THE WINSTON CHURCHILL MEMORIAL TRUST OF AUSTRALIA

Final Report

by

Catherine Woolcock
1999 Churchill Fellow

THE A V JENNINGS CHURCHILL FELLOWSHIP

To study ecological and 'healthy buildings, in particular the effect of the built environment design on indoor air quality – USA, Norway, Sweden, Denmark and Germany.

1.0 INDEX

2.0 INTRODUCTION AND WELCOME!

For all those of you who are interested in the relationship between our health and our environments, welcome! This report considers one aspect of this broad picture, a summary of my study of the world's best practice in ecological and 'healthy' building design, with particular regard to indoor air quality – which has consequential effects on our health, and that of the environment generally.

Although a rapidly emerging field, most people are not yet aware of the broad impact of Indoor Air Quality. It is not a topic that keeps most Australians awake at night! Most of us go to sleep at night, blissfully unaware of the fact that our homes, may not be as healthy and safe as we believe them to be. Even if we sleep fitfully, it is probably not due to concern at the extent of the problem and the seriousness of its implications. However, the irony is that the consequential health effects of poor indoor air quality, may be one of the factors keeping you awake after all!

In April, I boarded a Qantas 747 and embarked on the 1999 A V Jennings Churchill Fellowship, to learn as much as I could in this field in the USA, Norway, Sweden, Denmark and Germany. I strongly believe that Australians deserve to benefit from the experience of the best practitioners in this area, so they can have healthier environments in which to live, work and play. This report is a short summary of the broad range of information I gained whilst conducting my Fellowship, and the ways in which I propose to disseminate this information within the community.

Acknowledgements

I would like to acknowledge and thank the following people, without whose assistance this Churchill Fellowship would not have been possible:

Firstly, sincere thanks to A V Jennings and their SA General Manager, Mike Lenarduzzi, for their generous sponsorship of this Fellowship, and interest in my field of study. Warm thanks, too, to my colleagues and friends: Sue Averay and Heather Hales for their support, Gerhard Schurer for his teaching over many years, and Paul Downton and Cherie Hoyle, for their assistance and encouragement. Thanks also to Julie Black, General Manager at Asthma SA, for finding time to discuss ideas with me and for her supportive contribution.

Thanks to the Churchill Memorial Trust in Canberra, to Rear Admiral Ian Richardson for reminding us of the 'fire in our bellies and light in our eyes' and especially Elvie Munday for looking after me so very well. To Pam Freeman and Greg Chambers and those from the Churchill Fellows Association in Adelaide, your help and encouragement was appreciated. I am much indebted to Georgie Ritch at Qantas, whose travel arrangement skills and wonderful sense of humour when plans alter, are second to none!

I am thankful for the kind assistance of Gail Lindsey, Design Harmony, USA, for reviewing my USA Schedule, and providing me with useful feedback and contact information. Special thanks to all those with whom I met, and learnt from and who gave so freely of their time. I was continually surprised at the willingness of everyone I spent time with, to share their knowledge in this emerging field.

Last but by no means least, thanks to all my friends in Adelaide, especially Sandra and Carol, who helped me so much in my preparations. Many thanks to my parents for sharing different stages of an unforgettable journey with me, and most gratefully to my brother Jim, who held the fort so well for all of us, so we could.

3.0 EXECUTIVE SUMMARY

3.1 Project Details

Name: Catherine Woolcock
Address: 8 Montpelier Street, Parkside, SA, 5063
Occupation: Architect, Principal of Catherine Woolcock Architect
Environmental and Conservation Architecture
-Specialising in Healthy Building Consultation
Telephone: +61 8 8271 1833 Facsimile: +61 8 8271 1533
Email: catwoo@picknowl.com.au

3.2 Project Description

The project is the 1999 A V Jennings Churchill Fellowship to study the world's best practice in ecological and 'healthy' building design, with particular regard to the role of the built environment on indoor air quality, in the USA, Norway, Sweden, Denmark and Germany.

3.3 Project Highlights

I met with and interviewed leading architects and practitioners in this field in the USA, Norway, Sweden, Denmark and Germany, visited their built examples, and viewed Centres where best practice in this field is demonstrated so well. I attended two excellent conferences in the USA: 'The Natural Step Annual Conference' in Portland, and the leading ecological building conference - 'EnvironDesign 3' in Baltimore. They contained cutting-edge information, allowed for interaction with practitioners in this field, and were extremely optimistic in their outlook.
All those I met with, were extremely generous with their time, people who were especially helpful include, alphabetically: Thia Bankey, Susan Barnett, Tom Bender, Varis Bokalders, Chris Butters, Bill Christensen, Kirsten Childs, Geo Clausen, Logan Cravens, Barry Dimson, Kristin Ralff Douglas, Joachim Elbe, Pliny Fisk, Kathleen Guidera, Micheal Haas, Declan Kennedy, David Kibbey, Arne Klingborg, Kjersti Kviseth, Karin Landström, Lennart Larsson, Nita Lorimer, Jill Manlove Mayfield, Marsha Maytum, Per Monson, Bengt Ohlsson, Dorothy Payton, Arthur Ross, Lynn Simon, Victoria Schomer, Alan Scott, Carol Venolia, and Sim Van der Ryn.

2.4 Project's Major Lessons

The project's major lesson was that education and awareness is required on indoor air quality throughout the Australian community, as soon as possible. Lessons on the best methods of achieving this, followed on from this concept. Additionally, an overview of the current state of best practice was gained, in regard to the design of the built environment for indoor air quality. This comprised the processes used, the nature of the materials and construction, source reduction, dilution of the indoor air, and consideration of the relevant occupant's lifestyle factors. Methods for sourcing various types of necessary information in the field were also compiled.

2.5 Proposed Dissemination

I propose to disseminate this knowledge as widely as I can, through many different channels. In the short term, they include: setting up a web site, giving lectures at relevant functions and conferences, writing more detailed papers, and submitting articles to be published. I am facilitating the sharing of information and consultation with interested members of the building industry, and organisations with an interest in health and buildings. I am currently exploring other innovative ways in which the information can be distributed.
In the longer term, I would like to initiate a Network, to share information in this field. However, my vision is to create a 'Healthy Buildings' Centre, where people can experience a real working example of healthy and ecological construction. This would allow displays of healthy and ecological products, access to all types of relevant information, including a list of practitioners and associated services, and courses at different levels to be provided to the community.

4.0 DESCRIPTION OF CHURCHILL FELLOWSHIP

4.1 A Brief Introduction to Indoor Air Quality

Given that many people are unaware of the concept of indoor air quality in relation to the indoor spaces in which they live, work and play, I have included a brief overview of the topic, to better illustrate the major lessons learned from my Churchill Fellowship.

'Indoor air quality' refers qualitatively to the state of our indoor environments, sometimes holistically referred to as the 'the indoor climate', and is an emerging field throughout the world. There is an innate connection between the nature of the built environment and the quality of the indoor climate created by it. The other factors that influence the quality of our indoor climates are the activities and lifestyles of the people who use the space. This report is concerned with the first aspect only – the role of the design of the built environment on indoor air quality.

Indoor air pollution refers to the contamination of the indoor air by gases and particulates emitted from sources that are within the indoor space or have ingress into these spaces, and have deleterious effects on the occupants. Thus indoor air pollution has a direct effect on indoor air quality, as the less air pollution present, the better the quality of the indoor air or climate.

But do we have indoor air pollution, when we can't see it? Yes! If you were to look at the two photos, one of a typical home living space and one of a hazy cityscape, which would you think has the greater pollution? Unfortunately, it is usually the home living space! Many people are concerned to find out that their homes, are not as healthy and safe as they think they are. The US Environment Protection Authority (EPA) Indoor Environments Division state on their web site:

"*EPA studies of human exposure to air pollutants indicate that indoor air levels of many pollutants may be 2-5 times, and occasionally more than 100 times, higher than outdoor levels."*
US Environmental Protection Authority, Indoor Environments Division, web site, 1999

So what is indoor air pollution? It is a toxic chemical cocktail consisting of polluted outdoor air, entering into indoor spaces that is then compounded by the chemical out-gassing of synthetic building materials and furnishings,(eg carpets, paints etc), pesticides, cleaners, personal care products, heating and combustion products and controversially electro-magnetic radiation. This combination is usually sealed in buildings to increase energy efficiency through impermeable layers of synthetic materials, and then ventilated at low rates, often through ventilation systems which are themselves polluting! In addition to this, what has previously been considered 'safe' levels of chemicals, are now being reconsidered in the light of long exposure periods at low levels, showing demonstrable negative health effects.

The severity of indoor air pollution is a very complex issue. It depends on many variables: how large and how hazardous the pollution source is; whether it emits continuously or intermittently; the length of time it continues to emit for; how long it takes to the concentrations to significantly reduce; and lastly the nature of any cumulative effects caused by the interaction with any other pollutants present! The health effects relating to this are even more complex, with different individuals reacting differently to one another, given the same exposure levels!

Australian's spend on average, 90% of their time in such polluted indoor air – at home, in the workplace or in transit. Thus most of our lives today are spent in environments that are the least conducive to people's health. It is now acknowledged in countries addressing this problem, that indoor air pollution has a greater impact on people's health than outdoor air pollution!

Modern medicine has been very successful in the field of infectious diseases, however in first world countries there is now a great increase in illnesses significantly linked to environmental factors from the quality of the indoor environment. Opinions differ, but the emerging view includes asthma and allergies, some cancers, 'sick building syndrome', multiple chemical sensitivity and other degenerative diseases.

There is evidence to suggest that indoor air pollution is a contributor to asthma and allergies. Asthma has doubled in Australia in the last decade, and is our fastest growing health problem. We have arguably one of the highest rate of asthma and allergy in the world, and approximately 1/3 of South Australia's school-children suffer from asthma or allergy. They are the 'canaries down the coalmine', of our indoor environments, sending us a clear warning that our indoor spaces are not as healthy as we think they are.

The health system costs the Australia community $22 billion per year. Even if only a small proportion of illnesses can be attributed in part to indoor air quality, it is a cost-effective primary preventive health measure to design healthier buildings, based on the latest information from around the world. Some commentators in this field have said that the indoor environment may exert the single biggest modifiable influence on the health of the community.

There are three ways of improving indoor air quality. Firstly through source reduction, by identifying and then eliminating or reducing the sources of indoor air pollution, the indoor air quality must be improved. It is the identification and understanding which chemicals or toxins and at what concentrations cause problems, that is a huge on-going task. The second element is dilution, using ventilation to allow fresh outdoor air to move through the indoor spaces and replace the polluted air, and dilute the concentrations of pollutants in the remaining air, that improves indoor air quality.

The final variable that influences the indoor air quality is the lifestyle and activities of the occupants, which influence the way they use the spaces. Even if the spaces are well-designed for indoor air quality, the occupants may not ventilate the building as it requires, or they can introduce any numbers of activities which are new pollutant sources into the spaces, such as hobbies with toxic materials!

4.2 Major Lessons

The description of my Churchill Fellowship and the major lessons learnt are intertwined, and so they are combined within the following section. My itinerary included meeting with and interviewing leading architects and practitioners in this field in the USA, Norway, Sweden, Denmark and Germany, visiting their built examples, and viewing Centres where best practice in this field is demonstrated so well.

I attended two excellent conferences in the USA: 'The Natural Step Annual Conference' in Portland, and the leading ecological building conference - 'EnvironDesign 3' in Baltimore. They contained cutting-edge information, allowed for interaction with practitioners in this field, and were extremely optimistic in their outlook for a brighter future.

4.2.1 Education and Awareness

In the end, the most important lesson from my Churchill Fellowship was not what I had expected it to be! I found that the world's best practice in ecological and healthy buildings design in regard to indoor air quality, recognises, promotes and implements methods for education and awareness in this field. If the community at all levels (and this includes all sections of the construction industry, and health professionals) is not educated about the nature, extent and seriousness of indoor air quality, then the status quo will be remain - and much needed and far reaching improvements will not occur. If this is the case, then the majority of the public will continue to suffer the range of health effects associated with indoor air quality and we will continue to pay a very high price for this, both socially and economically.

A good general example of education and awareness was demonstrated at 'The Natural Step Annual Conference', in Portland, which concentrated on sustainability - health for both people and the earth. Many examples were given from companies such as IKEA and Nike showing the commitment and funding they had implemented for mandatory education and awareness training in these areas, for all their staff. The whole companies now have a genuine understanding of the principles and a personal connection to them, so they can really apply them. Unexpected bonuses have included the most united company teams, with the most motivated and committed employees, (the 'whole' person can now come to work, they don't have to leave their views/ethics at home) they have yet had!

The second part of this lesson is that the method of communication is so much more important than we often realise. When thought goes into the means of communication, when there is simplicity and clarity in the message, then you are able to transfer important information through to those who need to receive and understand it - then and only then, can they use it. It does not matter how important a concept you are trying to convey, if you cannot communicate it well, then it cannot be applied.

The Green Builder Program in Austin, Texas (sister-city to Adelaide) is a case in point. This is one of the most successful and awarded sustainable, (ecological and healthy building), programs in the world, yet it has the same premise as many of the other Green Builder Programs in the USA. One of the main reasons for its success (besides a dedicated and talented staff) is its concentration on clear communication, and ease of access to its resources by the community. For example, it has hundreds of individual facts sheets which concentrate on one particular aspect at a time, breaking down problems into manageable sections. Then a lot of time is spent simplifying the text to ensure its clarity and lack of technical jargon. A policy of ease of accessibilty to the

community of these resources has also gone ahead. It is a user-friendly system, hence people use it, like it, and understand it and it gets great results out in the community!

The third part of the lesson, is looking at the big picture, looking at indoor air quality as part of the greater holistic view of the planet and sustainability. We need to view the health of people and the earth as a totally interconnected and interdependent system. When people understand this, they understand the cause and effect relationship of every choice they make each day - they understand the principles and they can think for themselves. They can then grasp that we are a closed system - that we are not the passengers on spaceship earth, we are the crew, and its about time we took the role seriously!

A wonderful analogy from 'The Natural Step' is to change our perspective and look at the earth as a small spaceship that is sealed, to which nothing can be added to, (except sunlight) or taken away. When people are introduced to this concept as a team game and asked what they would like to take with them, they certainly don't want to take our sources of indoor air pollution such as chemicals in any form! They also start to understand the concept of social equity, for it is hard for them to argue that 20% of the spaceship crew should have 80% of the resources! However, this is the current breakdown of the use of the world's resources according to the Natural Step's figures. They can then understand that this concept isn't fair and socially just, and that we should be sharing the world's resources equitably.

This growing view of ecological sustainability is evidenced by the leading corporate sectors in the USA now espousing the 'triple bottom line' concept; of being environmentally, socially and financially responsible – referenced in short as: planet, people and profit. Indoor air quality relates to all three of these!

Finally there is a need to emphasise the positive side of learning about the often overwhelming and unsettling nature of indoor air pollution. We should not be fearful of knowing the extent and seriousness of the problem, but be pleased that there is so much we can do to remedy the situation and provide better environments for people to work, rest and play. Some of the ways in which education and awareness are being promoted in the places I visited are detailed as follows.

4.2.1.1 National Education Programs

I was surprised and encouraged to learn of the extent and level of importance now given to education and awareness on indoor air quality in the countries that I visited. This is illustrated by the major national education programs, conducted specifically in this field, both in Sweden and the US, which are examples of best practice.

This raising of education and awareness serves two purposes, firstly it informs the general public about the whole area of indoor air quality and the many practical measures they can take straight away as individuals, in their homes and workplaces, which do not require professional advice. Secondly it informs the entire construction industry, including practitioners and architects, of the seriousness of the problem, and where they can get further information and education, to provide the community with better services, for the benefit of all.

1999 is 'Year of the Indoor Climate' in Sweden (*Inne 99*), in the same manner as it is 'Year of the Older Person' internationally this year. This year of activities was divided into four seasons, each season concentrating on the needs of a different sector of the community (eg. schools, offices, the home, and the building industry). In this way, the specific requirements for education on the indoor climate, are extensively and creatively catered for, for both the public and the construction

industry. This program includes general booklets, specially developed education material, seminars, and film and television events etc. It is an information campaign that was initiated by a group of twenty Swedish Government Agencies in collaboration with the private sector, its aim being to inform people about the indoor climate and what they can do about it.

Healthy Indoor Air for America's Homes is a national project, running for the past two years, to provide clear and comprehensive information to consumers on indoor air quality. It is a partnership program initiated by the US Environmental Protection Authority, the Montana State University Extension Service, and US Department of Agriculture (Co-operative State Research, Education and Extension Service). October is designated 'National Home Indoor Air Quality Action and Awareness Month', in which each state's Program Managers spread the message using specially designed kits, featuring education manuals, booklets, posters, videos, bags etc. The program features support from the White House through a Presidential Proclamation, this states:

"…Home Indoor Air Quality Awareness and Action Month offers us a valuable opportunity to learn more about the importance of improving indoor air quality. I urge all Americans to find out about the common household practices and products that can contribute to poor indoor air quality and about how to protect your families from these hazardous pollutants."

Bill Clinton, President of the United States, Presidential Proclamation, 1998
"Healthy Indoor Air for America's Homes", Montana SUES, 1999.

4.2.1.2 Information Methods

In the course of conducting my Fellowship, I uncovered many different examples of information methods, as a major form of communicating knowledge on the indoor air quality field. I had not expected to find so many examples of successful communication techniques, many of which are applicable to Australia. Once again these methods, serve the dual purpose of educating the general public and the entire construction industry, depending on their application.

(i) Internet

Obviously there is a lot of information on indoor air quality on the Internet, unfortunately however, as the amount of information to be searched through continually increases, it is more difficult to effectively use this resource. The US Environmental Protection Authority, Indoor Environment Division, runs an excellent web site on indoor air quality, with links and booklets you can download directly. Networks in the field, as described below, have compiled updated web site lists of appropriate sites (eg in their newsletters) and what you can find there, which is very useful.

Bill Christensen, Austin, Texas, has pioneered a unique Internet resource known as 'Sustainable Sources' that provides free information to users, so the information can filter directly into the community. The uptake of the information by users has been extremely high. From this experience he acts as a consultant to healthy and ecological building organisations to create and maintain their web sites, to provide even more information to the community. This enterprise has been recognised with an EarthSummit award.

He has also created a Local Area Network (LAN) to allow his local community to communicate with each other better, and save money on access to the internet. It gives them the opportunity to

deal with information when they are ready to, and discuss issues that are important to them, it recreates the notion of community, rather than individual households.

(ii) Networks

There are many networks in different regions throughout the US, serving the community and themselves in the quest for natural and healthy buildings, within this rapidly growing field. An example is the former Natural Building Network, now incorporated with the national ADPSR, as the Architects/Designers/Planners for Social Responsibility, California Chapter. It is an open forum, non-profit organisation providing information to all those interested in ecological and healthy buildings. They state:

"We continue to educate ourselves and the public about issues of environmental health, sustainable architecture, non-toxic building methods and the spirit of human habitat."

"Building Naturally, A Guide to Professionals", David Kibbey (ed.), 1994

This network evolved to meet the need of providing a comprehensive resource for people in this area; to meet and share information with like-minded individuals, attend lectures and seminars, find information on the latest concepts and products, and to find practitioners, consultants, and suppliers etc. They carry out their own projects, build public exhibits, distribute newsletters, conduct reports and publish and sell several documents, from their experience. These include the widely used Architectural Resource Guides. This successful endeavour, is a very good example of the type of network that can be developed to serve the local community, and has a well-earned public profile.

Generally in this field, newsletters at regular intervals (usually monthly), whether electronic or printed are a very popular and successful medium for distributing the latest information in this rapidly growing field, and usually include updated web site addresses.

On a larger scale, the US Green Building Council is a national non-profit consensus coalition of the US Building Industry to promote education and implementation of ecological or 'green' buildings, through policies, programs, technologies, standards and design practices. It is an excellent initiative to promote understanding and co-operation at all levels and across all boundaries of occupations and organisations, including manufacturers of products. Some of its activities include sponsorship of conferences such as 'EnvironDesign', the *LEED Green Building Rating System* and a Sustainable Building Technical Manual. That is has been possible to create such a group, with wide and growing industry support, is a fantastic achievement!

Additionally, in Europe and the USA, there are informal networks of architects and practitioners working in this field. These informal networks use personal associations to facilitate information exchange, and working together on projects to achieve the best outcome is common.

(iii) Centres

There are good built examples of ecological and healthy buildings that act as 'Centres', to illustrate these concepts in a physical form which people can readily relate to. These Centres, such as the 'Solar Real Goods Living Centre', in Hopland, California, also stock an extensive range relevant products, materials and books. They are also popular public attractions in their own right, acting as tourist or visitor centres in the local area, beside being good sources of information.

Some Centres I visited, such as the 'Environmental Home Center' in Portland, act mostly as a specialist home building centre, displaying an extensive ecological and healthy building product

range, with well laid out displays and even demonstration sections of furnished areas. Architects or other consultants can bring their clients to these places so they can see, touch and smell different products and some homewares, that have been carefully selected against nominated criteria. They are much appreciated as a rare one-stop resource for these articles, by the public and practitioners alike.

Barry Dimson's EcoSmart Center, in the Trump Tower, Wall Street, New York, is an excellent example of a typical high-rise building floor which has been completely refurbished and refitted along ecological and healthy building principles. It houses a permanent and extensive display of products, materials, lighting systems, cleaning and maintenance products, lists of suppliers and consultants, energy management systems, furniture and ergonomics, and ventilation systems for viewing by the public and practitioners. It also has offices of consultants in this field, and runs many courses of different types in its meeting areas, for everyone interested. It has a prominent web site, and a high public profile.

Generally, these Centres are examples of best practice and are excellent methods of communicating information on indoor air quality with the community at all levels.

The Östratornskolan, in Lund, Sweden is an excellent example of a school designed and constructed on ecological and healthy principles. Within this design, clever methods of educating the students on the nature of the building they occupy, and why it was designed like this, have been incorporated.

There are gardens where flowers and vegetables are grown, crops are then stored in an earth cellar, and kitchen and food waste is composted in a heated plant, and then re-used. Other waste is sorted into seven types and placed in the prominent re-cycling system. The water and sewer systems integrate innovate systems to capture rainwater, minimise the use of water and reduce the release of chemicals into the environment. Urine is separated from feces in the sewer system, the urine is passed through a reed-bed system, then oxygenated and flows to a dam for evaporation. The feces are collected for composting and then taken by farmers for use on local fields.

Healthy materials with minimal energy use for their production were selected (ie ecological products), and their re-use later was carefully considered, many were recycled materials. Materials that are not degradable were reduced by 80%, therefore there is no pvc, cfc, hcfc, or foams used in the school.

The students are taught by the staff about the different ecocycles, (ie water, food, recycling etc.), and then see them demonstrated in their everyday surroundings - and the children then take home to their parents this knowledge. It is a wonderful concept, in which the reality of their ecological and healthy environment can be experienced everyday!

(iv) Education of the Construction Industry

In addition to the above, many Centres and organisations offer courses on ecological and healthy building design ranging from introductions to the public through to comprehensive courses for practitioners and the entire construction industry.

Some consultants such as Lynn Simon from Simon and Associates, Environmental Building Consultants in San Francisco, provide services that include training their construction industry clients' teams on ecological and healthy building concepts. Once everyone understands all the principles and particular the project issues, they can work as an integrated team and make

informed decisions. This is very important, and is illustrated by new ground-breaking ecological and healthy building projects being designed and actually constructed in their envisaged complete form.

More extensive training in this field throughout the building industry is available in Europe, especially in Norway, Sweden, Denmark, and Germany. However, there is still a long way to go, until this is standard practice, even in these countries, perhaps only 10% of work is currently carried out in an ecological and healthy way. The Swedish Government has a 'Building Sector Environmental Advice Section', which has created a very good dialogue with the entire building industry, and is a good model.

Dorothy Payton and others at the American Institute of Architects, Portland, Oregon, started an open 'Committee on the Environment' in the late 80's to teach more architects and those involved in the construction industry how to design and build healthier and more ecological buildings. Their innovative program of continual education and awareness in this field, has been very successful, and is used as a model in the USA. They hold workshops, have a library resource, keep current documents, put articles in the local media, create sample boards of materials, talk to schools, create kits for architects to take to clients, conduct special multi-disciplinary one-day training seminars, and create awards and exhibitions.

(v) Media

There appears to be an increasing media profile in the field of indoor air quality, apparent in magazine articles, advertising and television and other coverage, rather than sensationalist coverage of 'sick building syndrome', in the countries visited. Radio has also been successful in the US, with the 'Environmental Action Report' creating a daily awareness of these issues through regular and consistent reports.

4.2.2 Design of the Built Environment

From conducting my Churchill Fellowship throughout the countries with the world's best practice in the design of the built environment in relation to indoor air quality, I gained a valuable overview of this field. I found that there are generally three different stages in approaching the quality of the indoor environment, in relation to the design of the built environment. I have classified them as follows, for ease of clarity in describing the myriad of information sourced from many places. However, each stage is equally necessary and has its own merits and builds upon the foundation of those proceeding it.

I have classified these approaches as follows:

4.2.2.1 Low-Toxicity = Healthy Environments (Stage 1)
4.2.2.2 Low-Toxicity + Ecological = Healthy Environments (Stage 2)
4.2.2.3 Low-Toxicity + Ecological + Life-Enhancing = Healthy Environments (Stage 3)

It is very important to note that this report is not a complete guide to the design of the built environment in relation to indoor air quality, as this would require a book to detail all this information! This report contains samples of the information I gained, from the interesting or leading-edge concepts I learnt about, to add to my existing knowledge on the subject. Given the large amount of information I collected and the scope of this report, I have not included the full

details in each case. I have presented the information within the above classifications, as they required a framework for clarity.

4.2.2.1 Low-Toxicity = Healthy Environments (Stage 1)

(i) Source Control (Pollutant Source Removal/Reduction)

Materials and Finishes, Interior Furnishings, Household & Personal Care, Combustion Products

There is much work being done on evaluating building materials and finishes, interior furnishings, and household and personal care products as sources of toxic pollutants. Geo Clausen, at the new 'International Centre for Indoor Climate and Energy', Copenhagen, has been measuring the effects of human exposure to air-borne chemical pollutants in specially designed controlled climate rooms, which I viewed. They have been developing a system to test small-scale samples that can predict chemical and sensory effects in larger spaces. Their results are part of the data used to construct the European Database on Indoor Air Quality, and a 'healthy' or low-toxicity building materials and finishes list for use by practitioners in the field.

People's sensory perception levels of chemical or biological sources are also important, as it is this perceived air quality or perceived comfort in an indoor environment which is often the final arbitrator in people's responses. That is why this is also being tested, and the figures incorporated into the database. The Centre has documented the effect of an increase in temperature on people's sensory perception, rather than on higher chemical exposure in certain circumstances.

There is difficulty in measuring the effect on people of multiple exposures to chemicals, and the combined effects of different chemicals, and also to simulate long-term low level exposure. It has been found that people themselves can even be pollutants!

The Centre has also developed a computer program, which has not yet been released, which allows a designer to accurately know the chemical composition of the air (in % of gases), and likely human sensory perception. This is based on the surface areas of the materials in the design of a building from its floor plan and interior surfaces etc. It can model air-flows, changes in temperature and the change in the chemical composition of the air when building materials are substituted. This is an excellent concept, and one that would benefit so many practitioners, when it is available.

Moisture

Long term research by the Swedish Council of Building Research on moisture source reduction, has evaluated construction with a special emphasis on the prevention of water damage. It has concentrated on better plumbing details to prevent any leaks from any pipe joints, inside sinks, drains, heating pipes, and floor gullies etc. This has been very successful, after 4000 flats were constructed 10 years ago with these improved construction details, there has been virtually no water damage, and hence this source of indoor pollution has been minimised.

Lennart Larsson, a medical microbiology specialist in Sweden, has been studying the emissions from moulds and bacteria, especially in relation to damp building materials. These are biological, as opposed to chemical air-borne pollutants. His team has discovered that bacterial toxins can remain in a building material that has been subject to moisture, long after it has dried out. Therefore these toxins remain in indoor environments unless the material is physically removed, hence they need to be replaced. They have also discovered that different types of bacterial toxins grow on materials with high VOC levels, in comparison with natural products!

Lennart Larsson and his team have developed a new method of measuring micro-organisms in air-borne samples utilising gas chromatography-mass spectrometry, which takes advantage of the unique markers in microorganisms. This method gives highly accurate determination of the microbiological composition of air-borne organic dust and can be replicated, leading towards a standard way of testing and comparing results throughout the world. (This is a big advance on culturing dust samples will leads to inconsistent results.) This will lead to world standards in limiting values and is extremely important work.

The relative humidity of indoor air is very important, higher levels can promote mould and other pollutant growth. An interesting innovation from the Green Builder Program in Austin, Texas, which experiences high humidity, is to place humidity recorders in each room, in the same manner as temperature gauges. This allows for ease of the reading the values and a constant awareness of them. De-humidifiers are then utilised before any air-conditioning is turned on, drastically reducing the amount of air-conditioning required, and hence reducing energy use. It also inhibits the conditions that best suit mould growth.

David Kibbey, Healthy Building Consultant, Berkeley, has noted from his experience that materials need to be very sound and dimensionally stable, to prevent the ingress of moisture or particulates, over time. If they have over 20% moisture content, from whatever source, then mould will be present.

(ii) Dilution (Ventilation Improvements)

The location of fresh air intakes in ventilation systems is being carefully reviewed in existing buildings in Europe and the USA, to prevent polluted outdoor air, or returned air from the system itself, being used instead of fresher outdoor air. Also the percentage of fresh air in the systems is being reviewed, as figures from actual investigations are showing less fresh air actually making its way into building environments than originally thought. Improvements need to be made in this area of mechanical ventilation systems.

Significant new research in Scandinavia is now being conducted on the concept that the materials in HVAC (air-conditioning and ventilation) systems themselves, are a much greater source of pollutants than previously envisaged. Geo Clausen, mentioned previously, has noted that many field studies over the last ten years have found that air-conditioning and ventilation complete systems can be significant primary chemical pollution sources, other than the biological sources traditionally associated with microbiological contamination. There is a view that perhaps this is why natural ventilation systems have received fewer complaints, even though there are higher ventilation rates in the mechanically ventilated buildings.

Testing of HVAC systems for chemical and sensory perceptions is difficult, as these systems pollute the air ‘in-series’, in real life the air becomes more polluted as it travels through the different sequential parts of the system. Thus a method has been devised using the appropriate sum of the chain of individual components, also allowing for an increase in emissions over time.

It appears that ventilation criteria need to be better defined and many standards writing bodies such as CEN, ASHRAE, and DIN, around the world, are currently revising their standards for ventilation systems. The two factors causing this are energy savings requirements and indoor air quality. As previous standards were based on the number of occupants in a space (seeing these as the only source of pollutants), they need to be revised in the light of all the other pollutant sources now appreciated. New ways of calculating the required ventilation rates are currently being devised, considering all the pollutant sources. But these in turn are reliant on sufficient data on

emission rates and acceptable concentration levels from chemical and biological sources, as described in the previous section.

HVAC systems also require enhancement of their design, management and maintenance procedures. This concerns specialists in this field such as mechanical engineers and manufacturers of these elements, rather than architects directly in these fields. However, architects and practitioners need to be aware of the full implications of this area.

As David Kibbey, Healthy Building Consultant, Berkeley, explains from his experience, examining the ventilation systems in buildings, whether in home or work environments, to find the source of their problem and working out how to rectify it with appropriate consultants, is the most extensive and important part of his work.

(iii) General

There is research being conducted in Scandinavia and Denmark on the cumulative effects of toxins from various sources combining with one another. Given the myriad of possibilities in each indoor environment, the outcome of these effects are extremely difficult to quantify, however the problem itself has now been recognised. Therefore, it is wise to minimise the amount of toxins in all our environments as a preventative measure.

Various practitioners or organisations I visited, have noted that the lifestyles and activities of the people using the spaces is very important, and is one of the keys factors involved in source reduction. When people conduct hobbies that involve solvents or VOC sources, such as gluing, painting, or furniture stripping etc. this creates a new source of indoor air pollution.

Additionally, the way people choose their interior furnishings, the products they clean the spaces with, whether they smoke inside, the nature of cooking and heating appliances etc. and how they are ventilated, the way they open windows to air the house etc.- these are all sources of indoor air pollution. All these choices impact on the quality of the indoor air.

Regarding the lifestyle choices that people make in the way they clean their buildings, or kill pests, or ventilate them etc., changing these patterns comes down to a change in lifestyle, and this can take time and be difficult to do. You cannot expect people to change the way they have been living and doing things overnight!

4.2.2.2 Low-Toxicity + Ecological = Healthy Environments (Stage 2)

(i) Source Control (Pollutant Source Removal/Reduction)

This section builds on the knowledge of the previous one, and considers the additional ecological or sustainable approach to pollutant source control and improved ventilation, in addition to low-toxicity.

Building Materials

By adding the dimension of ecological consideration to healthy or low-toxic materials selection, a sustainable approach is created. This means that considering the implications on the health of the planet, as well as people, is included. Materials are analysed using the data available, for their life-cycle effects, (that is the cradle-to-cradle effects, as there is no such thing as cradle-to-grave in a closed system) for their total impact on the health of the environment. This includes the impact on the health of the workers in the production of the product.

Environmental Buildings Consultant, Lynn Simon, from San Francisco has developed innovative materials matrices and presentation methods for this purpose, which I learnt much from. These are based on agreed criteria for the health of people and the environment, against which different materials for construction of a building are evaluated. These matrices are then presented to the client, such as an architect for the final selection of the material.

As a consultant specialising in materials, Lynn devotes a lot of time to researching products to compile her matrices. One of these sources is Manufacturers Data Sheets for products. After much pressure, these are now available in the US, detailing the production and chemical composition of products. Resource Guides produced by the networks mentioned above are also very useful.

Michael Haas, of the Dutch Institute for Building Biology and Ecology, has created the very advanced TWIN-model system, which has a first layer that deals with the quantitative (or measurable) assessment of materials and products in a life cycle analysis (LCA) method. The second layer fills in the gaps in knowledge which are a problem in LCA studies, as all the data required cannot yet be sourced. Therefore the second layer consists of a double matrices system in which there is an assessment of both environmental impact and health impacts. This new system allows a far more realistic way of weighting the importance of health considerations, right through the life of a product, from the effects of its manufacture, until it is recycled. This system allows not only the comparison of building materials, but also components and even whole buildings, and has been extensively trialled. There is now a computer program based on this process, GreenCalc, which allows early assessment of the environmental and health impacts of design decisions, expressed in dollar terms of environmental costs. Such sophisticated tools will make the practitioners job much easier in the future.

Materials, Finishes and Construction

The construction detailing of the Östratornskolan by White Arkitekter, Sweden, features 80% less evaporative fluids such as glues and other adhesives to reduce this pollutant source. To achieve this they selected materials and created construction details that utilised direct fixing and required less use of these items.

David Kibbey, Healthy Building Consultant, Berkeley, has found from his experience that the roof is one of the most important elements in a healthy building, it should not allow the ingress of moisture, which can be a major pollutant source and it should be durable. The entire building construction must be detailed to be disassembled, to allow for recycling of its resources.

GASA architects in Norway have been cleverly detailing external construction for their residential projects which utilises less trades for the construction, less material use, and better regulation of moisture, humidity and ability of the wall to ‘breathe’. On top of this, their ecological initiatives in recycling and reclaiming water, active and passive solar techniques, and heat recovery have created very sustainable buildings, with low energy use and no air-conditioning required. They include user’s manuals for their proper operation of the buildings!

The American Lung Association’s ‘Health House’ project, began in 1993, utilising the skills of a consultant group of architects, building scientists, environmental health specialists and indoor air quality specialists to improve the indoor air quality of American homes, especially for sufferers of asthma. Specific performance criteria have been developed in relation to tightness of construction, ventilation methods, air pressure differentials, whole-house filtration, sealed combustion appliances, humidity control, window performance, water-proof foundations, insulation, design of houses especially in relation to attached garages and fireplaces, and interior

design products and materials. Once each house is constructed it undergoes testing for compliance. From all their research and testing their 19 completed examples in different climates, the ALA have compiled extensive data and manuals on best practice construction for different localities in the USA. This is an excellent program and is to be commended.

Daylighting/Lighting
Various projects I saw utilised clever systems for increasing the amount of daylight into buildings through innovative designs and by using light-shelfs etc., this reduced the amount of artificial lighting required. There have been various studies of health and productivity effects illustrating improvements associated with natural day-lighting in work environments. This also reduces the energy consumption, as lighting often has the highest energy use.

Internal Furnishings
Californian Interior Designer, Victoria Schomer, runs a healthy interior design consultancy specialising in selecting low-toxic furniture and furnishings, carpets, flooring products, paints and finishes. She provides a complete service from her long experience and research in this field, including design, specifications, mould mitigation and safe cleaning and maintenance programs. Her criteria include not only healthy products, but ecological or sustainable ones also. She publishes an excellent newsletter, and contributes articles and information web sites in this field also. The careful choice of internal furnishings such as floor coverings has a critical effect on the minimising the sources of indoor air pollutants.

Heating/Combustion
There is exploration of heating and combustion techniques that minimise indoor air pollution sources, as this can be a major source of emissions. These include the traditional German kachelofens, whose high temperatures ensure minimum emissions and whose radiant surfaces prevent anyone burning themself. Various successful types of underfloor heating techniques were also viewed, including hot water systems.

Personal Care/Cleaning Products
There is growing consumer awareness in the US and Europe of the health considerations of cleaning and personal care products. This change in perspective has followed on from learning about recycling and the quality of water, food and outdoor air. Thus there is a growing market for natural low-toxicity products to clean the house and for personal application, reflecting this new culture. This results in a source reduction due to emissions that would have occurred from these items.

Pest Control
Pest control has been another source of emissions, and now innovative new approaches to minimising or eliminating the need for chemical methods of pest control have been developed. Every toxic method of dealing with pests has a simple alternative that does not harm humans and works just as well! These methods have evolved from understanding the nature of the life-cycle and habits of each pest and coming up with a strategy to deal with it. There is now much literature available on this area, and organisations in the USA devoted to education and information in this area.

Landscaping
Site drainage is very important to prevent moisture ingress to the building, and prevent situations where mould and spores can occur close to the house. Landscaping may feature drought tolerant and low allergy planting, specifically designed to minimise the impact of air-borne pollen into the

building. Another factor is the height of vegetation and its proximity to the building for mould spores and to reduce daylight access into the building.

Electromagnetic Radiation
We are all now exposed to a growing level of man-made electromagnetic field radiation (EMF's), from microwaves to the 50Hz household wiring. The effects of EMF's on human health is a long-suspected, however very controversial field. It is starting to be recognised as an indoor pollution source in Scandinavia and Germany, where the most research has been conducted. Many epidemiological studies have now linked childhood leukemia with radiation from power lines, and household electrical wiring and appliances, through its suspected effects on blood cells. Other serious diseases of all ages are now also questioned in this light.

"New Zealand researchers have linked high-tension power lines - already associated with higher rates of leukemia among children - to asthma and depression in adults.
The ground-breaking research suggests that people living within 20m of high-voltage lines are three times as likely to suffer from asthma and twice as likely to have major depression. Researchers believe the danger levels drop rapidly beyond this area.
The major new study also indicates that these people have a higher incidence of diabetes and are twice as likely to suffer from immune-related illnesses such as allergies and dermatitis."
The New Zealand Herald, 12 May 1997

It is suspected that EMF's can promote illnesses such as cancer, when other factors are present such as exposure to environmental pollutants and genetic predisposition. Many measures can be taken to minimise exposure, such as minimum distances from sources of EMF's, however, it is best to have environments checked by the new specialists in the field of 'electro-pollution'.

Although there is not yet conclusive evidence in this field, it is very wise to take precautionary action. Thus Swedish Building Research is funding research in this field, and relevant Swedish authorities have been reviewing exposure levels and is limiting construction of schools and public institutions within prescribed distances from certain types of power lines.

(ii) Dilution (Ventilation Improvements)

In this context, the concept of ventilation is taken further and natural ventilation that requires a minimum of energy resource use is encouraged. The building envelope is thus viewed as a third skin for the human body, a 'breathing' or natural filter between our internal and external environments.

This is being cleverly utilised in Scandinavia and Germany via very carefully detailed building construction wall and roof elements. It requires a sophisticated understanding of the local climate and materials and the interconnection with the holistic functioning of the indoor environment. Good examples of this are the buildings designed by Dag Roalkvam of Gaia Architects, in Norway. These incorporate a balanced yet dynamic construction technique incorporating lime plaster inside and lime outside, allowing for moisture to move in or out through the construction depending on the seasonal requirements.

There is some concern over the amount of carbon monoxide levels being higher than relevant authority legislation, when only using only natural ventilation in public buildings, such as schools. This is currently controversial, and is being considered from all angles, as people tend to feel better in these environments, despite this. Additionally, the standards for designated levels in ppm of carbon monoxide were based originally on mechanical ventilation methods.

As David Kibbey explains from his experience, air-pressure differentials between inside and outside may cause a building to suck pollutants in through any cracks in the building envelope. It may even cause possibly polluted air from other locations such as the roof space, to be sucked into the interior spaces. Establishing whether there are air pressure differential problems, is one the most important parts of his work.

Bill Browning of the Rocky Mountain Institute, and others are now referring to the concept of 'thermal monotony'. The human body has evolved to appreciate the subtle changes in air temperature and breezes etc. of the natural environment and hence people do not like constant artificial environment temperatures at work all day. This is being reflected in how work environments are being designed for ventilation.

Following on from this is the new concept is the idea of the personal 'breathing space', in the design of work environments for ventilation. Each person has their own floor vent via which they can control the temperature and rate of air-flow from for their own comfort throughout the day. Access floor systems that have plenums for fresh air, allow great flexibility for vent locations. This combined with work-stations located within minimum distances of openable windows, gives people in these environments control back over their thermal comfort and ventilation preferences.

(iii) General

Lifestyle and Cultural factors
The concept of smaller buildings, ie the idea of how much space to we really need for a good quality of life is being examined by architects such as Carol Venolia, Santa Rosa, California. Smaller houses use less materials, and have smaller spaces to heat and cool, and therefore use less energy. It requires less cleaning and maintenance. Smaller houses require people to consider how they really live and what they really need, and hence prioritise. Often even in a large house people may only really use a few rooms for almost all their daily activities. This idea is gaining a following throughout the world, as we re-examine the way we really live and the resources we need to sustain this.

The Swedish Building Research's 'Healthy House' Project has been considering the impact of diet, our cleaner lifestyle's effect on the immune system, vaccinations early in life, and the way people live generally, in assessing the rise in health problems in their research on how we should build 'healthy houses'. There are so many factors to be considered to fully understand the problem. This is evidenced by studies of illness rates (eg. asthma and allergies) in comparison with the factors listed above. For example, in West and East Germany before and after re-unification, and by the Swedes in relation to comparison of their population with similar climate locations on the Baltic Sea in Russia. These populations not living in a traditional 'western' cultural sense, have shown lower rates of asthma and allergies, until their lifestyles have changed.

It is obvious from looking at this concept in various countries and cultures that the culture of a location has a very great bearing on what is considered good indoor air quality and what the interpretation of a 'healthy' indoor environment.

New approaches to the process
Pliny Fisk at the 'Center for Maximum Building Potential, Austin, Texas, has been developing very innovative mapping techniques for understanding the interdependent relationships between all areas of the community. This includes consideration of health and environmental factors, within local frameworks of networks of information and resources. It is an advanced form of life-cycle analysis, which considers all the economic and cultural variables. This method produces

local maps consisting of representative icons to identify all the resources of the area and their inter-relationships. Doing this, allows people to make the leap to understand the implications their everyday decisions have on the health of the environment, they see the consequences! This was the foundation of the Green Builder Program in Austin, Texas.

Croxton Collaborative Architects have created a highly developed approach to ecological and healthy building design, which incorporates extensive research into all aspects of the project. The site, locale and region is explored, the site's bio-diversity, history and endangered species are recorded, mapping is done in a similar way to Pliny Fisk's work, even cultural, environmental and historical factors are evaluated to give a complete picture of the situation to minimise any negative effects from the project. They work in a multi-disciplinary manner with architects, planners and interiors specialists for the entire project. They simulate energy modelling, optimise the financial burden of the project and provide clients with a maintenance schedule. This rigorous approach has created a very high standard of well-respected work in this field, such as Audobon House in New York.

Ecological approach – Resource use minimisation
Varis Bokalders, Swedish ecological architect, noted that once a major Swedish building firm started to do only ecological building work, this raised the general awareness, and forced everyone else to do likewise! Government financial incentives for creating housing which use energy below a certain level, has also been very helpful. This has also been applied very successfully to appliances, so that fridges are now using 23% of the energy they required previously, and washing machines only 10%!

The Swedes have been pioneering toilets to minimise water use and have reduced toilets from 12 litres per flush to a dual-system using 4 litres or 2 litres. They have also developed urine separating toilets (4 litres, 0.2 litres) and vacuum toilets (0.1 litre), which use even less water!

Deconstructing buildings rather than demolishing them is becoming more common, and allows a much greater level of material reuse. Recycling on construction sites for waste minimisation is now mandatory in some places. Incorporating permanent recycling systems of bins and shutes etc. is becoming inherent in the design of buildings. There are also reclamation programs now in the USA, where manufacturers of products agree to take back their carpet etc. at the end of its life, for recycling into new products, to minimise waste.

4.2.2.3 Low-Toxicity + Ecological + Life-Enhancing = Healthy Environments (Stage 3)

(iii) General

This section builds on the previous two, and assumes that low-toxicity and ecological methods are being utilised already, however, it takes these healthy environments one step further.

The concept of creating indoor environments that are in some way life-enhancing is a difficult concept to quantify in any objective sense. However, people know when they find an environment that they find uplifting, something which satisfies the human spirit in some way. This ideal, is the same ideal for which architecture has traditionally strived for. Therefore it is not unreasonable to consider, that when you combine this concept with the idea of low toxicity and ecological concepts of indoor air quality, you create a 'healthy' environment at the highest level.

This is concept is illustrated by the late Swedish architect, Eric Asmussen's 'Vidar Clinic' in Järna, Sweden. This building is known as a 'healing hospital'. It combines carefully designed patients rooms with wonderful daylight and views, which have very carefully and subtly designed

colour schemes according to the nature of the patients illnesses. There are spaces for different types of social interaction, careful ventilation, and rooms for music, movement, sculpture and painting, massage and baths as remedial therapy by the patients. This hospital has created an atmosphere unlike any other hospital I have ever visited, one that people instinctively feel promotes well-being, when they are not well.

"*Great effort is being made to promote the highest possible life quality in every area of treatment at the Vidar Clinic. Beautiful architecture and colouring as well as natural materials in the interior decoration of the rooms are examples of artistic values that have a therapeutical effect."*

Brochure, 'Facts about the Vidar Clinic', Vidarkliniken, 1999

Tom Bender, architect and Feng Shui practitioner, Nehalem, Oregon, has also been creating buildings that relate to the natural rhythms of their environments, and are ecological and healthy also. They are buildings that are very balanced and harmonious, to which people respond extremely well. He has published 'The Izu Principles' for Sustainable Communities, which consider equity, security, sustainability, responsibility, giving and sacredness- these have been adopted by various organisations throughout the USA. He looks at fine-tuning the aesthetics and physical expression and the natural patterns of a place, to enrich its abilities to resonate with our hearts and our lives. This is truly creating healthy environments.

In the USA, researchers such as James Wines have coined the term 'green building benefits'. This is to try and qualify and quantify the benefits that have resulted from 'green' or ecological buildings, in which the by-products of designing buildings in this way, have been greater productivity, less absenteeism and a general sense of 'well-being' for the people using them. Wines and others have been conducting very interesting research based on this concept, and have been trying to understand the implications to people's health of connecting them back with their natural environments, eg to views of nature, with natural ventilation and good daylighting. Recognition of people's circadian rhythms, in tune with the natural environment in which they evolved, is reflected in the design of healthy and ecological indoor environments, and is reflected in the studies of the users of these spaces. Concepts such as the 'personal breathing space' mentioned earlier obviously have a psychological component, people feel better and work better, when they have control and can meet their individual thermal comfort needs. Further research is now being conducted in this area of life-enhancing 'green' buildings.

German architect, Joachim Elbe's innovative Ökohaus building, in Frankfurt, is another excellent example that illustrates these concepts. The building contains office spaces, printing works, a publisher and a restaurant. The core of the building, is surrounded by carefully orientated and designed greenhouses, full of plants and the soothing sound and visual effect of flowing water. Natural materials, and a complex system of air circulation, and solar and water systems, ensures a healthy and ecological environment. The building is akin to a living organism, the interaction of its systems being so finely tuned and interconnected. The close relationship with the natural environment and its rhythms, and the nature of the beautiful internal spaces, have created a building which is truly life-enhancing.

Joachim Elbe is a proponent of building biology, as he states:

"Building biologists believe that we can only improve our living conditions and help our environment to recover if human beings are also able to learn afresh in the way they relate to both their life conditions and their physical and psychological capacity to experience. Stimulating and fostering the senses, such as touch, sight, smell can contribute towards the

development of our psyche when linked with an imaginative approach to design, as well as the use of colour and lighting."

Joachim Elbe in 'Designing Ecological Settlements', Magrit and Declan Kennedy (ed.s), 1997

The HAG company head office in Oslo, is their centre for furniture manufacture, including their wonderful chair made from recycled bottle-top lids. (These items had no previous application in recycling, and so this is a good use of resources). This office has been recently refurbished and is an excellent model for offices of the future. The design has good indoor air quality and is sustainability based, however it goes beyond this to create a life-enhancing place to work.

Apart from the progressive company policies that allow staff extremely flexible working times whether in the office or at home, the whole office has been designed to be a good environment to work in. There is a progression of welcoming spaces from the public to the private areas. The spaces are designed to allow both privacy and interaction and views to greenery outdoors, and permanent low-key interaction spaces. Everyone has original art-pieces in their offices and can sit down to together to eat the healthy lunch provided.

Furniture is fully ergonomic, allowing a range of working heights for people to change position for different tasks, and through the day, as it is best for the body to naturally do. There are sofas for resting when people are tired, so they can continue working. Two o'clock each day sees each department stop and have coffee together for half an hour to discuss work or whatever they like! People are loyal because there needs are met, and absenteeism is down, profits and productivity are up. It is an office that meets a higher need, where people feel they have a supportive environment on all levels.

4.2.3 General trends

(i) Education and Awareness

As discussed previously, the overall trend in this field is for increased awareness and education for everyone in the community. This serves two functions to educate the general public and the construction industry on indoor air quality. Awareness of the concept is growing, as illustrated by the increased media coverage.

(ii) Specialist skills

As this field emerges there are now specialised consultants emerging with different skills related to indoor air quality and healthy and ecological building design, in materials selection, education, and healthy building consultation. Generally within the construction industries in the different countries, engineers, product manufacturers and builders are all increasing their knowledge in the field so that they can contribute to it, and work in this new way.

Marsha Maytum of Tanner, Leady, Maytum, Stacy architects has demonstrated in her project for the Thoreau Center for Sustainabilty, that it is possible to conserve an existing heritage building, while at the same time creating an ecological and healthy building – recycled for a new use. This is the ultimate resource saving measure, to recycle a whole existing building. She believes that mostly what is required is a common-sense approach and that ecological and healthy building design will soon be the norm in architectural practice, rather than the preserve of specialists.

(iii) Inter-disciplinary approach

There is a growing trend for inter-disciplinary work, as evidenced by the 900 delegates from many different field attending the 'Indoor Air 99' International Conference in Edinburgh this year!

Inter-disciplinary research is also evidenced by 'The Healthy Building' project in Sweden which combined professional in the diverse fields of health care, allergy, agricultural sciences, climate and energy, housing research, ventilation, and the building industry etc. to try and find an answer to why we don't have healthy buildings yet! Other examples include the ALA's "Health House' approach, involving many specialists, the combined agencies/organisations running the National Education programs in the USA and Sweden, the European Database on Indoor Air Pollution Sources in Buildings, and the International Centre for Indoor Climate and Energy in Copenhagen.

This trend is apparent in the all networks being set up in the field, the make-up of the US Green Building Council, and the AIA's open 'Committee on the Environment' for the construction industry in Portland, Oregon. The nature of the problem of indoor air quality arising from the design of the built environment, is so extensive that it requires many specialists to join together and pool their resources for the benefit of communities everywhere.

5.0 CONCLUSIONS

Indoor Air Quality in relation to the design of the built environment, is a very important field, and one which can greatly influence the health of the community. Indoor air pollution is a serious problem, and one which has often gone unnoticed in the past.

Education and awareness are very much required in this field to combat this problem, both for the general public and for the construction industry as a whole, to provide better environments for people to live, work and play. There are many things that the public can do, once they are aware of them, to improve their indoor air quality generally, and many the construction industry can do too, specifically for the built environment.

A concerted program to tackle every facet of this problem is required as soon as possible, to improve the quality of life of the Australian community.

There are a diverse range of approaches throughout best practice in the world to this problem. However, in relation to the design of the built environment, they can be summarised as follows:

(i) Source Control

- Reduce or remove all known pollutant sources, chemical, biological and sensory.
- Especially reduce moisture levels in buildings to acceptable levels.
- This involves keeping up to date in developments on what are pollutant sources, their emission rates over time, and acceptable levels of concentrations. This is where so much work in the world is being concentrated.
- New methods of testing indoor air spaces for pollutant levels and their cumulative effects are also critical.
- Base materials, finishes etc. choices on low-toxicity (health) and ecological (sustainable) principles, ie consider the broader picture of total environmental health.

(ii) Ventilation Improvements (Dilution)

- Ensure ventilation rates meet new standards, for all pollutant sources.
- Carefully consider natural ventilation options for which people have control over their own comfort, supplemented with the least polluting sources of mechanical ventilation, as required.

(iii) General

- Consider lifestyle and cultural factors on indoor air quality in the design of the built environment.
- Consider ecological imperatives generally, such as minimum energy use and sustainable principles.
- Be aware of the latest approaches to achieving good indoor air quality, such as new tools or processes.
- Be aware of the best way to source information on the area.
- Consider the aspect of 'life-enhancing' qualities, such as natural daylight, colour, sound, aesthetics etc. in creating healthier environments.

5.1 Dissemination

I propose to disseminate this knowledge as widely as I can, through many different channels. In the short term, they include: setting up a web site, giving lectures at relevant functions and conferences, writing more detailed papers, and submitting articles to be published. I am facilitating the sharing of information and consultation with interested members of the building industry, and organisations with an interest in health and buildings. I am currently exploring other innovative ways in which the information can be distributed.

In the longer term, I would like to initiate a Network, to share information in this field. However, my vision is to create a 'Healthy Buildings' Centre, where people can experience a real working example of healthy and ecological construction. This would allow displays of healthy and ecological products, access to all types of relevant information, including a list of practitioners and associated services, and courses at different levels to be provided to the community.

5.2 Summary

The health system costs the Australia community $22 billion per year. Even if only a small proportion of illnesses could be attributed in part to indoor air quality, it is a cost-effective primary preventive health measure to design healthier buildings, based on the latest information from around the world. Some commentators in this field have said that the indoor environment may exert the single biggest modifiable influence on the health of the community.

I strongly feel the Australian community deserve to have healthier homes, workplaces and schools in which to live, work and play. Given the health implications of indoor air quality, and the strong effect the design of the built environment has on this, it is plain common-sense to design healthier buildings, based on all the information we currently have!

6.0 RECOMMENDATIONS

I can help to bring about improvements in Australia through the raising of education and awareness, as well as the implementation of knowledge through built examples demonstrating the role of the built environment in indoor air quality. These concepts can be achieved as discussed in the above section through lectures, articles, a web site, working with practitioners and relevant organisations and perhaps in the future establishing a 'Healthy Buildings' Centre.

The only drawback is that these measures are necessarily centred in my local community of Adelaide and in South Australia generally. I strongly believe there are many further improvements that should be made at a national level in Australia, and I would like to contribute to them in anyway possible. These include the following:

(i) National Education and Awareness Campaign

As discussed, there are good examples of these in Sweden and the USA, on which our national program could be based, benefiting from their methods, experience and successes. A national program for Indoor Air Quality is vital to our standard of living in Australia.

(ii) Prominent National Body responsible for Indoor Air Quality

A national body with prominent jurisdiction over this important field is definitely required, even if it is within an existing set-up or Department. The functions it needs to carry out include:

- A co-ordinated program of testing and evaluating of Australian IAQ levels in homes and workplaces
- Analysis of Australian IAQ levels in relation to international evidence, and directing research as required
- Co-ordination of the National Education and Awareness Program
- Co-ordination of dissemination of information between relevant bodies, and co-ordination of multi-disciplinary efforts
- Advice to Building Construction Industry including mandatory requirements, changes to standards, codes or legislation etc.
- Healthy buildings advisory service, and national list of practitioners, consultants and testing authorities and procedures
- Mandatory requirements for Manufacturers to supply data sheets, listing the chemical constituents in their products and their manufacturing processes

We need to act as soon as possible, to raise the awareness and education on indoor air quality in general, and in relation to the design of the built environment, for the benefit of the Australian community.

Disclaimer

This report is a summary of some information in this field, and is not a guide for improving indoor air quality through specific changes to the design of the built environment. Any action in relation to the general information contained in this report, should not be carried out without appropriate professional advice. Liability is disclaimed by the author and anyone associated with the report, for all loss suffered by any person acting or relying on information in this report, whether resulting from the negligence of the afore mentioned or any other cause whatsoever.