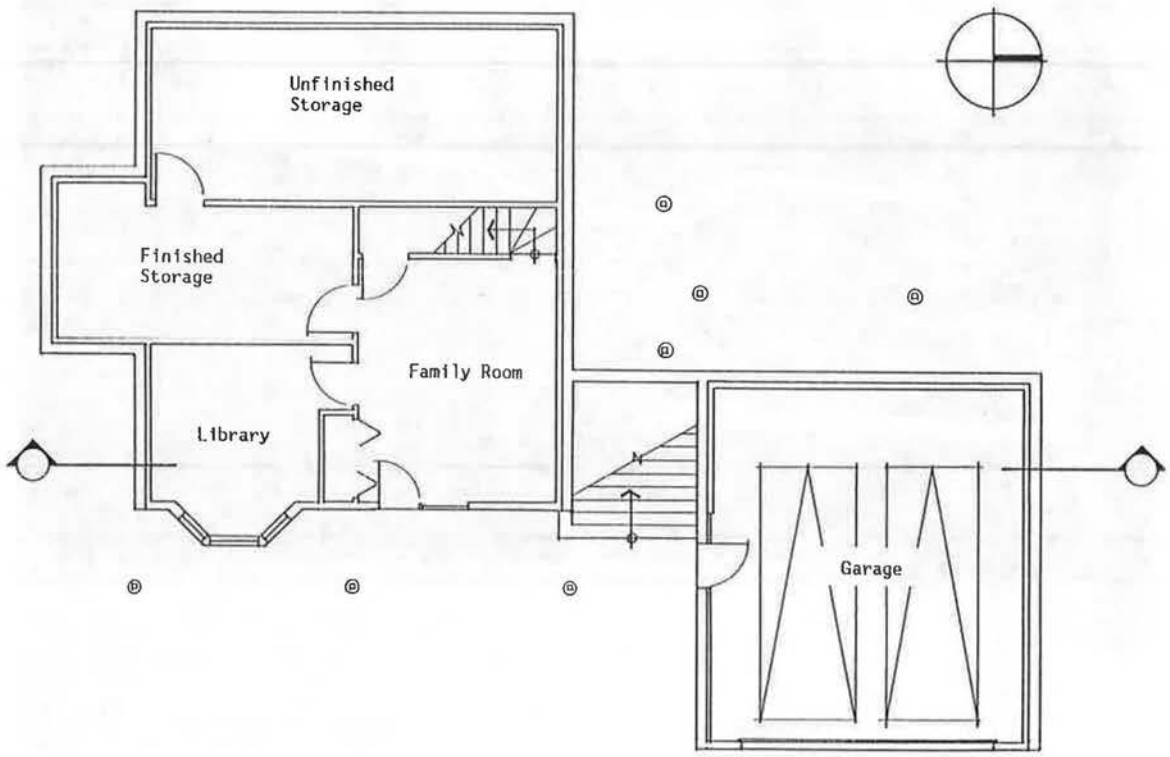
CASE STUDY #1

CONSTRUCTION MATERIALS /PRODUCTS TABLE

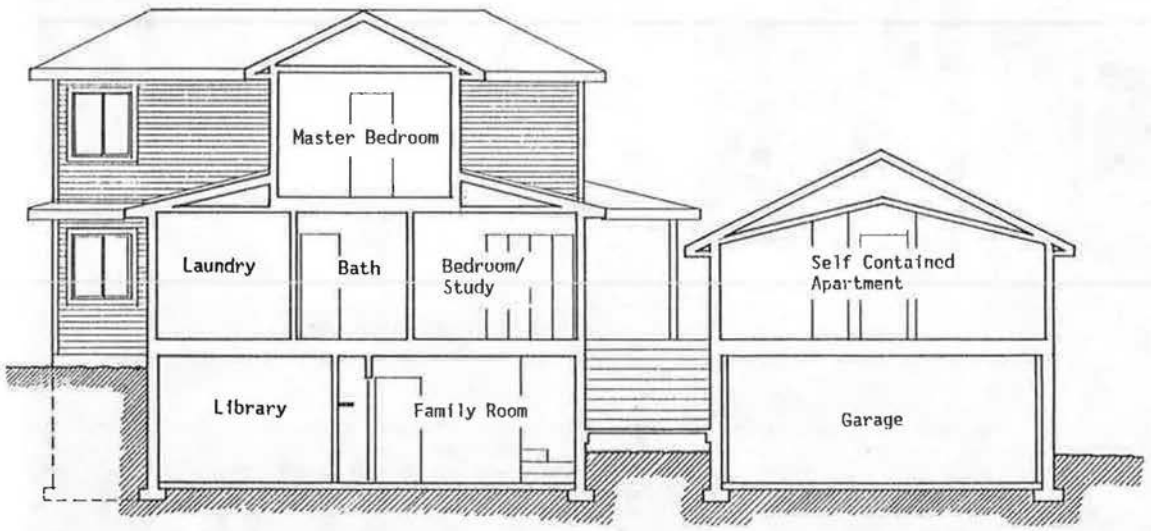
MATERIALS/PRODUCTS	LOCATIONS USED	COMMENTS
10.0 EQUIPMENT		
10.1 Cook top	Kitchen	Solid elements used for ease of cleaning
10.2 Walloven	Kitchen	Exhaust ducted directly outside
11.0 FURNISHINGS		
11.1 Cabinets	Kitchen and bathrooms	European particle board, all surfaces and edges veneered, all holes plugged and hardboard backs coated with 'Crystal Aire' hypoallergenic sealer
11.2 Beds	Bed rooms	Custom futon (no fire retardant), cotton sheets, down filled quilt, metal bed frame
11.3 Sofas and chairs	Through out	Gassed out (12 years old) reupholstered with cotton.
11.4 Tables	Through out	Solid wood
11.5 Rugs	Through out	Small area rugs of cotton and wool
11.6 Wire shelving	Closets	
12.0 SPECIAL CONSTRUCTION		
13.0 MECHANICAL (HEATING & VENTILATION)		
13.1 Wood burning airtight stove		Used regularly in winter
13.2 Natural cross ventilation	Through out	Using operable windows, clean ambient air, works well but not energy efficient
13.3 Exhaust fans	Kitchen, baths, laundry, library, master bedroom closet, wall oven	Easy to install and operate
13.4 Portable air cleaner	Through out	Occasional use
13.5 Portable ultrasonic humidifiers	Through out	
13.6 Central vacuum	Through out	Unit located in basement storage room
13.7 Polybutylene plumbing	Through out	
13.8 Distiller		For drinking and cooking water
13.9 Softner		For laundry and bathing
14.0 ELECTRICAL		
14.1 Electric ceiling radiant heating	Through out	Did not want gas in or near house, heating costs are high and response time slow

EAST ELEVATION

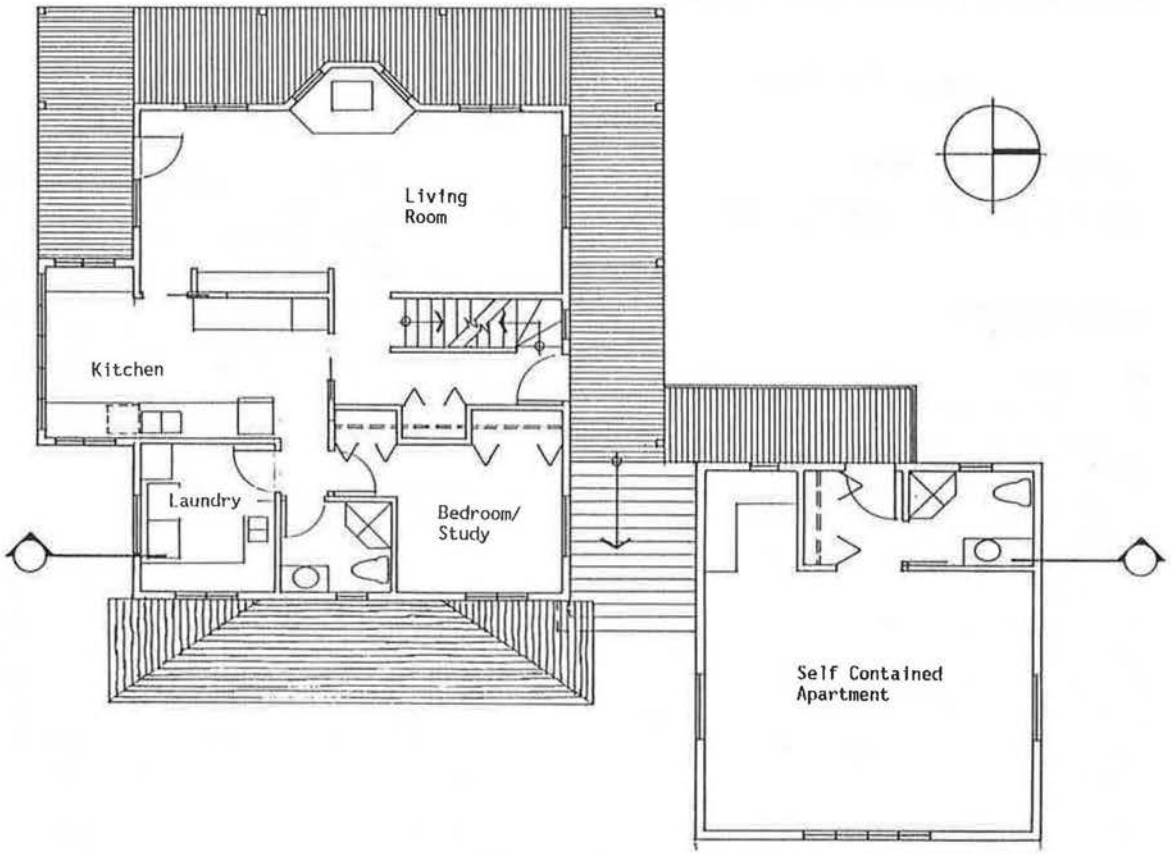
KITCHEN



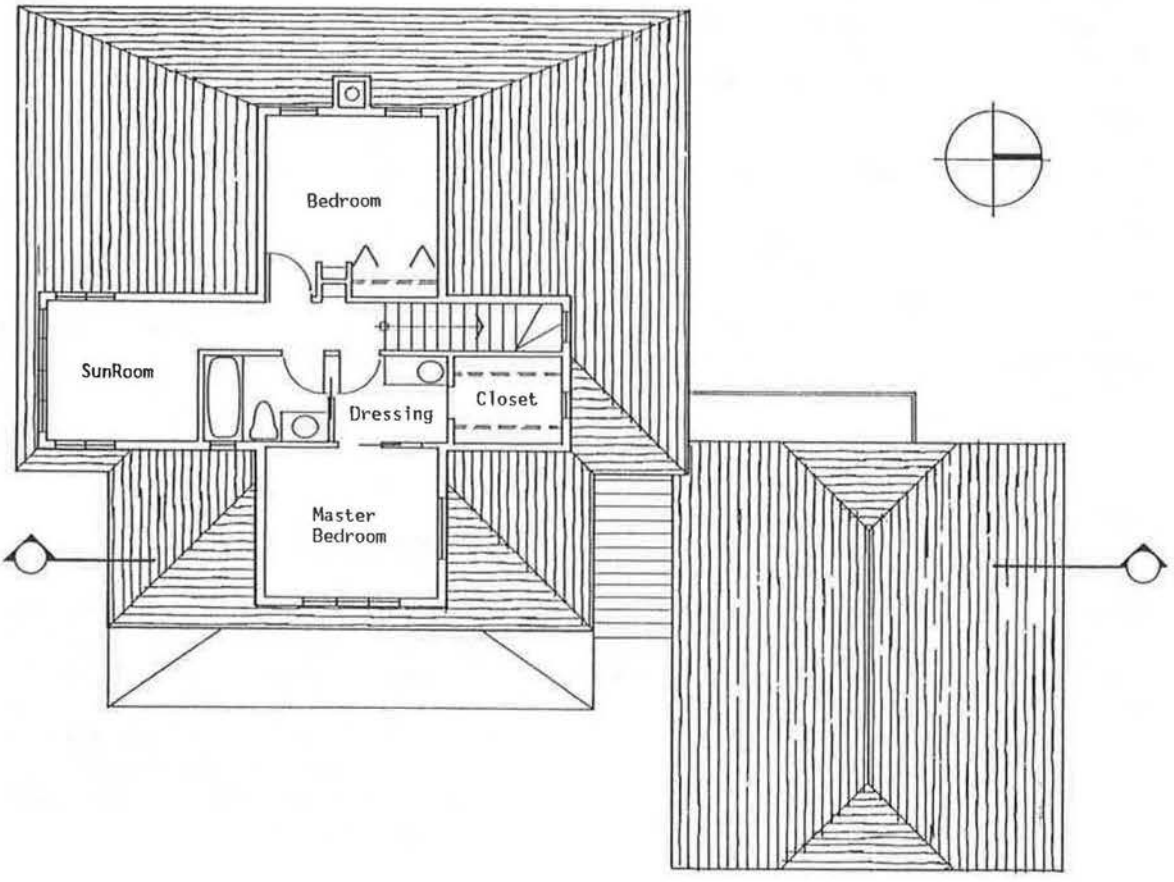
BASEMENT LEVEL



CROSS SECTION



MAIN FLOOR



SECOND FLOOR

CASE STUDY #2

LOCATION : SUBURBAN B.C.

SITE AMBIENT AIR QUALITY: VERY GOOD

INTRODUCTION

Ben discovered his sensitivities about three years ago after moving into the dream home that he and his wife had built in a new subdivision. Shortly after they moved in, he began to experience severe pains, fatigue and an inability to concentrate. Within three months he was hospitalized. Ben's health deteriorated for more than a year while several consulting physicians were unable to satisfactorily diagnose the problem. Ben had been exposed to some hazardous chemicals in the course of laboratory work at university, employment in a photography lab and some hobbies. These exposures had not produced any symptoms except a slight temporary loss of thought clarity and memory.

After several months of acute illness, Ben was sent to an environmental health unit in the U.S. where he was diagnosed as hypersensitive to many inhalant chemicals including formaldehyde, natural gas, odors from paints, carpets, plastics, synthetic fabrics, inks and paper. He also suffered from food intolerance and lesser allergies to mildew, house dust, pine and cedar resins and several other agents.

Treatment was begun, and Ben regained some strength and returned home, but he could not live in the new house. The house had been tested for formaldehyde and found to be too contaminated for him, though it was acceptable by national standards. He also could not tolerate the urban pollution in their suburban neighbourhood. Ben and his wife immediately began to look for another location to live. In the meantime, they spent many nights in temporary places, including a tent in his family's back yard.

They finally rented a house in a suburban area which was near the ocean and buffered by a large wooded park. This location meant long commuting distance for his wife, but it offered acceptable air quality for him. They negotiated with the owner who permitted them to renovate a detached guest cottage as a retreat room.

BUILDING RATIONALE

The 28 m^2 (300 ft^2) guest cottage is attached to an unused garage and provides Ben with an exceptionally clean-air retreat room for sleeping and working. Renovation of the entire house to meet his needs would have been prohibitively costly, particularly in a rental situation. The partial renovation was accomplished through the use of specific finishes and a high-capacity ventilation and fresh air filtration system.

CONSTRUCTION SUMMARY

The renovation involved building an entirely new room inside the old shell, replacing all existing finishes and installing a high capacity ventilation and filtration system. Ceramics, additive free concrete, and additive free plaster on wire lath were used to attain rigorous indoor air quality standards. The existing wood floor was replaced with an insulated poured-in-place concrete slab covered with ceramic tile set in plain sand and cement mortar. New walls were framed inside the existing exterior walls and insulated, and a continuous 150 micrometer (6 mil) polyethylene air/vapour barrier was then applied inside the insulation and framing with all joints sealed with aluminum tape. Over the polyethylene 1x3 horizontal strapping was used to support metal lath and a plain sand and cement plaster was applied to the lath. New aluminum windows were placed inside the existing wood frame windows. A large hood with a high capacity variable speed exhaust fan was installed to ventilate the entire room and extract odors emanating from a computer, television and stereo. Fresh air was also supplied by a large capacity variable speed supply fan with the air stream passing through four filters including activated charcoal, "permasorb" catalyst and a high performance bag filter. The ventilation system slightly pressurizes the room to prevent entry of unfiltered outside air.

ANECDOTAL NOTES

Fuel-oil contaminated soil which had been left, when a furnace tank was removed, had to be dug up and removed. Rigorous construction supervision was provided by a very experienced and meticulous builder who found tradespeople such as plasterers and supervised them closely. Because the house is rented, the ventilation and heating equipment is removable.

COSTS

Total Construction Costs $15,300

Approximate cost per m2: $550, per ft2: $51

Costs of special features
Replacement of all interior finishes $12,000
Ventilation and air cleaning equipment $3,300

OCCUPANT ASSESSMENT

The renovation has provided a very clean environment which gives Ben the necessary relief from irritants. Though he is still not able to work outside his special room he is able to spend some time in the main house and to go out occasionally. The ventilation system is very effective but it is uncomfortable in cold weather and adds substantially to space heating costs.

COMMENTARY

This is an effective solution when the renovation of an entire house cannot be undertaken. The concept of pressurizing the room to prevent the entry of unfiltered outside air has merit as a control strategy, but should be done within low pressure limits to prevent moisture accumulation inside insulated cavities.

CASE STUDY #2

CONSTRUCTION MATERIALS /PRODUCTS TABLE

MATERIALS/PRODUCTS	LOCATIONS USED	COMMENTS
1.0 SITE WORK		
2.0 CONCRETE 2.1 Poured concrete	Slab on grade foundation	Portland cement and gravel, no additives, mixed on site
3.0 MASONRY		
4.0 METALS		
5.0 WOOD AND PLASTICS 5.1 Conventional wood framing 5.2 Conventional wood trusses	 Exterior walls Roof	 Existing old trusses
6.0 THERMAL AND MOISTURE PROTECTION 6.1 Wood shingles 6.2 Extruded polystyrere insulation 6.3 Fiberglass batt 6.4 150 micrometer (6 mil) polyethylene 6.5 Asphalt shingles	 Exterior finish Beneath floor slab Exterior walls Continuous air vapour barrier Roof	 Old shingles Joints sealed with alumirum tape Existing
7.0 WINDOWS AND DOORS 7.1 Aluminum windows 7.2 Insulated steel	 Exterior walls Exterior doors	 Double glazed Enamel finish
8.0 FINISHES 8.1 Ceramic tile flooring 8.2 Plaster	 Through out Through out	 Portland cement and sand mortar, portland cement and sand grout On metal lath, no additives, white or brown sand with portland cement with hydrated lime mixed on site
9.0 SPECIALTIES		
10.0 EQUIPMENT 10.1 T.V, stereo and computer	 Bedroom/study	 Kept under fume hood

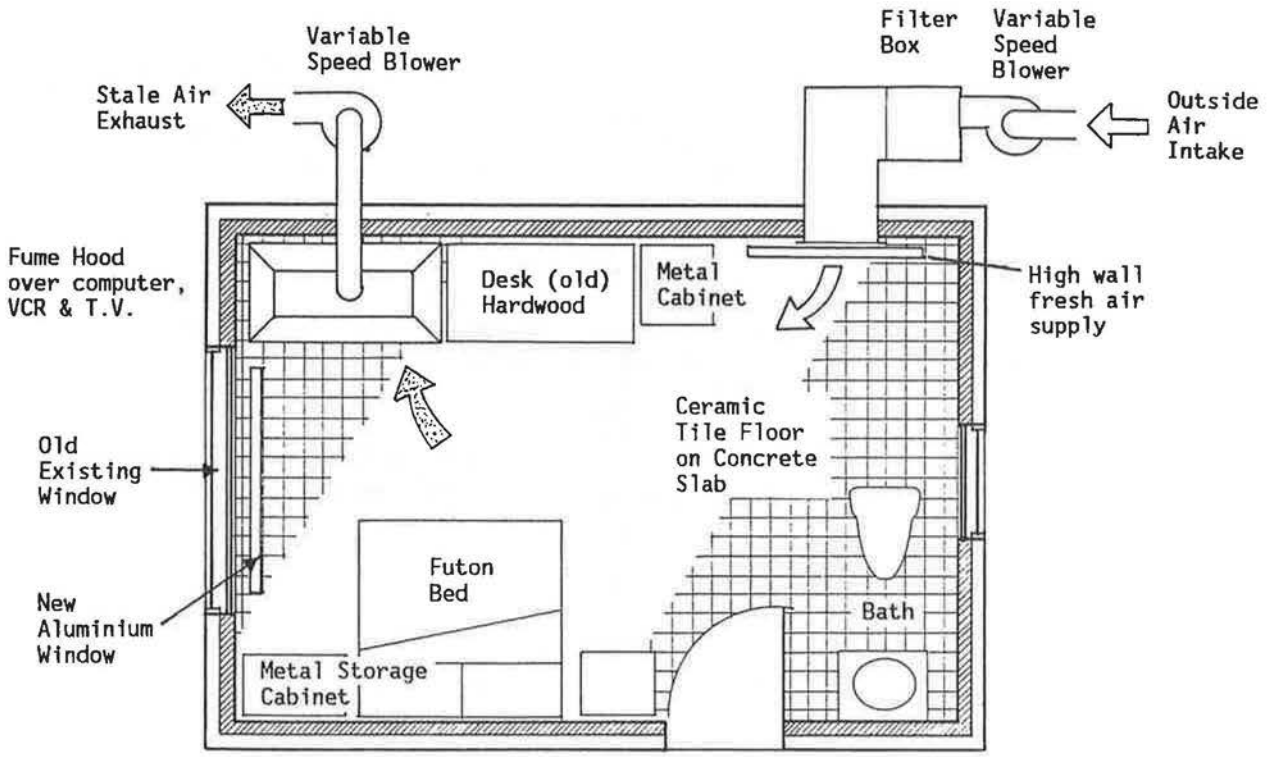
CASE STUDY #2

CONSTRUCTION MATERIALS /PRODUCTS TABLE

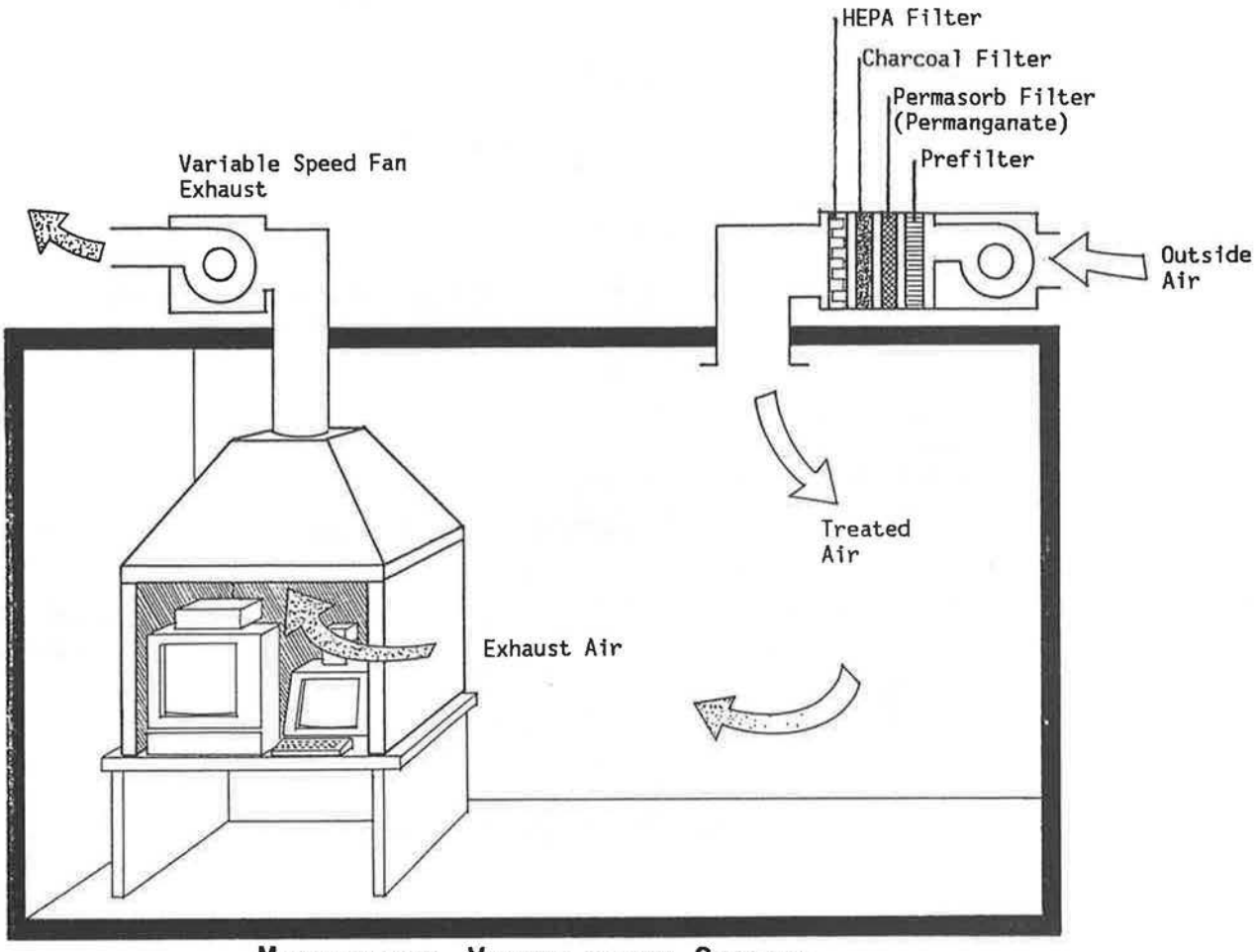
MATERIALS/PRODUCTS	LOCATIONS USED	COMMENTS
11.0 FURNISHINGS		
11.1 Cabinets	Bedroom/study	Frame of oak and sheet metal (fume hood), surfaces
11.2 Steel filing cabinet	Bedroom/study	solid beech with very well aged Swedish oil finish
11.3 Metal shelving	Bedroom/study	
11.4 Beds	Bedroom/study	Custom made futon bed on soild pine frame, futon cover prewashed several times
11.5 Chairs	Bedroom/study	Solid wood frames with cotton covers
12.0 SPECIAL CONSTRUCTION		
13.0 MECHANICAL (HEATING & VENTILATION)		
13.1 Exhaust hood & supply fan unit with air treatment system	Bedroom/study	Exhaust hood placed over T.V., computer and stereo to control fumes, varaible speed supply unit capable of large volume delivery, can pressurize room to reduce entry of contaminated air. High volume of system leads to high heating costs.
13.2 Air filtration		Prefilter, 'Permasorb' (permanganate) filter, charcoal filter 36 mm (1.5") and HEPA final filter.
13.3 Water treatment		Drinking water only
14.0 ELECTRICAL		
14.1 Low temperature liquid filled baseboard	Bedroom/study	Heat distribution relies on natural convection, low temperature to eliminate burning of dust

FUME HOOD OVER COMPUTER, VCR & TELEVISION

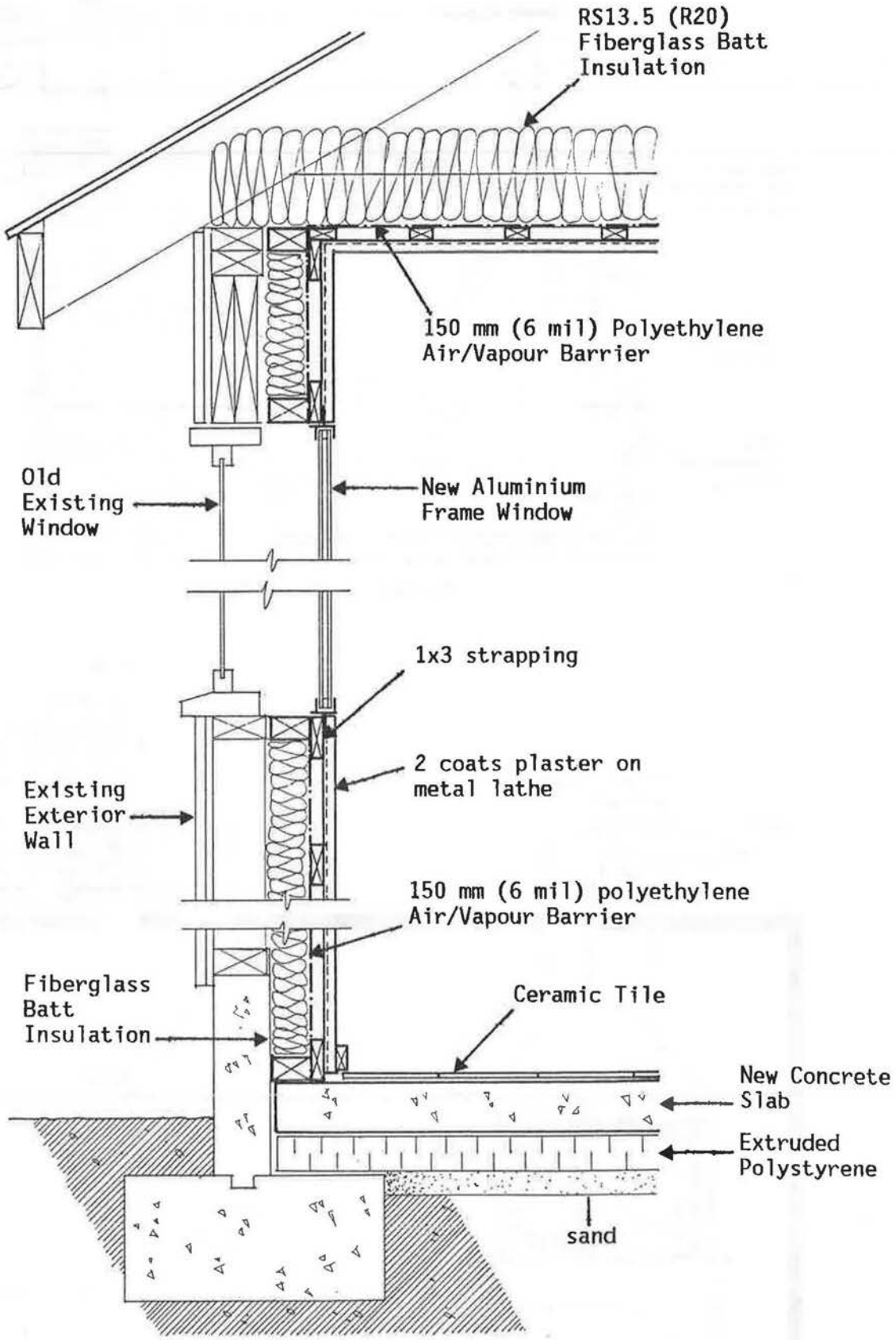
INTERIOR VIEW OF RETREAT ROOM



RETREAT ROOM PLAN



MECHANICAL VENTILATION SYSTEM



SECTION AT EXTERIOR WALL

CASE STUDY # 3

LOCATION: RURAL S.W. ALBERTA

SITE AMBIENT AIR QUALITY: EXCELLENT

INTRODUCTION

Ellen is the mother of two young adult children. She was working in an office about two years ago when renovations were taking place in the building. Up to that time she had been healthy and experienced no unusual allergies. During the renovations she became ill and was hospitalized with an acute lung infection. She reacted badly to the drug therapy prescribed for the infection and her health deteriorated rapidly. The infection was arrested but her health did not improve so she began seeing specialists, who were unable to provide a satisfactory diagnosis. By this time Ellen had lost a great deal of weight and was very weak. She began to recognize extreme sensitivities to inhalants such as natural gas, urban air pollution, odours from carpets, fabric softeners, perfumes and many other agents. The symptoms she experienced were general weakness, respiratory difficulty and depression and memory loss. She also suffers from chronic bronchitis which is aggravated by exposure to contaminants and has food allergies and some problems with house dust, pollens, feathers and mildew.

Ellen finally found medical help. She began a program to reduce exposure to inhalants and altered her diet. The family moved out of its urban neighbourhood to a location well outside the city. A home was purchased on a ten acre lot in a region where little highway traffic or agricultural spraying was likely to occur. The home was in very poor condition and was completely gutted and renovated for Ellen's needs.

BUILDING RATIONALE

The 325m2 (3500 ft2) house contained an attached garage, old carpets and a gas furnace. These were removed first and a new detached garage built. The objectives of the renovation were to produce a naturally lit, dust-free, clean-air home with low maintenance requirements. In order to isolate air pollutants within the house, most rooms were fitted with doors, the utility room was air sealed and isolated with a weather stripped door and most of the interior wall and floor finishes were replaced. Exhaust fans in most rooms provide local ventilation. Storage closets are fitted with windows where possible. Due to the low cost of gas in Alberta, a gas-fired boiler was purchased and installed in a separate building, which eliminated natural gas piping in the house and forestalled the possibility of leakage of flue gases into the living space.

CONSTRUCTION SUMMARY

Most interior finishes were covered or replaced with new finishes. The selection of finish materials was based on literature research, consultants' advice and personal challenge testing. The original basement floor slab was covered with extruded polystyrene foam board insulation, then covered with a second concrete slab. A hot water radiant heating system was placed in the new floor slab which was then covered in ceramic tile. New walls were framed inside the existing basement concrete and wood frame walls. The new walls were insulated and covered on the interior with a polyethylene vapor barrier. Most interior wall and ceiling surfaces were covered with conventional gypsum board and painted with latex paint containing a passive formaldehyde-absorbing agent (F-Sorb). Existing wood frame floors were stripped of particle board and covered with a new layer of exterior grade plywood (to support the ceramic tile flooring). The plywood was then sealed with a hypoallergenic sealer (Crystal Aire) and covered with ceramic tiles. The kitchen cabinets were replaced with new ones made from hardwood veneer cabinet stock with Corian tops.A central vacuum was installed.

ANECDOTAL NOTES

Ellen and her husband worked out a redesign and had it drawn by a professional draftsman. They hired a contractor who would permit the husband's participation in the renovations, which took about four months during which Ellen was away most of the time. The trades were carefully supervised and materials selections made in advance. Part of the house was of cedar plank and beam construction which was too costly to alter, so the wood was sealed with a clear hypoallergenic sealer (Crystal Aire). For ventilation, windows are slightly opened year-round. The individual exhaust fans are effective but are noisy and are wearing out quickly.

COSTS

Total renovation costs: Over $60,000

Approximate cost per m2: Over $180 ($17/ft2)

Costs of special features
Ceramic tile floors $13,000
Hot water heating $8,000
Hardwood kitchen cabinets $7,000
Hypoallegenic sealer and passive formaldehyde absorbing agent $500
Portable air cleaners $1000

OCCUPANT ASSESSMENT

The renovations have contributed noticeably to relief of Ellen's symptoms. She is able go out and even to travel occasionally, but cannot work. She tolerates having a dog and is slowly bringing house plants back indoors, though they are carefully watched for molds. She keeps two large portable room air cleaners containing activated charcoal but they are not used often. The hot water heating performs well and is inexpensive to operate.

COMMENTARY

This is an excellent example of an effective whole-house renovation, considering the extent of the renovations. The costs were reasonable and the results very good. The low quality exhaust fans are a noticeable shortcoming which is now being remedied. Most conventional bath fans are not designed for prolonged use and are noisy. High quality fans marked "low sone" or "continuous duty" cost more but perform much better. A central exhaust system or HRV ducted to all rooms could have provided quiet, effective ventilation in this renovation.

CASE STUDY #3

CONSTRUCTION MATERIALS /PRODUCTS TABLE

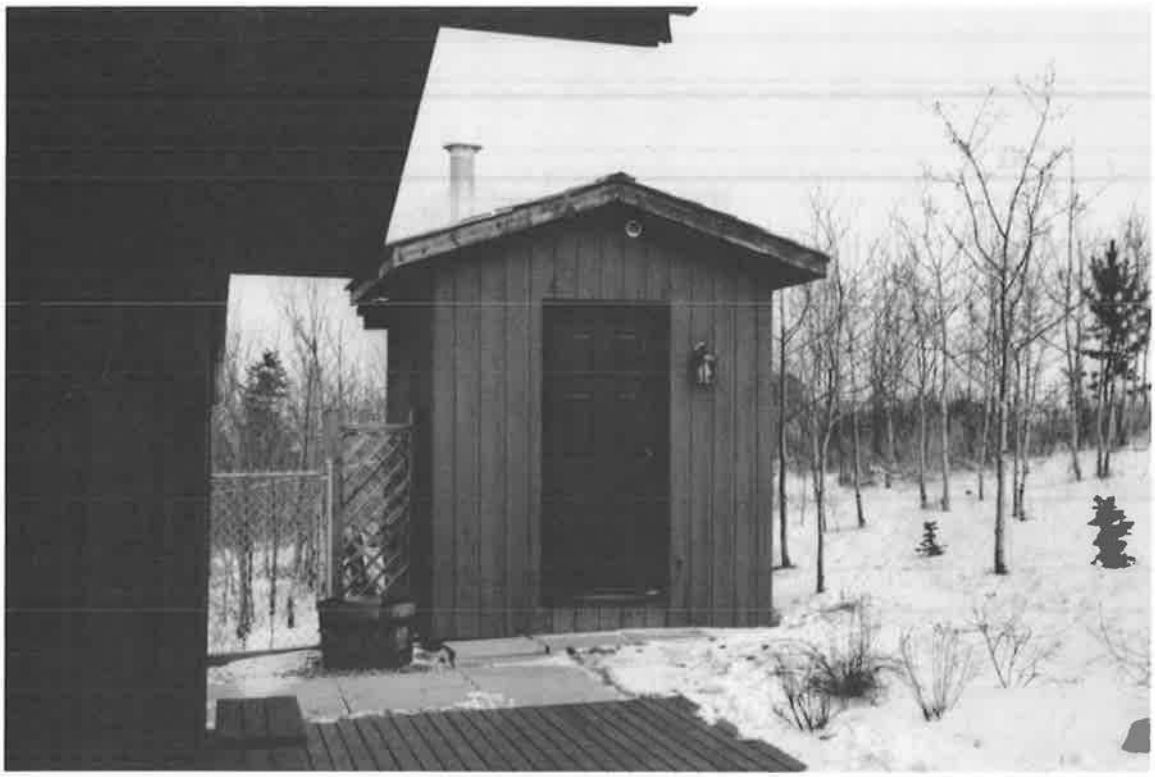
MATERIALS/PRODUCTS	LOCATIONS USED	COMMENTS
1.0 SITE WORK		
2.0 CONCRETE		
2.1 Poured concrete	Slab on grade and perimeter wall	
3.0 MASONRY		
3.1 Conventional brick	Fireplace	
4.0 METALS		
5.0 WOOD AND PLASTICS		
5.1 Wood framing	Interior and exterior walls	Standard framing lumber
5.2 Exterior grade plywood sheathing	Subflooring	Placed over existing joists and subfloor to support tile, plywood sealed with 'Crystal Aire' hypo allergenic sealer
5.3 Trusses	Roof	
6.0 THERMAL AND MOISTURE PROTECTION		
6.1 Stained Plywood Siding	Outside of exterior walls	Factory stained
6.2 Extruded polystyrene insulation	Beneath floor slab	
6.3 Fiberglass batts	Basement concrete wall, exterior walls ceiling	
6.4 Cedar shingles	Roof	
6.5 150 micrometer (6 mil) polyethylene	Continuous air vapour barrier	Joints sealed with caulking selected for owner tolerance
7.0 WINDOWS AND DOORS		
7.1 Steel insulated with enamel finish	Exterior doors	
7.2 Oak veneer plywood	Interior doors	
7.3 Fir with factory applied finish	Window frames	
8.0 FINISHES		
8.1 Ceramic floor tile	Entry, living room, kitchen, bedrooms, bathrooms, family room	Set in thin set mortar
8.2 Oak planking	Dining room floor	Wax finish
8.3 Gypsum board	Walls through out	Standard drywall filler
8.4 Plaster	All rooms except living room	Stiple treatment
8.5 Cedar plank and beam	Living room ceiling	All lumber sealed with 'Crystal Aire' hypo allergenic sealer
8.6 Oak	Trim	Sealed with 'Crystal Aire' hypo allergenic sealer
8.7 Latex paint	Walls and ceilings throughout	Mixed with 'F-Sorb' passive formaldehyde absorbing agent

CASE STUDY #3

CONSTRUCTION MATERIALS /PRODUCTS TABLE

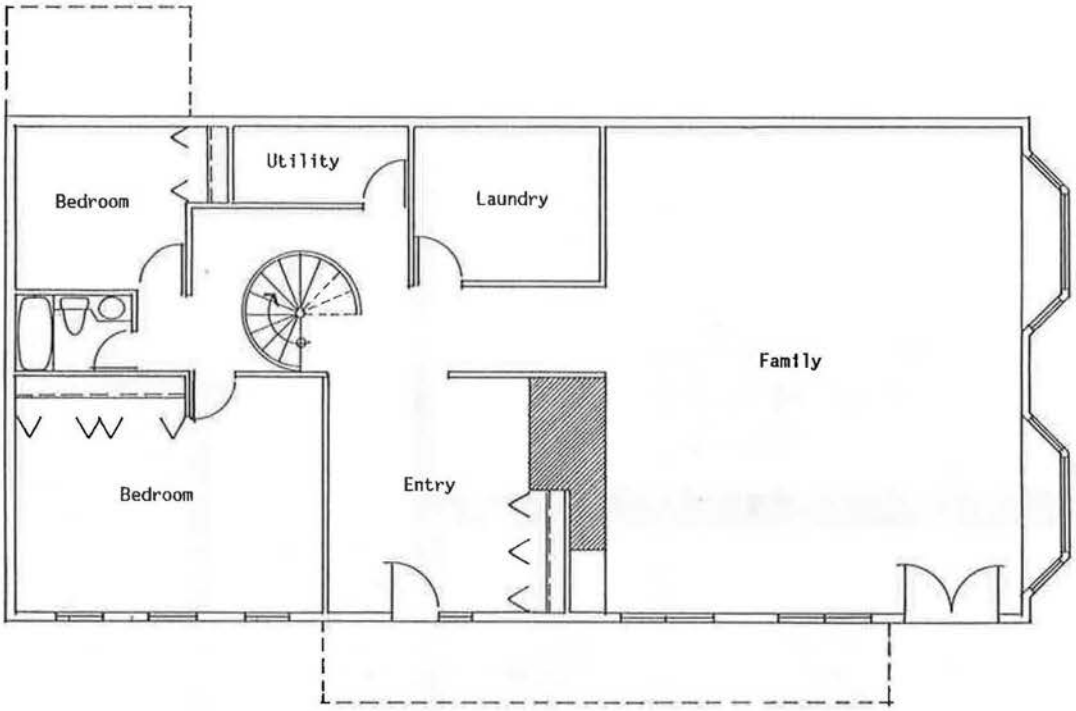
MATERIALS/PRODUCTS	LOCATIONS USED	COMMENTS
9.0 SPECIALTIES		
10.0 EQUIPMENT		
11.0 FURNISHINGS		
11.1 Oak and birch veneer on solid wood core	Cabinets	Sealed with 'Crystal Aire'hypo allergenic sealer
12.0 SPECIAL CONSTRUCTION		
13.0 MECHANICAL (HEATING & VENTILATION)		
13.1 Gas fired boiler	Outbuilding	Eliminates gas piping in house
13.2 Radiant floor slab	Basement	Does not cause dust movement like forced air
13.3 Hot water baseboards	Main and top floor	Does not cause dust movement like forced air
13.4 Air tight wood stove	Basement	Only for standby heating
13.5 Exhaust fans	Bathrooms, kitchen, oven, dressing room, laundry, family room, stereo alcove	Outside exhausting fans in many locations for maximum flexibility to exhaust rooms in use. Make up air by natural leakage and window located on opposite wall (for cross ventilation). All fans individually switched. Low price fans noisy
13.6 Portable air cleaners	Throughout	'Tibbets clean air machine' charcoal filter system
13.7 Central vacuum	Throughout	Exhaust outside
14.0 ELECTRICAL		
15.0 PLUMBING		
15.1 Water Softener	All locations except kitchen	Soft water not used for cooking and drinking

EXTERIOR ELEVATIONS

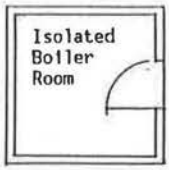


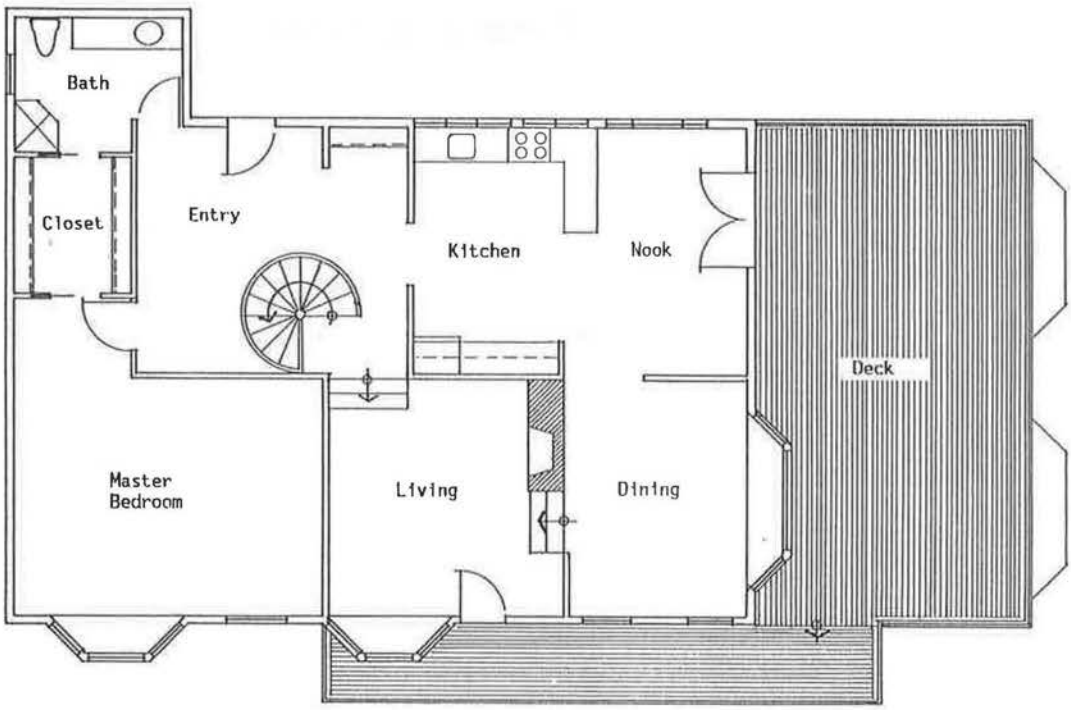
ISOLATED BOILER ROOM

LIVING ROOM

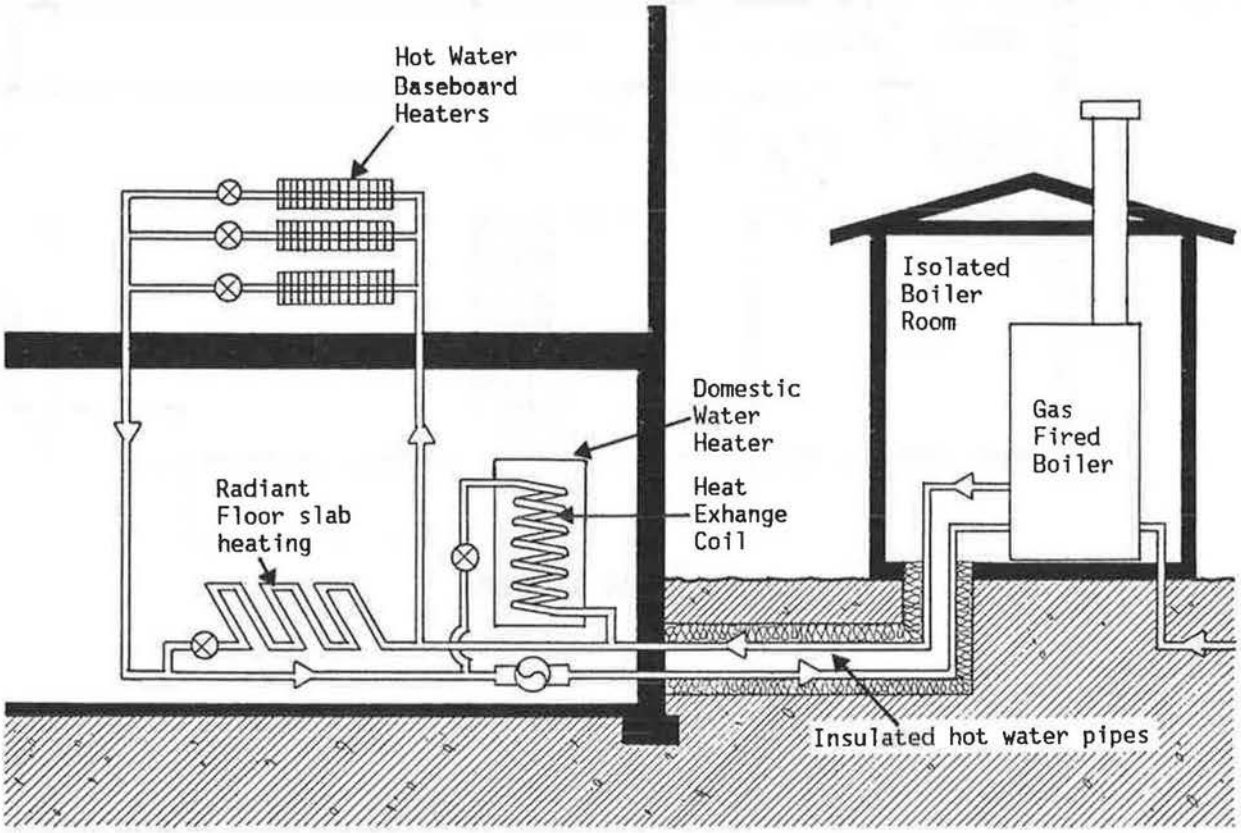


GROUND FLOOR

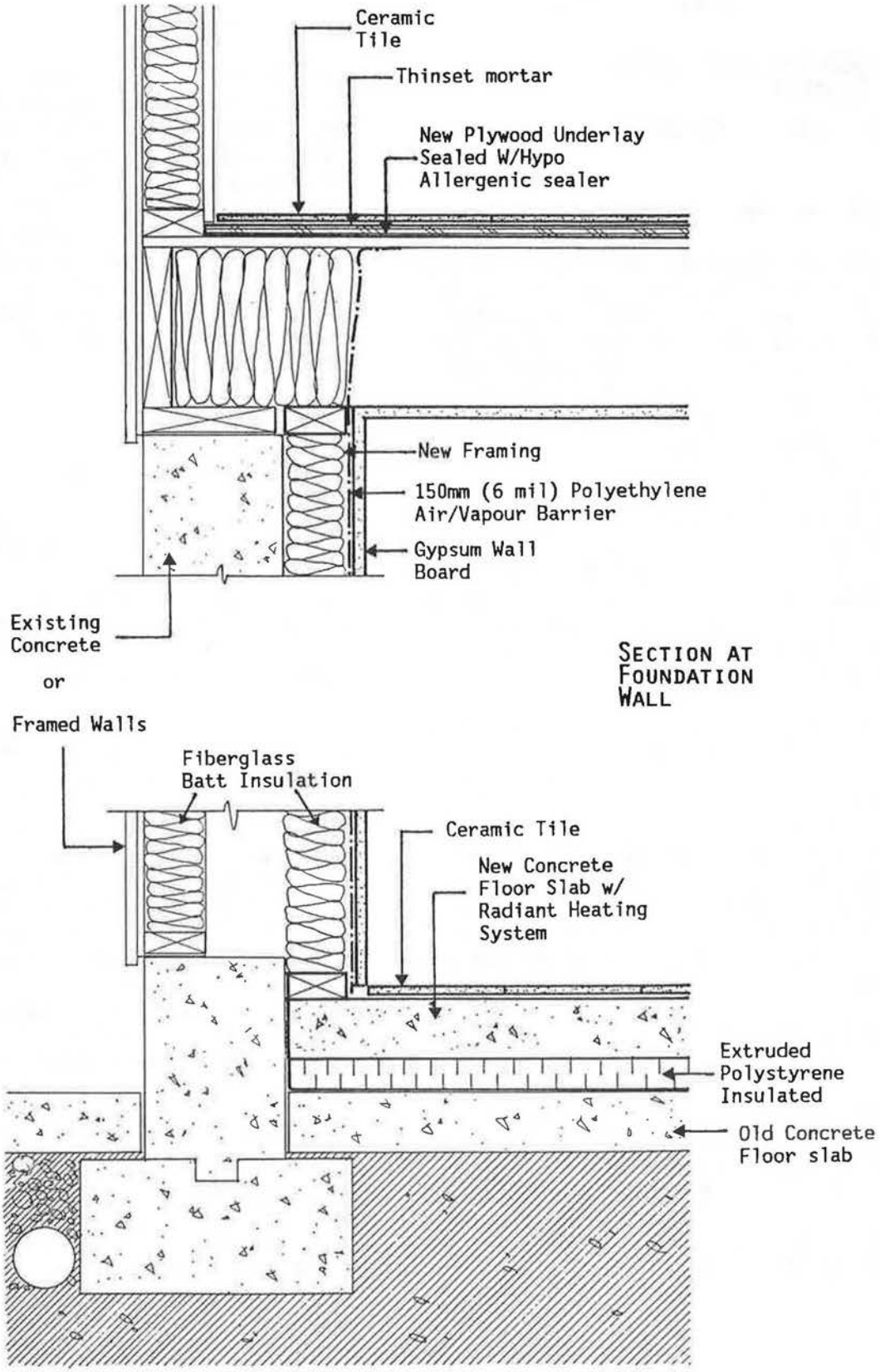




MAIN FLOOR



MECHANICAL SYSTEM


Ceramic Tile
Thinset mortar
New Plywood Underlay
Sealed W/Hypo Allergenic sealer
New Framing
150mm (6 mil) Polyethylene Air/Vapour Barrier
Gypsum Wall Board
Existing Concrete
or
Framed Walls
SECTION AT FOUNDATION WALL
Fiberglass Batt Insulation
Ceramic Tile
New Concrete Floor Slab w/ Radiant Heating System
Extruded Polystyrene Insulated
Old Concrete Floor slab

CASE STUDY #4

LOCATION: RURAL INTERIOR BRITISH COLUMBIA

SITE AMBIENT AIR QUALITY: EXCELLENT

INTRODUCTION

Kate is the mother of three adult children. She began to experience health problems about four years ago while living in a coastal suburb where a petroleum plant and local terrain which trapped urban pollution made air quality very poor. Kate first noticed flu-like symptoms from exposure to mildew, pollen and house dust, but these were followed by more severe symptoms such as dizziness, irregular heart beat and memory loss. Her health deteriorated for a long period while a diagnosis was unsuccessfully sought. Eventually she was tested for chemical and food sensitivities and was found to be acutely reactive to petroleum products, formaldehyde, pollens, etc., and allergic to many foods such as grains, some nuts and foods containing yeast. Her reactions to some challenge tests were so severe that she began to have convulsions and tests were discontinued.

At this point her health had declined so seriously that she was 20 pounds underweight and very weak. She reacted to perfumes, synthetic fabrics, smoke, natural gas and odors from carpets and plastics. She began on a rotation diet programme, eating only a few tolerated foods and began to consider how to reduce air pollution exposure. It might have been possible to renovate their suburban home but the urban air quality was unacceptable. Kate's symptoms became so severe that the family had to keep oxygen on hand to treat occasional seizures. Because Kate's husband was to retire soon, the family decided to look for a rural property.

Their search took them to a remote interior valley where they found a 50- acre farm on a river quite far from any highway or industry. The air quality was excellent despite occasional minor problems with the neighbours' wood smoke, and the soil was suitable for a large organic garden to meet their own needs. There was a large 18-year-old home on the land which needed complete renovation.

BUILDING RATIONALE

The 280 m^2 (3000 ft^2) house was in good condition but contained carpets, particleboard and other materials which Kate could not tolerate. A shallow basement had minor moisture problems. The intent was to renovate the entire house for Kate needs and then to build a clean-air sanctuary/sun room which could be even more controlled and could also act as an airlock entry in winter. The renovation involved the removal of all existing plywood, carpeting and particle board from the house and replacement with chemically non emitting materials.

CONSTRUCTION SUMMARY

The house was raised onto a new masonry wall and an insulated airtight wood floor built so that the old foundation became a crawlspace. Most interior finishes were removed and replaced and a fully ducted ventilation system was installed. Materials selection was based on literature research, consultation and personal challenge testing.

All original flooring was removed and replaced with hardwood flooring or linseed oil-based linoleum (Forbo) in the bathrooms. Hardwood flooring was nailed to the original shiplap subflooring and the linoleum was placed over an exterior grade plywood underlay. Vermiculite concrete was poured on an exterior grade plywood subfloor in the sunroom. Conventional drywall with a hypoallergenic drywall joint filler (AFM) and sealer (AFM Water Seal) was used for wall and ceiling finishes. Any new framing lumber used in the renovation was locally milled and had not been treated with anti-fungal agents. All walls and exposed floors were insulated with fiberglass insulation, and the ceiling was insulated with blown mineral wool. A continuous 150 micrometer (6 mil) polyethylene vapor barrier was placed over the insulation and sealed with aluminum foil tape. New stucco was used on the exterior for the additions. A water-based additive-free paint (AFM Safecoat) was used on all walls and ceilings. An additive-free clear finish (AFM Hardseal) was used on all trim, and a water-based urethane product (AFM Polyureseal) was used on the wood floors. Existing kitchen cabinets were replaced by locally made solid hardwood cabinets.

A fully ducted central heat recovery ventilation system was installed with a double aluminum core HRV. Air is exhausted from bathrooms, kitchen, laundry and closet/storage room, and fresh air is supplied to the bedrooms and living room. A range hood was installed in the kitchen to exhaust odors during cooking. A built-in vacuum was also installed. Heating is primarily provided by an airtight wood stove with low watt density electric baseboard heaters as backup.

ANECDOTAL NOTES

Installing the ducted ventilation system and built in-vacuum in an existing house was difficult. Kate found it stressful to live in the house during its renovation, particularly during the flooring sanding and drywall phases. She wanted to use additive-free plaster on metal lath for the walls and ceilings but trades were not available. The family supervised construction closely and had full cooperation of the builder. A good deal of the work was done by family members. When the sunroom was added, the builder found some used plywood in good condition, which was used for sheathing because it had very low emissions. Polyolefin weather barrier (Tyvek) was chosen for the exterior wind/water barrier because asphalt-impregnated paper was unacceptable.

COSTS

Total renovation costs (approx.) $100,000

Approximate cost per m2: $350 ($33/ft2)

Costs of special features
Ventilation system $5000
Built-in vacuum system $2000
Hardwood flooring $12,000
Sanctuary room/sunroom addition $16,000
Hardwood cabinets $10,000

The renovations were assisted in part by the CMHC RRAP program and the RRAP disability program.

OCCUPANT ASSESSMENT

The house was completely unacceptable before renovation, but is now quite tolerable. Though the renovation is not completely finished, Kate is in much better health and is able to function there without an air cleaner. She gardens regularly and feels strong enough to make occasional brief shopping trips to the city .

COMMENTARY

This is an excellent example of a clean-air retrofit. Though the costs were significant, the whole house was successfully upgraded and added to for less than half the cost of new construction. Building the sunroom earlier would have provided Kate with a tolerable retreat during renovations.

CASE STUDY #4

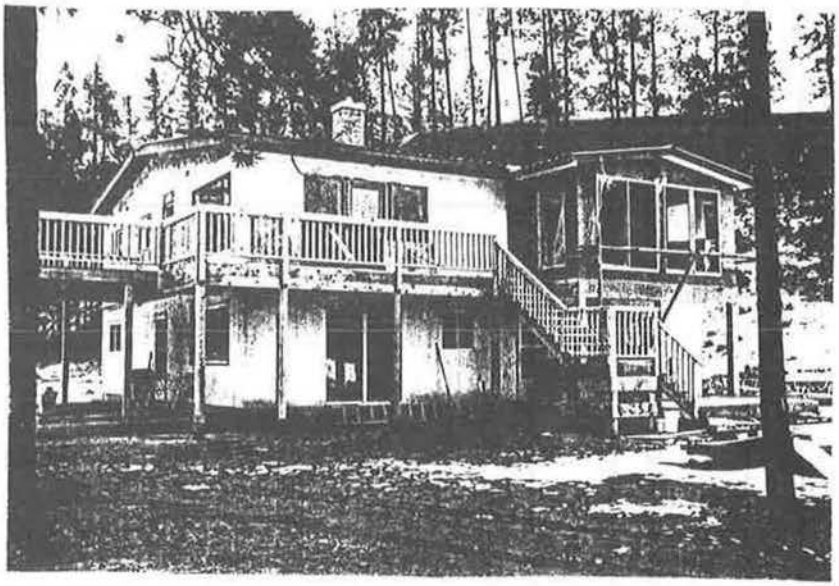
CONSTRUCTION MATERIALS /PRODUCTS TABLE

MATERIALS/PRODUCTS	LOCATIONS USED	COMMENTS
1.0 SITE WORK		
2.0 CONCRETE		
2.1 Conventional Ready-mix	Existing concrete slab & foundation	
2.2 Handmixed vermiculite concrete	New floors, poured 2" thick over subfloor	
3.0 MASONRY		
3.1 Concrete block wall	New addition foundation	Original poured concrete footing used
4.0 METALS		
5.0 WOOD AND PLASTICS		
5.1 Conventional wood framing	Walls 38x89 & 38x140 (2x4 & 2x6)	
5.2 2" and 1" solid lumber subfloor	Floors, over 2" wood joists	38x235 (2x10) Spruce/fir joists;50mm(1") sheathing milled locally no anti fungal treatment used on lumber
5.3 Used plywood	Exterior sheathing	
5.4 Hardwood	Floors, kitchen cabinets	Maple and Ash
6.0 THERMAL AND MOISTURE PROTECTION		
6.1 Fiberglass batts	All exterior walls and floors	RSI 7 (R 40) in floor, RSI 7(R 20) in walls
6.2 Energlass (Rockwool)	Ceilings	
6.3 Polyethylene	air/vapor barrier	'Milrol 2000' virgin polyethylene sealed with aluminum foil tape
6.4 Silicone sealant	general sealing	Plain sealant no fungicide
6.5 Urethane drywall gaskets	at sill plates	
7.0 WINDOWS AND DOORS		
7.1 Aluminum frame w/ baked enamel	Windows	
7.2 Wood	Windows	Fixed windows , locally milled pine with sealer
7.2 Solid Douglas Fir	Exterior doors	
7.3 Hollow core plywood	Interior doors	
8.0 FINISHES		
8.1 Water-based urethane	Hardwood floor and cabinet finishes	'AFM Polyureseal'
8.2 Water based paint	Wall finishes	Gypboard sealed both sides with waterseal
8.3 Hypoallergenic sealer	Wood trim	'AFM Hardshell'
8.4 Ceramic tile	Kitchen countertops	
8.5 Linoleum	Kitchen floor	European linseed oil polymer
8.6 Concrete stucco	Exterior wall finish	Installed over metal lath
8.7 Concrete dye and sealer	Floors	'Waterglass' sodium silicate
8.8 Drywall	Interior walls and ceilings	'AFM Hypo Allergenic Drywall Filler'

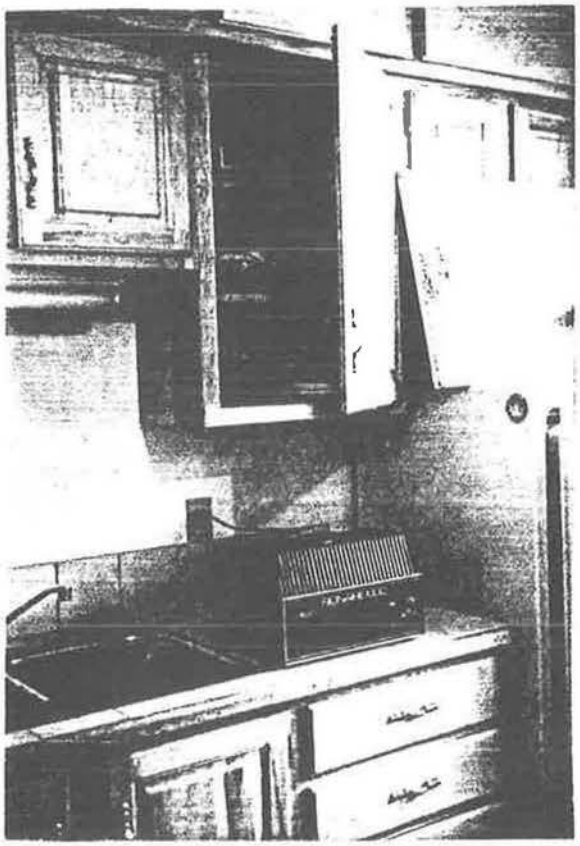
CASE STUDY #4

CONSTRUCTION MATERIALS /PRODUCTS TABLE

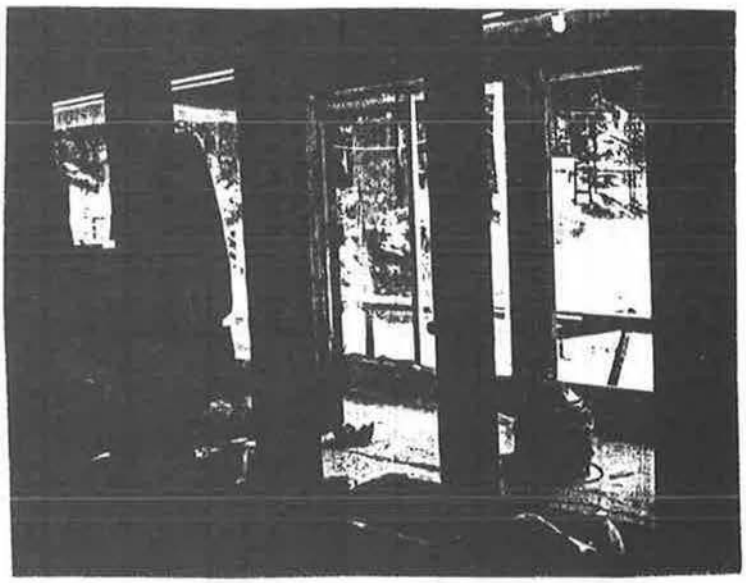
MATERIALS/PRODUCTS	LOCATIONS USED	COMMENTS
9.0 SPECIALTIES		
10.0 EQUIPMENT		
11.0 FURNISHINGS 11.1 Bedding and blankets	Bedrooms	Cotton
12.0 SPECIAL CONSTRUCTION		
13.0 MECHANICAL (HEATING & VENTILATION) 13.1 Woodstove 13.2 Open water pan on woodstove 13.3 HRV ventilation system	 Throughout house Used to humidify home in winter Fully ducted (4 exhaust, 4 supply)	 Used in winter; wood is cheap Lifebreath 300 DCS double core aluminum cross-flow HRV
14.0 ELECTRICAL 14.1 Electric baseboard heaters	Throughout house	Used in mild weather
15.0 PLUMBING 15.1 Water supply lines	Throughout house	Standard copper with 95-5 solder



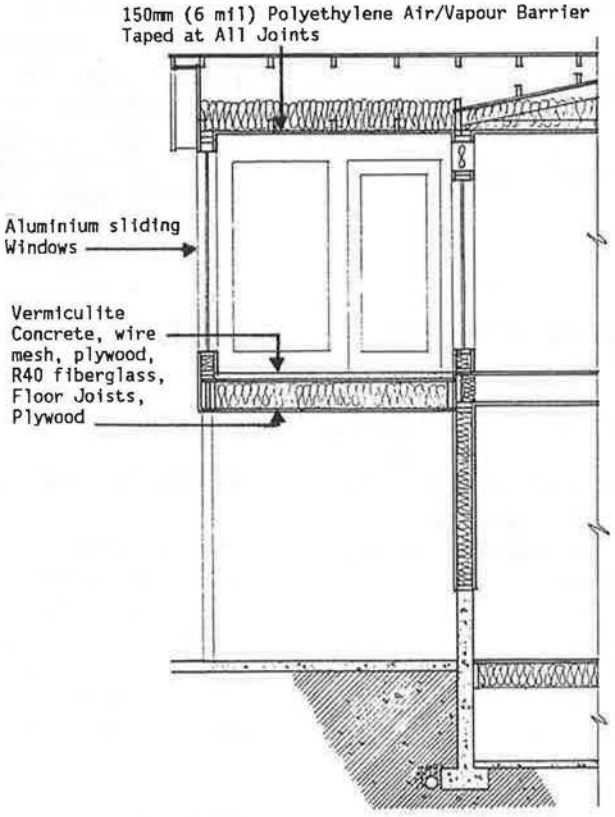
EXTERIOR VIEW SHOWING ADDITION UNDER CONSTRUCTION



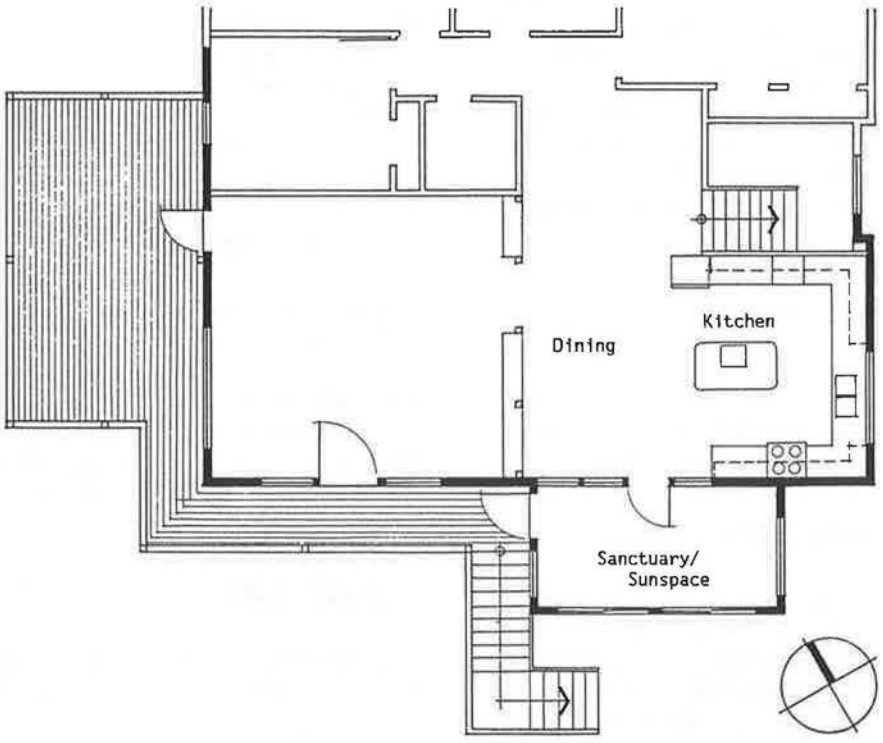
Portable
Air Purifier



INTERIOR VIEW INTO SANCTUARY/
SUNSPACE DURING CONSTRUCTION



SECTION OF ADDITION



PLAN OF HOUSE ADDITION

CASE STUDY #5

LOCATION: SUBURBAN S.W. BRITISH COLUMBIA

SITE AMBIENT AIR QUALITY: GOOD

INTRODUCTION

Several years ago Joan had heart and circulatory trouble which was treated with drug therapy for seven years. During this period her health deteriorated to the point where she became sensitive to many foods and inhalants and was no longer functioning well. She reacted to pollens and mildew, formaldehyde and other gases from building materials, natural gas and other petroleum products, as well as to many other household agents. The symptoms produced by exposure included severe breathing difficulty, general muscle weakness and tingling and numbness of the hands and feet. In the past few years she has also become extremely light-sensitive and cannot be outside for any extended period. For comfort she must wear tinted glasses even inside a shuttered house.

Eight years ago, Joan and her husband moved from their urban home to a low density suburb very near the ocean where air quality was much more acceptable. The home was over thirty years old and seemed a likely candidate for renovation because it had wood floors. There was, however, a small amount of mildew damage in the basement. Also, when particleboard cabinets and floor underlay in the new kitchen were tested, formaldehyde levels equaled or exceeded the maximum allowable under national standards.

BUILDING RATIONALE

The main floor of Joan's house was renovated to reduce airborne dust levels and formaldehyde emissions. The slight dampness in the basement cannot be completely remedied without great expense.

CONSTRUCTION SUMMARY

The existing oil furnace was replaced with an electric air-source heat pump. The heat pump compressor was located outside and the heat exchange coil placed in the old furnace ductwork. A two speed fan and 50mm (2") high capacity passive electrostatic filter (Dusteater) were installed in the return air plenum. Later all the existing kitchen cabinets and linen shelves were removed and replaced with plastic laminate. The cabinet trims and splash are Karadon sheet. Fresh air ventilation is provided by an exhaust fan in the main bathroom and a range hood in the kitchen. Make-up air is provided by natural leakage of the envelope and by open windows. A central vacuum was installed, and metal blinds were placed on all windows to relieve Joan's light sensitivity. The basement was renovated for her husband's office and is separately heated by electric baseboard heaters; the air quality there is not acceptable to Joan.

ANECDOTAL NOTES

There is still more to do. Joan would like to replace the old vinyl kitchen floor with ceramic tile and renovate the main bathroom. The cabinetmaker who built the new kitchen cabinets was well informed and responsive to special requirements. Joan has ordered a vehicle with specially tinted glass, to permit travel in spite of her light sensitivity.

COSTS

Total costs of alterations $14,400

Costs of special features
Kitchen cabinets $6,000
Heat pump $4,000
Passive electrostatic filter $200
Blind and cotton drapes $2,000
Wool area rugs $2,000

OCCUPANT ASSESSMENT

The heat pump, passive electrostatic filter and central vacuum have significantly reduced dust levels. The new kitchen cabinets have had little noticeable effect, perhaps because there are still small quantities of particleboard in the kitchen floor underlay and the bathroom cabinets. The location is good, though neighbours' wood smoke is sometimes a problem.

COMMENTARY

Modest changes have made an important difference to Joan's comfort and ability to function.

CASE STUDY #5

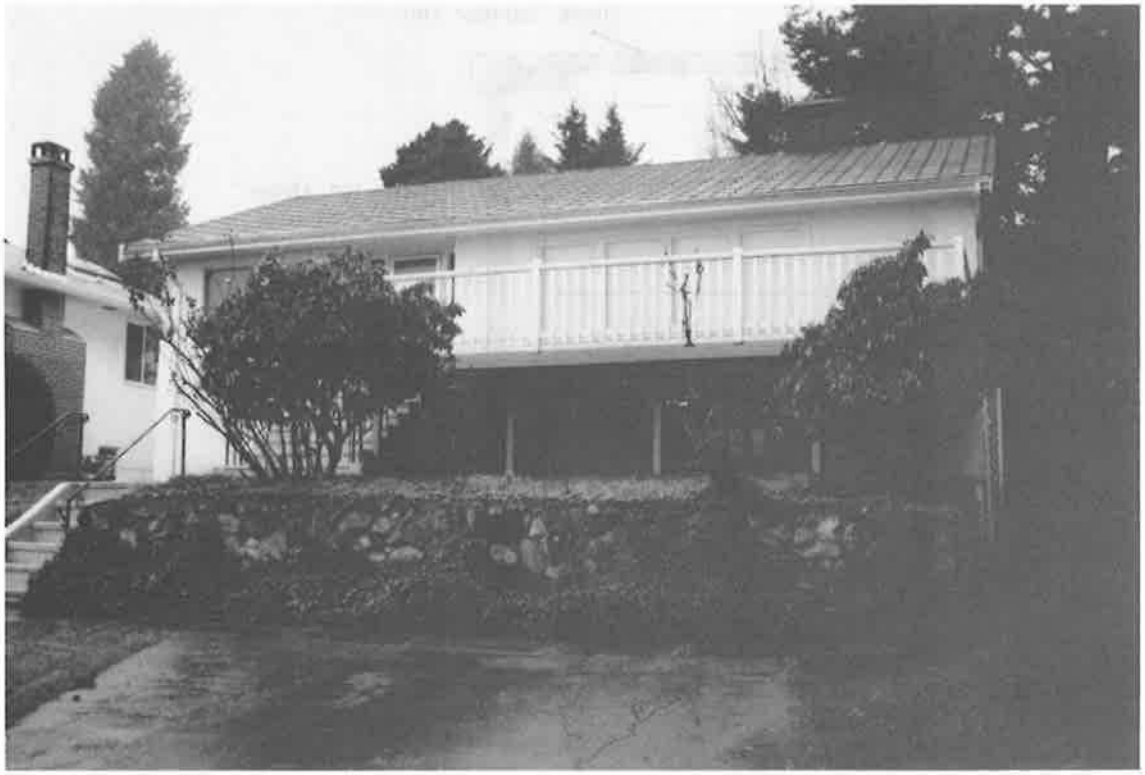
CONSTRUCTION MATERIALS /PRODUCTS TABLE

MATERIALS/PRODUCTS	LOCATIONS USED	COMMENTS
1.0 SITE WORK		
2.0 CONCRETE		
2.1 Conventional poured wall and slab	Existing basement	Some slight dampness
3.0 MASONRY		
4.0 METALS		
5.0 WOOD AND PLASTICS		
5.1 Conventional wood framing	Walls 38 x89 (2x4) & 38x140(2x6)	
5.2 Plywood, shiplap and wood lath	Exterior and interior sheathing	
5.4 Hardwood, fir	Floors	Existing Fir & Oak, with urethane varnish
5.5 Alder plywood	Kitchen cabinets and linen shelves	Low emission adhesives
6.0 THERMAL AND MOISTURE PROTECTION		
6.1 Fiberglass batts	All exterior walls and floors	Existing
6.2 Mineral Wool	Ceilings	Existing
6.3 Polyethylene sheet	Air/vapor barrier	New area only
6.4 Silicone sealant	Backsplash at kitchen	
7.0 WINDOWS AND DOORS		
7.1 Aluminum frame	New windows	
7.2 Wood frame single glazed	Existing windows	
7.2 Solid wood and plywood	Exterior doors	
7.3 Hollow core plywood	Interior doors	
8.0 FINISHES		
8.1 Gypsum board	Kitchen and basement walls & ceilings	
8.2 Lime gypsum plaster over wood lath	Existing walls and ceilings	Older sections of the house
8.3 Ceramic tile	Existing bathroom at tub	
8.4 Vinyl sheet flooring	Kitchen floor, bathroom	
8.5 Polyester sheet	Kitchen cabinet counter top	'Karadon'
8.6 Plastic laminate	Kitchen cabinet sides, doors & shelves	
8.7 Hypoallergenic sealer	Wall and ceilings	Not very successful (builder's judgement)
8.8 Latex paint	New wall finish	

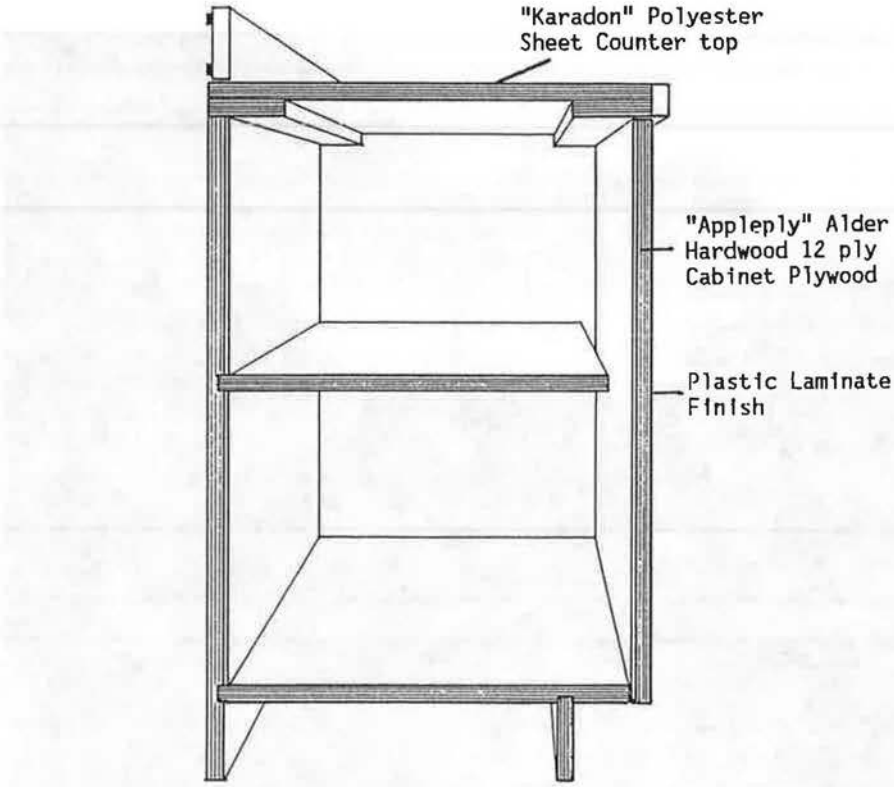
CASE STUDY #5

CONSTRUCTION MATERIALS /PRODUCTS TABLE

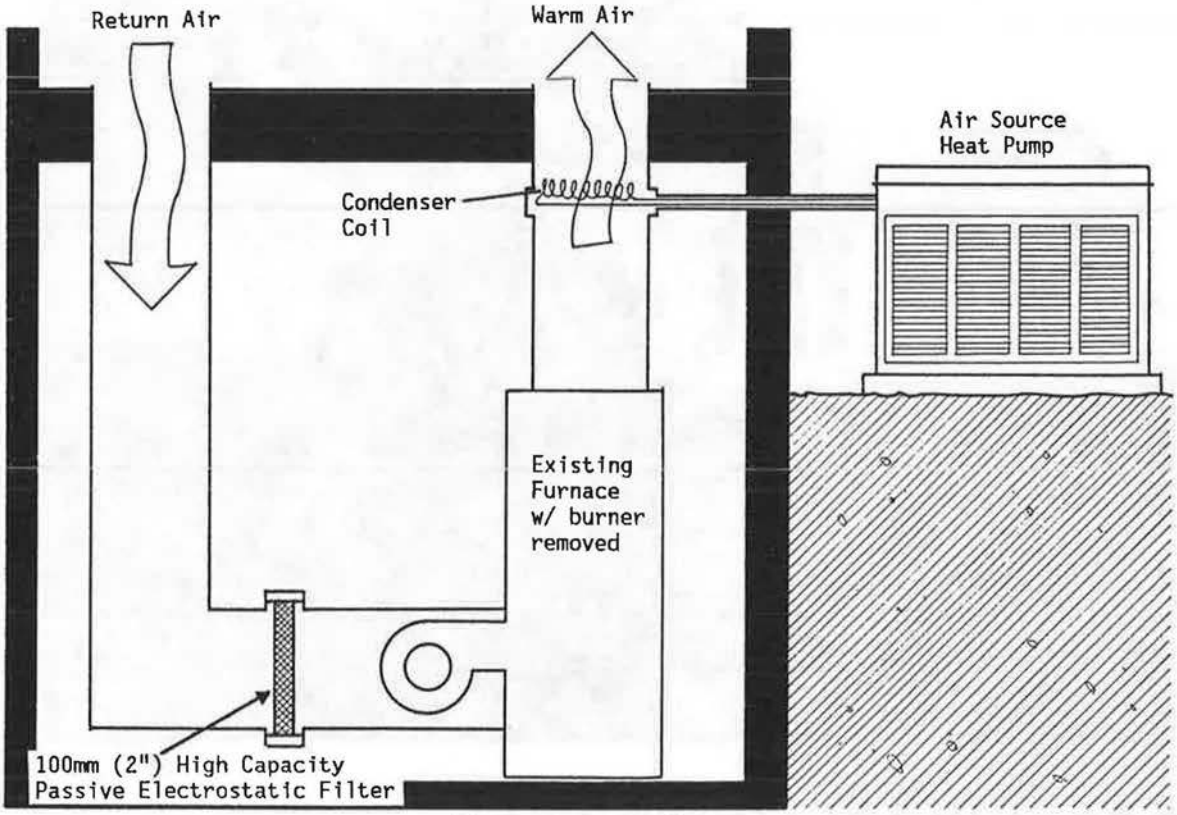
MATERIALS/PRODUCTS	LOCATIONS USED	COMMENTS
9.0 SPECIALTIES		
10.0 EQUIPMENT		
11.0 FURNISHINGS		
11.1 Bedding and blankets	Bedrooms	Cotton
11.2 Wool carpets	Partial coverage of floors	Cotton throw rugs were not tolerated
11.3 Leather couch	Existing (old)	
11.4 Solid wood antiques	Existing (old)	
11.5 Cotton drapes & metal blinds	Existing	
12.0 SPECIAL CONSTRUCTION		
13.0 MECHANICAL (HEATING & VENTILATION)		
13.1 Electric Heat Pump	Ducted throughout house	Ties into old oil fired furnace
13.2 Electrostatic air filter	In return air duct to Heap Pump coil	50 mm (2") thick, high capacity
13.3 Local exhaust fans	Range hood and bathroom	Existing exhaust units (2nd bath has no fan)
14.0 ELECTRICAL		



EXTERIOR VIEWS



KITCHEN CABINET CROSS SECTION



MECHANICAL SYSTEM

CASE STUDY #6

LOCATION: URBAN ONTARIO

SITE AMBIENT AIR QUALITY: GOOD

Janet has experienced allergic reactions all her life and was diagnosed as having petite mal when she was a child. She has sensitivities to house dust, pollen, fungus, natural gas, carpets, tobacco, wood smoke, urban and industrial air pollution and perfumes. Her reactions to these irritants include itching nose and throat, dry mouth, tightness in the throat, very severe and repetitive migraines, fatigue and depression. Her food allergies are made worse when she has been exposed to air borne irritants. In order to deal with her enviromnental sensitivities she decided to buy her own home. The home was selected on the basis of affordability and whether she could smell any objectionable odors in the home. After three months of searching she found a co-op townhouse unit which met her needs with some modifications. Before moving in she obtained permission form the co-op to make modifications descibed below. In order to finance the changes to the home she obtained a $15,000 grant from the Ontario Ministry of Housing under the Home Renewal Program for the Disabled. An architect helped her with the home modifications but in many cases she had to make here own decisions as to the aceptability of construction materials by living with a sample of the particular material for a week.

BUILDING RATIONALE

This 13 year old home (a condominium town-house unit) was selected and purchased because it was affordable, had no objectionable odou rs and required minimal modification to meet the occupants needs. The basement has patio doors that open onto a rear yard allowing for entry of daylight and natural ventilation and may have accounted for the low mould level found there. The alterations to the home included elimination of all gas fired appliances, reduction of house dust levels, and increased ventilation.

CONSTRUCTION SUMMARY

Modifications to the house consisted primarily of removing all carpets (the existing parquet was left exposed), installation of a heat recovery ventilation system and replacement of the existing gas furnace and gas water heater with electric boiler/fan coil unit. The boiler/furnace was chosen for its low temperature heat exchanger which reduces the burning of dust particles that occurs with electric baseboard and conventional electric furnaces. The existing heating system duct work was used and was cleaned before and after all work was completed. The heating system incorporates a three stage filtration system consisting of a washable aluminum prefilter, activated carbon filter and passive electrostatic filter. The heat recovery ventilator is fully ducted to all levels of the house. Air is supplied by the HRV directly to the living space unless additional tempering is needed, fresh air is then passed through the furnace. The HRV utilizes a heat pipe core and was chosen because the core was metal (rather than plastic) and effectively separates supply and exhaust air streams. Additional ventilation is provided by exhaust fans in the bathrooms. The originally installed recirculating range hood in the kitchen was left because the condominium association would not allow its replacement.

Interior walls and ceilings were painted with latex paint and left to out gas before occupancy. New aluminum windows were installed (all other units in the building used vinyl windows). Any new finish materials incorporated in the house were selected based on past allergy testing or personal exposure testing.

ANECDOTAL NOTES

It was difficult to find information on building and renovating to reduce exposure to chemicals and other allergens. More information is needed in this area. Specifications and contracts with all tradesmen and contractors must be thorough and precise. It is necessary to supply the contractors with information on where to obtain specialized building materials.

COSTS

Total costs of alterations: $14,000

Costs of special items
Heat recovery ventilator, furnace conversion, new electrical service $7,157
Filters, filter trays $430
Windows $3300
Portable air cleaner $463

OCCUPANT ASSESSMENT

The home now meets the occupants needs and she has experienced a significant reduction in her symptoms. Removal of the carpets and gas furnace and replacement with the electric boiler/fan coil unit has made a significant difference and has reduced the impact of other environmental irritants.

CASE STUDY #6

CONSTRUCTION MATERIALS /PRODUCTS TABLE

MATERIALS/PRODUCTS	LOCATIONS USED	COMMENTS
1.0 SITE WORK		
2.0 CONCRETE 2.1 Conventional poured wall and slab	Existing basement	Some slight dampness
3.0 MASONRY		
4.0 METALS		
5.0 WOOD AND PLASTICS		
6.0 THERMAL AND MOISTURE PROTECTION 6.1 Fiberglass batts	Added to ceiling	RSI 4.2 (R 24, two layers of R 12)
7.0 WINDOWS AND DOORS 7.1 Aluminum frame	New window inserts	Don't open in cold weather (freezing shut?)
8.0 FINISHES 8.1 Latex paint 8.2 Vinyl tile unchanged	New wall finish	
9.0 SPECIALTIES		
10.0 EQUIPMENT		
11.0 FURNISHINGS 11.1 Bedding and blankets 11.2 Wool carpets 11.3 Sofas and chairs	Bedrooms Dining area Existing (old)	Cotton
12.0 SPECIAL CONSTRUCTION		

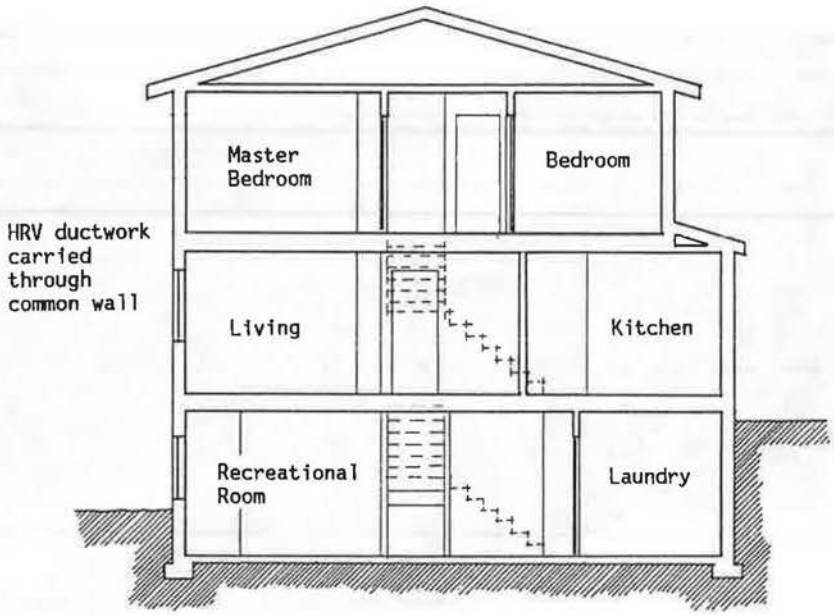
CASE STUDY #6

CONSTRUCTION MATERIALS /PRODUCTS TABLE

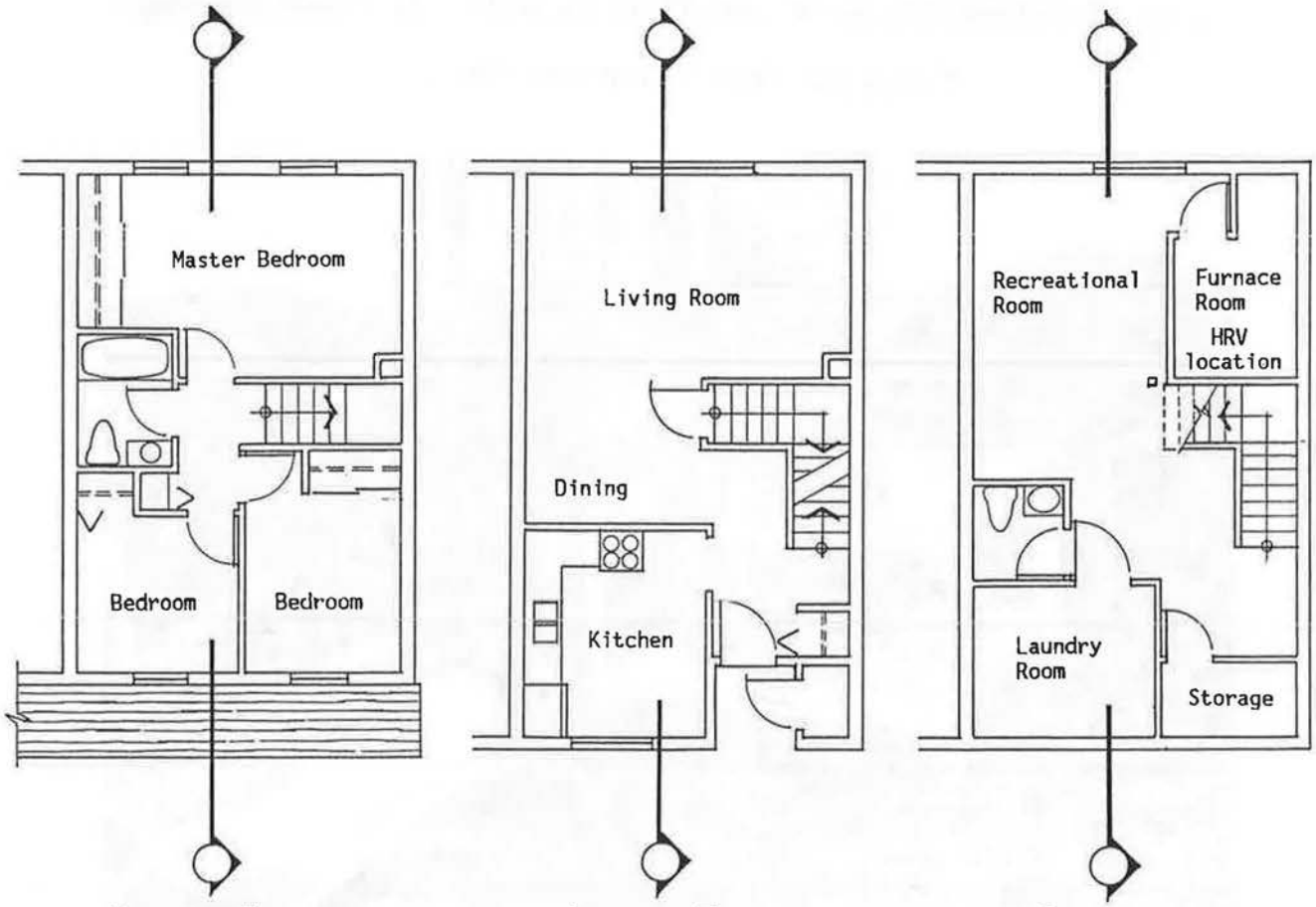
MATERIALS/PRODUCTS	LOCATIONS USED	COMMENTS
13.0 MECHANICAL (HEATING & VENTILATION)		
13.1 Electric boiler; forced air heat	Ducted through out house	Coil installed into old furnace housing
13.2 Activated carbon filter	In cold air return	
13.3 Electrostatic air filter	In return air duct after carcoal filter	Passive type
13.4 Local exhaust fans	Kitchen and both bathrooms	
13.5 Whole house HRV	Direct duct to LR, Bedroom, and Basement. Feeds into furnace when cold.	Copper coil with sealed freon heat exchanger
13.6 Air conditioning	Movable window units (2)	Spot cooling
13.7 Humidifier	Portable unit	
14.0 ELECTRICAL		
14.1 Upgraded entrance to 200 Amps	Whole house	
15.0 PLUMBING		
15.1 Carbon water filter	Kitchen faucet only	Bottled water is used for drinking

EXTERIOR VIEW TOWNHOUSE UNIT

INTERIOR VIEW



CROSS SECTION



SECOND FLOOR GROUND FLOOR BASEMENT

CASE STUDY #7

LOCATION: RURAL, EASTERN ONTARIO
SITE AMBIENT AIR QUALITY: EXCELLENT

INTRODUCTION

Aileen and Rachel are two young children who have experienced environmental hypersensitivity from very early age. While living in a older house they were found to have sensitivities to house dust, pollen, mould, mildew, fungus, natural gas, oil combustion products, carpets, odors from building materials, paint, wood resins (pine and cedar), tobacco, wood smoke, pesticides, urban and industrial air pollution and perfumes. These sensitivities manifested themselves in the form of asthma, eczema, fatigue, and low resistance to infections. The children were also found to have numerous food allergies and were placed on restricted rotational diets. In an attempt to reduce Aileen and Rachel's environmental sensitivities an air purifier containing a high efficiency particulate filter and a gaseous absorption filter was installed in their bed room. The air purifier provided marked relief and lead their parents to conclude that the construction of a clean air house was the only long term answer. The house was built on a limited budget and therefore it was kept small in size so that a high level of workmanship could be maintained and high quality finishes could be used in construction. Since moving into their new low pollution home Aileen and Rachel have shown enourmous improvement and have found that thier food allergies have also decreased significantly. The frequency of asthma attacks has decreased markedly and the children are now no longer on asthma medication.

BUILDING RATIONALE

This 170 m2 (1800 ft2) house is located on a 1 3/4 Hectare (4 1/2 acre) lot in a small rural subdivision. The house has a slab on grade foundation (unusual in this area) to eliminate the possibility of indoor mould growth common in basement and crawlspace foundations. The house was built of carefully selected non-toxic materials and constructed to the R-2000 air tightness and energy use standards. The incorporation of a continuous air barrier allows for filtration of all air entering the house. Continuity of the air/vapour barrier is critical for comfort, moisture control, energy use and to ensure that no insulation fibers or gases enter the house. Air lock entries were also incorporated in the plan to further control entry of outside contaminants. A ventilation system is incorporated to continuously supply fresh air through out the house and to exhaust areas of contamination. The design and construction of the house was dictated in part by a limited budget.

CONSTRUCTION SUMMARY

The house foundation consists of a reinforced concrete footing with an insulated block stem wall. An extruded polystyrene skirt is located over the footing to prevent frost heaving. The entire area of the floor slab is insulated with extruded polystyrene which is covered by a continuous moisture and soil-gas barrier of 100 micrometer (4 mil) cross laminated polyethylene taped to all plumbing penetrations. The floor slab is made from additive free reinforced concrete. All exterior walls are of double stud construction and are insulated to RSI 7.7 (R 44) with fiberglass batt insulation. The roof was constructed of factory made trusses strapped with purlins and covered with steel roofing. Windows are triple glazed in wood frames to reduce possible condensation and accompanying mould growth. A continuous air/vapour barrier of 100 micrometer (4 mil) cross laminated polyethylene was applied to the inside face of the ceiling and exterior wall framing. The air/vapour barrier is sealed at all lapped joints with caulking and staples. These joints in turn were covered in aluminum tape to eliminate off gassing from the caulking. All electrical boxes in exterior walls were placed in air tight boxes fabricated from framing lumber and sheet metal which were sealed to the air vapor barrier. The ceiling is insulated with blown mineral wool insulation to RSI 10 (R 56). Wall exterior finishes consist of stucco and cedar trim. All interior wall and ceiling surfaces are covered with gypsum lathe and finished with additive free plaster. All floors except in the mechanical room are covered with ceramic tile or quarry tile. All tile work was set in an additive free mortar. All kitchen cabinets are solid hardwood (birch) glued with white glue and finished with shellac. Counter tops are made from polyester sheets (Corian).

The mechanical ventilation system consists of a fully ducted double flow (balanced) system. Fresh air is supplied and stale air is exhausted from all

bedrooms. Stale air is also drawn from "wet rooms, all closets, from behind the refrigerator and from the kitchen cabinet toe space beneath the sink. Stale air is ducted to the mechanical room which in turn is exhausted. This design ensures that the mechanical room is always under a negative pressure preventing seepage of contaminants into the house. Heat is extracted from the exhaust air by an air to water heat pump which provides both space heating and domestic water requirements. Additional heating if required is supplied by an electric element in the hot water tank. Return air and fresh air entering the house is filtered by a coarse prefilter and two passive electrostatic filters. The heat-pump fan-coil unit provides a low temperature heat exchanger which eliminates burning of dust particles.

ANECDOTAL NOTES

The success of this project was largely due to the thorough design, selection of materials, and high standard of construction.

COSTS

Total Costs: $210,000

Cost per m2 $1240 ($115/ft2)

Costs of special features
Plaster $14,000
Ceramic tile on cement $12,400
Solid wood cabinets w/out doors $8,220
Birch doors (interior) and trim $9,000
Windows and exterior doors $14,200
Heat pump and ventilation system $10,000

OCCUPANT ASSESSMENT

Significant improvement in symptoms were experienced almost immediately after moving into the house. Medications have been eliminated.

COMMENTARY

One of the houses that pioneered state of the art housing for the chemically sensitive. A very successful project which has clearly met the client's goals.

CASE STUDY #7

CONSTRUCTION MATERIALS /PRODUCTS TABLE

MATERIALS/PRODUCTS	LOCATIONS USED	COMMENTS
1.0 SITE WORK		
2.0 CONCRETE		
2.1 12" Insulated concrete blocks	Foundation	'Sparfil' RSI 4.2 (R 24) covered with parging cement
2.2 Double layer concrete floor	On grade slab	Full depth granular fill with R SI 1.8 (R10) Polystryrene under entire slab
3.0 MASONRY		
4.0 METALS		
4.1 28 gauge sheet metal	Ductwork	Washed with natural soap prior to installation to remove oil
5.0 WOOD AND PLASTICS		
5.1 Double wall framing system	Exterior walls	38x89 (2x4) studs at inner and outer walls, each with RSI 2.1 (R12). 125 mm (5") cavity between walls with RSI 3.5 (R 20) all fiberglass insulation. Metal lath and stucco on exterior, Gypsum lath and plaster on interior.
5.2 Interior 2x4 partitions	Interior walls	38x89 (2x4)spruce studs with gypsum lath and plaster
5.3 Birch finish lumber	Interior trim and moulding	
6.0 THERMAL AND MOISTURE PROTECTION		
6.1 Fiberglass batts	Walls	RSI 7.7 (R 44)
6.2 Polystyrene boards	Under floor slab and foundation Insul.	RSI 1.8 (R 10)
6.3 Blown Rockwool	Ceiling	Larger particles than fibers of blown fiberglass
6.4 Polyethylene sheet	Continuous barrier in floor, walls and ceiling	Cross laminated 4 mil polyethylene. Floor membrane was one piece.
6.5 Acoustical sealant covered w/ aluminum tape	Sealing and caulking	
7.0 WINDOWS AND DOORS		
7.1 Redwood window frames	Made without preservative treatment	Triple glazing in house, double in greenhouse
7.2 Redwood & Oak doors	Exterior	
7.3 Solid Birch doors	Interior	
8.0 FINISHES		
8.1 Ceramic Floor Tile	Living room, bedroom, bathroom, study, Laundry room and "Cold cellar"	
8.2 Quarry Tile (6")	Entry and Greenhouse floor	
8.3 Oil	Window frames	'Livos Kaldet Oil'
8.4 Shellac	Kitchen cabinets and doors	Took a year for odor to disappear
8.5 Hypoallegenic sealer	Interior doors	'Crystal Aire'
8.6 Polypropelene	Kitchen countertops	

CASE STUDY #7

CONSTRUCTION MATERIALS /PRODUCTS TABLE

MATERIALS/PRODUCTS	LOCATIONS USED	COMMENTS
9.0 SPECIALTIES		
10.0 EQUIPMENT		
10.1 Central vacuum system	Through out house	
11.0 FURNISHINGS		
11.1 Bedding and blakets	Bedrooms	Cotton
11.2 Wool carpets	Dining area	
11.3 Sofa	Living area	Untreated cotton, hardwood frame, custom made.
11.4 Table		Solid Oak
11.5 Chairs	Living and dining areas	Oak frame with cowhide webbing.
12.0 SPECIAL CONSTRUCTION		
13.0 MECHANICAL (HEATING & VENTILATION)		
13.1 Electric Heat pump, hydronic delivery to forced air system.	Copper coils distribute heat to air. Air delivery to house.	Heat pump is in a sealed mechanical room. Air drawn from bathrooms, kitchen, etc. is drawn into this room and heat extracted before being exhausted outside.
13.2 Electrostatic filters (2)	In return air to hot water coil of heat pump.	Washable. Can be augmented with charcoal filters.
13.3 HRV	Heat pump water heater with integral heat recovery.	Mechanical room is under negative pressure. Heat in stale air from vented rooms is extracted by heat pump prior to being exhaused from the room.
13.4 Fans ducted directly outside	Kitchen stove hood	
13.5 Exhaust ducted to mechanical room	Bathrooms. kitchen and laundry	Heat extracted by heat pump ventilator
13.6 Fresh air supply fan	Mechanical room	Fan motor located outside fresh airstream
14.0 ELECTRICAL		
14.1 Electrical wiring	In wall wiring	White vinyl sheathing instead of coloured
15.0 PLUMBING		
15.1 Distilled water	Kitchen	Used for drinking and cooking
15.2 Water softener	All except kitchen	All plumbing copper joined with 95/5 solder

EXTERIOR

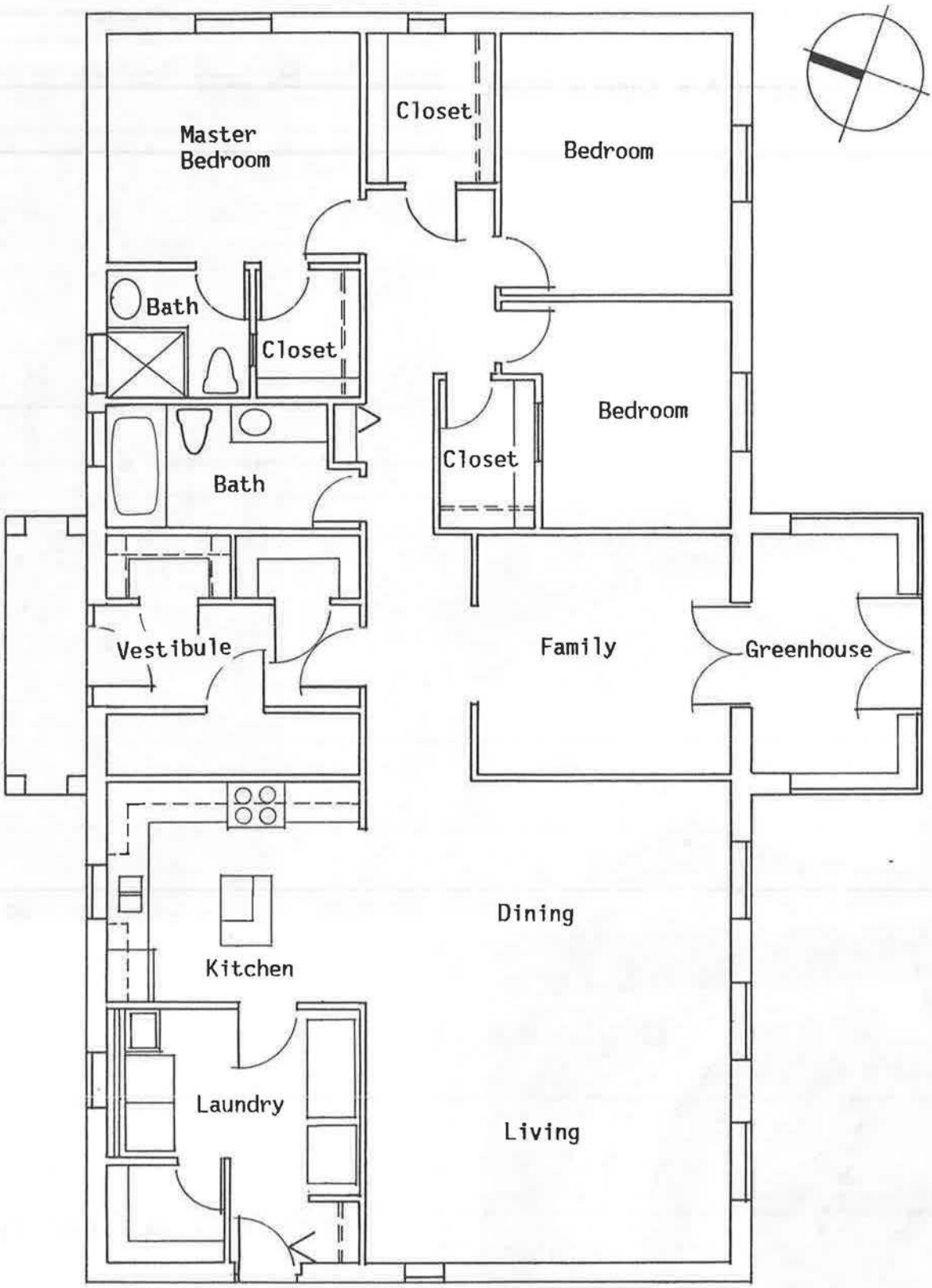
EXTERIOR DETAIL, SHOWING AIR INTAKE IN GABLE END

KITCHEN

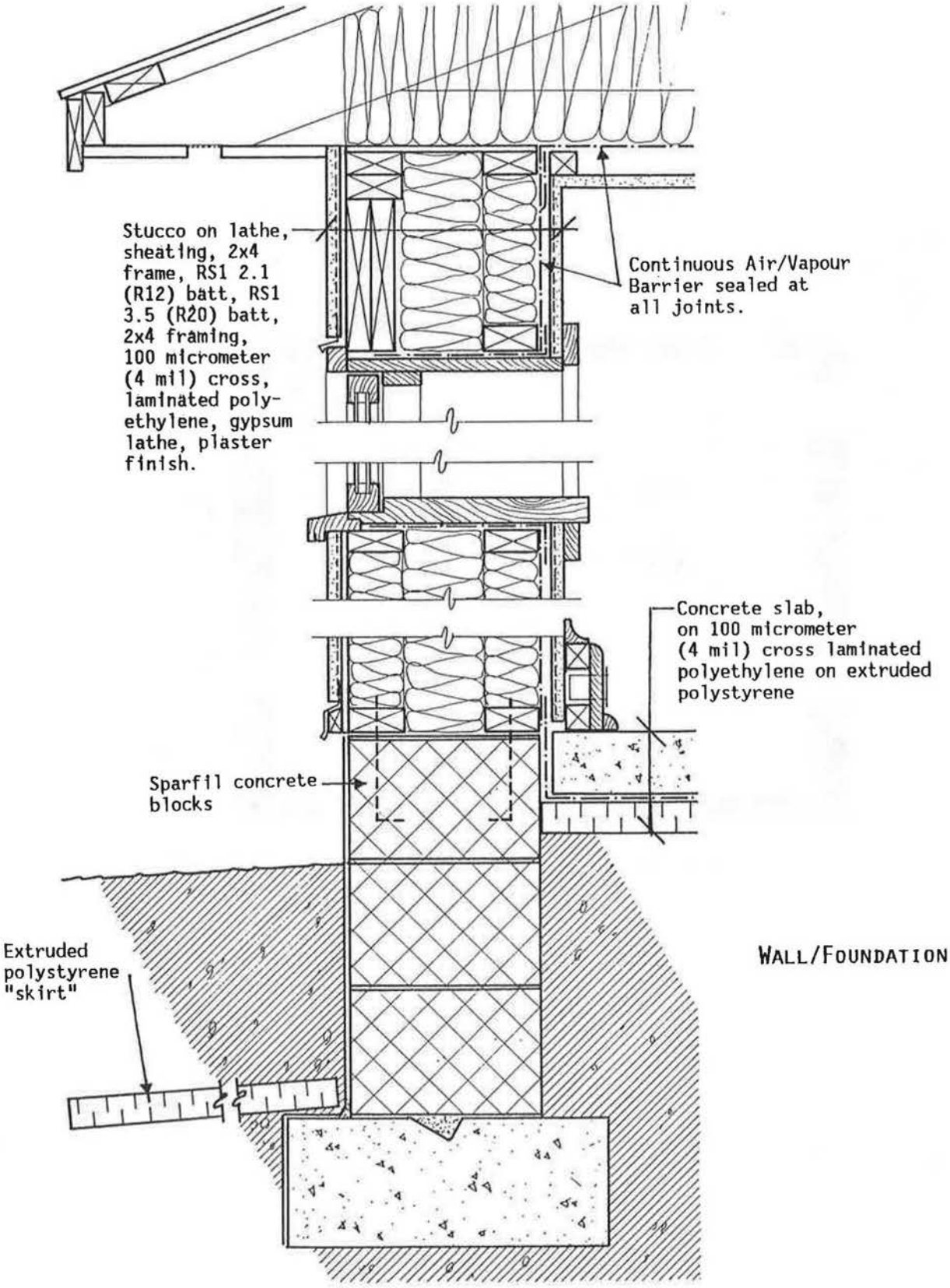
LIVING ROOM

FRESH AIR SUPPLY GRILL

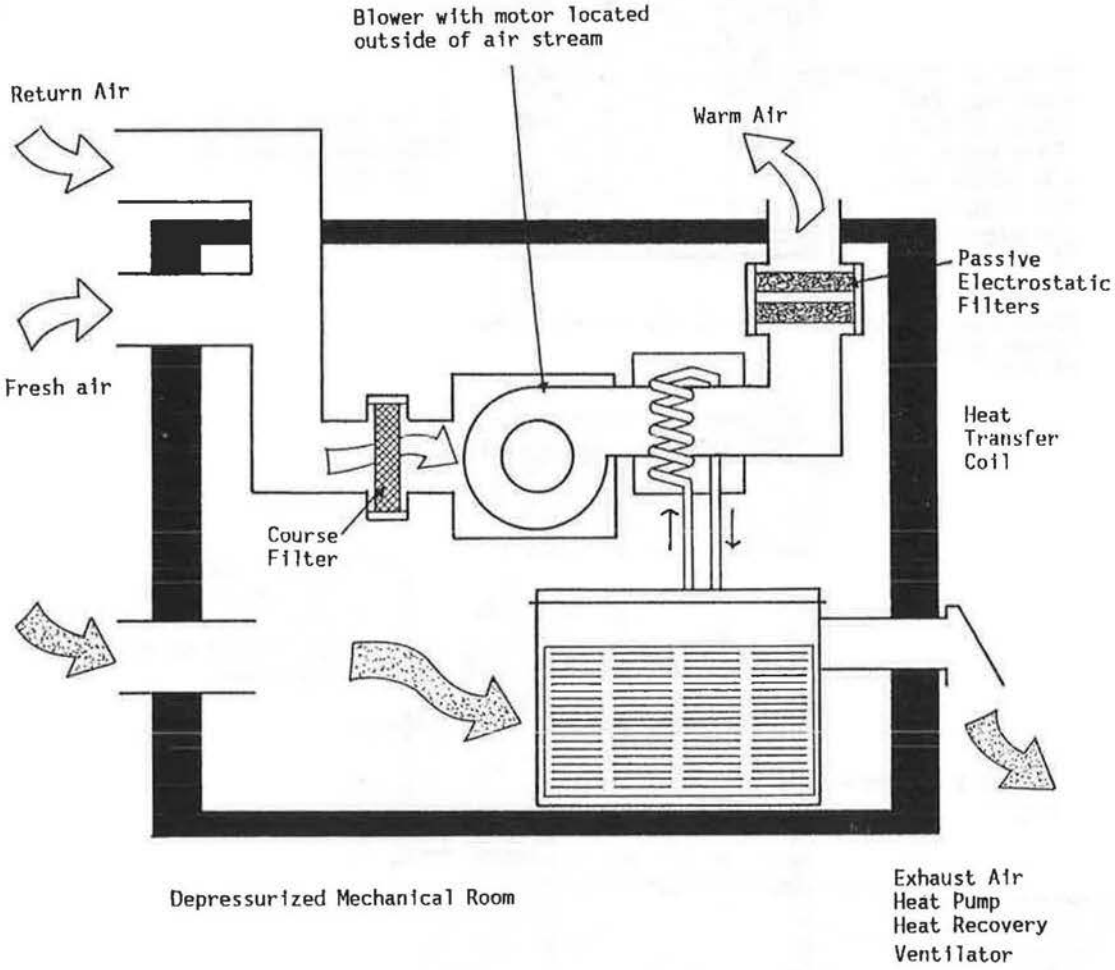
EXHAUST GRILL IN CLOSET CEILING


Master Bedroom
Closet
Bedroom
Bath
Closet
Bedroom
Closet
Bath
Vestibule
Family
Greenhouse
Dining
Kitchen
Laundry
Living

FLOOR PLAN



WALL/FOUNDATION



MECHANICAL SYSTEM

CASE STUDY #8

LOCATION: RURAL, CENTRAL ONTARIO

SITE AMBIENT AIR QUALITY: EXCELLENT

INTRODUCTION

Catherine has been hypersensitive to air borne pollutants since her childhood. The irritants that she has sensitivities to include house dust, pollen, mould, mildew, fungus, natural gas, odours from carpets, odours from building materials, paint, wood resins (pine), tobacco, wood smoke, pesticides, urban and industrial air pollution and perfumes. Catherine also has numerous food allergies. The symptoms of her environmental sensitivities include loss of muscle control, migraines, digestive and bladder problems, arthritic pain and rashes. Pesticides can trigger life threatening reactions and were responsible for her being bed ridden for long periods of time. In an attempt to deal with her environmental sensitivities Catherine and her husband John moved to an old house in the country and found that her health progressively improved over a seven year period, unless pesticide spraying occurred in the area. In order to improve her health further and to more effectively control pollution levels in her living environment Catherine and John had a clean air house built on a 25 acre site as described below. Since moving into their new home Catherine's health has improved markedly. She attributes this both to the pollution free environment provided by the home and the strict diet that she is on. She is now able to carry out many activities that were impossible for her previously such as gardening.

BUILDING RATIONALE

This 260 m2 (2800 ft2) house is located on a 9.7 Hectare (25 acre) rural lot. The lot was selected because of the absence of pesticide sources, automobile exhaust and general high ambient air quality. The home was built to provide exceptionally good indoor air quality with energy efficiency as a secondary criteria.

CONSTRUCTION SUMMARY

The house foundation consists of an exterior insulated concrete crawlspace with extruded polystyrene place beneath the floor slab. A 100 micrometer (4 mil) cross laminated polyethylene moisture and soil gas barrier is located between the insulation and concrete slab. Wall framing consists of a modified 38x140 (2x6) balloon framing with interior and exterior horizontal cross strapping. A 100 micrometer (4 mil) cross-laminated continuous polyethylene air/vapour barrier is located between the 38x140 (2x6) studs and the interior 38x38mm (2x2) cross strapping. The walls are insulated with RSI 3.5 (R20) batts between the studs and RSI 1.4 (R8) between the exterior strapping. The roof consists of factory built trusses. A continuous cross laminated polyethylene air vapor barrier is located on the underside of the trusses with 38x38mm (2x2) cross strapping beneath. The cross strapping in the walls and ceiling allows for running services inside the air/vapour barrier and minimizing penetrations. The ceiling is insulated with rock wool blown insulation to RSI 10 (R 56). All walls and ceilings are finished with additive free plaster on gypsum lath. The plaster is painted with lime white wash or left unpainted. In the bath rooms ceramic tile is used on the walls. The floor system consists of a tongue and groove spruce subfloor with additive free concrete topcoat and ceramic tiles or hardwood flooring. All windows are thermally broken aluminum frames with triple glazed lights (fixed) and double glazed lights (opening). Interior doors are solid ash prefinished with lacquer. Exterior doors are solid ash prefinished or prepainted metal insulated. Kitchen cabinets are of solid butternut joined with white glue and finished with lacquer, counter tops are polyester sheet (Corian).

Space heating is provided by an electric boiler and fin tube radiators. The ventilation system consists of dual flow (balanced) system that draws fresh air from the peak of a roof dormer through two passive electrostatic filters and over a fan coil unit. The fan motor is located outside the fresh air stream. Fresh air is distributed to all rooms of the house. Stale air is exhausted from the wet rooms and closets into the mechanical room where it passes through a heat pump. A glycol loop heated by the heat pump provides heat to the fresh air supply fan coil unit. The mechanical room is continuously under a negative pressure eliminate possible leakage of contaminants into the house.

ANECDOTAL NOTES

The chemically sensitive individual must be directly involved in the design of the house and selection of materials. Prescreening of all materials is necessary to ensure a successful project.

COSTS

Total Costs: $370,000

Cost per m2 $1400/m2 ($132/ft2)

Costs of special features
Heating system $10,000
Ventilation $5,000

OCCUPANT ASSESSMENT

The occupant has experienced a significant reduction in symptoms which she feels is directly attributable to the cleaner environment.

COMMENTARY

An excellent example of state of the art clean air housing.

CASE STUDY #8

CONSTRUCTION MATERIALS /PRODUCTS TABLE

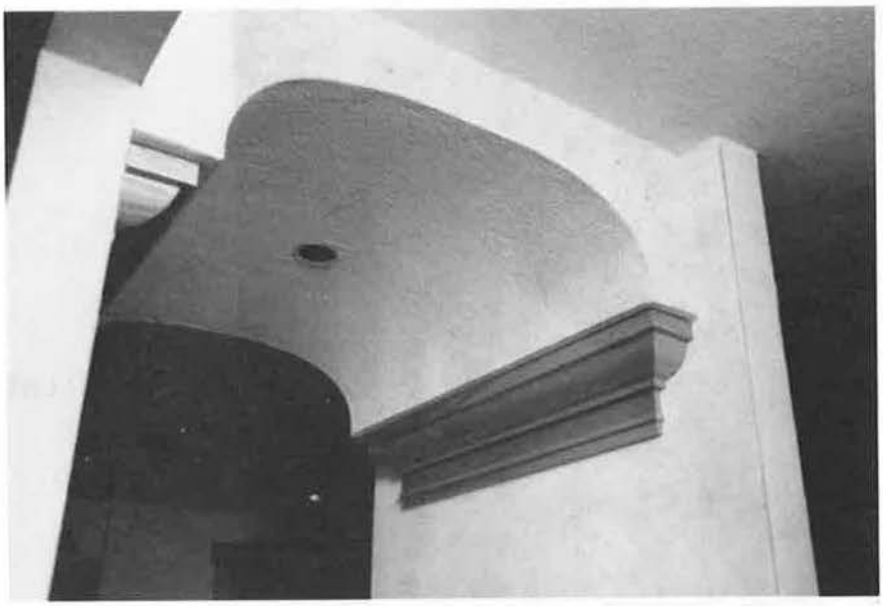
MATERIALS/PRODUCTS	LOCATIONS USED	COMMENTS
1.0 SITE WORK		
2.0 CONCRETE		
2.1 Poured concrete with E.P.S.	Foundation walls	
2.2 Concrete floor	In floor of crawlspace	Extruded polystyrene and cross laminated polyethylene membrane under floor slab
2.3 Concrete subfloor for ceramic tile	Main floor areas	Poured over spruce decking and joist system
3.0 MASONRY		
4.0 METALS		
4.1 28 gauge sheet metal	Ductwork	Washed with natural soap prior to installation to remove oil
5.0 WOOD AND PLASTICS		
5.1 Strapped wall framing system	Exterior walls	38x140 (2x6)studs at 600mm (2'-0") with 38x38(2x2) strapping on interior and exterior. Gypsum lathe and plaster on interior, metal lathe and stucco at exterior. Cross laminate polyethylene air/ vapour barrier at interior side of 38x140 (2x6).
5.2 2x4 Interior partitions	Interior walls	38x89 (2x4) studs with gypsum lath and plaster
5.3 Ash finish lumber	Interior trim and moulding	
5.4 Hardwood flooring	Living, dining rooms, upper wing	
5.5 Butternut cabinet frames	Kitchen	Glued with 'Presto Set' and 'Elmers' white glue
6.0 THERMAL AND MOISTURE PROTECTION		
6.1 Fiberglass batts	Walls	RSI 3.5 (R20) between studs, RSI 1.4 (R 8) between ext . strapping
6.2 Polystyrene boards	Under floor slab and foundation Insul.	RSI 1.8 (R 10)
6.3 Blown Rockwool	Ceiling	Larger particles than fibers of blown fiberglass
6.4 Polyethylene sheet	Continuous barrier in floor, walls and ceiling	Tu-Tuff 100 micro meter (4 mil) cross laminated polyethylene
6.5 Silicone sealant	Sealing and caulking	
7.0 WINDOWS AND DOORS		
7.1 Prefinished Aluminum windows	Throughout the house	Triple glazing in fixed units, double in operable windows.
7.2 Insulated metal doors	Exterior	
7.3 Solid Ash doors	Interior	Pre-finished with lacquer.

CASE STUDY #8

CONSTRUCTION MATERIALS /PRODUCTS TABLE

MATERIALS/PRODUCTS	LOCATIONS USED	COMMENTS
8.0 FINISHES		
8.1 Ceramic Floor Tile	Bedroom, bathroom, halls	Set with concrete mortar and wire lath
8.2 Polyurethane varnish	Hardwood floor finish	
8.4 Lacquer	Kitchen cabinets and doors	
8.5 Corian	Kitchen and bath countertops	
8.6 Whitewash	Smooth plasterwork on walls	Lime and water
9.0 SPECIALTIES		
10.0 EQUIPMENT		
10.1 Central vacuum system	Through out house	Exhausts into mechanical room
11.0 FURNISHINGS		
11.1 Bedding and blankets	Bedrooms	Cotton
11.2 Wool carpet	Living room	Untreated
11.3 Sofa	Living area	Cotton or Kapok filled, hardwood frame, custom made.
11.4 Window shades and drapes	Throughout house	Cotton, custom made
12.0 SPECIAL CONSTRUCTION		
13.0 MECHANICAL (HEATING & VENTILATION)		
13.1 Electric boiler, hydronic delivery	Copper radiator coils distribute heat	
13.2 Electrostatic filters (2)	In ducted HRV system	'Dustfree' passive electrostatic filters
13.3 HRV	Customized heat pump with integrated heat recovery	Heats incoming fresh air that has been passed over the electrostatic filters. Heat pump warms fresh air with heat from outgoing air stream.
13.4 Fans ducted directly outside	Down draft cooktop	
13.5 Fans ducted to HRV system	Bathrooms, kitchen and laundry	Heat extracted by heat pump ventilator
14.0 ELECTRICAL		
14.1 Electrical wires have white vinyl sheathing instead of colored	Walls	
15.0 PLUMBING		
15.1 Distilled water	Kitchen	Used for drinking and cooking
15.2 All copper piping	Throughout house	Includes waste and vent plumbing. Low lead solder.

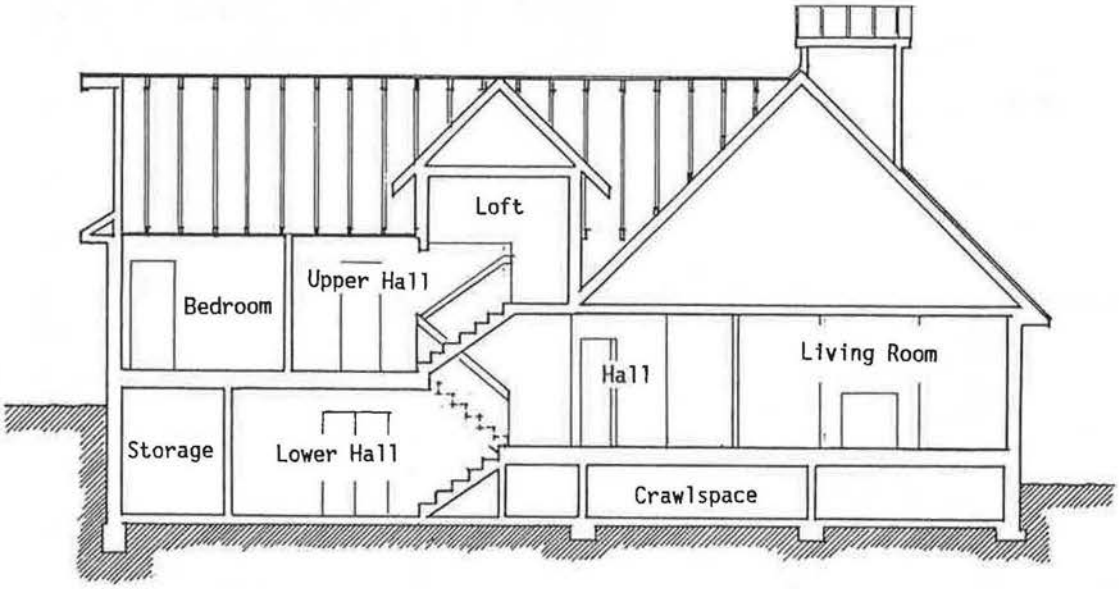
EXTERIOR



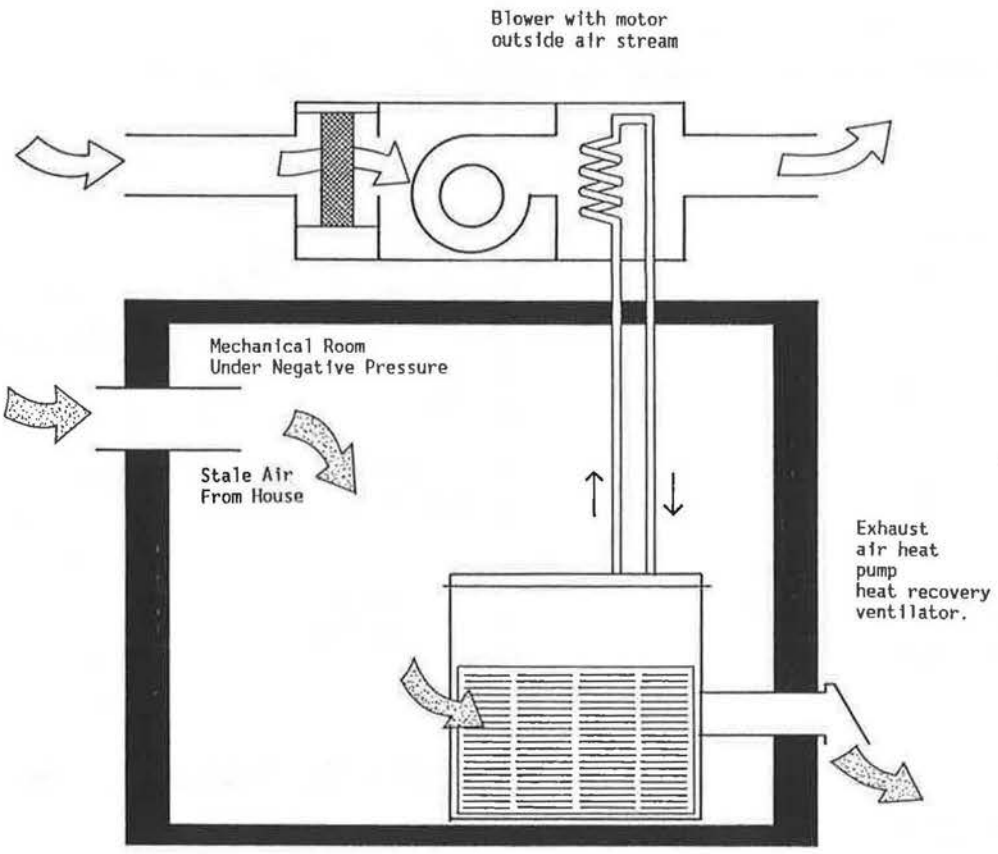
INTERIOR ROUGH PLASTER FINISH

LIVING ROOM

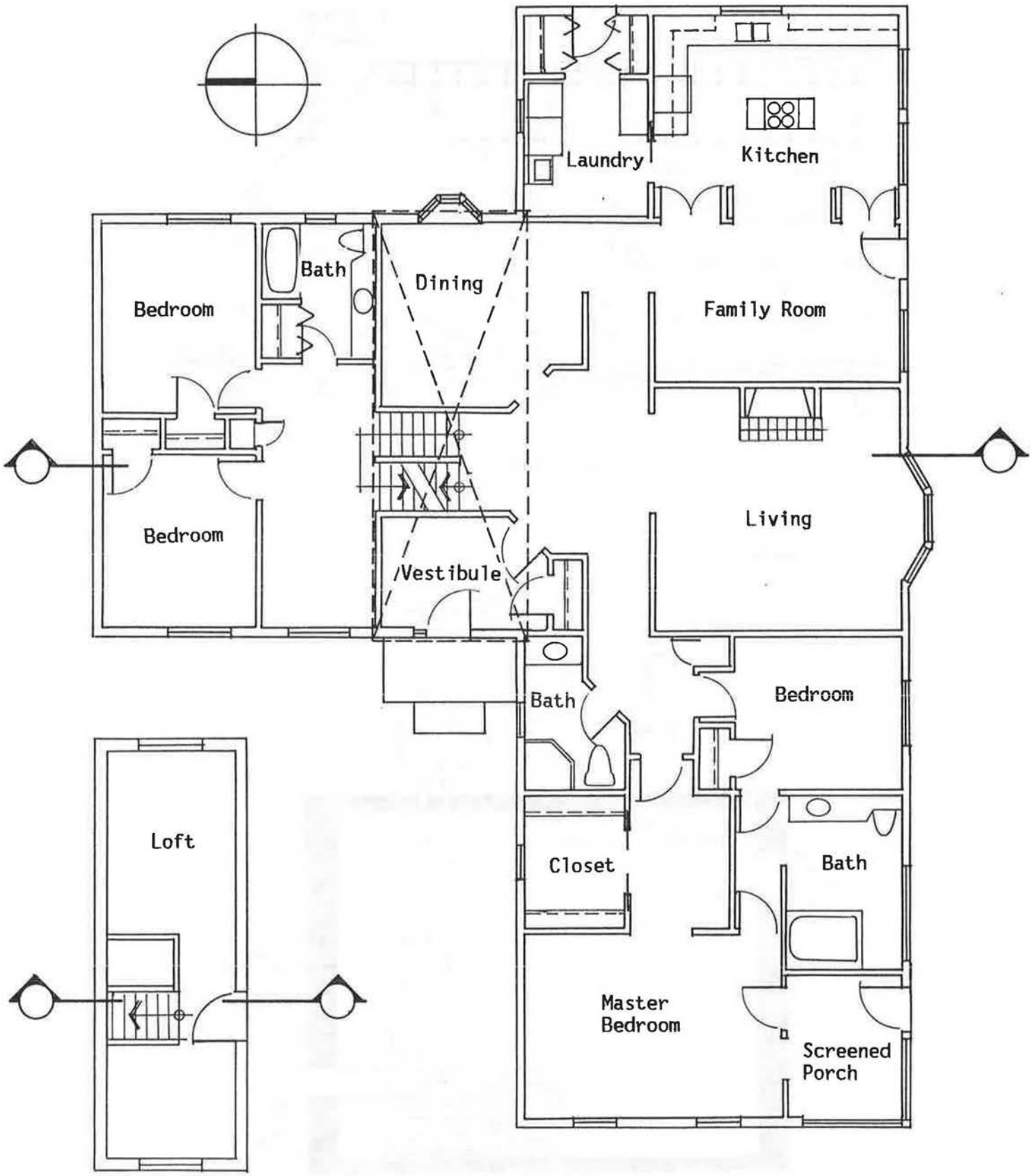
KITCHEN/DINING



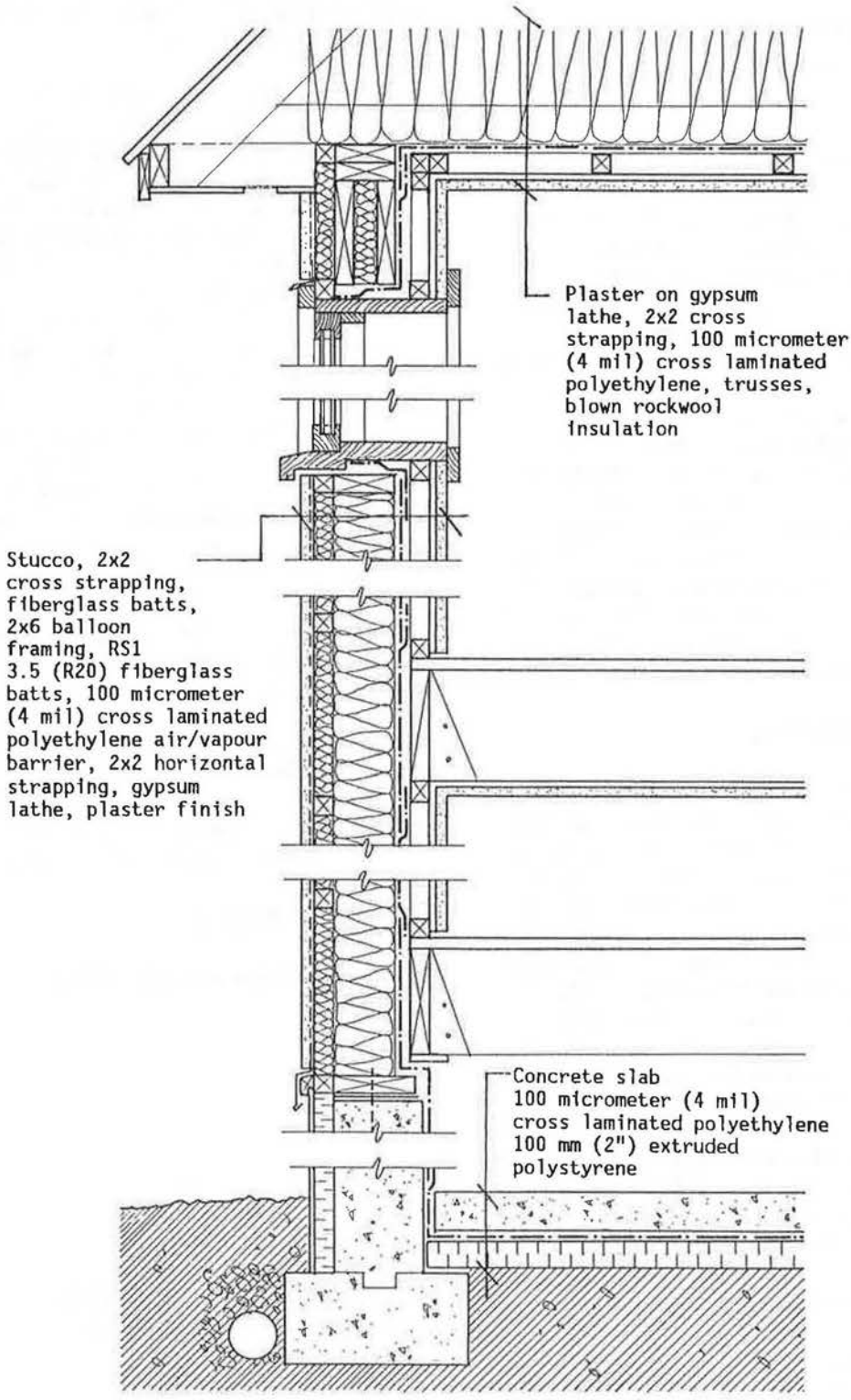
ELEVATION



MECHANICAL SYSTEM



MAIN FLOOR AND LOFT



WALL CROSS SECTION

CASE STUDY #9

LOCATION: RURAL, NOVA SCOTIA

SITE AMBIENT AIR QUALITY: EXCELLENT

INTRODUCTION

In 1982, Barbara became very ill and was seen by numerous doctors and consulting specialists. Her symptoms included fainting, asthma attacks, fatigue, headaches and muscular pain. None of the diagnoses and related treatments appeared to help, until she saw a clinical ecologist who suggested that the oil furnace in her house be removed. This was the first step toward recognition of the necessity to remove a whole range of irritants from the interior of the house. Since that time, Barbara has established that she has sensitivities to house dust, mildew, fungus, gases emitted by carpeting, wood resins (pine), saw dust, plant materials, household cleaning products, natural gas, oil combustion products, pet hair and dander. Following removal of the heating system and replacement of many of the house's interior finishes, Barbara is recovering her health.

BUILDING RATIONALE

The home is a 150 m2 (1600 sq. ft) 100-year-old farm house located in a well-buffered rural location with excellent ambient air quality. The home is a two storey wood frame structure on a basement foundation. Prior to the discovery of her sensitivities, Barbara and her husband had updated their home and had renovated extensively. When, a few years later, Barbara's sensitivities became apparent and the offending substances were identified, a number of these renovations were found to be problematic. The owners determined to attain the same level of air quality that is found in a hospital operating room. The house is now ventilated through the heat pump air exchange unit with a multi-stage filtration system, and the upper two floors are slightly pressurized to reduce entry of unfiltered air. The basement is continuously ventilated to the outside by exhaust fans.

CONSTRUCTION SUMMARY

The house has undergone three stages of renovations. The first stage, before the appearance of Barbara's sensitivities, was in 1976. At this time, the house was generally upgraded. The interior finish plaster was removed and the walls insulated, a vapor barrier installed and the walls replastered. Plywood subflooring was installed with carpeting and the exterior of the house was retrofitted with tar paper and foam-backed aluminum siding.

Interim renovations were carried out after Barbara's chemical sensitivities were identified. These included removing all carpeting and covering plywood subflooring with aluminum foil sheets, and removing the oil furnace and installing a ground source heat pump with an electrostatic filter and activated charcoal and amasorb (permanganate) filters. The house is operated under a positive pressure with fresh air being drawn in through a 140 mm (6") diameter duct connected to the return air plenum. Air is continuously exhausted from the house through exhaust fans in the basement and an exhaust hood is located over the oven. An exhaust fan was also installed over the main bookshelf. The aluminum sheeting covering the floors had to be cleaned extensively to remove an oil film on its surface.

The third stage of renovations involved the removal of the aluminum sheeting, and replacement with prefinished birch flooring. All interior walls have been painted with latex.

The storage room on the second floor was originally a pine panalled bedroom. To make the the room clean, the panelling was removed but eventually the renovation was abandoned and the room effectively sealed off from the rest of the house.

ANECDOTAL NOTES

Much of the work was carried out by the homeowner.

COSTS

Total Costs: Over $50,000

Costs of special features
Heat Pump $11,000
Ducting for heating/ventilation $5,000
Multistage filtration system $5,000

OCCUPANT ASSESSMENT

The renovations have substantially reduced Barbara's symptoms.

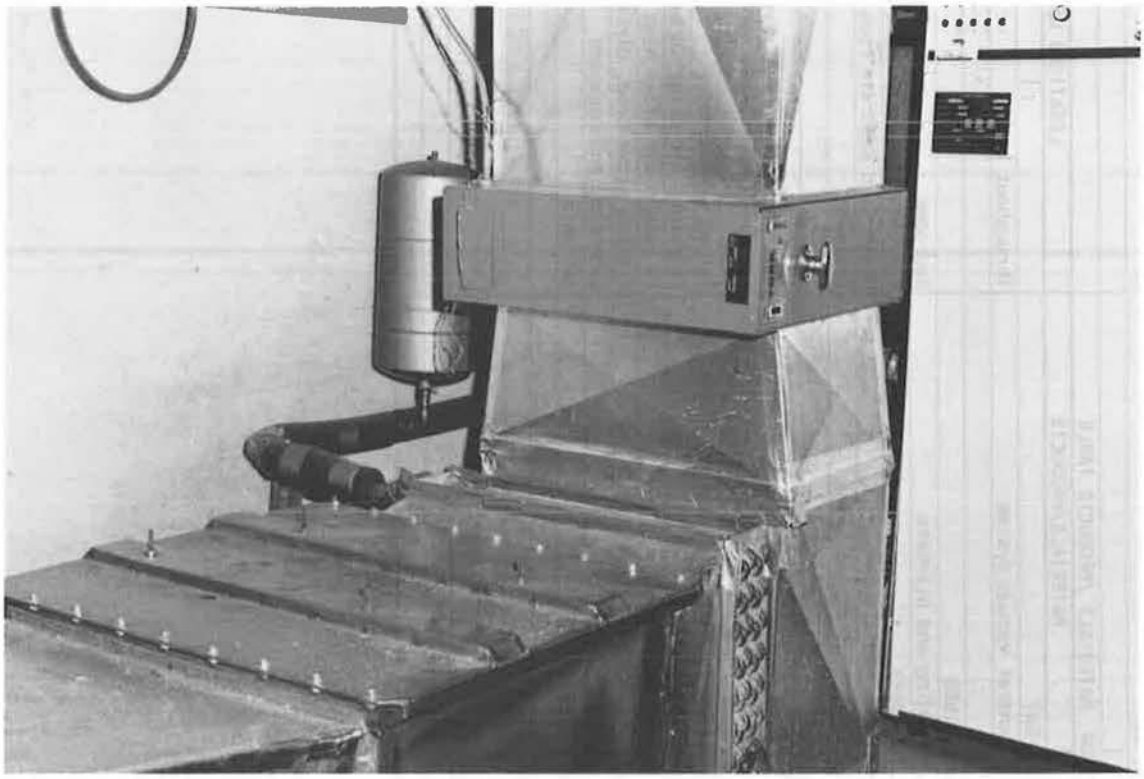
COMMENTARY

The electrostatic filter is a source of ozone, though this should be trapped by the activated charcoal and alumina/permanganate filters. A passive electrostatic filter which does not produce ozone would be another option, though not as effective for dust removal.

CASE STUDY #9				
CONSTRUCTION MATERIALS /PRODUCTS TABLE				
		MATERIALS/PRODUCTS	LOCATIONS USED	COMMENTS
1.0	SITE WORK			
2.0	CONCRETE			
3.0	MASONRY			
4.0	METALS			
	4.1	Foam backed Aluminum siding	Exterior siding	Existing
5.0	WOOD AND PLASTICS			
	5.1	Prefinished hardwood flooring	Bedroom, study	
6.0	THERMAL AND MOISTURE PROTECTION			
	6.1	Fiberglass batts	Walls, ceiling	Existing
	6.4	Polyethylene sheet	Vapor barrier in walls	Existing
7.0	WINDOWS AND DOORS			
	7.1	Pine windows, vinyl clad	Exterior	Existing
	7.2	Steel insulated doors	Exterior	Existing
	7.3	Solid Walnut doors	Interior	Existing
8.0	FINISHES			
	8.1	Lath and plaster	Walls and ceilings (most rooms)	Existing (done in 1976)
	8.2	Prefinished birch panels	Bedroom walls	Existing
	8.3	Linoleum	Floors (most rooms)	Existing (done in 1976)
	8.4	Prefinished hardwood flooring	Floors in bedroom and study	
	8.5	Latex paint	Walls and ceilings	
9.0	SPECIALTIES			

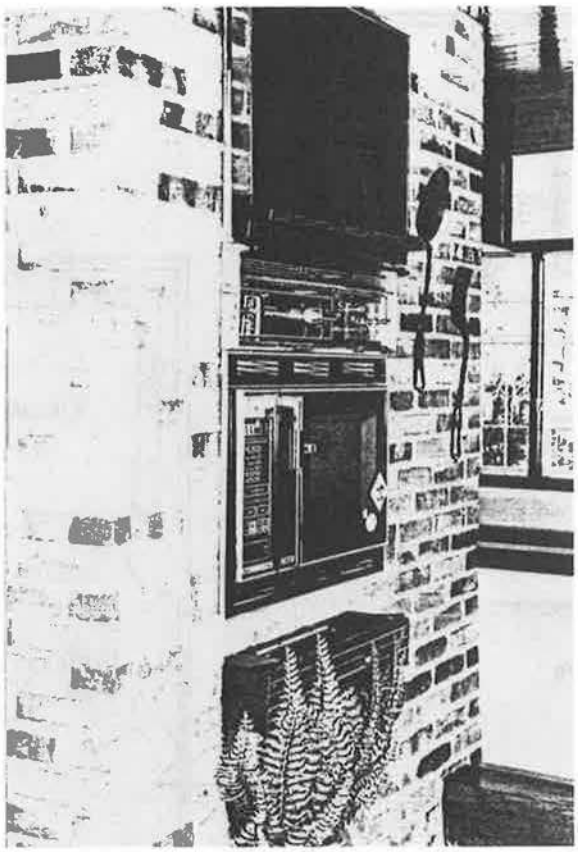
CASE STUDY #9				
CONSTRUCTION MATERIALS /PRODUCTS TABLE				
		MATERIALS/PRODUCTS	LOCATIONS USED	COMMENTS
10.0	EQUIPMENT			
	10.1	Central vacuum system	Throughout house	
11.0	FURNISHINGS			
	11.1	Bedding and blankets	Bedrooms	Cotton
	11.2	Carpets	Removed throughout house	
	11.3	Books and clothes	Moved into seperate room	
	11.4	Removal of stored items	Basement	Removed paints and other stored items
12.0	SPECIAL CONSTRUCTION			
13.0	MECHANICAL (HEATING & VENTILATION)			
	13.1	Electric Heat pump, ground source	Forced air delivery	CanTherm ground source heat pump
	13.2	Electrostatic filter	In return air prior to heat pump coil	
	13.3	Charcoal filter	In return air after heat pump coil	Also Amasorb filter
	13.4	Fans ducted directly outside	Kitchen stove hood, dining, study,	
			bathroom, and basement	
	13.5	Dehumidifier	Portable	Intermittant use
14.0	ELECTRICAL			
15.0	PLUMBING			
	15.1	Bottled water	Kitchen	Used for drinking and cooking

HOUSE EXTERIOR

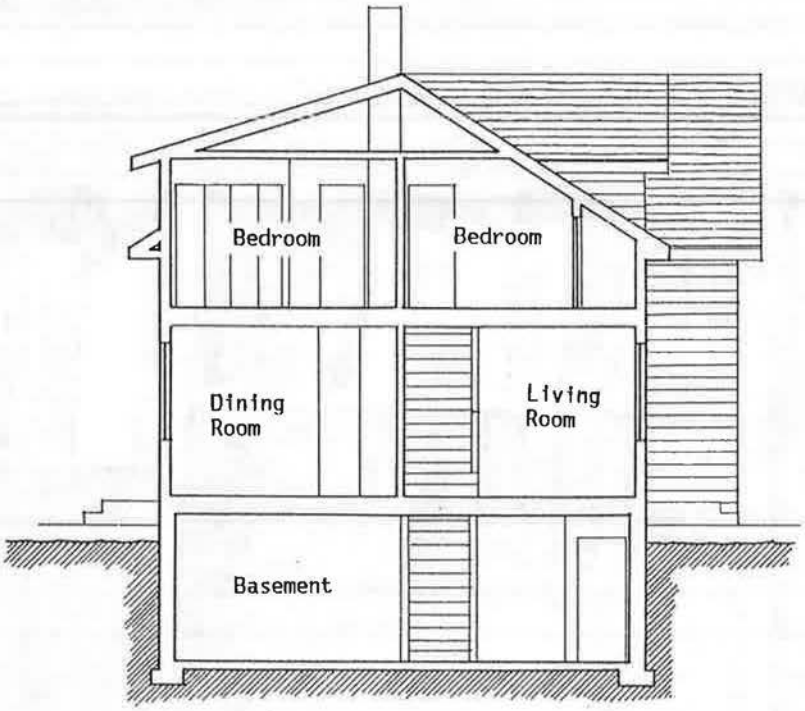


HEAT PUMP CONDENSING COIL, DUCTWORK AND ELECTROSTATIC FILTER

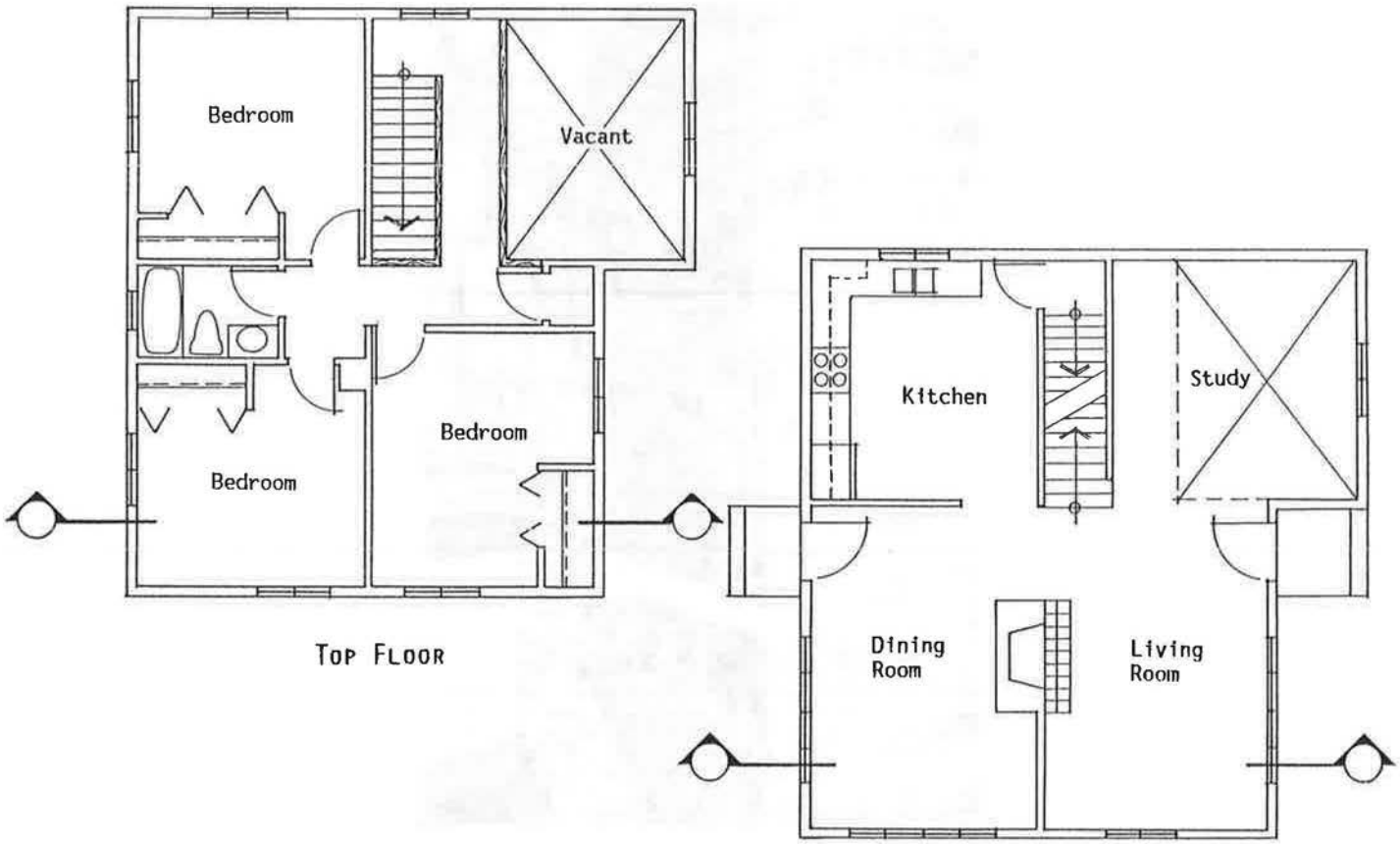
OVEN WITH RANGE HOOD OVER



Exhaust grills
above book case

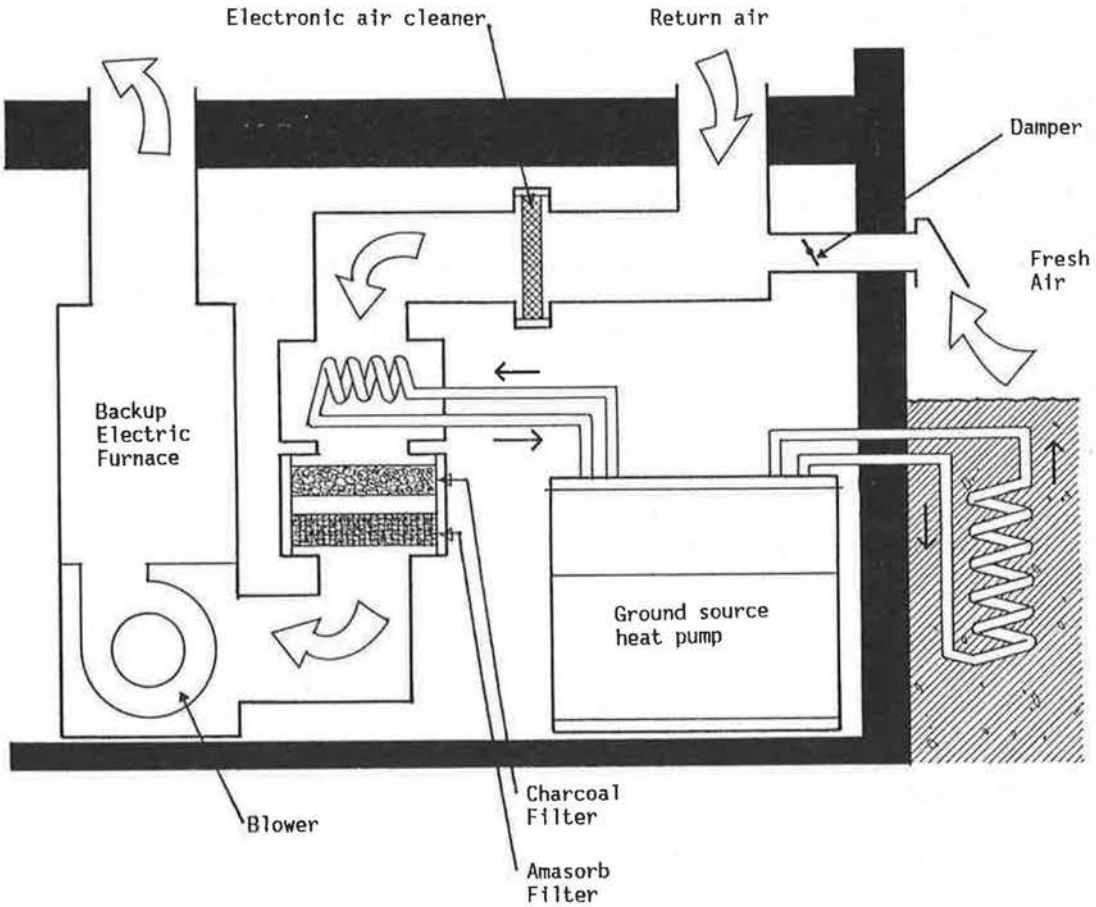


HOUSE CROSS SECTION



TOP FLOOR

MAIN FLOOR



MECHANICAL SYSTEM

CASE STUDY #10

LOCATION: URBAN, QUEBEC

SITE AMBIENT AIR QUALITY: MODERATE

INTRODUCTION

Julianne has experienced environmentally related illness since the age of ten. She has sensitivities to house dust, pollen(trees, ragweed, and golden rod), mildew, fungus, wood resins, urban and industrial air pollution, natural gas, paints, carpets, plastics, household cleaning products, perfumes and cigarette smoke. The symptoms of her illness are: swollen glands, loss of concentration, loss of muscle control, violent headaches, auditory and visual hallucinations, swelling of the face and hands, periodontal abscesses, heart palpitations and gastrointestinal pain. She has lived in a high-rise apartment building in an urban center since 1983. In 1984, a clinical ecologist diagnosed Julianne as having multiple allergies and sensitivities. Since that time she has modified her apartment to eliminate irritants.

BUILDING RATIONALE & CONSTRUCTION SUMMARY

When Julianne was diagnosed as being chemically sensitive, she moved from a north-facing apartment to a 56 m2 (600 ft2) south-facing unit in the same building. The change in apartment orientation had a positive affect on her health. She stripped the apartment of all materials except those she could tolerate such as wood, wool, cotton, glass and metal. At one point mould was found to be growing behind the bathroom tilework. The old tile was stripped, and a concrete backer board and mortar with no additives was used for mounting the new tilework. Plants in the apartment have a plastic sheet placed over the soil to reduce the release of any mould. All furniture is made of solid wood and is well aged. The apartment is aired daily after major train and automobile traffic is over. All hot air registers have been sealed off and the cold air return left open.

ANECDOTAL NOTES

All modifications to the apartment were made at Julianne's expense. The apartment must be kept extremely clean to be tolerable. The landlord's attitude towards Julianne's problems has been generally unco-operative.

COSTS

Total Costs: $2,500

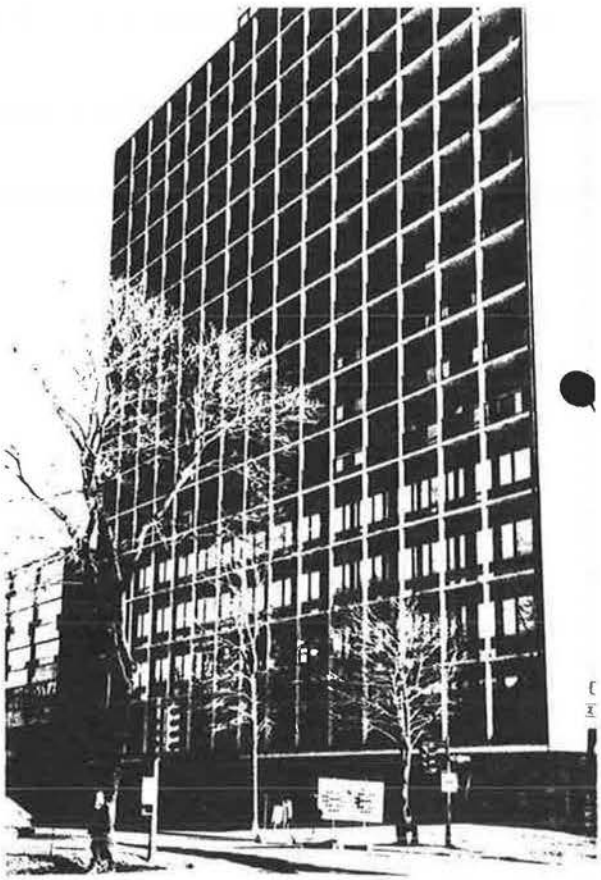
OCCUPANT ASSESSMENT

The modifications to the apartment have made a haven in the city, but Julianne looks forward to moving to the country at some point.

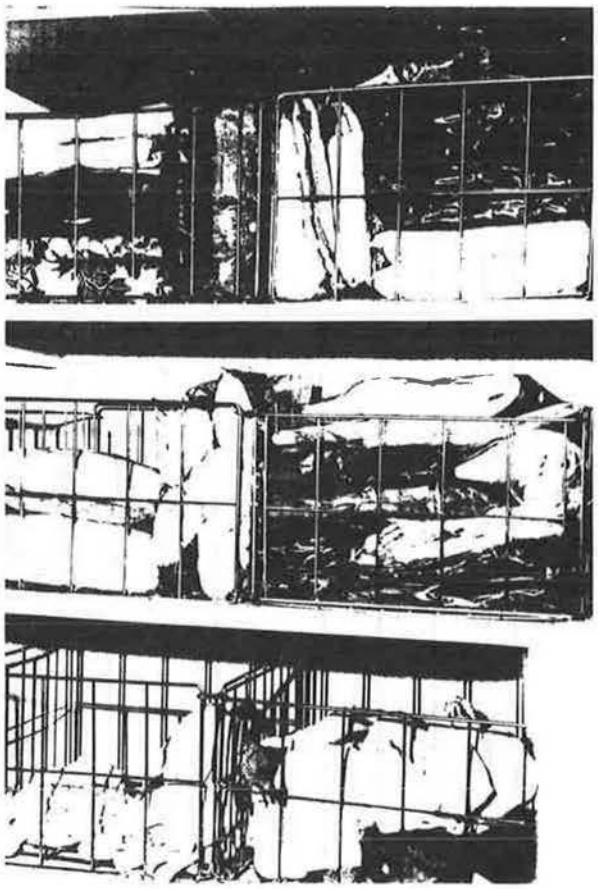
CASE STUDY #10

CONSTRUCTION MATERIALS /PRODUCTS TABLE

MATERIALS/PRODUCTS	LOCATIONS USED	COMMENTS
1.0 SITE WORK		
2.0 CONCRETE		
3.0 MASONARY		
4.0 METALS		
5.0 WOOD AND PLASTICS		
6.0 THERMAL AND MOISTURE PROTECTION		
7.0 WINDOWS AND DOORS		
8.0 FINISHES 8.1 Ceramic tile 8.2 Enamel paint	 Bathroom All surfaces	 Mounted on concrete backer board using addditive-free mortar and grout 'Livos' brand enamel paint
9.0 SPECIALTIES		
10.0 EQUIPMENT		
11.0 FURNISHINGS 11.1 Chairs and table aged wood	 Living room	 Sealed with 'Crystal Aire' sealer
12.0 SPECIAL CONSTRUCTION		
13.0 MECHANICAL (HEATING & VENTILATION)		
14.0 ELECTRICAL		
15.0 PLUMBING 15.1 Water distiller	 Kitchen	 Water distilled for all drinking and cooking

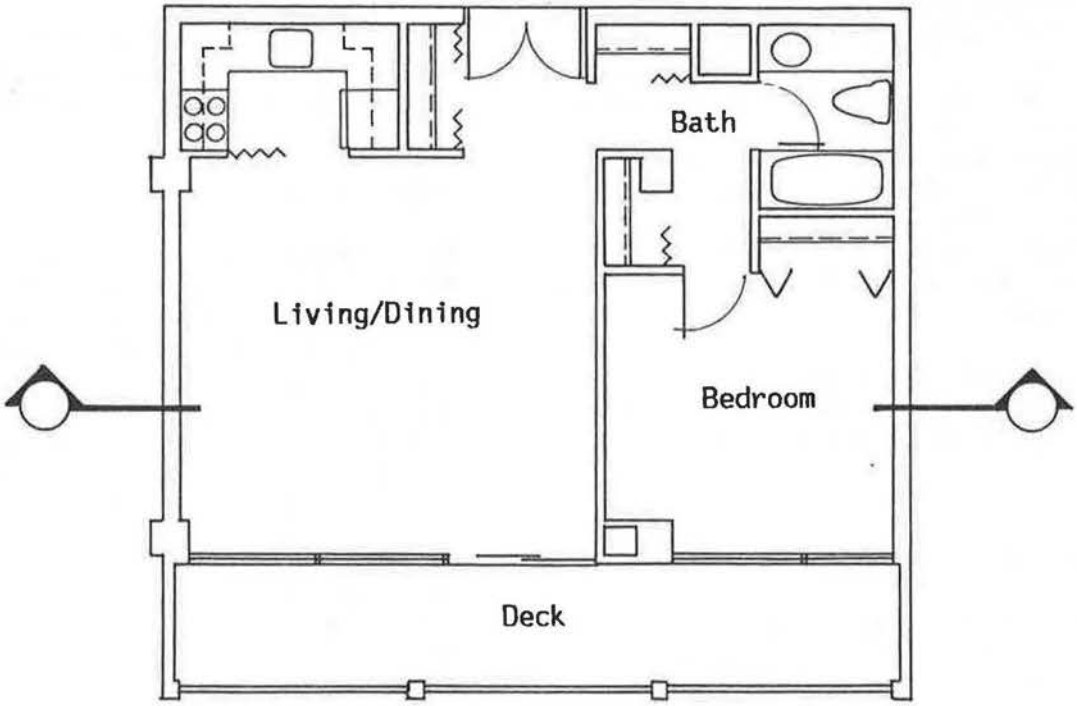


EXTERIOR VIEW OF APARTMENT BUILDING



Cloths storage in metal racks all contained in plastic bags

INTERIOR



PLAN

OTHER HOUSES OF INTEREST

Rural Manitoba

Ann Sumner lived with severe allergic reactions for 20 years before she discovered that they were triggered by environmental exposure. Eventually, she found a house which, according to Ann, enabled her to survive.

The house, built in 1910 and renovated most recently in 1950, was constructed of spruce (frame, interior wall, and siding), and insulated entirely with rockwool, with no fiberglass to which Ann is very sensitive. The house was moved 50 km. to a prepared foundation on a lot in Saskatchewan. An electric cast iron radiator system (originally coal-fired) was installed, and some floors were changed. Ann's health improved, but after only two years, oil wells drilled within a mile of the house compelled her to move it again, this time 250 km. away to its present location.

Unfortunately, in recent years, smoke from forest fires and burning hay stubbles have caused Ann severe difficulties in the new location.

Rural Manitoba

Gordon's house is one and a half stories, on an insulated slab foundation. Spruce and poplar were used for framing, and spruce boards were used for the siding and walls. A polyethylene vapour barrier was installed next to the inside walls. No paints have been used; instead, boiled linseed oil has been the only finishing material. The ten-inch thick insulation consists of spruce shavings, from a local sawmill, mixed with lime to discourage insects and rodents. Hot water pipes imbedded in the additive-free concrete floor distribute the heat generated by a wood furnace located in a sealed room. The house is situated on the edge of a ravine to enhance the natural ventilation on which it relies. Large windows with aluminum frames were salvaged from a schoolhouse.

Gordon, with the help of friends, is building his house himself, using materials which are locally available and which he can tolerate.

Rural Ontario

Pat and Ken's cottage was 25 years old and had a dirt crawlspace. In an effort to eliminate the mouldy crawlspace, the house was lifted ten feet, and the original first floor became the second storey. The first floor is concrete on an insulated slab foundation. The cottage uses electric baseboard heat and has no mechanical air filtration because Pat is sensitive to filter materials. The second floor, as yet uncompleted, still has the original wall panelling and linoleum floor on plywood.

The renovation was financed though a combination of a CMHC RRAP grant, an Ontario Ministry of Housing loan and $25,000 of Pat and Ken's own money.

Suburban Ontario

Judy's asthma and her two childrens' sensitivities motivated her to renovate her ten-year old semi-detached house. The gas furnace was replaced with an electric boiler. Air purification and ventilation were integrated into the forced air system. The wall-to-wall broadloom was removed, and both the top and lower sides of the particle board subfloor were sealed with four coats of Crystal Aire sealant (Pace chem. Ind.) before the solid wood flooring was installed.

The improvement in the air quality has permitted Judy to breathe more easily, and has also resulted in a reduction of the medication necessary to control her asthma.

Rural Ontario

When Evelyn was severely disabled by her sensitivities two years ago, the only suitable place the Ontario Ministry of Housing could help her to find was an electrically heated apartment in a senior citizens' building. Evelyn is 33 years old.

The Ministry removed the carpets on top of the parquet floor. Carbon filters to remove chlorine from the water were installed in the kitchen and bathroom sinks and the bathtub. Evelyn purchased a distiller and uses a portable air purifier near the hallway to remove odors entering from other parts of the building.

Although Evelyn has improved, she considers her present accommodation temporary until she can find a better place to live.

Rural Saskatchewan

Hurst started to build his house nearly three years ago. His unique wall system employs concrete block walls on the inside, aluminum foil vapor barrier, six-inch metal studs, metal lathe and stucco. The floor is ceramic tile laid on cement on a concrete slab. Hot water pipes imbedded in the cement distribute heat from an electric boiler. Counters are concrete, with ceramic tile surfaces.

Hurst's health has improved as a result of his approach to house construction, and he is considering finishing the walls with more conventional materials, like gyproc and paint.

Urban Ontario

George's daughter spent five months at the Environmental Clinic in Texas. She has been living in a special trailer constructed of ceramic on steel (see Appendix *). The trailer is currently in a park in Texas, but her family is planning to move it to Canada.

Rural Alberta

By spending a lot of time outdoors, Sue manages to stay well enough to teach. The air inside the school bothers her however, so when weather permits, Sue, who has made few changes to her house, sleeps in a travel trailer in her backyard. To optimize her exposure to the outdoor air, she opens all four windows of the trailer.

Rural Alberta

Following renovations necessitated by his own environmentally hypersensitive family, Hans has helped to plan and carry out renovations for several other affected individuals. He is currently planning a multi-unit building project with clean air units for his family and for sale. His plans include a 160-acre healthy subdivision with stiff environmental guidelines.

CHAPTER 15...CHOOSING A SITE

While the most important criteria for choosing a building lot are usually price and location, people suffering from environmental hypersensitivity must also consider ambient air quality. Many people choose to leave cities and move to rural environments when they discover their sensitivities, and it is usually true that air quality is better in the country, but there are compromises. Country air is sometimes laden with pollens, moulds, wood smoke and agricultural sprays. In addition, commuting time to hospitals, schools, libraries and work is longer. In some suburbs there may also be smokestack industries nearby.

When selecting bare land, access, water/sewer, drainage and power must all be carefully reviewed, and the property must be zoned for the proposed use. In a city it is wise to check the quality of municipal water by asking the local utilities office for a water quality report. Though many people use a water treatment unit for their drinking and cooking water the quality of the water supply is still an important consideration. In a rural location one can check with neighbours for well records and consult the local public health office for water quality advice. The site will need to be tested for percolation according to provincial public health regulations to insure sewage disposal capability. The power company will provide information on the accessibility and cost of a power connection.

In addition to these basic concerns there are several other aspects of a location which need to be researched:

- Expected zoning changes in an area which may bring new development, industry or highways.
- The prevailing wind direction and upwind sources of air pollution.
- The proximity of major roads and highways.
- The use of agricultural chemicals in the area.
- Roadside right-of-way spraying.
- The use of road salt and road oil.
- Proximity to gas mains and high voltage lines.
- Proximity to trees and shrubs with high pollen release or high odor (e.g. pine or cedar forest).
- Density of vegetation around building site and amount of average breeze available
- Neighbors who burn wood.
- Proximity to low lying areas near ponds, lakes and swamps.

Though this may seem like a difficult task, many people have been through this process and have managed to find property which suits them very well.

CHOOSING AN EXISTING HOUSE

When selecting a home for rental, purchase, or renovation the age of the building is one useful guide. With the exception of recently renovated buildings and those older buildings which have suffered moisture damage over the years, older buildings contain fewer of the building materials linked to environmental hypersensitivity. Unfortunately this does not always mean that older is better. Older buildings often suffer from poorly drained basements and may have serious mould growth and even rot in the walls and ceilings. This is particularly common in those rooms with a local humidity load such as the bath, laundry or kitchen.

It is important to be aware that moisture problems are more likely to occur in regions without a good drying cycle such as maritime climates. Local soil conditions and slope are also important drainage considerations. Capillary moisture rises from damp soil in all older masonry and concrete foundations and contributes to mold growth. For this reason buildings which are constructed on a slab-on-grade or have sloping sites which allow the basement to be drained to daylight are often preferred. Basements in some older buildings *can* be properly drained, ventilated and insulated to render them fully acceptable but this requires propitious circumstances and great care.

Many older homes have also had insulation added after construction, which under some circumstances can increase indoor air pollution or moisture damage. An environmentally sensitive person would be well advised to be wary of choosing a home presently insulated with Urea Formaldehyde Foam Insulation, or even one which once contained UFFI which has since been removed, as it cannot usually be proven to the full satisfaction of

those concerned that all of the UFFI has been removed. Residential pollution from UFFI gases or from associated mould growth can, in some cases, be at high enough levels to cause or aggravate hypersensitivity over time. Loosefill insulation types, such as chopped cellulose fibre which are often added to walls and ceilings of older homes, have also proven to be a problem for the environmentally hypersensitive because small amounts of the material leak into the building through cracks and electrical outlets, etc.. Retrofitted insulation can also cause trapped moisture damage in walls and ceilings when warm moisture-laden air leaks through cracks in inside finishes and condenses in the insulation. It is ironic that buildings with no insulation often are the driest because air can move freely through cavities.

Another problem with older buildings is that they tend to contain larger quantities of asphalt materials which produce odors unacceptable to the environmentally hypersensitive. This is often due to multiple layers of roofing shingles, tar paper or tar impregnated sheathing board under the siding, or mastics used to repair or prevent moisture damage. Metal roofing is a preferred material for this reason.

Other building materials in existing homes which may cause problems are chip boards, plywoods and prefinished woodgrain wall paneling. These should not be rejected out of hand, but carefully tested by each individual for suitability, since in some circumstances these materials may be sufficiently sealed from outgassing to prevent significant problems. Finally some older buildings may have survived a house fire. Even when repaired and made cosmetically acceptable, such a house may cause serious problems for a person sensitive to the products of combustion.

Newer buildings which have been built to draft-free standards have significant advantages for the environmentally hypersensitive, both because they are likely to be free of moisture problems in the structure and because the same draft sealing techniques which prevent moisture damage also prevent the entry of gases and dust from wall and ceiling cavities. This is particularly true if they have been built with carefully selected low emission materials and have good ventilation systems. *It must be stressed that poor air quality does not come from a house built too tightly but only from poor ventilation and poor choice of materials.*

The heating system in an existing house is another important consideration. Many of the survey participants chose to replace their heating systems during renovation in order to switch to electrically operated units with low temperature surfaces which do not "toast" dust.

When looking for an apartment the ventilation of the building and the heating system should be given careful consideration, as well as the interior finishes. Some apartments have problems with entry of air from corridors or parking garages due to the stack effect, particularly those units which are in the upper part of the building. Others allow considerable leakage from neighboring units through pipe chases and cracks under baseboards. This air flow may carry perfumes, tobacco smoke, perfumed toiletries, and pesticides into the unit. Many apartments also do not have adequate kitchen and bathroom exhaust.

Sometimes apartment problems can be remedied by measures taken within an individual unit. For example, cracks and pipe chases can be sealed meticulously to prevent odor entry. Window mounted heat recovery units can be installed to improve ventilation and counter the pressure of stack effect. Removable cloth "snakes" can be used to minimize infiltration of corridor air under doors.

To live safely within a multiple unit dwelling, a hypersensitive individual may be required to exercise communication skills and take leadership in encouraging integrated pest management methods. Fortunately, the same sealing measures which minimize infiltration of polluted air from other units also inhibit the spread of insects throughout a building. Likewise, an individual may need to take initiative to influence maintenance staff to avoid the use of strong volatile cleaners and sprays in corridors, vestibules, elevators, laundry areas and garbage chutes.

GETTING ADVICE

In some regions of the country there are now building consultants who offer services to the environmentally sensitive. These consultants often have direct experience with environmental sensitivity themselves and may have training and experience in fields as diverse as building science, construction, engineering, chemistry, physics, ventilation and energy efficiency. At the present state-of-the-art, the advice available may vary considerably, and information from more than one source may be required, before conducting final

tests to confirm which methods are the most suitable for particular sensitivities and circumstances. Your regional branch of the Allergy and Environmental Health Association may be able to supply a list of consultants.

SELECTING AN ARCHITECT AND CONTRACTOR

The process of selecting an architect or contractor for a project which must meet the requirements of an environmentally hypersensitive individual is not very different from the process of choosing any professional, though it might be far more rigorous. It is wise to see examples of a firm's work and talk with clients who have employed it in the past. It is also wise to check a contractor's standing with the provincial home warranty program. Not all contractors participate in this program, particularly renovation contractors, but membership does provide some measure of consumer protection.

Remember that designing and building for the hypersensitive is often an extraordinary challenge for designers and contractors and may seriously test their organizational abilities. Most designers and builders have little experience with this special type of project and will have to do some research, rely on specialized consultants and demand extraordinary things from tradespeople and suppliers. For example, every item which is used on a job site, from the concrete in the foundation to the weatherstrip on the doors, will have to be scrutinized for its potential contribution to indoor air pollution. Smoking may not be permitted on-site and any substitution for approved materials must be reviewed by the client whose special health needs will determine most decisions.

In view of the extra complexities involved in such a project it may be tempting to become one's own designer and general contractor. Though this can be a successful arrangement, many find that they lack the design experience and the necessary working relationship with tradespeople to successfully and economically manage a project.

Finally, it is important to remember that even the best relationship between an individual and his or her designer and builder is likely to be strained before a building project is completed, and this is even more likely when there are extra demands and special supervision is required.

Some points which should be considered when choosing a designer and contractor are:

- As many materials as possible should be selected during the design stage, to reduce the number of expensive and trying changes midstream.

- Specifications should be clearly spelled out and rigorously adhered to. Any changes or substitutions must be approved by the client.

- The designer and contractor can only be expected to meet contractual obligations; they cannot be expected to be responsible for the health of the client.

- Though previous experience with the environmentally hypersensitive may be hard to find, designers and builders with energy efficient building experience are often better prepared to understand the special construction techniques and exacting quality control required for a successful "clean air" project.

In the next chapter a complete discussion of the methods available for controlling indoor air quality will better acquaint the reader with the detailed understanding that designers and contractors will be expected to master.

CHAPTER 16...CONTROLLING INDOOR AIR QUALITY

GENERAL METHODS

There are several methods of controlling indoor air quality . All rely on some combination of reducing the potency of the pollution sources and improving ventilation or filtration.

SOURCE CONTROL / AVOIDANCE

The first and best defence against indoor air quality problems is careful monitoring of the materials and products used in the home. Because some indoor air pollution arises from building materials themselves, source control starts with the construction process; for example, the use of solid wood or plywood in place of particle board reduces the sources of formaldehyde. However, many, indoor air pollutants are, in the long term, introduced by people and their activities. For example furniture, floor polish and other consumer products may contain formaldehyde.

VENTILATION

Ventilation is necessary in all buildings in order to dilute and remove air contaminants which come from breathing, cooking, washing and cleaning, as well as from building and finishing materials and furniture. *Ventilation is not a substitute for reducing the sources of indoor air pollution*, but it is necessary for maintaining good air quality and comfort. Ventilation can be achieved by open windows, or fans or a combination of both. However, most building scientists agree that opening windows alone does not provide reliable ventilation, particularly in colder climates where serious discomfort will result. Fan-operated ventilation provides reliable air quality and can also result in energy savings if an HRV is installed.

Most people who are renovating for health reasons have found that the minimum requirement is a series of exhaust fans strategically located to remove air contaminants directly from their sources such as kitchens and bathrooms. A more elaborate solution is the installation of a full heat recovery ventilator system which delivers fresh air to all rooms through ducts, and extracts exhaust from bathrooms, kitchens and closets.

AIR PURIFICATION

Special air cleaning equipment is available which can "adsorb" or capture and chemically neutralize air pollutants. The most common type uses activated charcoal filters which are capable of trapping odors from building materials, cooking and other sources. Other types use activated alumina, potassium permanganate and other chemicals to trap and neutralize (by oxidation) gases which are difficult to trap with charcoal.

ISOLATION

Some items which contribute to indoor air contamination can be isolated from the house air space by providing special rooms or special ventilation for them. For example, a fuel-burning boiler may be installed in a furnace room which is separated from the home, in order to prevent fuel leakage and the inadvertent entry of flue gases. A special storage closet with separate ventilation may be constructed for "airing out" clothing which has been dry cleaned or freshly printed material which has strong ink odors.

CONTAINMENT

Some building materials, finishes or furnishings which emit indoor air contaminants are difficult to avoid. Most furniture and cabinet millwork for example, contain particleboard which emits small amounts of formaldehyde gas. It is possible to reduce these emissions by sealing the product with veneers and special varnishes (especially at the edges) and plugging all holes. This procedure is inexpensive and has been found to be reasonably effective in laboratory and field tests for some materials (15). Because containment is not entirely reliable, it is not a preferred method for the environmentally hypersensitive. It is sometimes a workable temporary measure and has in some cases worked as a permanent solution.

AGEING OR BAKEOUT

Materials such as wood composition board, carpets and other products which release volatile gases are sometimes stored for a period before in-

stallation to allow for the release of a portion of their potential air pollutants, but this precaution is usually inadequate for the environmentally hypersensitive. Other finishes such as paints and varnishes are sometimes "baked out" after application by increasing the temperature and ventilation rate in the home for a few weeks. Heat lamps or portable heaters are used for this purpose.

SPECIFIC CONTROL MEASURES

MOISTURE CONTROL

Moisture is not traditionally considered a pollutant, yet any discussion of contaminant control in housing begins with humidity control. Water vapour is released from cooking, washing and breathing and from building materials and the sub-soil. It quickly dissipates throughout the house, increasing the humidity. Excess humidity encourages the growth and survival of allergenic fungi and dust mites as well as other microorganisms. It also increases the outgassing rate of some volatile gases such as formaldehyde from pressed wood products (2).

When the humidity is too high (above 60% RH), allergenic fungus grows readily on almost any surface, bacteria and viruses released by sneezing and breathing survive longer and more readily infect others, and dust mite growth increases. Condensation on windows, persistent dampness in basements, closets and bathrooms, and mildew odours or fungus stains are the most common signs of moisture problems. Excess moisture can lead to building damage, particularly around windows, bathtubs, and in insulated cavities, if warm moist air escapes and condenses there.

Standing moisture in air conditioners, humidifiers and dehumidifiers can also breed moulds and hazardous bacteria.

The most important control for excess moisture is adequate ventilation, especially by regular use of *outside vented* exhaust fans in kitchens and bathrooms. (Caution: in homes where there is considerable basement air leakage, increased exhaust can aggravate rather than decrease moisture problems, because soil gases with high moisture content may be drawn in. Proper sealing below grade and deliberate intake ventilation above grade should be combined with adequate exhaust of high moisture areas). To monitor indoor humidity, an inexpensive gauge can be bought at a hardware store. The accepted range for indoor humidity is 30% to 80% RH (relative humidity) in summer and 30% to 55% in winter (14) though a range of 40% to 60% is preferred if there is respiratory illness in the home. In most regions of Canada, excessive dryness in winter is a serious problem, particularly for those with respiratory illness. This is due to the very low levels of available moisture in outdoor air when it is very cold. An ultrasonic humidifier, furnace register humidifiers, or pans of water on a heater or radiator are simple methods of adding humidity. Be sure to follow manufacturers safety precautions and clean these devices regularly to prevent mould, bacteria and algae growth. In a very humid region, building envelope tightness and insulation coupled with air conditioners or dehumidifiers may be used to reduce humidity in summer, particularly in the basement.

Fungus particles are present in every home to some extent, especially in damp areas such as bathrooms and basements. Dampness in basements, cold spots on poorly insulated walls and ceilings, damp carpets (especially in basements) and mildew stains in closets and around tubs and kitchen cabinets are indicators of moisture problems. Mildew-damaged carpets and fabrics should be discarded and replaced with durable floorcoverings, but stained tub enclosures, shower curtains, walls and ceilings can usually be scrubbed clean with a bleach-free scouring powder, rinsed, then regularly treated with a borax solution to retard fungus growth. Proper insulation of cold water piping, especially in basement areas, can reduce condensation in more humid seasons. The use of dehumidifiers can also be effective at these times.

CONTROL OF FORMALDEHYDE AND OTHER VOLATILE ORGANICS

The main sources of formaldehyde in homes are particle board; indoor plywood and other glue-bonded wood products; adhesives used for flooring, carpet and wallboard; upholstery materials; paints; waxes and polishes. Other organic chemicals come from carpets, cleaning products, paints, pesticides and gas and oil leaks.

The use of exterior plywood , natural fiber carpets and upholstery, solid wood or metal furniture frames and carefully selected paints and waxes makes an important difference. Several manufacturers now offer "low emission" lines of paints,

sealers, adhesives, cleaners, waxes etc. which many environmentally hypersensitive people find more acceptable than conventional products (See Appendix). Safe and simple home maintenance methods using soap, vinegar, baking soda, borax and washing soda can help reduce exposure.

CONTROL OF COMBUSTION GASES

Cooking and heating with electricity instead of gas is clearly preferable in housing for the environmentally hypersensitive. An outside-vented exhaust fan in the kitchen is also a necessity for extracting odors and smoke.

Flue gas spillage, another cause of combustion gas entry, can occur when large exhaust fans or several smaller fans operating simultaneously, are used in homes that are reasonably air-tight. The vacuum created by these fans can suck fumes back down a chimney into the house. If there are any combustion appliances in the home and a high-capacity exhaust fan is being used, pressure must be relieved by opening a window or installing a properly designed "make-up" air opening. All ventilation equipment should be sized and installed by a qualified ventilation contractor who can verify that the units used are compatible with the house.

Self cleaning ovens release all their combustion gases into the room during the clean cycle, so full kitchen ventilation must be in operation. Some wall oven units have built-in exhaust fans which vent them directly.

Smoking, of course, is another source of hazardous gases including cancer-causing agents. Woodburning fireplaces and heaters can present a similar risk if smoke enters the home.

CONTROL OF PARTICULATES

If an older home is being renovated and asbestos is present or suspected, provincial health authorities should be contacted for advice.

ASBESTOS REMOVAL IS A TRICKY AND DANGEROUS BUSINESS BEST LEFT TO PROFESSIONALS.

Installing a tight ceiling in the basement will reduce dust, especially in old houses. Upholstery, such as mattresses and cotton futons, can be covered tightly with special fabric which reduces the release of fibers. Weathersealing and airlock entries can be used to reduce entry of pollens.

Filtering indoor air and controlling humidity reduces dust circulation. When the air is too dry (less than 40% RH), dust is stirred up easily, and the nose and throat tend to dryness and irritation. Air filtration can be readily incorporated into any type of warm air heating system, or can be accomplished with portable room-sized air cleaners.

Many hazardous dusts besides asbestos are generated by demolition and construction. It is wise to wear a good quality respirator mask (look for an acceptance stamp on the unit), and to isolate the construction area from the living area with a curtain taped to walls and floor or a tight-fitting door. Furnace or ventilation ducts in the construction area must be sealed to prevent dust circulation throughout the house.

The use of a feather duster or portable vacuum tends to stir up all of the fine particles of dust in a room and catch only the coarse ones which probably would not be inhaled anyway. Dusting with a damp cloth and installing a central vacuum cleaner can be helpful.

SELECTING BUILDING MATERIALS

Beyond a few well known cases such as formaldehyde from pressed wood products, it is difficult to predict which and how chemical properties in building materials will adversely affect a sensitive person. Manufacturers may provide materials safety data sheets for specific products, but the information given may be both technically inaccessible to the general reader, and irrelevant or inadequate for the hypersensitive.

The acceptability of materials is an individual matter and must be carefully determined before selection and usage. The affected individual should identify as many low emission materials as possible and test each product against his or her sensitivities. In addition, appropriate control measures from the "Indoor Air Quality Control Section" should be incorporated into the structure or renovation. Materials may be individually tested by techniques administered by an experienced physician, and/or by "personal challenge testing" for which an environmental

consultant may be helpful. Before considering "personal challenge testing", an individual should consult a qualified physician to determine the kinds of reaction possible, the nature of the risks involved, and the advisability of such "field-testing" for the particular individual. Persons with severe hypersensitivity or with a tendency to life-threatening reactions, such as asthma or heart arrythmia, should not be exposed to potential irritants except under direct medical advice and supervision.

In personal challenge testing, the affected individual and a sample of the suspected material remain in close contact sufficiently long enough to determine if and what adverse reactions will occur. The sample must be large enough and fresh enough to reasonably simulate actual conditions of exposure. For example, a sample of a paint may be applied to a non-emitting surface such as metal or glass and be allowed to cure for a few days, then checked closely for odours and reactions by sniffing. Placing the sample by the bedside simulates a longer exposure.

Not all problem materials have a detectable odour. One test for odorless suspected materials, particularly fabrics, is to place a small sample in a glass jar, seal it tightly and keep it in a warm area or in the sun for a day. Any emissions will collect in the jar and may be more detectable when the jar is opened.

A small sample of a suspected fabric may be taped to the inside of the forearm of a person who has experienced skin sensitivities. A day of exposure is usually long enough to elicit a reaction.

DRAFTSEALING, VENTILATION AND HEATING

Draft-free homes are less prone to contamination caused by infiltration of outside air through the building cavity, where it picks up gases and particles from products such as insulation, plywood, lumber and sheathing paper. They are also less prone to concealed moisture damage which occurs when warm air leaks into insulated cavities. They are more energy efficient and less affected by wind and weather than conventional housing.

A draft-free home can also be less prone to air contamination from ambient air pollution. In high-pollution events (e.g. direct line smoke from a neighbours chimney, a skunk passing by, pollution alerts, train derailments etc.), having a well-sealed house can also be an advantage, since the ventilation can be turned off during the high-pollution event, and the well sealed structure will exclude the pollutants far better than leakier, conventional construction. Low-pollution interior design can extend the time during which vents can remain safely closed. If the ventilation system filters intake air, draft-free homes can also be less affected by ambient air pollution the remainder of the time.

The process of draftsealing requires careful attention to detail. Air leakage points, such as door and window frames and electrical and plumbing outlets in insulated walls and ceilings, must be meticulously sealed with gaskets, tapes or caulkings acceptable to the hypersensitive person. The Airtight Drywall System (see Appendix II) is widely used by builders to draftseal houses built with drywall. Normally, however, the system employs neoprene gaskets and caulking which are not tolerated by the chemically sensitive. The substitution of urethane gaskets, plain silicone caulking and metal foil tape may make this system tolerable.

In cases in which plain plaster rather than drywall is used, penetrations of the finish are minimized by a special raceway or channel for electrical wiring or plumbing, which is constructed on the inner surface of the wall. Of course, in draftsealed houses or renovations, it is vital that proper ventilation be in place to guarantee an adequate supply of outdoor air to all living spaces.

INTEGRATING HEATING AND VENTILATION

Heating and ventilation systems in a single house must be compatible and able to complement each other. Where forced air heating is used, for example, ventilation air can pass through existing ducts. In clean-air houses, the design and integration of heating and ventilation can be sometime be more complex and may require consultation with experts.

VENTILATION METHODS

Natural Ventilation (open windows):

Advantages:
- -Simple and comprehensible.
- -No extra cost to install.

Disadvantages:
- -Comfort problems.
- -Large energy loss.
- -Unequal distribution of ventilation air.
- -Ventilation rates dependent on variations in out side weather conditions.

Local Exhaust Systems (conventional bathroom, kitchen and laundry exhaust fans ducted directly outside):

Advantages:
- -Inexpensive exhaust method
- -Simple and comprehensible
- -Air contaminants can be removed effectively at source

Disadvantages:
- -Negative pressure caused by high capacity fan operation may affect chimneys, radon gas entry and other ventilation equipment.
- -Can be noisy
- -Cannot recover energy
- -Do not insure ventilation comfort
- -Are not used regularly
- -Usually not durable enough to run continuously.

Central Exhaust Systems (centrally located exhaust fan ducted to bathrooms, kitchen, and bedrooms. Fig.6.1 and 6.2):

Advantages:
- -Much quieter than individual fans
- -Easily automatically controlled
- -Quiet, simple, effective system
- -Less costly to install than HRV systems
- -Usually better fresh air distribution than individual fans
- -Can have heat pump added for heat recovery

Disadvantages:
- -Do not heat supply air. Limited to mild climates
- -More costly to install than local fans
- -Negative pressure may increase radon entry
- -Energy costs may be higher than HRV systems unless fitted with a heat pump

Heat Recovery Ventilators (air to air heat exchangers): Fig. 6.3 and 6.4)

Advantages:
- -Readily ducted to all rooms to provide both reliable exhaust and supply air
- -Intake air can be filtered
- -Recovers heat energy
- -Easily automatically controlled
- -Preheated supply air for comfort
- -Pressure across house envelope can be accurately balanced reducing possible soil gas entry.

Disadvantages:
- -More costly to install than exhaust only systems
- -Maintenance is more complex
- -Not as easily understood as simple fan systems

Some tips on selecting ventilation equipment:

- -When choosing a central exhaust ventilator ensure that it is rated for continuous operation.
- -Choose high quality exhaust fans with low noise ratings (2 sones or less).
- -When choosing a heat recovery ventilator ensure that it has been tested according CSA C439 M.
- -Choose a ventilation installer who is HRAI certified. Insist that HRAI installation guidelines be followed including, sealing all ducts with metal foil tape.
- -Insure that the equipment is in a location which permits easy access for servicing

HEATING

The choice of heating system is of major importance in the clean-air home. For the environmentally sensitive, the choice of *fuel* for heating and cooking is particularly significant, because traces of combustion gases and unburned fuel pose a serious health risk. In addition, some systems tend to stir up and "toast" dust. Finally, a system's ability to filter recirculated air is important.

HEATING SYSTEMS

Heat Source:

- Oil, gas. If oil or gas is chosen for reasons of economy or availability, an isolated furnace room will prevent gas entry into the home. Alternatively, a sealed draft unit can be used in the home but is not as safe.

- Wood. Some environmentally hypersensitive people find that a clean-burning, airtight wood stove is acceptable as long as flue gases are prevented from entering the home. The stove must have a combustion air supply.

- Electric Resistance. Electric heating is often chosen though energy costs are high. Low temperature units are preferred.

- Heat Pump. A heat pump uses far less energy than electric heat, though the initial cost is high. Heat pumps provide the preferred low temperature heat exchange.

Conventional Warm Air Furnace:

Advantages:
-Inexpensive to install
-Easy to filter
-Readily integrated with ventilation system

Disadvantages:
-Stirs up and "toasts" dust

Low temperature Warm Air Furnace (fan coil type unit):

Advantages:
-Reduced "toasting" of dust
-Easy to filter
-Readily integrated with ventilation system

Disadvantages:
-Expensive to install

Conventional Electric Baseboard:

Advantages:
-Inexpensive to install
-Good local control

Disadvantages:
-Tends to "toast" dust
-No filtration
-Expensive to operate

Low Temperature Baseboard (liquid exchange or low watt density electric):

Advantages:
-Reduced "toasting" of dust
-Good local control

Disadvantages:
-Expensive to install
-Slow response time
-No filtration
-Expensive to operate

Radiant Floor or Ceiling Heating (electric or liquid exchange):

Advantages:
-Even, comfortable heat with lower air temperatures.
-Minimum dust stirring and "toasting"
-No wall space used

Disadvantages:
-Expensive to install
-No air circulation or filtration
-Slow response time
-Expensive to operate

AIR FILTRATION AND CLEANING SYSTEMS

In a recirculating air system, air is passed through a filter. Standard furnace filters are not very effective for removing small dust particles but other filter types are more effective. Pleated paper "medium efficiency" disposable filters are available to fit standard furnace filter sizes or custom sizes. They cost from $6 to $15 each, should be replaced after three months use and are available from filter suppliers.

A "passive" electrostatic plate filter, or "electret" filter, fits standard filter sizes. These use no electric power but rely on permanently charged plates which are washed under a tap periodically. These cost $150 to $250 and are available from

specialized filtration suppliers or from allergy specialty stores.

Electronic filters also fit standard filter sizes. These use electric power and must be shut off and cleaned periodically. This type has a tendency to produce small amounts of ozone gas which irritate the nose and throat, and is therefore not recommended for homes in which there are asthmatics. These cost $300 to $450 and are available from heating contractors, filtration suppliers and some department stores.

A wide range of portable electric "room air purifiers" is available. All contain fans and filters, and some also contain charcoal filters or catalytic agents which remove gases and odours from room air. These units cannot move air around a room effectively, and tend to treat only the air immediately surrounding the unit. A large capacity portable filter in an enclosed room can be helpful in a house with no form of air filtration. This type will not treat a whole house however, and will not give protection against strong contaminants produced locally, such as cigarette smoke.

A sophisticated built-in air filtration system which filters both outdoor air as it enters the home and the recirculated air indoors, may be required for a person with extreme sensitivities. This type of unit is most likely to be necessary where the outdoor air is not acceptable to the affected individual.

SUPERVISING CONSTRUCTION

All contractors, both professionals and owner/builders, need to be aware of several important items regarding the supervision of construction. It is important to remember, for example, that tradespeople have intimate knowledge of their specialties and generally wish to do a job well. The contribution of each trade is important to the project as a whole, and should be recognized as such. Teamwork and good relations are essential to the construction of clean-air housing, and clear, explicit instructions of what is to be done and why are due to all those involved in the project. Good, conscientious work should always be acknowledged.

A serious and not uncommon supervisory problem occurs when work which has been well done has to be removed due to changes or poor co-ordination of trades. The effect of this situation, on the morale of tradespeople and on the project's budget, can be disastrous, and underscores the necessity for clear and accurate plans and specifications before starting work. On the other hand, plans and specifications which appear too extreme will alarm many builders and their subcontractors and cause them to either bid too high or not at all. Probably the least stressful and most cost-effective solution for the inexperienced new homebuilder is to find an experienced and sympathetic contractor who has good working relationships with local trades. The contractor, as well as any other appropriate consultants, should be included in discussions between the owner and the architect at as early a point as possible.

Another important consideration when supervising any building site is site cleanliness and organization. It is well worth the time and effort to clean up every day after work, in order to maintain safe, efficient working conditions. Owners may wish to take this task upon themselves, to demonstrate their commitment to the project and to save money, or they may wish to pay someone to do it on a regular basis.

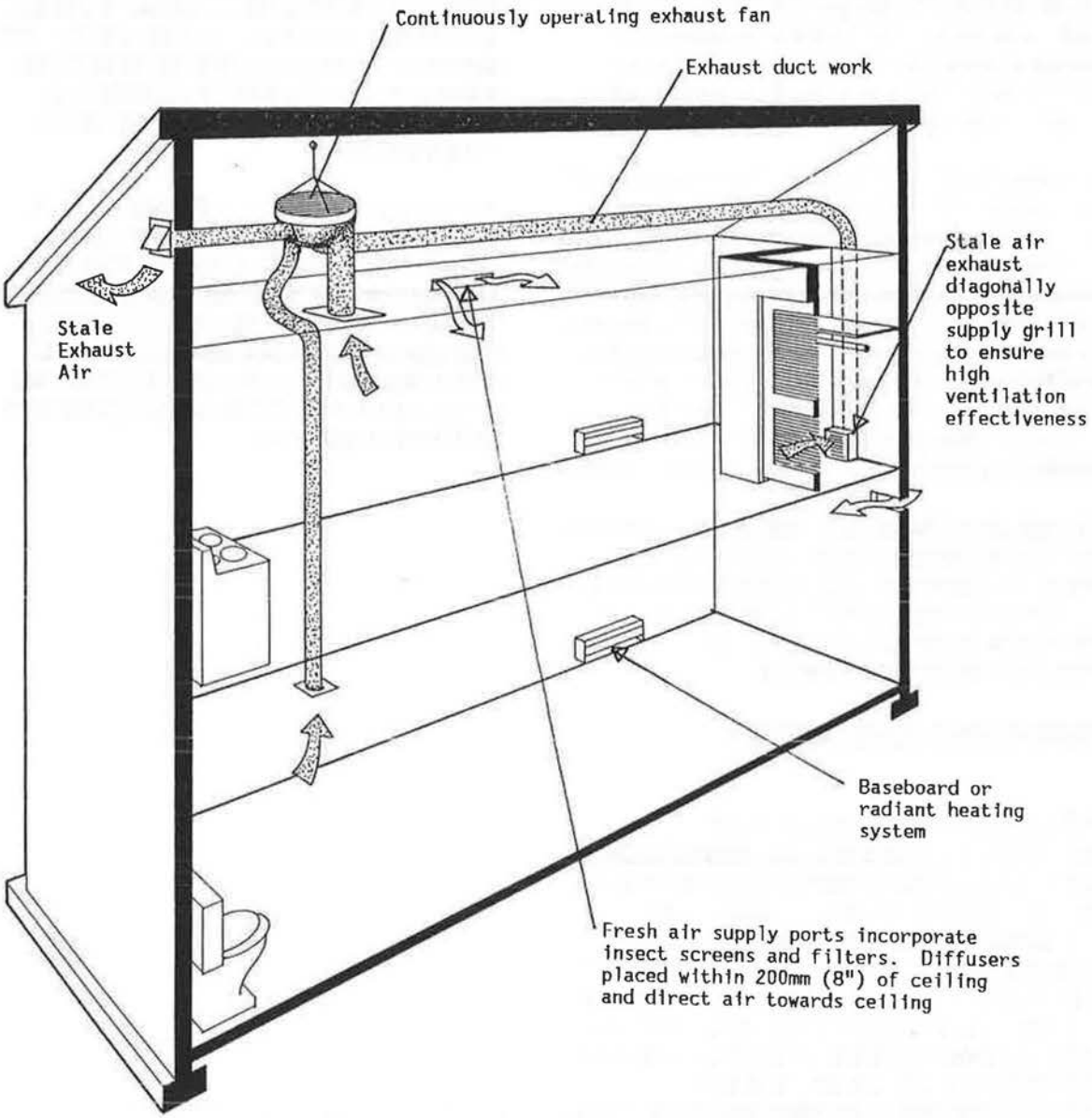


FIG. 6.1 CENTRAL EXHAUST VENTILATOR (CEV) WITH THROUGH WALL SUPPLIES

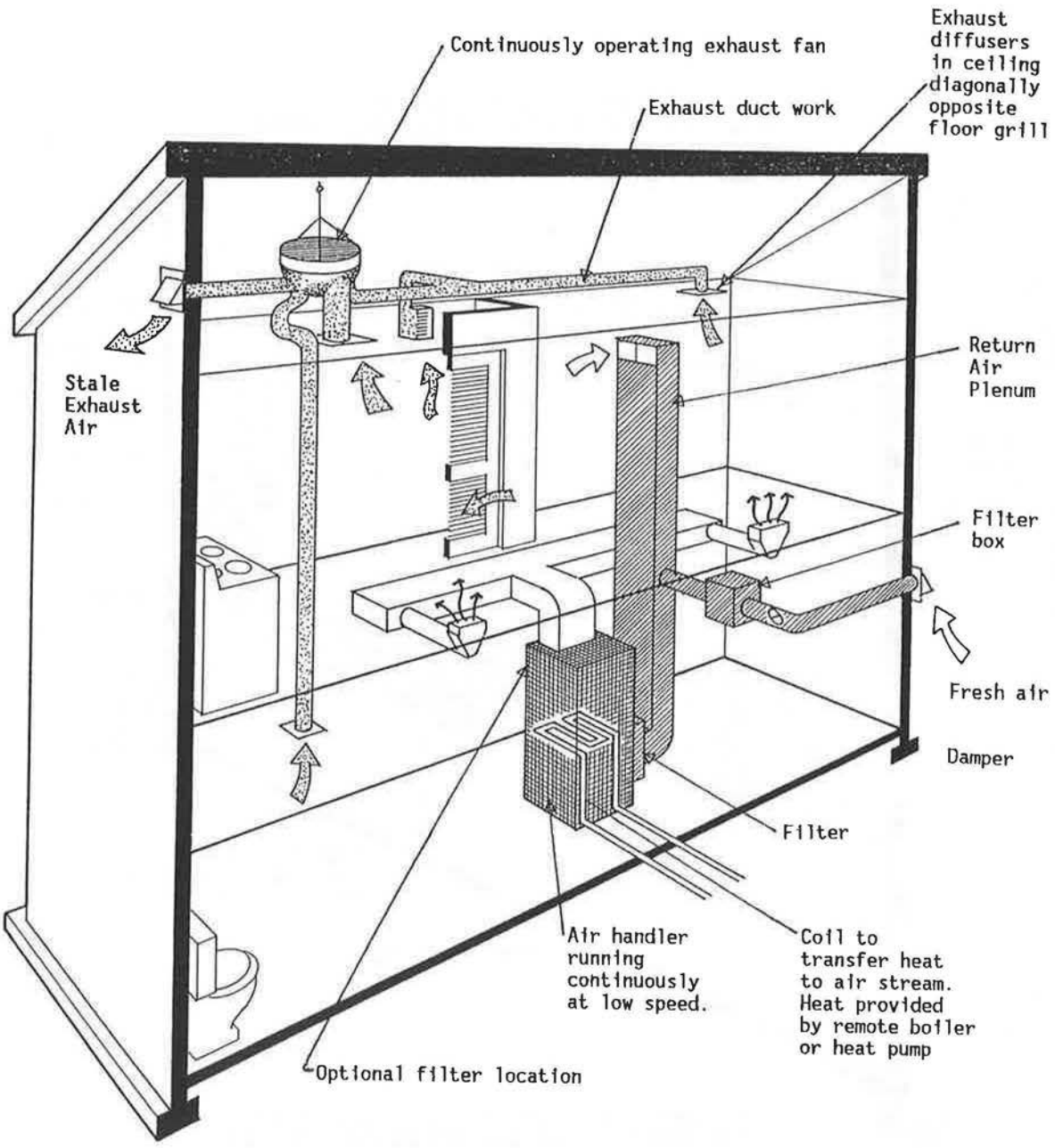
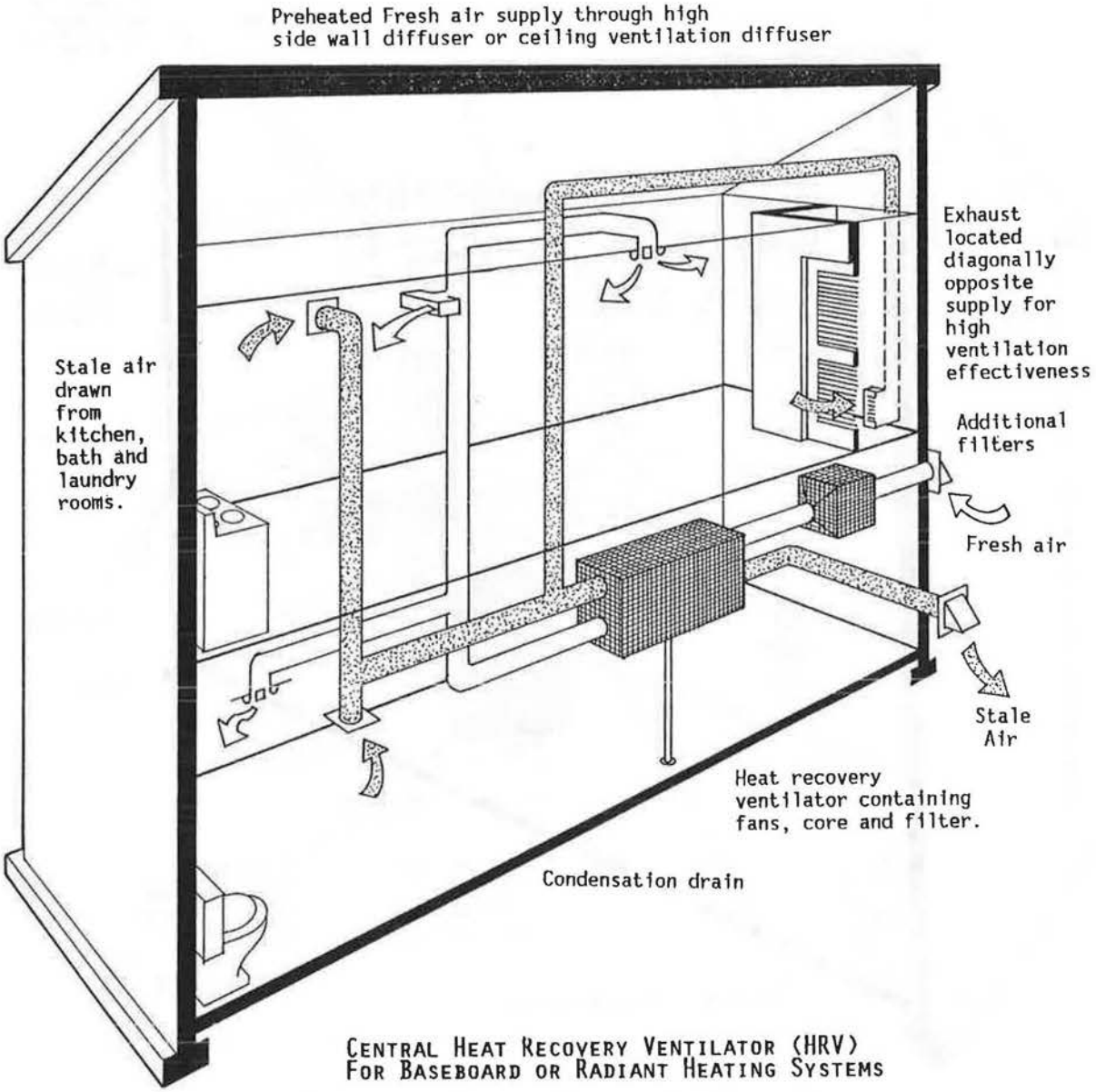
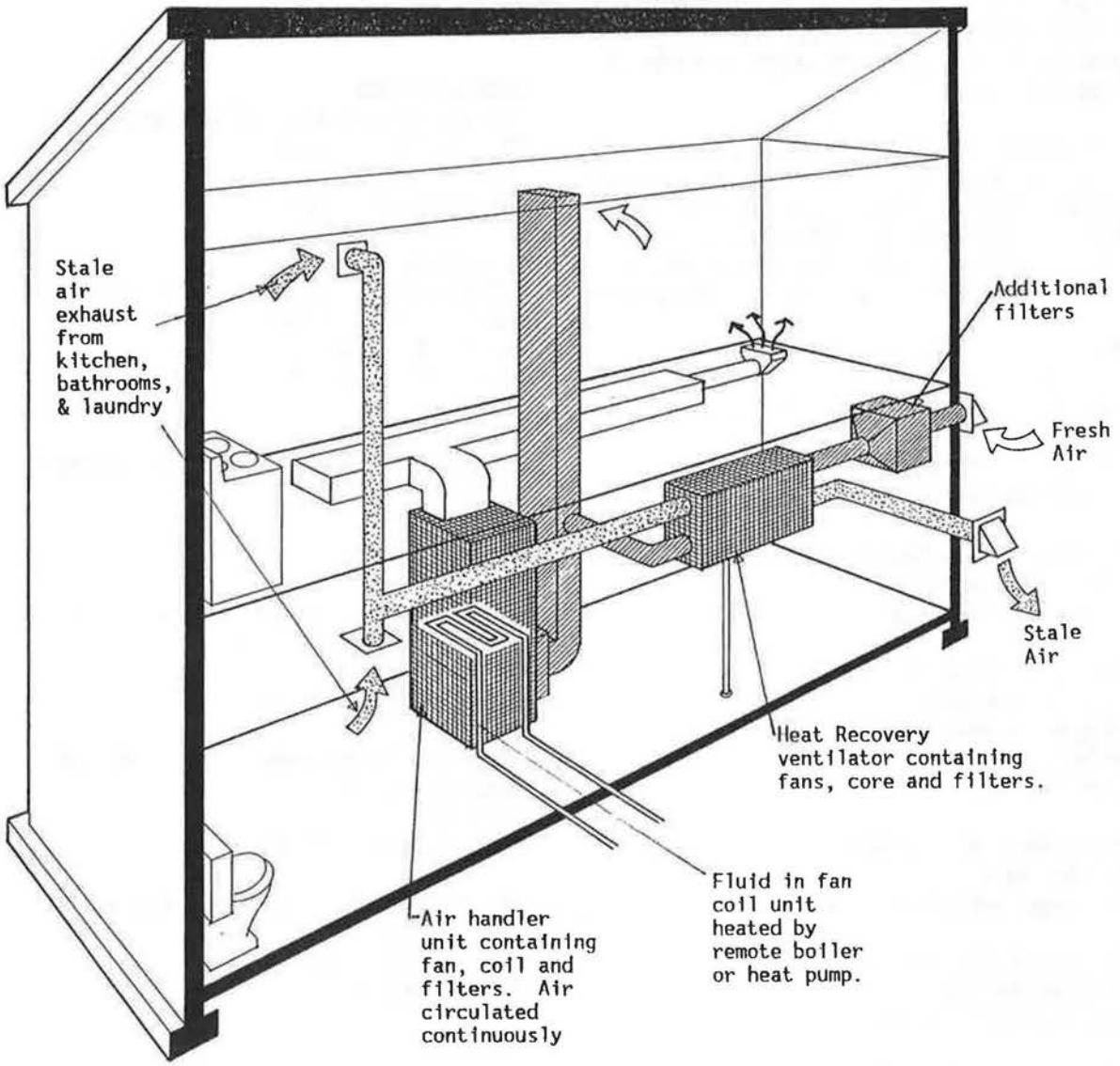


FIG 6.2 CENTRAL EXHAUST VENTILATOR (CEV) WITH FORCED AIR SUPPLY



CENTRAL HEAT RECOVERY VENTILATOR (HRV)
FOR BASEBOARD OR RADIANT HEATING SYSTEMS



CENTRAL HEAT RECOVERY VENTILATOR (HRV)
FOR FORCED AIR HEATING SYSTEMS.

GETTING HELP/ AS OF SPRING '90

In many provinces there are branches of the Allergy and Environmental Health Association which can provide information about services for the environmentally ill. In those regions which do not have branches you may be able to get help from the regional Allergy Information Association, an organization with many years of experience helping allergy sufferers.

The Canadian Society for Environmental Medicine is an information organization for physicians which can provide a list of physicians in your region. It is important to note that many physicians who may be knowledgeable regarding environmental medicine may not be members of the organizations listed here.

National Organizations

Canadian Society for Environmental Medicine
R.R.#6
6901 2nd Line West
Mississauga, Ont. L5M 2B5

Allergy and Environmental Health Association
10 George Street North
Cambridge, Ont. N1S 2M7

Allergy Information Association
65 Tromley Avenue,
Islington, Ontario.
M9B 5Y7
(416) 244-8585

Allergy Foundation of Canada
P.O. Box 1904
Saskatoon, Saskatchewan S7K 2S5

Parents of the Environmentally Sensitive
151 Sutherland Dr.
Toronto, Ont. M4G 1H8

Advocacy Group for the Environmentally Sensitive
1887 Chaine Crt.
Orleans, Ont. K1C 2W6

Candida Research and Information Foundation
41 Green Valley Court
Box 583, Kleinburg, Ont. L0J 1C0

Alberta
Alberta Association for Environmental Health
Box 7, Site 29, RR#12
Calgary, Alta. T3E 6W3

British Columbia
Allergy Information Association
214-2619 Alma St.
Vancouver, B.C. V6R 3S1

New Brunswick
Allergy and Environmental Health Association,
New Brunswick Branch
P.O. Box 4073
Dieppe, N.B. E1A 6E7

Nova Scotia
Allergy and Environmental Health Association,
Halifax-Dartmouth Branch
P.O. Box 8212, Stn A
Halifax, N.S. B3K 5L9

Ontario
Allergy and Environmental Health Association of Ontario
RR #5
Georgetown, Ont. L7G 4S8

Allergy and Environmental Health Association
Hamilton-Burlington Branch
356 Rankin Dr.
Burlington, Ont. L7N 2B4

Allergy and Environmental Health Association
Kitchener Branch
11 Calais Pl.
Kitchener, Ont. N2M 5M1

Allergy and Environmental Health Association
Ottawa Branch
P.O. Box 11428, Stn.H.,
Nepean, Ontario.
K2H 7V1

Allergy and Environmental Health Association
Toronto Branch
P.O. Box 2311, Station C
Downsview, Ont. M3N 2V8

Allergy and Environmental Health Association
Quinte Branch
P.O. Box 202
Cannifton, Ont. K0K 1K0

Allergy and Environmental Health Association
London Branch
1509 Rushland Ave.
London, Ont. N5V 1X6

Allergy and Environmental Health Association
Waterloo- Wellington Branch
11 Drew Ave.
Cambridge, Ont. N1S 3R2

Prince Edward Island
Allergy and Environmental Health Association,
P.E.I. Branch,
P.O. Box 2656
Sherwood, P.E.I. C1A 8C3

Saskatchewan
Allergy Foundation of Canada
P.O. Box 1904
Saskatoon, Saskatchewan, S7K 2S5

APPENDIX I...SUPPLIERS OF SPECIALTY PRODUCTS.

The following list of suppliers is provided for information purposes only. Neither CMHC nor the authors endorse or warranty any product whatsoever for any purpose nor is any claim made as to the completeness of the list. The suitability of a product for purchase or use is the responsibility of the purchaser.

CANADA

Air Purification

Tibbits Ltd.
Cobourg, Ontario.

Aircare/Enviroscience
1962 W. Broadway
Vancouver, B.C. V6J 1Z2
(604) 734-4211

Sunnyhill Research Centre,
R.R. #1,
Goodwood, Ontario.
L0C 1A0
Tel: (416) 649-1356
Fax: (416) 649-1314

Fabrics - Bedding

Island Shepherd International Inc. (Natural wool products)
Hillsborough, Mount Stewart
Prince Edward Island C0A 1T0
(800) 565-0264 Canada
(800) 565-9070 USA
Fax (902) 676-2806

Paints etc.

Teekah, Inc. (Auro natural paint and sealers)
5015 Yonge Stret

North York, Ontario M2N 5P1
(416) 229-4199

Livos Plant Chemistry, Canada (natural paints and sealers)
Natural Structures & Supplies Inc.
P.O. Box 92
Apohaqui, New Brunswick E0G 1A0
(506) 433-3455

Bona Kemi ("Pacific" waterbase urethane wood finishes)
Available through some wood flooring suppliers.
Supplier of "F-SORB" Paint.
Smiths Pharmacy.
3477 Yonge St.
Toronto, Ont. M4N 2N3
(416) 488-2600

Floor Coverings

Forbo Kromeenie (Linseed Oil Linoleum)
Erv Parent Ltd.
791 Caldew Street, Annacis Industrial Park
New Westminster, B.C. V3M 5S3
(604) 525-4142

Phoenix Wall & Floor Products
111 Westmore
Rexdale, Ontario.
M9V 3Y3
(416) 745-4200

Purgil from:
Circul-Aire
5585 Ouest, Henri Bourassa
Montreal, P.Q.
H4R 1B7
(514) 336-3330

Heat Recovery Ventilators.

Conservation Energy Systems Inc.
3310 Millar Ave.
Saskatoon, Sask.
S7S 7G9
(306) 242-3663

Venmar Ventilation Inc.
1715 Haggerty St.
Drummondville, P.Q.
J2C 5P7

Nutech Energy Systems
124 Newbold court
London, Ontario
N6E 1Z7

Star Heat Exchanger
B109 - 1772 Broadway St.
Port Coquitlam, B.C.
V3C 2M8
(604) 942-0525

Can Ray
255 Restigouche Rd.
Oromocto, New Brunswick
E2Y 2M1
(506) 357-9811

A range of products (filters, sealers, fabrics, vitamin supplements etc.)

Smiths Pharmacy
3477 Yonge St.
Toronto, Ont. M4N 2N3
(416) 488-2600

Springfield Plumbing
1091 Gordon Dr.
Kelowna, B.C. V1X 3E3
(604) 861-8080

Pur et Simple
R.R. #3, Ayer's Cliff
Quebec, J0B 1C0
(819) 838-4203/838-5705

Allergy Relief Distributors
10-8291 Westminster Hwy.
Richmond, B.C. V6X 1A7
(604) 270-0015

The Allergy Shop
729 W.16th.Av.
Vancouver, B.C. V5Z 1S8
(604) 877-0100

Allergy Resource Products Ltd.
Edmonton, Alta.
(403) 434-3181

Household Products and Personal Goods

The Soap Factory
141 Cushman Rd.
St. Catharines Ont. L2M 6T2

Nature Clean
PO Box 248
West Hill, Ont. M1E 4R5

La Balance
1249, Rue de Conde
Montreal, Que. H3K 2E4

Echo Logic
126 Cornwall St.
Toromto, Ontario
M5A 4K5
(416) 360-8799

Foundation Sealers

Thoro Products (cement based sealers)
Available from concrete accessory suppliers.

US

Air Purification

E.L. Foust Co. Inc. (air cleaners)
PO Box 105
Elmhurst, IL 60126
(312) 834-4952

Allermed (air cleaners)
631 J Place
Plano, TX 75074
(214) 422-4311

American Air Filter (filters)
PO Box 37220
Louisville, Kentucky 40233
(502) 454-9235

Fabrics - Bedding

Garnet Hill (Natural Fibres)
262 Main Street
Franconia, New Hampshire 03580
(800) 622-6216

The Cotton Place
P.O. Box 59721
Dallas, Texas 75229
(214) 243-4149

Purafil Corp. (air-cleaning agent)
P.O. Box 1188
Norcroos, GA 30071
(404) 662-8545

Allergy Relief Shop
2932 Middlebrook Pike
Knoxville, Tennessee 37919
(615) 522-2795

The Vermont Country Store
P.O. Box 3000
Manchester Centre
Vermont 05255-3000

Homespun Fabrics
4464 Mc Grath St. Ste 109
PO Box 3223
Ventura, CA 93006
(805) 642-8111

*Paints etc.

Bona Kemi ("Pacific" waterbase urethanes)
Denver, Colorado
(303) 371-1411

Auro Products (natural paints and sealers)
Sinan Co. (Importers)
PO Box 181
Suisun City, CA 94585
(707) 427-2325

AFM Enterprises Inc. (low-tox paints and sealers)
1440 Stacy Court
Riverside California 92507
(714) 781-6860/781-6861

Pace Chem Industries Inc. (low-tox paints and sealers)
779 S. La Grange Avenue
Newbury Park, CA. 91320
(805) 499-2911

Livos Plant Chemistry (natural paints and sealers)
614 Agua Fria St.
Santa Fe, NM 87501
(505) 988-9111

Old Fashioned Milk Paint Co. (natural paints and sealers)
Box 222
Groton, Mass. 01450
(508) 448-6336

Miller Paint Co. (low-tox paints)
317 S.E. Grand Ave.
Portland, Oregon 97214
(503) 233-4491

Murco (paint and drywall filler)
300 N.E. 21st Street
Fort Worth, Texas 76106
(817) 626-1987

Negley Paint Co. (low-tox paints)
PO Box 47848
San Antonio, Texas 78265-8848
(512) 651-6996

Insulation

Air Krete Inc. (silicate based insulation)
P.O. Box 380
Weedsport, New York 13166
(315) 834-6609

Badger Cork Insulation (cork insulation)
26112 - 110th Street
P.O. Box 25
Trevor, Wisconsin 53179
(414) 862-2311

A range of products (paints, adhesives, filters etc.)

Nigra Enterprises
5699 Kanan Road
Agoura, California 91301
(818) 889-6877

The Ecology Box
425 East Washington
Ann Arbor, Michigan 48104
(313) 662-9131

The Allergy Store
7345 Healdsburg
Sebastopol, CA 95472
(800) 824-7163

Floor Coverings

Forbo North America (Krommenie Linseed oil linoleum)
P.O. Box 32155
Richmond, Virginia 23294
(804) 747-3714

Bangor Cork Co. (Cork filled natural linoleum)
Bangor, PA
(215) 863-9041

Household Products and Personal Goods

Ecover (soaps and cleaners)
Imported by:
Mercantile Food Co.
Georgetown, Connecticut 06829

Grannys Old Fashioned Products
Box 256
Arcadia California 91066
(818) 577-1825

Green
Walnut Acres
Penns Creek, Pennsylvania 17862
(800) 433-3998

N.E.E.D.S.
527 Charles Avenue 12-A
Syracuse, New York 13209
(315) 446-1122
(800) 634-1380

Building Foil

Denny Sales Corp. (aluminum building foil)
1651 W. McNab Rd.
Ft. Lauderdale, FL 33309
(800) 327-6616
(305) 971-3100

Foundation Coatings

Thoro Systems Products Inc.
7800 NW 38th St.
Miami, FL 33166
(305) 592-2081

APPENDIX II

SPECIALIZED CONSTRUCTION FOR CLEAN AIR HOUSING

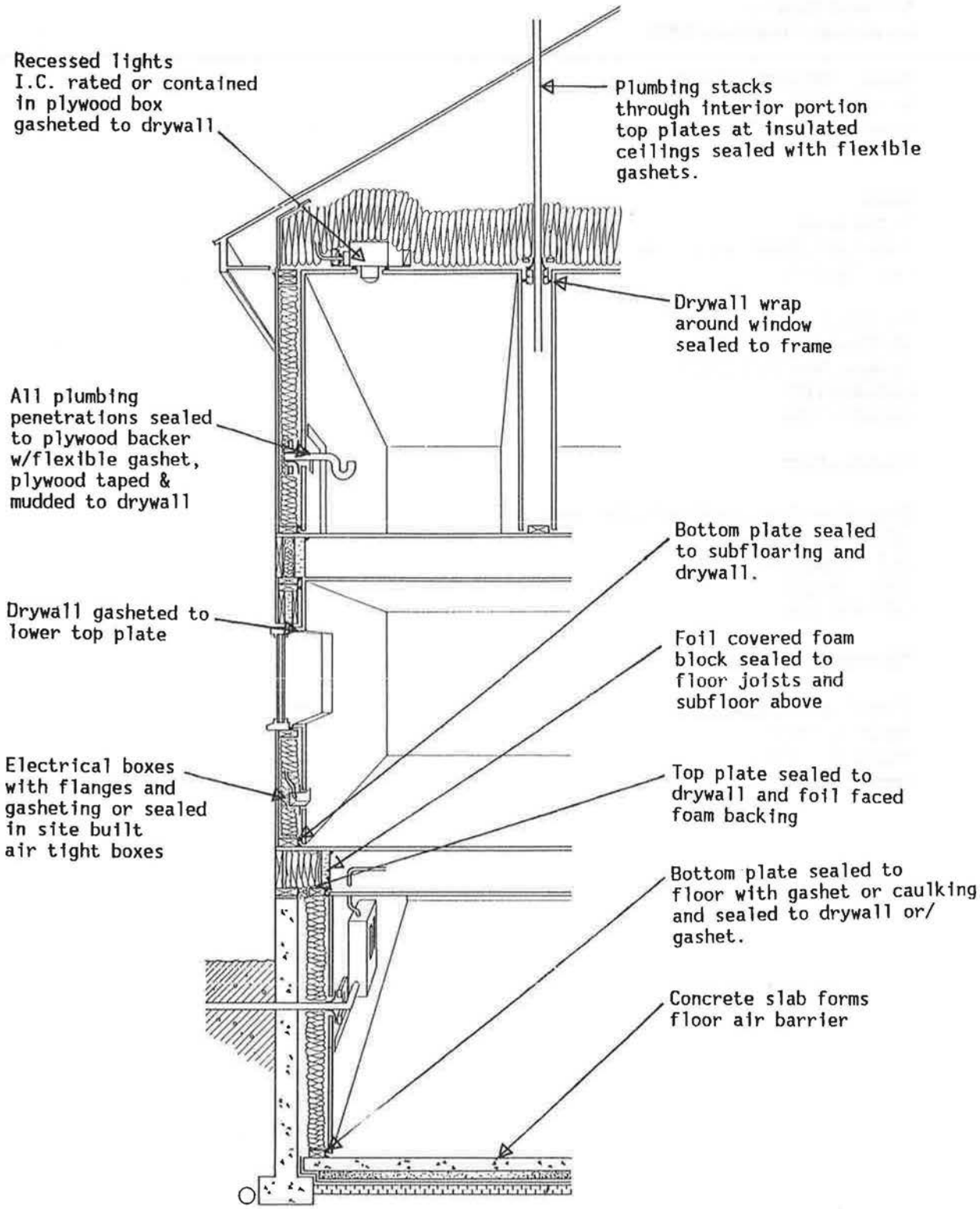
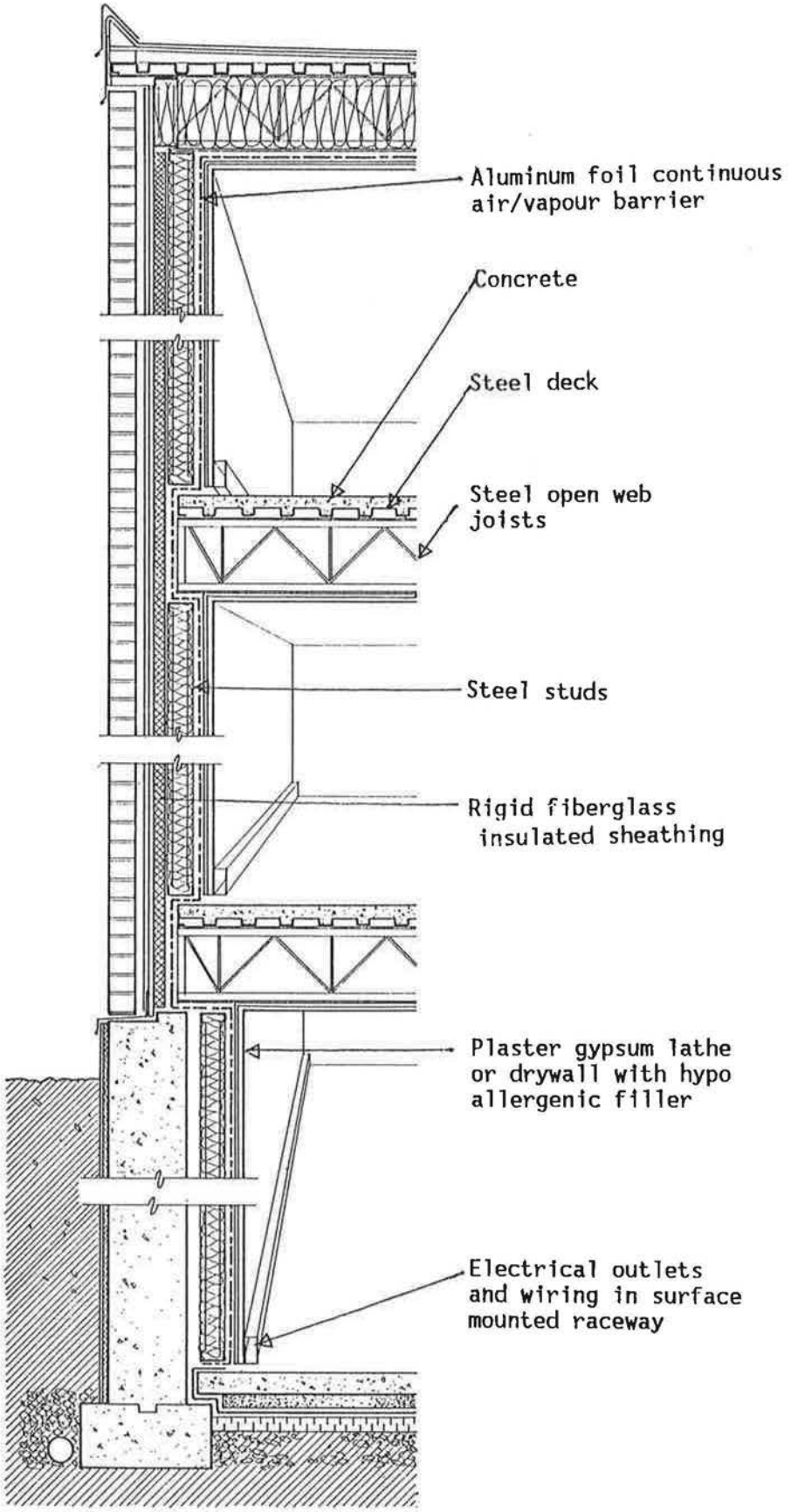


FIG. 6.5 AIR TIGHT DRYWALL AIR BARRIER SYSTEM



ALTERNATIVE WOOD FREE CONSTRUCTION