Sustainable Sub-divisions: Ventilation Data Monitoring

Report 2002-077-B-02

Anne Miller, Fanny Boulaire and Michael Ambrose

The research described in this report was carried out by

Project Leader	Anne Miller
Team Members	Michael Ball, Fanny Boulaire, Helen Caswell, Angelo Delsante, Nur Demirbilek, Robin Drogemuller, Guy Gibson, Medha Gokhale, Daniel Grunbaum, Danny O'Hare, Rosemary Kennedy, Anne Miller, David Paterson

Research Program: B

Program Name: Sustainable Built Assets

Research Project No: 2002-077-B

Project Name Sustainable Sub-divisions Ventilation

Date: December 2006

Distribution List

Cooperative Research Centre for Construction Innovation

Authors

Disclaimer

Please direct all enquiries to:

Chief Executive Officer

Cooperative Research Centre for Construction Innovation

9th Floor, L Block, QUT, 2 George St

Brisbane Qld 4000

AUSTRALIA

T: 61 7 3864 1393

F: 61 7 3864 9151

E: enquiries@construction-innovation.info

W: www.construction-innovation.info

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

AGO	Australian Greenhouse Office
BCA	Building Code of Australia
BLL	Bovis Lend Lease
BoM	Bureau of Meteorology
BV/C	Brick veneer/concrete floor
BV/C+T	Brick veneer/concrete + timber floors
CBD	Central Business District
CO_2	Carbon dioxide
CRC CI	Cooperative Research Centre for Construction Innovation
CSD	Centre for Subtropical Design
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DB/T	Double brick/timber floor
DoH	Department of Housing
EER	Energy-efficiency regulations
GHG	Greenhouse Gas
GIS	Geographic Information Systems
ISS	Integrated Sensor Suite
LW/T	Lightweight/timber floor
m	Metre
m^2	Metres squared
MJ/m^2/annum	Mega joules per metre squared per annum
OUM	Office of Urban Management
PC	Personal computer
PIFU	Planning Information & Forecasting Unit
QDPW	Queensland Department of Public Works
QUT	Queensland University of Technology
SEAV	Sustainable Energy Authority Victoria
SEDA	Sustainable Energy Development Authority
SEQ	South East Queensland
SIM	Sensor Interface Module
SLA	Statistical Local Area
SOHO	Small Office Home Office
WAH	Work at Home

PREFACE

A major project in the Sustainable Built Assets core area is the Sustainable Sub-divisions – Ventilation Project that is the second stage of a planned series of research projects focusing on sustainable sub-divisions.

The initial project, Sustainable Sub-divisions: Energy focused on energy efficiency and examined the link between dwelling energy efficiency and sub-divisional layout. In addition, the potential for on site electricity generation, especially in medium and high-density developments, was also examined. That project recommended that an existing lot-rating methodology be adapted for use in SEQ through the inclusion of sub divisional appropriate ventilation data. Acquiring that data is the object of this project.

The Sustainable Sub-divisions; Ventilation Project will produce a series of reports. The first report (Report 2002-077-B-01) summarised the results from an industry workshop and interviews that were conducted to ascertain the current attitudes and methodologies used in contemporary sub-division design in South East Queensland.

This report (Report 2002-077-B-02) describes how the project is being delivered as outlined in the Project Agreement. It includes the selection of the case study dwellings and monitoring equipment and data management process.

The next report, due in December 2006, will provide early findings through an analysis of the data analysis for winter 2006.

A fourth report will provide an analysis and review of the approaches recommended by leading experts, government bodies and developers throughout Australia that aim to increase the potential for passive cooling and heating at the subdivision stage. This data will inform considerations ahead of the development of the enhanced lot-rating methodology. At this stage, this report is due in March 2007.

The final report, due in June 2007, will detail the analysis of data for summer 2007, leading to the development and delivery of the enhanced lot-rating methodology.

EXECUTIVE SUMMARY

Australia's current pattern of residential development is typified by relatively low-density subdivision of land and highlights the necessity for development to be more sustainable to avoid unnecessary demand on natural resources and to prevent environmental degradation and to safeguard the environment for future generations. What role can climatically appropriate sub-division design play in decreasing the use of energy required to cool premises by maximising access to natural ventilation? How can this design be achieved?

Background

The sub-division design stage is critical to urban and suburban sustainability outcomes, as significant changes after development are constrained by the configuration of the sub-division, and then by the construction of the dwellings. Existing Australian lot-rating methodologies for energy efficiency, such as that by the Sustainable Energy Development Authority (SEDA), focus on reducing heating needs by increasing solar access, a key need in Australia's temperate zone. A recent Cooperative Research Centre for Construction Innovation (CRC CI) project, Sustainable Sub-divisions: Energy (Miller and Ambrose 2005) examined these guidelines to see if they could be adapted for use in subtropical South East Queensland (SEQ). In this region, solar access for heating is less important and orientating lots to increase access to natural ventilation to reduce energy used to cool dwellings is becoming increasingly important. In Queensland, the incidence of residential air-conditioning was predicted to reach 50% by the end of 2005 (Mickel 2004). Setting aside the social reasons for this increase, the question remains

> *What role can climatically appropriate sub-division design play in decreasing the use of energy required to cool dwellings by maximising access to natural ventilation?*

Examining a range of recent sub-divisions, the project found that although sub-divisions with larger lots (defined as being over 560M²) could achieve the lot-rating guidelines, the increasingly prevalent smaller lot-size sub-divisions were not achieving the desired outcomes. Correlating the lot-ratings with dwelling ratings, the project found that the existing lot-rating guidelines would need to be modified for use to make allowance for natural ventilation. But what is currently known about the availability of natural ventilation in our increasingly densely constructed urban environments?

All available ventilation data relies on Bureau of Meteorology (BoM) data that is collected on large open, unobstructed spaces such as airports, or on the tops of buildings, as the aim is to measure unobstructed air movement. Ventilation data for suburban and urban (that is, for increasingly obstructed) areas, does not exist. AccuRate does have external shielding settings that are based on expert interpretation of the BoM data. Using AccuRate to model a range of 'what if' scenarios to mimic more densely constructed urban areas revealed that the energy required to cool dwellings in these settings were similar to that achieved by altering the orientation alone. A worst case combination of poor orientation and close external structures, potentially added another 30 per cent to the energy required to cool the dwelling. So this closer examination of the case study dwellings has revealed that in order to apply a ventilation factor to the existing methodology, the role that natural ventilation (or breezes, or air movement) can realistically play in passively cooling dwellings required further investigation.

Sustainable Subdivisions: Ventilation

This report sets the scene for the examination of ventilation in a range of suburban settings throughout SEQ. This examination will quantify – and either verify or challenge – the importance of orienting for ventilation in sub tropical climate zones. It will quantify the link

between sub-divisional layout, access to natural ventilation, external and internal temperatures to inform the development of a lot-rating methodology for use in sub tropical climates. It is also expected to recommend that the existing lot-rating methodology be amended to allow for ventilation as all areas have the potential to be passively cooled in summer.

Objective

The objectives of the project are to:

- Acquire the data identified in Sustainable Sub-divisions: Energy Project and thereby;
- Quantify, and verify or challenge the role natural ventilation has in cooling residences in sub tropical climates; through monitoring wind speed and direction in a range of sub-divisional settings throughout SEQ
- To establish the degree of degradation in natural ventilation imposed by increasingly densely constructed suburban environments
- Compare this data with BoM monitoring stations in SEQ
- Apply a ventilation factor to the existing lot-rating methodology; and
- Thereby develop a lot-rating methodology for use in SEQ.

The project may also make a recommendation that the existing lot-rating methodology in use in other parts of Australia be modified to allow for the impact of ventilation as all areas have the potential for passive cooling in the warmer months. The project may also inform the ongoing development of thermal modelling programs.

Engaging industry – a workshop and interviews

In sub tropical SEQ, everyone 'knows' to orient dwellings for ventilation. How this knowledge is embedded within current sub-division and dwelling design was the subject on the first report for this project. That report summarised findings from an industry workshop and interviews and found that, due to the complexity of the development process, while ventilation is considered; competing pressures make it a low priority. Disturbingly, the report also revealed concerns that knowledge of climatically appropriate design appears to be diminishing at all levels within the industry.

These findings are not a criticism of current practice, rather an attempt to inform discussions with the realities facing planners and regulators and developers as they plan to accommodate an increasing population. There is an urgent need to ensure that vernacular knowledge regarding appropriate design options are researched (quantified) and embedded within the increasingly regulatory framework that seeks to eliminate worst practice.

Case study dwelling lots

Sustainable Sub-divisions: Ventilation will continue to focus on sub tropical SEQ as this is a growth area for residential development in Australia. It is also a practical choice based on the need to locate the dwellings close to the principal researcher. The dwellings are owned and occupied by staff from the Project Partner Organisations, who agreed to equipment installation, and to collect and transmit the data on a regular basis (fortnightly) for a period of up to a year. Restricting the pool of volunteers to those already associated with research ensures they have an understanding of the commitment required. Participation is voluntary and is covered by a letter informing all the registered homeowners that the CRC CI will not be responsible for claims related to dwelling damage or occupant injury.

There are insufficient resources for this project to install and monitor dwellings outside this area, but as all climate zones throughout Australia have the potential for passive cooling through natural ventilation in summer, the findings will be analysed within in this wider context.

Data collection system

Wind speed and direction and external temperature data will be collected at approximately 2.5 metres above the ground, which is an approximate height to capture outside air moving past tell fences and entering dwellings through windows and doors and potentially cool the interior. This data will be compared with data from the BoM and the differences analysed. Internal temperatures will also be recorded and compared against the lot temperature and then the BoM data.

'Off-the shelf' weather station monitoring equipment is being used to collect and store the data. Utilising a system used and recommended by other researchers kept selection, purchase, installation and monitoring costs to a minimum. The equipment was designed to be affixed to the outside of the dwelling – on eave, roofline or similar. However this had potential to increase project costs with repairs and repaints being required when the equipment is removed. Instead, a simple free standing pole installation process was devised to reduce potential damage to the dwellings and to make repositioning the equipment easy if that is required throughout the monitoring period. The equipment is at slightly greater risk of theft, but this has been balanced by placing the equipment in reasonably secure areas such as in fenced areas to the rear of the property. Theft and damage (accidental or otherwise) of the equipment is the greatest threat to the project.

Next steps

The data collection phase commenced on 1 April 2006 and will continue for up to a year. This phase involves the collection, analysis and interpretation of ventilation data acquired through monitoring a range of typical sub-divisional settings in SEQ. The aim of this Phase is to quantify the degradation in wind speed and direction between Bureau of Meteorology (BoM) sites and a variety of dwelling sites and types through monitoring of wind conditions in SEQ. It will quantify, and verify or challenge, the potential natural ventilation has in passively cooling residences in sub tropical climates.

The most critical period is the summer period from December 2006 to February 2007. The data will be used to enhance the existing lot-rating methodology identified in Sustainable Sub-divisions; Energy by including ventilation parameters. This data may also highlight the need for the existing methodology to be modified as all regions throughout Australia have the potential for passive cooling in summer. It is also expected to highlight the increasing need for expert design in urban and suburban areas where the lot size is predetermined and external ventilation barriers (in terms of existing structures and established vegetation) are established.

This report is the second of a series of progress reports for this project. The next report will provide early findings by examining the data analysis of the winter period.

1. INTRODUCTION

This report is a component of the Cooperative Research Centre for Construction Innovation project 2002-077-B Sustainable Sub-divisions: Ventilation. This project is the second of a multi-stage sustainable sub-divisions project theme and focuses on the energy performance of sub-divisions by examining the correlation between lot orientations and dwelling efficiencies in terms of the energy required to heat and cool premises in sub tropical SEQ.

The project consists of three discrete phases.

- Phase One, the consultative phase, was conducted and resourced through Queensland University of Technology (QUT) and the Centre for Subtropical Design (CSD). It involved a workshop and interviews with industry stakeholders, carried out to determine the importance practitioners apply to designing for ventilation to create climatically appropriate sub-divisional settings in subtropical SEQ. This has been an essential part of the research, invaluable to understanding the current knowledge base and practices of professionals actively engaged in sub-division design.
- Phase Two, data collection and analysis, is being conducted by CSIRO in Queensland and Victoria. It involves the selection of case study lots and monitoring equipment and the collection, analysis and interpretation of ventilation data acquired through monitoring a range of typical sub-divisional settings in SEQ. The aim of this Phase is to quantify the drop (degradation) in wind speed and direction between BoM sites and the dwelling lots. It will quantify, and verify or challenge, the role natural ventilation realistically has in passively cooling residences in sub tropical climates. The outcome of Phase Two will be the development of an enhanced lot-rating methodology.
- Phase Three, delivery, will be conducted through QUT and the CSD. It will involve a workshop to deliver the proposed lot-rating methodology to industry professionals engaged in sub-division design in SEQ.

1.1 Objectives

The objectives of the study are to:

- Acquire the data identified in Sustainable Sub-divisions: Energy Project and thereby
- Quantify and verify or challenge, the role natural ventilation has in cooling residences in sub tropical climates; through monitoring wind speed and direction in a range of sub-divisional settings throughout SEQ
- To establish the degree of degradation in natural ventilation imposed by increasingly densely constructed suburban environments
- Compare this data with BoM monitoring stations in SEQ
- Apply a ventilation factor to the existing lot-rating methodology; and
- Thereby develop a lot-rating methodology for use in SEQ.

The project may also make a recommendation that the existing lot-rating methodology be modified to allow for the impact of ventilation as all areas have the potential for passive cooling in the warmer months. The project may also inform the ongoing development of thermal programs.

1.2 Project Partners

The partners involved in this research project were:

CSIRO Manufacturing and Infrastructure Technology

Queensland University of Technology including the Centre for Subtropical Design

Queensland Department of Public Works

Lend Lease Communities

Brisbane City Council

1.3 Key Assumption

The key assumption behind this research is that there is an expanding market for information on energy efficient sub-divisional practices. As energy efficiency regulations increase, this need will grow and create significant demand for information on available assessment tools for creating sustainable sub-divisional layouts (orientation, solar access and the like), rating energy efficient designs and products that deliver energy efficiency (solar technology).

2. BACKGROUND

Australia's current pattern of residential development is typified by relatively low-density subdivision of land and highlights the necessity for development to be more sustainable to avoid unnecessary demand on natural resources and to prevent environmental degradation and to safeguard the environment for future generations. This becomes more apparent when noting facts such as:

- Australia's per capita consumption of space (floor space, private open space), energy and water rank among the highest in the world and are continuing to increase
- Australia's per capita waste streams rank among the world's highest; and
- Australia's metropolitan planning and development strategies deliver poor environmental outcomes in relation to energy production and consumption and CO_2 emissions, with rapid growth in vehicle kilometers travelled and low take-up of distributed or solar energy in suburbs.

2.1 Planning for growth

As our cities expand, developers are transforming more and more land to create future suburbs. Developers and government bodies have the opportunity to design suburbs that are not only great places to live, but are also environmentally sensitive and sustainable. A sustainable approach is essential, in order to avoid unnecessary demand on natural resources, to prevent environmental degradation and to safeguard the natural and built environment for future generations.

At this suburban level, change is occurring across Australia. Energy-efficiency regulations (EER) are mandatory for new residential dwellings. Whilst the performance levels differ from state to state, a brief examination of trends throughout Australia reveals that once EER provisions are adopted, they tend to;

- Increase in rigour – in Victoria the star rating for new dwellings has increased from 3 stars in 1991 to 5 stars in 2004;or
- Increases in range – in the Australian Capital Territory, all dwellings are rated at point of sale – capturing the existing market.

A 'business as usual' approach is no longer appropriate for dwelling designers. But what about sub-division design? In 1999, the Australian Greenhouse Office noted in its Report, Australian Residential Building Sector Emissions 1990-2010,

> *Should it be decided that new housing stock will be required to meet more stringent thermal performance standards, then the need for land sub-division design to address the issue of solar access and building orientation will be a necessary adjunct to such a program. (AGO 1999)*

This suite of projects focuses on the sub-division design as significant retrofitting after development to improve dwelling EER's – or any other sustainable outcome - is constrained by the configuration of the sub-division, by the construction of the dwellings and by the changes that occur as suburbs mature.

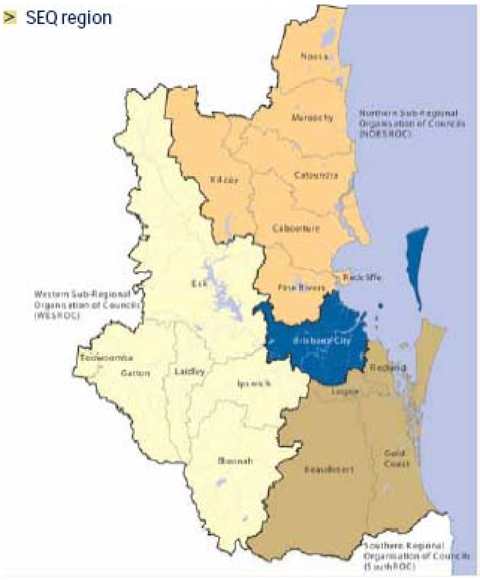
2.1.1 Residential Growth in South East Queensland

The preceding research project, Sustainable Sub-divisions: Energy delineated SEQ as its research area as that is the fastest growing region in Australia. In this subtropical region, regulators and developers plan to house an increasing population. This region has:

- Experienced sustained population growth since the 1980s
- is growing by an average of 55,300 persons each year; and
- requires some 575,000 new dwellings to be constructed by 2026 (OUM 2005).

The region, shown in Figure 2-1, encompasses eighteen local governments, and extends from Brisbane north to Noosa, south to the New South Wales border and west to Toowoomba.

Figure 2-1 South East Queensland Region



Source: (Office of Urban Management 2004)

Source: Google earth , 2006

In response to a coastal subtropical climate with warm humid summers and mild winters, SEQ had developed vernacular dwelling styles that differ from the more populous and cooler southern states. But the pattern of dwelling design and settlement throughout the region is rapidly changing. As the population increases, mountains to the west of the region limit the amount of flat land available for residential development, forcing developers, designers and builders to adapt to an increasing number of sloping lots.

Looking ahead, there will be a greater demand for a diversity of housing forms to match the needs of changing household structures, particularly an increase in one and two person households across all adult ages (Office of Urban Management 2004). Additionally, the South East Regional Plan has recommended changes to the development patterns in SEQ by 'promoting a more compact form of development' (OUM 2005). The Plan also requires

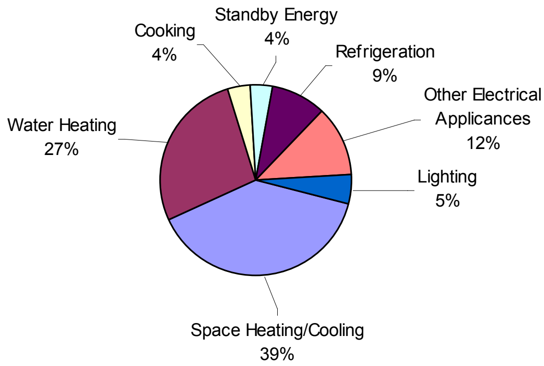
> *There is a substantial national trend towards increased energy efficiency. Despite this, the orientation, siting and design of buildings to respond to local climatic conditions are largely neglected. (and)…ensure that all new development incorporates subtropical design principles, including orientation, siting and passive climate control (OUM 2005).*

These factors combine to place different pressures on regulators, developers and dwelling designers from those faced by their southern counterparts and require innovative responses that address the subtropical climate, lifestyle and amenity.

2.1.2 Increasing residential energy consumption patterns

The use of energy in the dwelling is the largest source of greenhouse gas emissions from Australian households. The average household's energy use is responsible for about eight tonnes of CO_2 the main greenhouse gas, per year (Reardon 2001). Figure 2-2 shows the typical Australian breakdown of energy consumption within the dwelling and shows that space heating/cooling and water heating dominates the energy use profile. Reducing a dwellings need for such energy or seeking alternative renewable means of energy for these areas will greatly reduce Australia's overall environmental impact and greenhouse gas production.

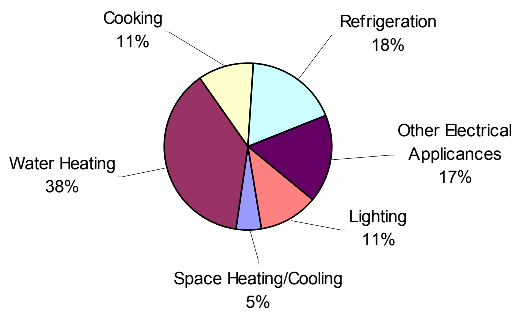
Figure 2-2 Australian household energy use



Source: (Reardon 2001)

Energy use in Queensland is quite different from the pattern for the rest of Australia. Figure 2-3 shows that in Queensland, the single biggest consumer of energy in the dwelling is heating water rather than rooms (Queensland Conservation Council 2004).

Figure 2-3 Queensland household energy use

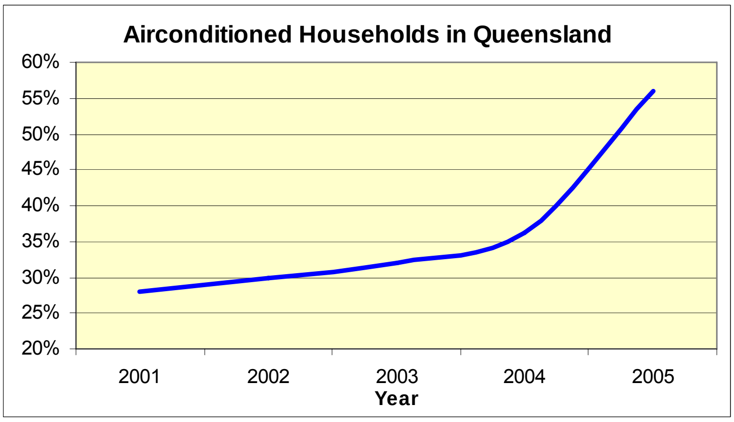


Source: (Queensland Conservation Council 2004)

Energy use could be significantly reduced with the widespread adoption of solar hot water systems, which in Queensland are able to deliver up to 90 % of a household's hot water requirements without the need for fossil fuel energy.

Figure 2-3 also shows that heating and cooling energy accounts for only five per cent of the total, compared with 39 per cent as the Australian average Figure 2-2. This difference is due to the sub tropical climate where the need for air-conditioned spaces should be minimal. . While the percentage of energy used to cool dwellings is small compared to the 'southern' figure for heating and cooling, savings in this area are still important. In any event, this percentage is set to increase as Queenslanders install air-conditioning at an increasing rate. In Queensland, residential air-conditioning was forecast to reach 50 per cent of dwellings by the end of 2005 (Mickel 2004).

Figure 2-4 Percentage air-conditioned households in Queensland



Source: (Mickel 2004)

Although air-conditioning accounts for a fraction of total household energy use, its main impact is on increasing peak demand for electricity and it is this demand that drives requirement for any new or additional generation, transmission and distribution infrastructure (Queensland Government 2004). While figures for 2006 are not available, informants at an industry workshop held earlier this year, confirmed consumer expectation for air-conditioned dwellings;

> *The house and land packager argued that they can no longer find buyers for non-air conditioned houses, particularly as there are no price signals to deter the installation and use of air conditioning (O'Hare, Kennedy et al. 2006).*

Interestingly, other reports (Queensland Government 2004) show space heating and cooling 10 per cent, perhaps already reacting to this increase in air conditioning.

2.2 Rating sub-division design to improve energy efficiencies

Energy-efficient sub-division design is concerned with manipulating the key variables of aspect, shape and density with site or lot characteristics such as topography and slope, to achieve an optimal mix of lot sizes, appropriately oriented for solar and ventilation access. When lots are correctly aligned and proportioned, individual energy-efficient houses, with good solar access, can more readily be provided. So across a sub-division, the aim should be to maximise the number of correctly aligned lots to increase the likelihood that the dwellings will be able to benefit from passive heating and cooling.

In 1999, the Australian Greenhouse Office noted that:

> *Although some states have guidelines for the development of energy efficient sub-divisions that provide for good solar access and facilitate correct orientation, this is not mandatory in any state. (AGO 1999)*

Just like dwellings or appliances, building lots can be rated for their energy efficiency. One such set of guidelines was developed several years ago by Sustainable Energy Authority of Victoria (SEAV) and was later modified by Sustainable Energy Development Authority (SEDA) (SEDA 2003). This (SEDA) methodology sought to provide developers with guidelines that would enable them to maximise the number of lots designed to access passive heating to reduce the energy used to heat dwellings.

In southern states, the objective of solar efficient residential design is to limit the solar collector area to that which is sufficient to make a significant reduction in the non-renewable heating energy requirements of living areas.

A 5 Star lot can save a house up to twice as much heating energy as the same house on a 1 Star lot' (Loder & Bayly Consulting Group with Sustainable Solutions Pty Ltd 1991).

2.2.1 The existing lot-rating methodology

The existing lot-rating methodology Appendix A - is a simple, paper based process that aims to award a lot a star rating between 1-5 stars with 5 being the optimum. As with all rating systems, the objective is to demonstrate compliance with a specified set of performance criteria. In the case of dwelling lots, these criteria include;

- Lot orientation
- Lot size
- Lot gradient.

The lots are rated on their ability to accommodate a dwelling with good solar access within the following parameters;

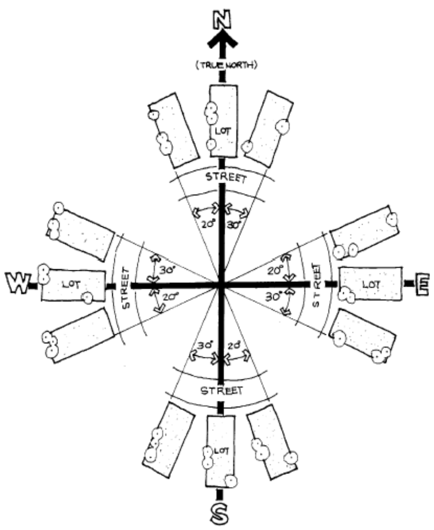
- The methodology applies to separate lots between 300–1000m²
- Lots under 300m² receive 1 star as solar access is closely integrated with building design and siting
- Lots over 1000m² receive 5 stars as these offer a better chance of achieving good solar access
- Lot slope will either improve or hinder solar access, but as a guideline, lots with a slope of over 20 % receive a 1-star rating, regardless of slope orientation.

For lots within these parameters, applying the methodology is a simple three-step process:

Step one – determine the lot orientation

Determine the orientation of a lot along its long boundary. To achieve the highest rating of 5 Stars, the long boundary must be oriented so that one axis is within 30° east and 20° west of true solar north, as shown in Figure 2-5. Lots outside these orientations receive a 1 Star rating. Orientation guidelines such as these appear in numerous passive design texts.

Figure 2-5 Lot orientation



Source: (Commonwealth Department of Housing and Regional Development 1995)

Step two – determine the lot width

Determine the width of the block by measuring at right angles to the long axis that falls within the acceptable orientation range. East/west lots have a greater width requirement than north/south lots to allow for set back of the dwelling along the northern boundary to avoid overshadowing from the adjacent lot.

Figure 2-6 Lot width

Step three - determine the star rating

Determine the star rating by finding the appropriate width band from Figure 2-7.

Figure 2-7 Star rating

Lot orientation	Minimum lot width (metres) Star Rating ★★★★★	★★★★	★★★	★★	★
East/West					
(Coastal NSW)	> 16.2	15.1-16.2	14.2-15.0	13.4-14.1	< 13.4
(Inland NSW)	> 16.8	15.6-16.8	14.4-15.5	13.8-14.3	< 13.8
North					
(Coastal NSW)	>13.5	11.7-13.5	10.9-11.6	10.5-10.8	< 10.5
(Inland NSW)	>14.1	12.2-14.1	11.1-12.1	10.5-11.0	<10.5
South					
(Coastal NSW)	>15.5	13.7-15.5	12.9-13.6	12.5-12.8	< 12.5
(Inland NSW)	>16.1	14.2-16.1	13.1-14.1	12.5-13.0	<12.5

TABLE 1

USE THIS TABLE IF THE HEIGHT OF BUILDINGS TO THE NORTH IS NOT LIMITED.

Definitions

East / West: Bearing of one long side within 250 and 300°, street on east or west side

North: Bearing of one long side within 340 and 30°, street on southern side

South: Bearing of one long side within 340 and 30°, street on northern side, note that greater lot widths are to allow for car access to north.

It will be noted from Table1 that reducing lot width results in a reduction in the solar access star rating. This need not be the case. Lot width can be reduced without impacting on the solar access rating by placing height restrictions to houses on the north boundaries.

Source: Extract from (SEDA 2003)

The goal is to achieve 5-star lot-ratings for 80 per cent of the total, with the remainder rating either 4 or 3 stars. Further detail on this methodology can be found at Appendix A - .

2.2.2 Rating divisions in SEQ

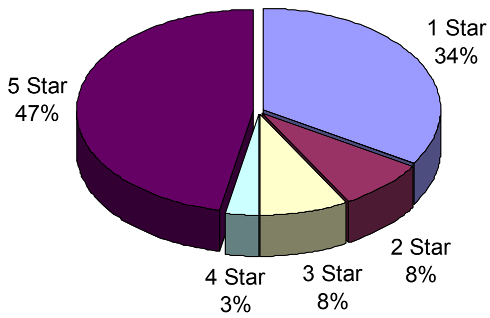
In sub-tropical climates, solar access for heating is less important, but orientation still has a critical role in excluding excessive solar gain and increasing natural ventilation. The lot-rating tool as it currently exists assesses only the solar orientation of the lot to maximise solar gain. The effects of ventilation are not considered and this is an important aspect in SEQ. The ability of a house to capture breezes is directly linked to the orientation of the house and thus like solar orientation, the orientation of the lot can be used to determine how well it is sited to capture those breezes.

Assessing a number of sub divisional layouts, the 2005 project found that, although sub-divisions with larger lots[1] could achieve the existing lot-rating guidelines, the increasingly prevalent, smaller lot-size sub-divisions were falling well short of the mark. The following example illustrates this point. This sub division Figure 2-8 had a high proportion (50 per cent) of smaller lot sizes averaging 520m².

Figure 2-8 Sustainable Subdivisions: Energy - case study sub-division

This resulted in a low percentage (47 per cent) of 5-star lots as shown in Figure 2-9.

Figure 2-9 Lot-rating profile



Examining a range of sub division layouts, the project found that the methodology was a good starting point for sub-division design (Miller and Ambrose 2005). At the very least, it quantifies the number of lots that are likely to require more intensive design solutions to minimise the amount of energy required to passively cool dwellings. From a purely passive heating perspective, using the tool could trigger a re-examination of the sub-divisional layout to assess alternative patterns. But in SEQ, correlating the lot-ratings with dwelling ratings proved more problematic.

2.3 Sustainable Sub-divisions: Energy

Energy assessed a range of contemporary dwellings to test the correlation between lot-rating

[1] Based on terms used by the key informants, larger lots were defined as being over 560m².

and dwelling energy efficiency. The project took advantage of a new thermal analysis tool, AccuRate[2], which takes into account not only the built form, but also site specific criteria such as orientation, ventilation and external barriers that reduce ventilation

2.3.1 Assessing the energy efficiency of contemporary dwellings

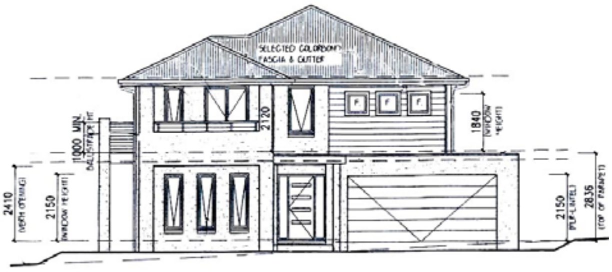
The project examined the performance of a range of contemporary residential dwelling designs representing the latest generation of demonstration, experimental and mainstream display project homes. All included the relatively recently introduced deemed to satisfy levels of insulation in the ceilings and external walls. All were expected to meet, or exceed the 3.5 star requirements in Queensland. A brief overview of these dwellings is shown in Figure 2-10.

Figure 2-10 Sustainable Sub-divisions: Energy – case study dwellings

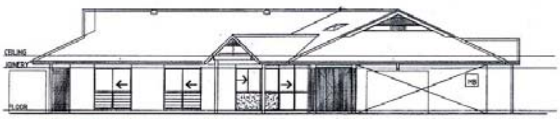
Overview of the case study dwellings

Lot type
Flat or cut and fill lots – all suitable
Sloping lots - case studies 2 and 6 -9
Small lots – case studies 2,3, 6, 8 and 9

Dwelling type
Case study 1 - research and demonstration dwelling
Case study 2 - demonstration dwelling
Case studies 3 – 7 display dwellings
Case studies 8 and 9 – experimental prefabricated



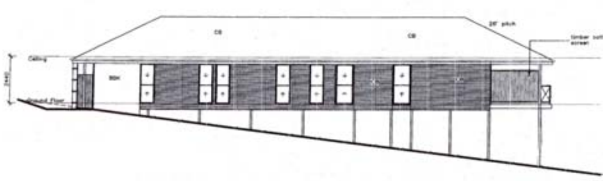
Case study 5 - two storey brick veneer on slab, metal roof, 287m² internal space with 4 bedrooms, 3 pedestals



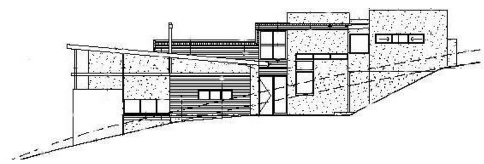
Case study 1 - single storey block work on slab, metal roof with 220m² internal space, 4 bedrooms, 2 pedestals

Case study 6 – elevated lightweight dwelling, metal roof, 189m internal space with 3 bedrooms, 2 pedestals. Elevations not provided

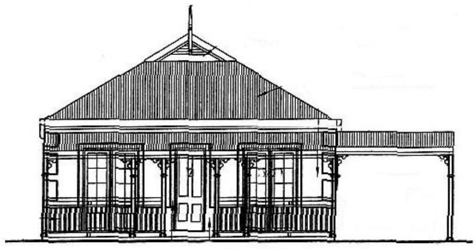
[2] AccuRate is the thermal modelling tool being developed by CSIRO for the Australian Greenhouse Office



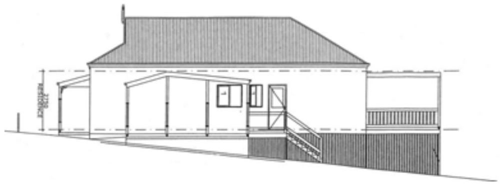
Case study 2 – single storey, elevated, metal clad, metal roof, 150m² internal space with 3 bedrooms, 2 pedestals



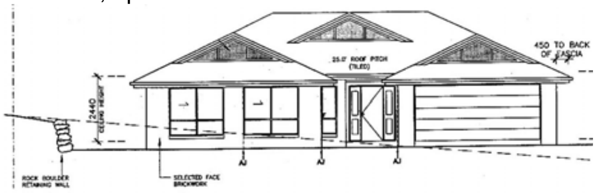
Case study 7 - split level, clad, metal roof, 263m² internal space with 3 bedrooms, 2 pedestals



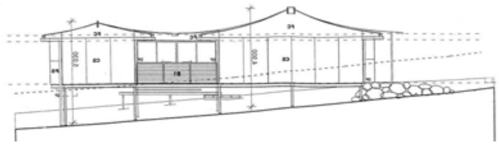
Case study 3 - brick veneer on slab, metal roof with no eaves on long axis, 104m² internal space with 3 bedrooms, I pedestal



Case study 8 - single storey elevated, clad, 100m² internal space with 3 bedrooms, 1 pedestal



Case study 4 - brick veneer on slab, tiled roof, 194m² internal space with 4 bedrooms, 2 pedestals



Case study 9 - single storey elevated, lightweight clad, metal roof, 140m² internal space with 2 bedrooms, 1 pedestal

Further details of these dwellings can be obtained from the Industry Report (Miller and Ambrose 2005), which is available online at http://www.construction-innovation.info/images/pdfs/SusSubdivsRTI_final.pdf.

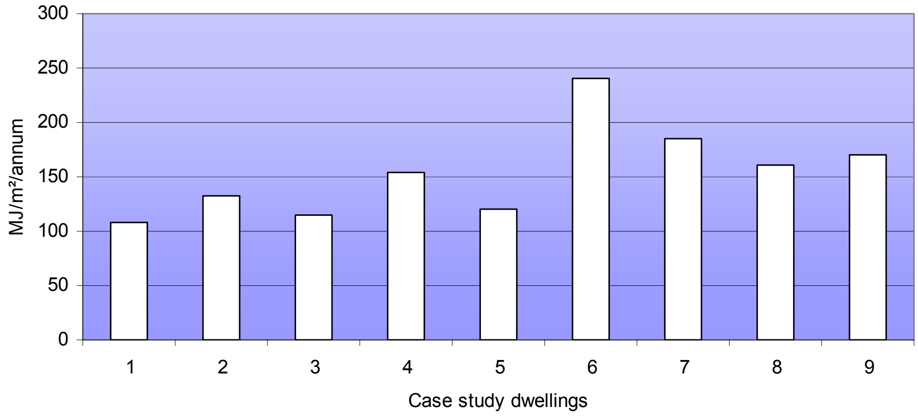
The case study dwellings were modelled in the same climate zone to avoid variations in energy consumption due to climatic differences. The climate zone selected was Springfield, (Climate Zone 9), a typical new outer suburban Greenfield development of 2850 hectares located 28 kilometres from the Brisbane Central Business District (CBD), and expected to house some 30,000 residents by 2020 (Delfin Springfield Pty Limited 2004).

2.3.2 The range of EER's in contemporary dwelling designs in SEQ

At the time of the Energy project, the Star Band settings covered a range of 1-5 stars with 5 being the highest and optimum level. The star band settings are derived from the annual total energy load, which is expressed in mega joules per metre squared per annum (MJ/m²/annum). A significant variation in annual total load was 'defined' as one that causes the star band score to alter by ±½ star. However at that time, there were calibration issues to be resolved with the Area Adjustment Band Score Thresholds. As a result, the dwelling ratings were discussed not in terms of stars, but in terms of the underlying measure of MJ/m²/annum. This added an unexpected degree of difficulty in interpreting the data and led to the need to include more detail in each case study in place of a relatively simple 1-5 star indicator. The points of comparison were the same - within the simulations run for each dwelling and in the totals between the case studies. It was hoped that star ratings would be available for the final report, but this did not occur.

The total annual loads of energy used for heating and cooling the nine dwellings ranged from 107.7 to 241.0 MJ/m²/annum, as shown in Figure 2-11.

Figure 2-11 Comparative energy efficiencies of contemporary dwellings



All the case study dwellings meet, or exceeded, the 3.5 star rating required under Building Code of Australia (BCA) 2003 construction requirements for Queensland. So the first point of comparison (and concern) was in the range of dwelling energy efficiencies.

The most efficient dwelling uses approximately 44 per cent of the energy required to cool/heat the least efficient dwelling. Or the least efficient dwelling consumes some 124 per cent more energy than the most efficient dwelling. Even without the star ratings to interpret this variation in terms of ±'x' stars, the range is of concern. As energy efficiency requirements increase, dwelling design will undoubtedly have to be modified. One way of achieving this is to provide dwelling designers with tools that will allow them to augment passive design principles[3] by testing the potential energy efficiency of design options at design development stage.

This snapshot of dwelling EER's does not take into account the range of external factors that impact on dwellings in the project home market. In Queensland, homeowners commonly purchase land and dwelling separately. The dwelling is then constructed with little or no design modification and a common problem is that project homes are often sited on a lot that is inappropriate for the dwelling's design. To investigate the potential impact on energy required to cool/heat dwellings, Energy examined the impact of two critical lot factors;

- Lot orientation
- Lot density.

A summary of the project findings follows.

2.3.3 Quantifying the impact of lot orientation on dwelling EER

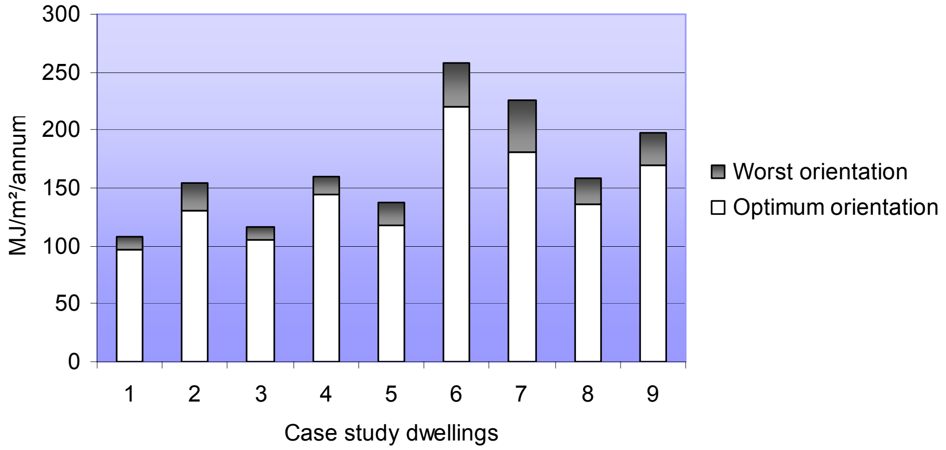
The aim of the existing lot-rating methodology is to design sub-divisions that increase solar access and reduce the energy used to heat a dwelling. The effects of ventilation are not considered and this is considered an important aspect in Queensland, where the focus of lot orientation should be on limiting solar gain in summer and increasing access to the cooling effects of natural ventilation. As with solar orientation, the ability of a dwelling to capture breezes is directly linked to the orientation of the dwelling and so orientation can be used to determine how well both there things are catered for.

To assess the impact of this altering of the orientation of the dwellings on the EER's, the case study dwellings were modelled at 45° increments throughout 360°. That is, all the dwellings were modeled oriented toward north, north-east, east, south-east, south, south-

[3] Passive design is design that does not require mechanical heating or cooling. Homes that are passively designed take advantage of natural energy flows to maintain thermal comfort.

west, west, and north-west. Figure 2-12 shows the result of modeling these seventy-two dwelling and combinations, with white representing the optimum orientation and red the worst for each of the case study dwellings.

Figure 2-12 Impact of orientation on dwelling energy efficiencies



Altering the orientation increased the annual total load (and decreased the energy efficiency) by between 10 and 32 % above the optimum levels achieved for each of the dwellings.

- At their most efficient orientation, the dwellings total annual loads for heating and cooling ranged from 97.4 to 216.7 MJ/m²/annum
- At their worst orientation, the same dwellings ranged from 107.9 to 254.6 MJ/m²/annum.

The Energy Project starts to quantify common knowledge principles of the importance of achieving the correct orientation in a sub tropical climate. Given the separate purchase decisions that drive lot and dwelling selection and purchases, it is unlikely that the majority of project homes will achieve the optimum energy efficiencies. Project home dwelling designers have no influence over the lots their designs are sited on and can only make so many design decisions to accommodate the full range of lot types on the market. To date, these designers have not had access to tools that would enable them to quickly test their designs and a range of alternative design solutions in the range of contexts that are available.

2.3.4 Is there a correlation between lot-rating and dwelling EER?

The lot orientation will often dictate the orientation of a dwelling, and it is most probable that any dwelling constructed on an appropriately oriented lot will also be appropriately oriented. So it follows that there should be a correlation between the lot-rating and the dwelling EER.

When the best and worst orientations were compared with those predicted by the lot-rating methodology, the correlation between lot-ratings and dwelling EER's was not as clear-cut as first thought. In six of the nine case studies, the optimum orientation complied with the guidelines. The same pattern applied for the worst orientations. The result is that in three out of the nine case studies, the lot-rating methodology did not predict either the highest or lowest energy loads. As one of the aims of the project was to test the methodology for its appropriateness for use in SEQ, it was clear that the methodology would need to be modified. As the lot-rating methodology does not take ventilation into account, it seemed that all that would be required to develop a lot-rating methodology would be to 'add a ventilation factor'. There appeared to be considerable actual and anecdotal data to guide this process.

2.3.5 The potential for natural ventilation in SEQ

Figure 2-13 shows two wind roses for Brisbane, one for 9am (left) and 3pm (right). These roses have eight sides corresponding with the four cardinal and four semi cardinal points of the compass, giving directions from where the wind comes from. Each side has twelve lines, corresponding to the twelve months of a calendar year in a clockwise direction. The outer octagon defines the scale: 12.5 %, i.e., if the wind were evenly distributed, coming from all eight directions with the same frequency, all lines would be this length. The twelve numbers inside the octagon indicate the percentages of calm for the twelve months in sequence (Szokolay, 1988).

Figure 2-13 Brisbane wind rose for 9AM and 3PM

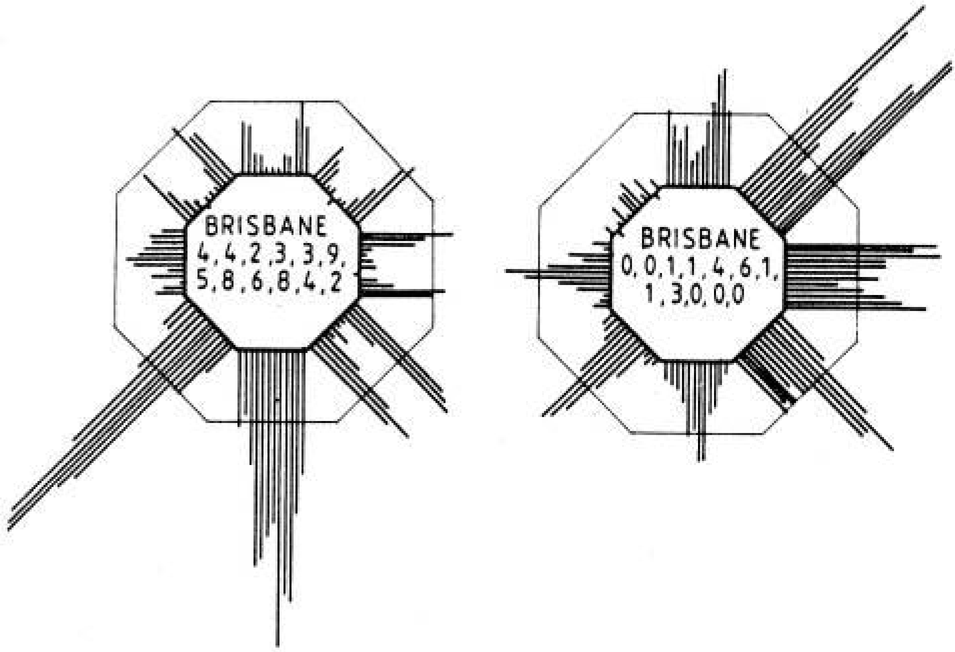


Image reproduced with permission Szokolay, 2006

For Brisbane, the important times to receive breezes are during summer afternoons to aid in the cooling process. The 3pm wind rose shows that these breezes are strongest and most frequent from the north-east, and the east and south-east to a lesser degree. Consequently, it is important that sub-division and dwelling design take this into consideration and lots that allow for this should be rewarded accordingly in any rating methodology.

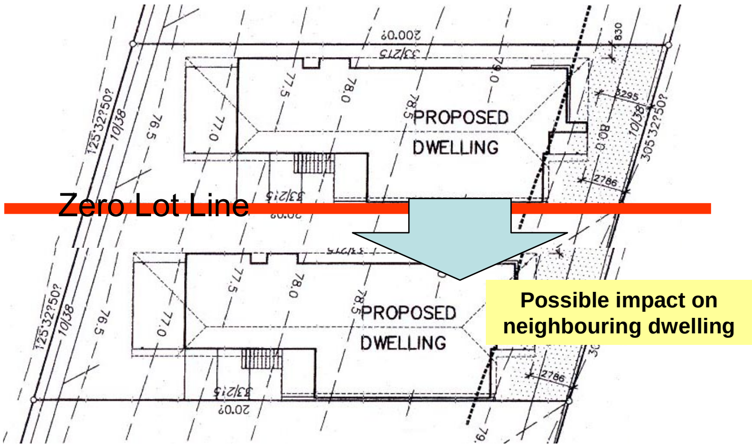
Wind roses such as these are available for all capital cities. They are based on BoM data and that data is normally collected in large, open sites such as airports, or on the top of buildings, as the aim is to measure unobstructed air movement. But a closer examination of the case study dwellings revealed that in order to apply a ventilation factor to the methodology, the role that natural ventilation (or breezes, or air movement) can realistically play in passively cooling dwellings required further examination. This is particularly important as Australia's pattern of residential development will continue to change as suburban densities increase and as regulations governing energy efficiencies toughen.

2.3.6 Quantifying the impact of suburban densities

Examining one of the dwellings, case study 5, (see Figure 2-10), known to be located in close proximity to its neighbour, as shown in Figure 2-14, triggered an examination of the impact of increasing the external 'shielding' for all the case study dwellings.

Zero lot line lots tend to be narrow lots and the likelihood of a future dwelling taking advantage of being able to locate a wall along a boundary line is relatively high. The shielding effect that this would have on any other lot should be taken in consideration. As shown in Figure 2-14, neighbouring dwellings can be close, indeed it has been observed that some dwellings are separated by less than a metre and would greatly reduce the ability to capture breezes or sunlight for either dwelling along those shielded walls.

Figure 2-14 Zero lot line

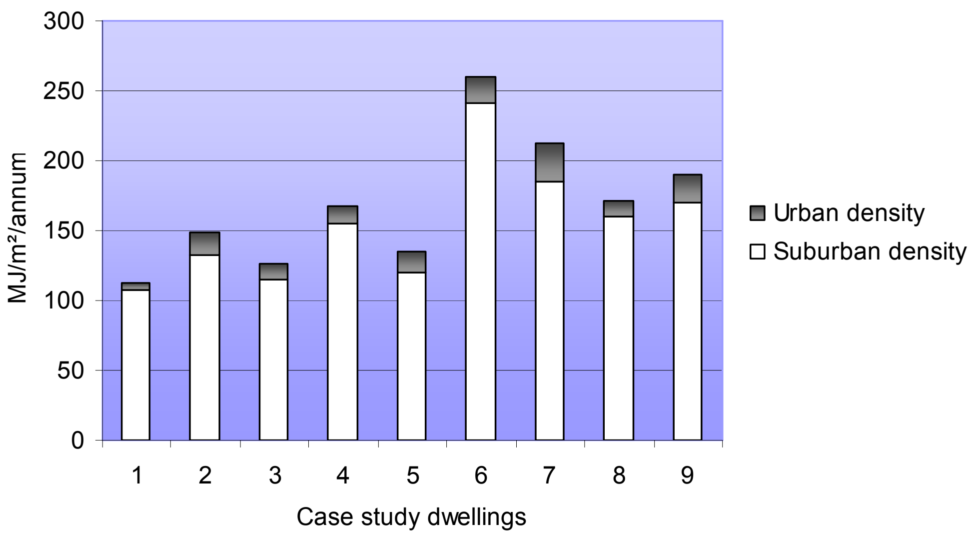


An examination of the potential impact of increasing suburban densities was made possible because AccuRate, allows the external shielding factor to be selected from a range, which includes:

- None: no surrounding obstructions
- Light: a few surrounding obstructions (e.g. a house in the country)
- Suburban or moderate: obstructions typical of suburban housing
- Urban or heavy: obstructions typical of inner-urban housing.

The results of the changing the external conditions by increasing the degree of external shielding, are shown in Figure 2-15.

Figure 2-15 Impact of increased suburban density on dwelling energy efficiencies



Increasing the external density, or shielding factor, increased the annual total load (and decreased dwelling energy efficiency) by between 5 and 15 % above the rated levels for each dwelling.

- In a normal suburban setting, the dwellings ranged from 97.4 to 216.7 MJ/m²/annum
- In a densely developed suburban or urban setting, the same dwellings ranged from 113 to 259 MJ/m²/annum.
- This range compares with that (107.9 to 254.6) achieved by altering the orientation in a suburban setting.

The Energy project has started to quantify the impact increasing suburban densities on dwelling energy efficiency and found that the potential increase in energy consumption is similar to that caused by poor lot orientation. Because of the numbers of simulations involved, the combined effect of poor orientation and increased urban densities was not explored in detail. But in dwelling 3, which is one of the better performing dwellings, this worst-case combination resulted in an increase of some 40 MJ/m2/annum (or approximately 30 per cent) above the optimum annual total load for that dwelling.

2.3.7 Applying a ventilation factor

But what is actually known about ventilation at dwelling level? The ventilation factors examined thus far all rely on Bureau of Meteorology data or on expert assessment of how much that data should be modified. The results of this examination has led to further questioning of the potential that ventilation can realistically play in passively cooling dwellings in increasingly densely constructed suburban settings. If a ventilation factor was to be applied to the lot-rating methodology, what would that factor be? Additionally, regardless of how well designed a sub-division or dwelling may be, external conditions will change as the suburb matures. The most likely change is that over time, additional structures, higher fences or increasing vegetation may 'shield' a dwelling from access to natural ventilation. It will become increasingly important that dwelling EER be measured in terms of the dwelling's context within the sub-division.

These comments are not a criticism of current practice, rather an attempt to inform ongoing need to plan to house an increasing population. There is no disputing that dwelling design experts can design a dwelling appropriate to any lot, but the aim of these projects is to address contexts where such expertise is not available in order to improve energy efficiencies throughout the project home market – and to inform discussions about the efficiencies of dwellings in the existing market. Toward that end, more knowledge is needed regarding the role of ventilation in our increasingly densely constructed suburbs. Obtaining that data is the object of the current project, Sustainable Subdivisions: Ventilation.

3. PROJECT METHODOLOGY

The focus is to examine, and inform, sub-divisional and building practices in an area that is presently undergoing rapid growth and the resultant spread of urban development. The brief for this project delineates the subject area as sub tropical SEQ, focusing on Brisbane and the surrounding and expanding cities of Ipswich, the Gold Coast and the Sunshine Coast. This growth area in Australia was also the study area for the Energy project.

3.1 Parameters

This research focuses on energy efficiency of sub-divisions by collecting wind speed and direction and internal and external temperatures in twelve dwellings sited on a representative range of dwelling lots, including:

- Range of lot sizes from 300m² to 1000m²
- Range of topographies – flat, sloping and steeply sloping
- Range of dwelling types – important for the extent of lot coverage and the connection between lot design and dwelling energy efficiencies
- Range of settings – established and newer suburbs, to capture an indication of the impact maturing suburbs may have in obstructing natural ventilation.

The dwellings are owned and occupied by staff from the Project Partner Organisations, who have agreed to equipment installation, and to collect and transmit the data for a period of up to a year. Restricting the pool of volunteers to those already associated with research ensures they have an understanding of the commitment required. Participation is voluntary and is covered by a letter informing all the registered homeowners that the CRC CI will not be responsible for claims related to dwelling damage or occupant injury.

There are insufficient resources for this project to install and monitor dwellings outside SEQ. But as all climate zones throughout Australia have the potential for passive cooling through natural ventilation in summer, the findings will be analysed within this wider context.

Data will be collected over a one-year period. The most critical periods will be winter 2006 and summer 2006/07. 'Off-the shelf' weather station monitoring equipment is being used to keep purchase, installation and monitoring costs to a minimum. The system selected is wireless, has data logging facilities and enables a connection to a personal computer (PC) for easy data transfer.

BoM data will be sourced and compared with data collected at site stations and differences compared. The ventilation changes noted will then be used to enhance the existing lot-rating methodology identified in Sustainable Sub-divisions: Energy to include ventilation orientation parameters. Creating the need to assess multiple criteria, i.e. solar gain/protection, breeze access and shielding potential, requires the need to determine the impact that each of these criteria will have on the overall performance of a particular lot. Once the respective level of impact has been determined, then appropriate weighting factors can be assigned to each criterion and an overall rating for the lot established.

This data may also highlight a need for other regions to allow for the impact of increasing urban densification. The project is expected to highlight the need for expert design in inner urban areas where the lot size is pre-determined and the external constraints to ventilation are established. Researchers will also liaise with 2004-003-B Microclimatic Impacts on the Built Environment Project.

3.2 Significance

This is the opportunity to provide the local authorities and the design and construction industry with critical information regarding the impact an increasingly densely developed built environment has in obstructing breezes from reaching and cooling, residential dwellings. With increasing thermal performance requirements, this project will inform the ongoing development of these regulations and the tools used to assess compliance for sub-tropical conditions.

The unique aspect of this project is:

- The focus on sub-division design to augment dwelling design; and
- The connection of 'sub-division technology' to 'housing technology' in sustainable sub-divisions.

While the focus of the project is energy efficiency of sub-divisions, solar access is only one aspect of energy efficient sub-divisions and development. This project does not examine the following factors, which significantly affect dwelling and sub-division sustainability:

- Embodied energy of the materials used in construction of the dwellings
- The impact of occupant preferences and behaviours
- Local planning guidelines.

3.3 Methodology

The project methodology consists of the following activities:

In Phase One – industry consultation;

- Conducting a workshop and interviews with building industry professionals from the private and public sectors within SEQ on the requirements of sub-divisions and the performance of current assessment tools
- Preparing a project report and PowerPoint presentation.

In Phase Two – data collection and analysis

- Case study assessment and selection
- Completing a letter of involvement with the project participants
- Selecting appropriate monitoring equipment
- Installing the equipment
- Developing and implementing the data collection process
- Analysing data following the key monitoring periods of winter 2006 and summer 2006/07
- Developing the lot-rating methodology
- Preparing a project report, industry brochure, booklet and PowerPoint presentation.

In Phase Three – delivery to industry;

- Conducting workshop(s) to disseminate the lot-rating methodology with the similar group of development and building industry professionals from the private and public sectors within SEQ targeted for the first workshop.

3.4 Ethics

The dwellings selected were restricted to those that were offered by members of the Project Partners organisations. These participants will not be identified and the location of their dwellings will only be identified generically. A Letter of Involvement was developed in conjunction with the CRC CI to protect all parties and specifically notes that the CRC CI will not be responsible for claims related to property damage or occupant injury. Under the Partner Agreements, this also excludes claims made to any of the Project Partner organisations. Also under the Partner Agreements, the provision of any plans, images or documents constitutes permission to use these for this project. Permission to use privately provided plans was obtained and is held by the CRC CI. Permission to use selected images from published materials was obtained and is held by the CRC CI.

3.5 Project Management

The use of privately owned dwellings and volunteers to transmit the data over a twelve month period required careful consideration. The equipment was selected for ease of use and attractiveness to engage householder interest over this extended period. Regular contact throughout the project should ensure that any potential problems are resolved.

There are a number of ongoing risks;

- Participants may withdraw from the project at any time. Restricting the pool of potential volunteers to those associated with research ensures they had an understanding of the commitment required
- The equipment may fail, be damaged or stolen
- Faults in project monitoring equipment will need to be quickly rectified to avoid large data loss
- BoM equipment failure is beyond our control, but unlikely as stations being used are significant monitoring points.

Project Partners have provided valuable input and feedback through a series of Project Team and individual meetings. In the period to 30th June, these included:

- Project Team Meeting1, 25th November 2005
- Meeting 2, 30th January 2006
- Meeting 3, 6th March 2006
- Meeting 4, 3rd April 2006
- Project Notes, 15th May 2006
- Meeting 5, 19th June 2006.

4. CASE STUDY DWELLING LOTS

The aim of the research is to determine the differences between wind speed and temperature data collected at BoM monitoring stations and a variety of dwelling types through monitoring of wind conditions in SEQ. The project will assess the role natural ventilation (or breezes) can have in passively cooling lots (and by extension, dwellings) by monitoring twelve sites in a range of suburban settings over a twelve month period. Wind speed and direction and internal and external temperatures in 12 existing dwellings representing the range of dwelling and lot types, such as:

- Range of lot sizes from 300m² to 1000m²
- Range of topographies – flat, sloping and steeply sloping
- Range of dwelling types – important for the extent of lot coverage and the connection between lot design and dwelling energy efficiencies
- Range of settings – established and newer suburbs, to capture an indication of the impact maturing suburbs may have in obstructing natural ventilation.

The data collected will be compared with data from BoM and differences compared. The ventilation changes noted will then be used to enhance the existing lot-rating methodology identified in Sustainable Sub-divisions: Energy to include ventilation orientation parameters.

4.1 Case study selection process

The pool of lots (dwellings) was restricted to those owned and occupied by staff from the Project Partner Organisations, who would agree to equipment installation, and to collect and transmit the data for a period of up to a year. Participation in this project is voluntary and participants may withdraw from the Project for a range of reasons, but this decision was driven by a number of practical constraints including:

- Restricting the pool to those already associated with research ensured an understanding of the commitment required and were likely to be willing and able to collect data and transfer at regular intervals
- Homeowners were targeted to avoid any tenancy issues
- Medium and high density homeowners were not included due to the complications inherent in negotiating with bodies corporate to install equipment in common areas.

4.1.1 Call for homes

The 'call for homes' (Appendix B -) was circulated by email within the partner organisations in February 2006. Some 50 homes were offered. This generous response enabled researchers to focus on selecting from a range of dwelling types similar to those examined in the preceding project and located on a range of typical sites within the 300-1000m² limits of the lot-rating methodology. Within these parameters, three suburban contexts were targeted;

- Inner urban suburbs where increasingly densely constructed settings may be compromising the ability of new or existing stock to continue to be passively cooled
- Outer urban established suburbs to assess the impact of ongoing constructions (sheds, fences etc) and mature vegetation; and
- Outer urban Greenfield developments which generally have little vegetation and fewer structures such as sheds etc.

The development corridors of interest are those extending toward the south-west or north-west that are shielded from sea breezes. The initial culling included;

- Lots in excess of 1000m² - this is the upper limit existing lot-rating methodology based on the supposition that dwellings on large sites have better options to be well sited
- Lots located very close to the coast were also eliminated without inspection.

4.1.2 Letter of Involvement

Approximately 20 dwellings were assessed from outside the property line and the home-owners were contacted to assess their willingness to participate. All were asked to commit in principle to the letter of involvement (Appendix C -).

- While respecting the volunteer nature of the participation, this letter constitutes an agreement between the CRC CI and the homeowners that notes that
- Participants can withdraw at any time
- Outlines the terms of participation, expectations; and
- Informs the homeowners that the CRC CI will not be responsible for claims related to dwelling damage or occupant injury.

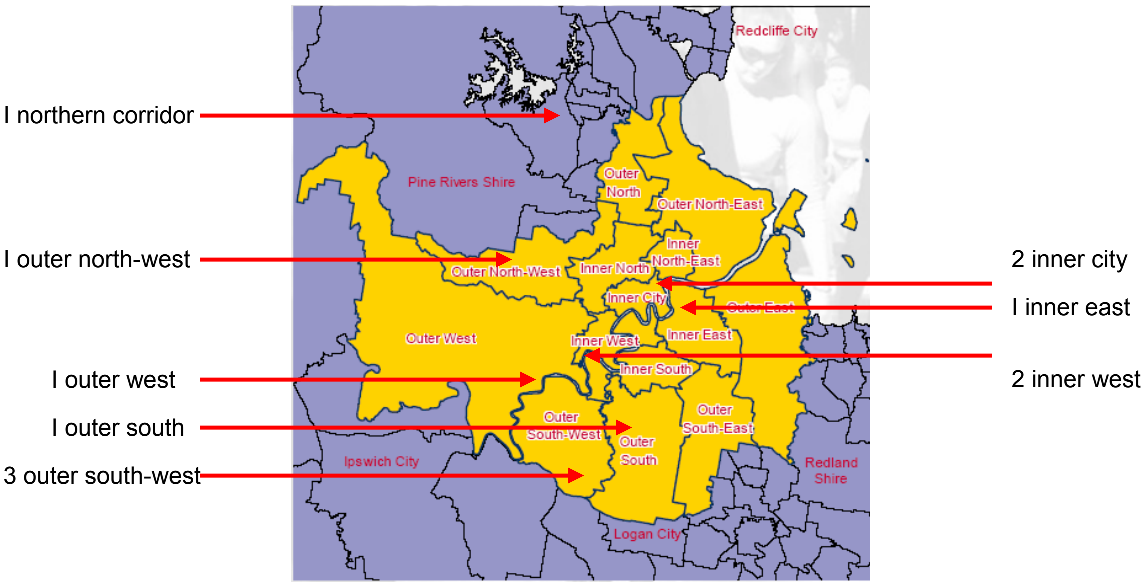
The Centre Agreement protects Partner Organisations from similar claims. Damage to premises was carefully considered in the design of the installation system as described later in this report.

In the process of these discussions, a number of potential participants either withdrew or failed to respond. As the details of the data transfer process had not been finalized at that stage, a reasonable degree of flexibility and high level commitment was required from the potential participants – so those who failed to respond were not contacted again.

4.1.3 Case study locations

The locations shown of the twelve dwellings selected are shown in Figure 4-1. The descriptors used are the Statistical Portrait Regions identified by the Queensland Government (PIFU 2003). Each of these Regions comprises a number of Statistical Local Areas (SLA) with a population of 40,000 to 80,000 people. These descriptors are used in preference to suburb names as most areas describe developments in terms of their relationship to the nearest CBD, while suburb names can be meaningless outside the local area. These descriptors will be used in conjunction with lot size, dwelling construction and age to profile the case studies throughout this and subsequent reports.

Figure 4-1 Overview of case study locations



Source Map: (Planning Information & Forecasting Unit 2003)

In addition to these twelve dwellings selected, a small number of 'back up' dwellings have also been selected to enable substitution should a participant withdraw throughout the project. These homeowners have made an 'in principle agreement' to participate.

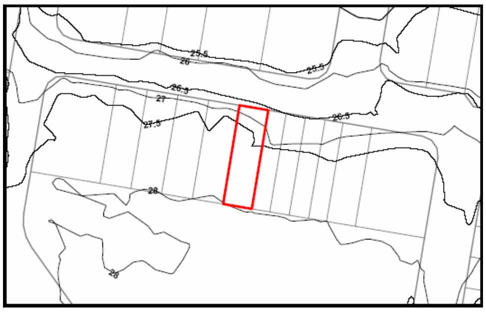
4.2 Overview of the case study lots

This section provides an overview of the selected lots, their sub-divisional contexts and the dwellings.

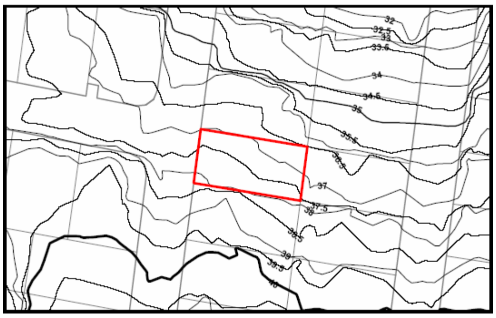
An overview of the selected lots, listed in ascending order of lot size, is shown Figure 4-2. Further details are at Appendix D - . In the Energy Project, the key informants commonly referred to small lots as being less than 450m², as or less than 15 meters wide, and large lots as over 560m². These sizing conventions have been retained for this project.

The existing lot-rating methodology takes into account lot size, orientation and slope and the range within the selected lots is evident, as are the varying sub divisional densities.

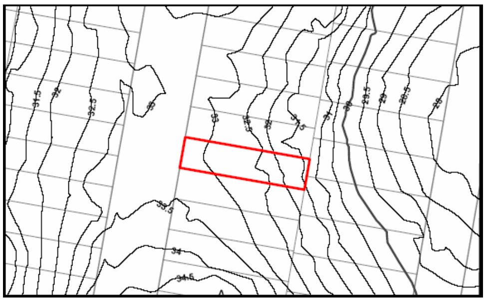
Figure 4-2 Overview of case study lots



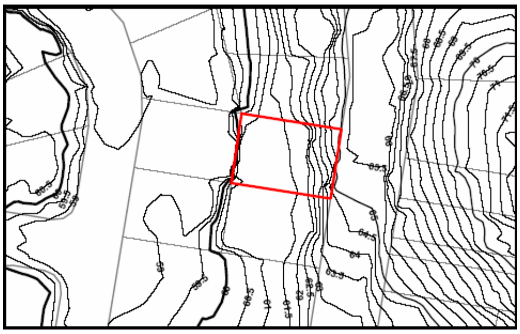
Case study 1, small lot, 300m², outer south (region)



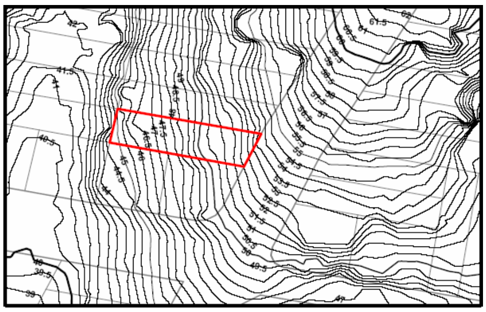
Case study 7, large lot, 608m², outer south west



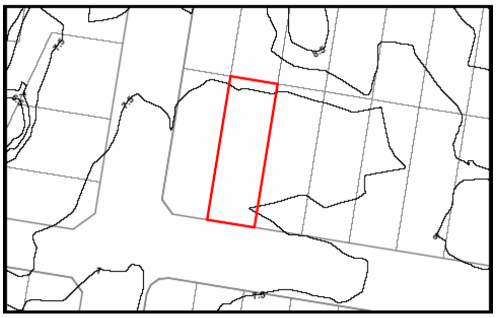
Case study 2, small lot, 405m², inner city



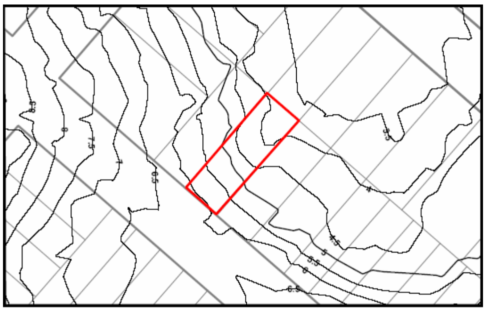
Case study 8, large, steep lot, 630m², outer north west



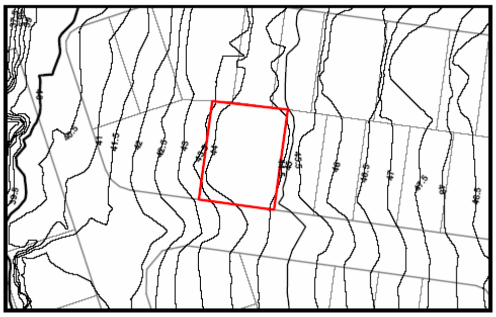
Case study 3, steep lot, 476m², inner west



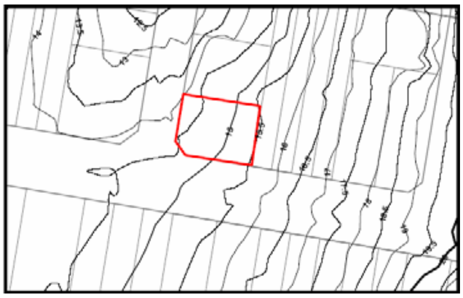
Case study 9, large lot, 703m², inner west



Case study 4, standard lot, 539m², inner city



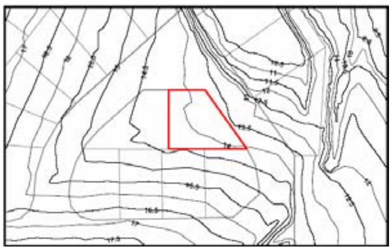
Case study 10, large lot, 766m², outer south west



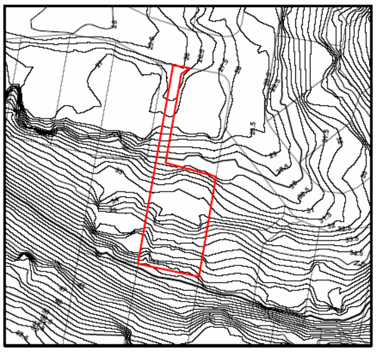
Case study 5, average lot, 541m², inner east

Outside BCC region - no image available at present

Case study 11, large lot, 860m², northern corridor



Case study 6, average lot, 560m², outer south west



Case study 12, large, steep lot, 1000m² + 200m² access easement, outer west

Images courtesy Brisbane City Council

Each case study lot will be examined in detail in subsequent reports.

4.2.1 Sub-division (suburban) context

Aerial photographs of the developed lots provide an overview of the sub-division, or suburban context of the case study lots, as shown in Figure 4-3. These photographs also provide an indication of the degree of shielding for each lot from adjoining dwellings or vegetation. The descriptors included in Figure 4-3 include:

- An indication of the age of the surrounding development
  - New or
  - Established
- Orientation of the street facade of the dwelling
- Indication of how well ventilated the lot is based on homeowner anecdote. In some instances the lot was well ventilated, but the dwelling was not.

Figure 4-3 Aerial view of case study lots

Case study 1, established, north (facing) well ventilated lot

Case study 7, established, west facing, well ventilated

Case study 2, established, west, well ventilated

Case study 8, established, east facing, poorly ventilated

Case study – established, east, well ventilated

Case study 9 – established, south, well ventilated

Case study 4 – established, south, poorly ventilated

Case study 10, new, south, well ventilated

Case study 5 ,established, south, poorly ventilated

Case study 11, established, west, poorly ventilated

Case study 6, new, north, well ventilated

Case study 12, established, north, well ventilated

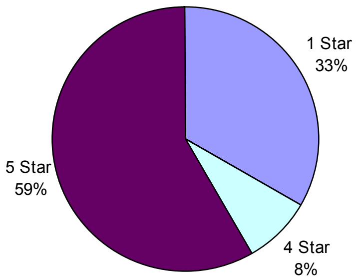
Images courtesy Brisbane City Council

The opportunities, or barriers, to natural ventilation will be examined in greater detail in the next report.

4.2.2 Comparative sub-division

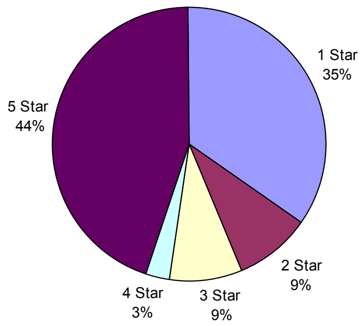
These lots effectively form a 'research sub-division' that can be rated using the existing lot-rating methodology.

Figure 4-4 Ventilation sub-division - lot-rating profile



This profile is similar to that from one of the case study sub-divisions from the earlier research project, shown in Figure 4-5. This sub-division was described in Chapter 2, Background (Figure 2-8).

Figure 4-5 Energy sub-divisions - lot-rating profile



This similarity in profiles provides a correlation between the issues identified in Energy and the lots being monitored in Ventilation. Neither 'sub-division' meets the current lot-rating requirement of 80 % with 5 stars and the balance to achieve 3 or 4 stars – in general this is because of the number of small and/or steep lots. But with the increase in population, decreases in the number of residents per dwelling, decreasing flat land available for development, a blanket approach to rating smaller and steeper lot sizes is no longer appropriate. As one of the aims of this project is to develop an enhanced lot-rating methodology (based on the existing methodology), a more sophisticated approach will be required that takes into account the slope and size of the land with regard to orienting for solar gain in winter and natural ventilation in summer. This issue will be explored further in subsequent reports.

4.3 Overview of the case study dwellings

The primary focus was on selecting an appropriate range of dwelling lots, but the point of developing sub-divisions is to accommodate dwellings. So the lot selection process was balanced to ensure that a cross section of the range of contemporary and existing project home dwelling types typically found throughout the region was represented. While the focus is on new sub-divisions, examining mature suburbs provides an indication of the changes that are likely over the life of the dwellings - in terms of landscape maturing, changes in fencing types and heights, or the construction of close or high structures such as significant alterations and additions to adjoining properties. The case study dwellings, listed in the same order as the lots, are shown in Figure 4-6. Additional descriptors include.

- Approximate age of the dwelling based on home-owner anecdote and expressed in 4 categories
  - New - under 10 yrs
  - Between 10-20 years
  - Between 20-50 years
  - 50+ years.
- The basic construction types are expressed in the following categories
  - Brick veneer/concrete floor - BV/C
  - Brick veneer/concrete + timber floors – BV/C+T
  - Lightweight/timber floor - LW/T
  - Double brick/timber floor – DB/T
- An indication of how well the dwelling is ventilated (good, poor) based on home-owner anecdote.

Figure 4-6 Overview of case study dwellings

Case study 1,10-20 yrs, BV/C, good ventilation

Case study 2, 50+yrs, LW/T, good ventilation

Case study 3, new (2005) dwelling, BV/C+T, good ventilation

Case study 4, 50+yrs, LW/T, poor ventilation

Case study 7, 20-50 yr BV/C , poor ventilation

Case study 8, 10-20 yrs, BV/C+T, poor ventilation

Case study 9, new (2005) dwelling, LW/T, good ventilation

Case study 10, new (2005) dwelling, BV/C, good ventilation

Case study 5, 50+ yrs, DB/T, poor ventilation

Case study 11, 20-50 yr, BV/C, poor ventilation

Case study 6, new (2005) dwelling, BV/C, good ventilation

Case study 12, 10- 20 yrs, BV/C+T, good ventilation

Images Author, 2006

Further details of the dwellings are at Appendix D - .

In some instances, high fences and dense foliage made photographing the dwellings problematic. These and other barriers to natural ventilation will be also examined in subsequent reports. The dwelling design and construction and, where available, the homeowner's anecdotes regarding the dwellings suitability for the climate, and their preferred methods of heating and cooling the dwellings, may also be examined further.

4.3.1 Comparative dwelling stock

Queensland has the highest proportion of relatively new dwellings of any state or territory in Australia. As shown in Table 4-1, throughout Australia more than half the dwellings are 20 or more years old (57.5 per cent) (DLGP 2001). By contrast, Queensland has relatively newer stock with only 45.1 per cent of dwellings in this category.

The case study dwellings selection approximates that examined for the Energy project, as shown in Figure 2-10 and also approximates the range of dwelling stock in Queensland.

Table 4-1 Age of dwelling stock compared with case study dwellings

	Australia	Queensland	Case study
Under 20	42.5 %	54.9 %	50 %
Under 10	14.0 (Vic)	26.1 %	25 %
Over 20	57.5 %	45.1 %	50 %
Over 50	18.0 %	14.7 %	25 %

Source: Derived from (DLGP 2001)

The percentages are somewhat artificial given the size of the sample and a higher percentage of older dwellings were selected to ensure the elevated lightweight style of dwelling, once popular in SEQ, was represented in this study. With the influx of southern dwelling styles such as brick veneer on slab, popularity of elevated lightweight construction has diminished in recent years. This change in dwelling types is an area of ongoing contention between local designers and project home market providers. Due to the lack of relevant research, designers engaged in promoting climatically appropriate dwelling styles are yet to demonstrate that the vernacular dwelling designs are more energy efficient, especially given the constraints imposed by small lots and increasing suburban densities.

The internal temperatures of the dwellings will be monitored and compared with the external temperature, providing indicative data on how the range of dwellings performs during winter 2006 and summer 2007. Subsequent reports may also provide an overview of how the home-owners respond to these variations in internal temperatures imposed by the combination of climate, dwelling lot and dwelling type. Whilst there are too many variables to conclude a preference for one type over another, it is precisely the individualized nature of the combination of lots, dwelling design and occupants preferences that designers are attempting to match in a period of increasing scrutiny and regulation with regard the thermal performance of dwellings in a sub tropical climate.

5. DATA MONITORING SYSTEM

The key assumptions underpinning this project are:

- Increasing energy efficiency standards will require better understanding of natural ventilation opportunities, especially in tropical and sub tropical climates
- Regulatory authorities and industry have both indicated a strong need for better understanding of natural ventilation in urban environments
- Urban developers and designers need tools to aid in promoting natural ventilated dwellings in all climate zones; and
- BoM wind data is not representative of urban wind/ventilation conditions in our increasingly densely constructed suburban settings.

To acquire the data that will inform these issues, wind speed and direction and internal and external temperatures are being monitored in twelve privately owned dwellings representing a range of dwelling types and lot characteristics as explained in the previous chapter.

Data will be collected over a one-year period. The first critical period is the winter period from June to August 2006, but the most critical period will be from December 2006 to February 2007. This chapter describes the monitoring equipment selection and installation, and the data collection processes.

5.1 Monitoring system selection

A number of Australian based researchers engaged in various aspects of recording and analysing weather data were contacted for advice and system recommendations. Selecting an 'off the shelf' weather station system recommended by credible sources kept purchase, installation and monitoring costs to a minimum.

Other important considerations included;

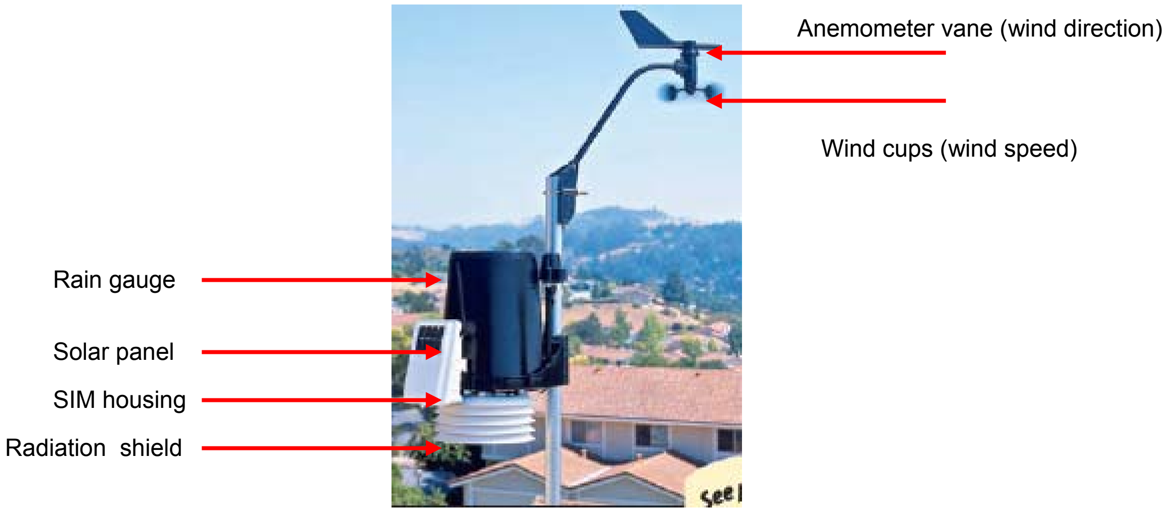
- Cost
- Reliability
- Ease of installation and removal
- User friendliness for project volunteers

Price per unit removed some of the more specialised systems from consideration. Four systems were considered and a brief description of each is at Appendix E - .

5.1.1 Selected system

The system selected is solar powered, wireless, has data logging facilities and is connected to a personal computer (PC) for easy data transfer to CSIRO in Melbourne. Figure 5-1 shows the external components of the system, called the Integrated Sensor Suite (ISS).

Figure 5-1 Monitoring system – external components



The ISS collects outside weather data and sends the data to the console located inside the dwelling. This wireless system is solar powered and sends the data to the console via a low-power radio. The ISS contains a rain collector, temperature sensor, humidity sensor and anemometer. The temperature and humidity sensors are mounted in a passive radiation shield to minimise the impact of solar radiation on sensor readings. The anemometer measures wind speed and direction and can be installed adjacent to, or apart from the ISS. There is a cabled connection between the anemometer and the ISS and these units are mounted together.

The anemometer and external temperature gauge are critical for this project. The system was also priced to exclude the other components, such as the rain gauge, but there was no cost saving as that option involved the cost of a different mounting device. The benefit of including the full range of weather information is in the added interest to the project participants. So while rain and humidity data is being collected, it will not be analysed in this project.

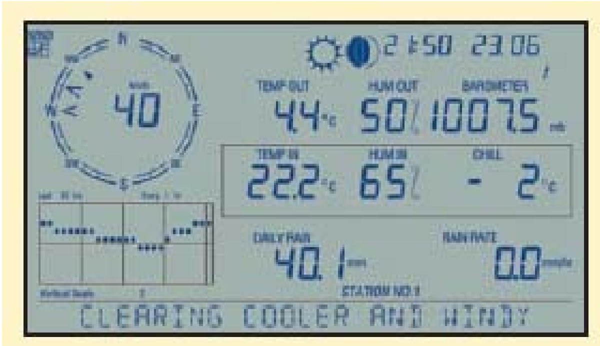
The Sensor Interface Module (SIM) contains the 'brains' of the ISS and the radio transmitter and is located in the SIM housing. The SIM collects the outside weather data from the ISS sensors and then transmits the data to a console located inside the dwelling (Figure 5-2) and connected to mains power.

Figure 5-2 Monitoring system - internal console

According to the manufacturer, the console batteries should provide back up power for up to four to six weeks, depending on the data intervals. Project Participants were provided with backup batteries and asked to contact the researchers if they planned to be absent from their dwellings for more than two weeks and wished to leave the power off during their absence.

The console displays and records the full range of weather station data as shown in Figure 5-3 and interfaces to a computer using specialized software.

Figure 5-3	Console screen



Initially, it was hoped that the data collection procedure could be automated, but when the equipment arrived and was installed for testing, it became apparent that the Participants would have to manually connect their PCs, upload and transmit the data. All project participants had a home PC, set up in a home office room or area of the dwelling, as shown in Figure 5-4.

Figure 5-4	Typical console and PC setup

5.2 Siting the system

5.2.1 Standard siting guidelines

The manufacturer provides general weather station siting guidelines that include placing the anemometer above local objects that obstruct, or block, wind flow. The standard collection point for meteorological and aviation applications is 10meters (m) above the ground. In a residential setting, the manufacturer recommends placing it 3 meters above the roof line. Figure 5-5 shows two typical roof mounted residential installations, indicated with a red arrow. The dwelling on the left is located in the case study 12 in Brisbane's outer western region. The dwelling on the right is Research Home, Rockhampton. Data from this project is freely available via a range of reports accessible at http://www.build.qld.gov.au/research/library/.

Figure 5-5 Standard roof-mounted installation systems

Both these dwellings are located in the sub tropical climate zone and both data sets have been offered for this project. This offer will be considered when the data analysis begins in October 2006. But in general, data collected at the roof top is inappropriate for this project which aims to monitor the obstructed breeze that flows across the lot to enter the dwelling at door or window level and either cooling or heating the dwelling in the process.

A number of other mounting suggestions were also considered and rejected

- Affixing to the eaves or a pergola meant that the screw holes would need to be patched and painted at the conclusion of the project – incurring additional cost and the possibility of disagreements over the amount of patching required
- Affixing the equipment at verandah level of multi-storey dwellings was rejected for the same reasons.

Affixing to fences was considered and rejected because

- May have resulted in disputes with neighbours or the local council if any part of the equipment went outside the boundary
- The more obvious the equipment is from outside the property, the more likely it is to be damaged or stolen
- The variety of fence types would have meant individualized installations, increasing the complexity and cost.

The tripod option offered by the manufacturer was also rejected because

- Additional cost per unit
- Area required at base level (1 to 1.5 M^2) would create an inconvenience in most back yards and especially in small lots.

5.2.2 Project siting guidelines

The aim of this project is to examine the impact of the surrounding obstructions to determine approximately the percentage of the naturally cooling breezes available to the lot enter the dwelling.

Because of the cost per unit, only one anemometer (wind gauge) could be installed per dwelling. So the main factors influencing the optimum siting for the equipment included;

- Preferably on either the north-eastern or south-eastern sides of the property first to capture the prevailing cooling breezes as indicated on the wind rose (see Figure 2-13); and
- Ideally this would be adjacent to the main living areas to measure the breezes available to the lot that would improve indoor air comfort

- Approx 2.5m from the ground – at the approximate opening height for windows for low set dwellings and in a (relative) degree of free air above 2m fences
- Approx 1.5m in from the fence line to avoid surface layer effects on the ventilation patterns – free air space is achieved at around 0.5m.

It was expected that some in some sites the equipment would be shielded more than others precisely because of the complexity of the conditions evident in the case studies. So in each case, the optimum siting decisions were also constrained by the following requirements;

- Need to reach agreement with the homeowners with respect to their individual usage patterns and preferences; and
- To achieve a reasonable degree of security - such as in a fenced backyard area
- To avoid service pipes (power, sewerage, water lines) – in the absence of reliable maps
- Considering normal usage patterns (mowing etc) meant the best position would be within a garden bed, yet clear of heavy vegetation.

Balancing these frequently conflicting requirements added an unexpected degree of difficulty to each installation and also led to the development of a simplified installation system that met home-owner and researcher requirements. The final siting decisions are outlined in Appendix D - .

5.2.3 Installation

The installation was carried out by an appropriately qualified and licensed sub-contractor, who worked with researchers to devise a free-standing, but stable platform pole that avoided the need for the equipment to be affixed to the dwelling. Instead the external equipment is mounted on a free-standing steel pole rammed approx 0.5m into the ground as shown in Figure 5-6.

Figure 5-6 Project specific free standing installation system

The benefits of this system include;

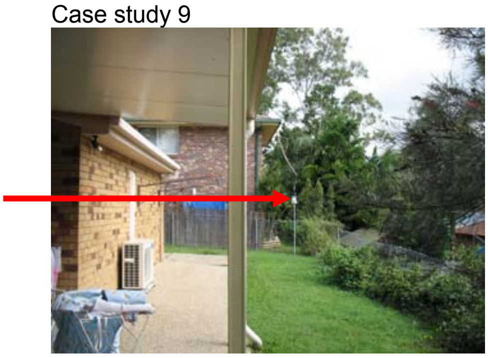
- The equipment is generally located within a garden bed to minimize accidental dislodgement through everyday use of back yard – such as mowing, trimming, children playing
- Allows for easy relocation throughout the project if required
- Allows for easy retrieval and relocation in the event that a Participant withdraws and the equipment had to be relocated to a fallback property; and finally
- Facilitates easy removal at the completion of the data collection period if the equipment is to be retrieved and re-used – or easy relocation at the choice of the homeowner if the equipment is to be left in situ.

The following images (Figure 5-7) provide an overview of the range of system siting in relation to the dwellings. For further information, please refer to the detailed case study descriptions at Appendix D - .

Figure 5-7 Monitoring equipment in relation to case study dwellings

Case study 9

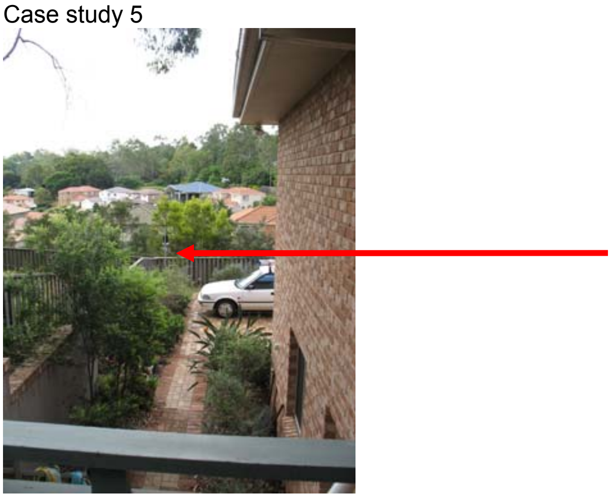
Case study 10



Case study 8

Case study 5

Case study 6



Case study 12

Steep sites, such as case studies 8 and 12 above, posed a particular challenge as one anemometer cannot capture the full range across the site. But each weather station is collecting data in relation to the area surrounding the lot and on a steep lot, measuring the breeze available to the ground floor of the case study dwelling may be capturing the breeze available to the second floor of an adjoining dwelling.

5.3 Data management

Participants were provided with an information folder containing:

- Aims and objectives of the project
- Equipment manuals
- Contact details within CSIRO
- Information on the CRC CI
- Energy Project industry booklet; and
- Contact details for questions, concerns or problems with the equipment.

5.3.1 Data collection

The consoles record the internal temperature of the dwelling and these temperatures will be compared with the external site temperatures to establish the site and dwelling heating and cooling patterns.

The optimum siting for the console would have been in the living area immediately adjacent to the outdoor area being monitored. Living areas are generally 'conditioned' (that is, either air conditioned or heated) more regularly than other areas in the dwelling and are assumed to be 'conditioned' when the temperature exceeds certain parameters in thermal modeling programs. However during installations, the participants elected to place the console adjacent to their PCs, as shown in Figure 5-4. All twelve dwellings had a SOHO (small office, home office), located in either a spare bedroom or in a dedicated room or space adjacent to the dwelling entry. Whilst this practical placement is not theoretically ideal, there is an element of consistency across the twelve consoles. A key deciding factor was that the more difficult the data upload and transferal process, the less likely Participants would be to remember to complete the task and the more likely it would be that data would be lost or participants withdraw.

Data recording and collecting began in all case study dwellings at the end of March 2006. The Participants are requested to upload the data and transmit it as an attachment to an email on a weekly or fortnightly basis, prompted by a reminder email. Upon receipt the data is checked for completeness and archived until the end of the analysis period. The consoles can only store three weeks of data, so any delays in uploading the data mean that the earliest data in the period is overwritten and lost. It is inevitable that this will occur from time to time throughout the project, but at the time of this report this data collection process has settled into an efficient routine.

5.3.2 Minimising data loss

There are a number of ongoing risks associated with this project and these are being managed as follows:

- Loss of dwelling - Project Participants may withdraw from the project at any time, but restricting the pool of potential volunteers to those associated with research ensures they had an understanding of the commitment required
- Should one, or more, withdraw, a number of backup properties have been identified
- Loss of data - Participants forward the data on a weekly or fortnightly basis and this process is prompted by a reminder email. On receipt, the data is checked for completeness, but data can be overwritten at source if the Participant fails to upload for three weeks
- Loss of equipment through theft or damage – the steps taken to minimise this risk have been described elsewhere in this report.

Hailstorms or destructive winds remain the greatest ongoing risk to the equipment. Funds remain to replace one or two systems. But depending on the timing of equipment failure, loss or damage, the delay and/or the cost of obtaining and installing a replacement system may be deemed impractical. There is no provision to replace numbers of weather stations.

5.4 Decommissioning the system

The Letter of Involvement clearly states that Participants acknowledge that the equipment will be removed at the conclusion of the monitoring period. The Project Team has recommended that the systems be left in-situ at the conclusion of the project in consideration of the time and effort invested by the Project Participants throughout the project. But as the equipment belongs to the CSIRO, ownership at the conclusion of the monitoring period is at the discretion of that organisation. This issue is to be resolved during the course of the project. If the equipment is to be removed, this will be a simple procedure involving removal of the pole and the weather station and disconnection and removal of the internal console.

6. NEXT STEPS

This report covers the period from the project commencement to the 30 June 2006. The next report, due on 30 December 2006 will examine the data collected to 31 August.

6.1 Data analysis

Wind speed and direction data collected at the case study lots will be compared with BoM data and the differences analysed with respect to the micro-climatic conditions to determine the impact increasingly densely constructed and vegetated lots have on obstructing the flow of natural ventilation.

The images provided throughout this report emphasize the range of lot characteristics, such as size, slope and orientation that exist and are being studied in this project, including;

- Small lots (1 star) with good ventilation (case studies 1 and 2)
- Standard lots (5 star) with poor ventilation (case study 5)
- Standard lots (5 star) with good ventilation (case studies 6,7, 9 and 10)
- Large lots (5 star) with poor ventilation (case studies 4, 8 and 11)
- Sloping lots (1 star) with poor ventilation (case study 8) and
- Sloping lots (1 star) with good ventilation (case studies 3 and 12).

Data from these case studies will be used to enhance the existing lot-rating methodology to include ventilation orientation parameters.

6.1.1 Data analysis milestones

At each of the case study sites, data is being recorded at 15 minute intervals for each day for up to twelve months. There are two critical data analysis periods throughout this project. The first period concluded on 31st August 2006 (winter 2006). The data from this period is presently being analysed and the report is due by 31st December 2006.

This report will provide some early findings on the degree of degradation in wind speed between the BoM and the obstructed breezes available to the case study dwellings. Importantly, the analysis period will allow for confirmation of the equipment siting before the critical summer period commences on 1st December 2006 and concludes on 28th February 2007.

Owing to the tight timeframe between the conclusion of monitoring and the expected completion of the project, the report from this period will also deliver the lot-rating methodology. Both are due by 30 June 2007.

6.1.2 Analysing ventilation data – previewing winter 2006

The first step will be to compare BoM data for winter 2006 with the averaged climatic data for the region to provide a comparative context for the subsequent comparisons between BoM and the case study dwellings for 2006/07. With the context established, the case study lots, and dwellings will then be examined in detail. As a preview to this process, data from May 2006 was briefly examined to ensure that the data recording procedure was proceeding as expected and to give researchers an early indication that the data was also as expected. Data monitoring began in April, but the initial settling down period meant that some early data was lost, leaving May as the only complete month that could be examined to meet a 30 June deliverable target. It is important to note the following;

- May is not a critical month for ventilation – either in terms blocking strong, cold winds in winter, strong hot winds in summer or for capturing cooling breezes in summer

- Those homeowner ventilation anecdotes relate to summer, not winter.

Four dwellings were selected for this brief examination, including two well ventilated and two poorly ventilated lots as based on homeowner anecdotes. Figure 6-1 provides an early indication of the variations in wind speed for these dwellings.

Figure 6-1 Comparing 9AM wind speed for selected case study lots against BoM data

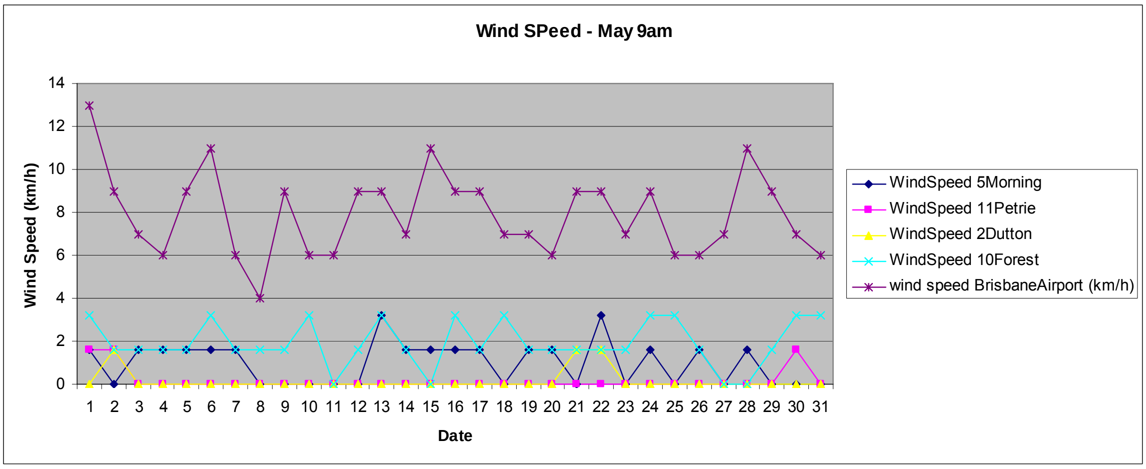
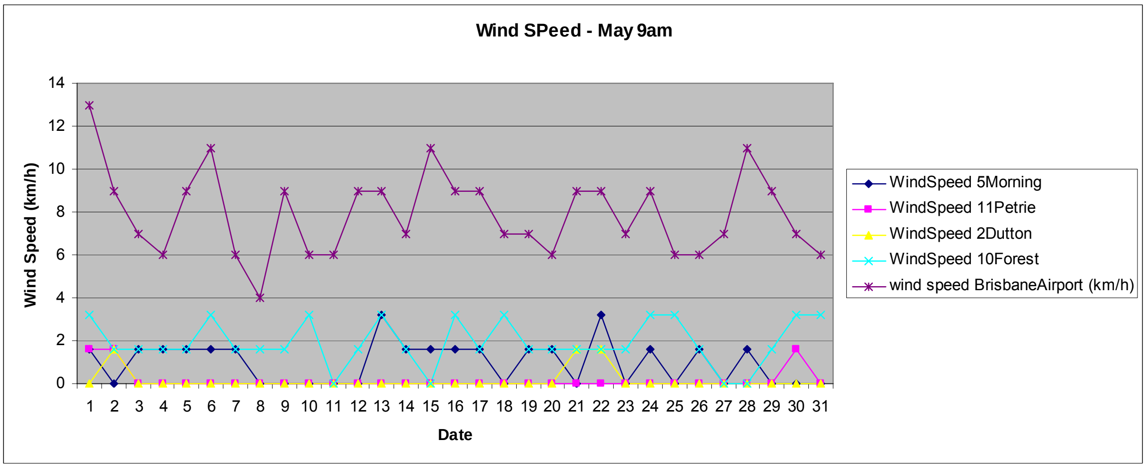


Figure 6-2 Comparing 3PM wind speed for selected case study lots against BoM data



The gap between the BoM data and the winds recorded at the four dwellings is marked, but that observation must be tempered by the following:

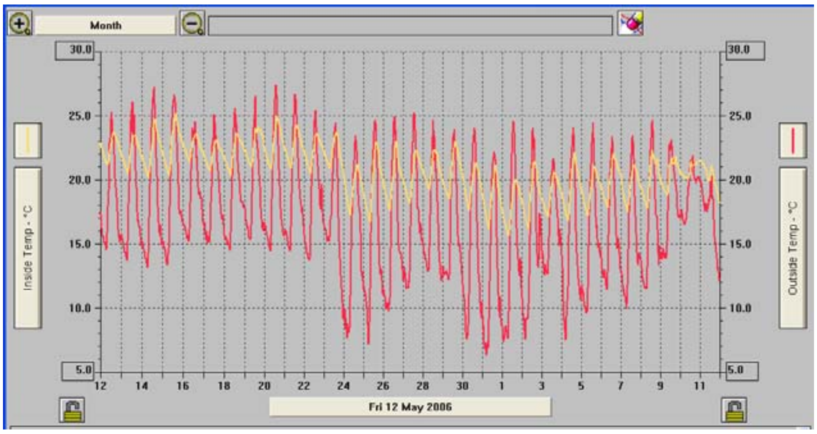
- As only one wind vane is recording at each of the case study lots, the optimum siting is on the north or north east side of the property to capture the prevailing summer breezes
- In May the prevailing breezes come from the south, south-west
- That necessarily means that the dwelling, other structures, or vegetation will significantly block breezes
- But in the same manner that these barriers may significantly block breezes from the case study dwelling at crucial times during the year.

Each site will require detailed analysis to separate the site specific impacts from a more generalised pattern. That detail will be provided in the next report.

6.1.3 Connection between lot and dwelling

Along with wind speed and direction, the external temperatures (maximum and minimum) at each of the lots will also be compared with BoM data. With the external context analysed, internal temperature variations will show how effectively the dwelling moderates (or conditions) the external (lot) climatic conditions. As an example, Figure 6-3 shows the external (red) and internal (yellow) temperature variations for case study 5.

Figure 6-3 Case study 5 – external and internal dwelling temperatures May 2006



For this case study, the small variation in temperature range inside this dwelling, shown in yellow above, is to be expected for a double brick and timber dwelling in winter. The same dwelling could be expected to show unacceptably high internal temperatures during periods of prolonged high temperatures next summer. At this early stage in the project, the BoM data has not been added, but when viewed over the one year period, graphs such as this for each of case study lots, will provide the heating and cooling 'heartbeat' for each lot and dwelling. When combined, these graphs could be seen to provide a 'pulse' for winter 2006. The final report will show how this 'pulse/heartbeat' pattern changes throughout the year.

These analyses are not intended to show a preference for one dwelling style over another, rather to examine the range of temperatures within one climate zone. Brief homeowner anecdotes (where available) may add another layer in interpreting how the residents of SEQ perceive and prefer to manage the external climatic conditions. Some of these factors cannot be taken into consideration in developing the lot-rating methodology, but the intent behind this series of projects is to improve sub-divisional sustainability over the lifetime of the dwelling stock. With that larger objective in mind, these analyses and anecdotes may provide an invaluable snapshot of contemporary attitudes and practices toward dwelling heating and cooling in a sub tropical climate.

6.2 Toward an enhanced lot-rating methodology

The current lot-rating methodology is based on passive heating requirements and it is expected that the enhanced lot-rating methodology would augment these passive design principles with ventilation data appropriate to the location to reduce the amount of the power required to heat and cool dwellings in a basically benign climate.

There is a need to assess multiple criteria (solar gain/protection, ventilation and shielding potential) so the impact each of these will have on a particular lot needs to be considered. Once these levels of impact have been determined, appropriate weighting factors can be assigned to each criterion and an overall rating for the lot established. Lot slope and size will examined in more detail as the current 1 star rating for small or steep lots is counter productive in a region where higher percentages of small lots on more difficult topographies are likely.

6.2.1 Linking to other climate zones

As noted elsewhere in this report, the current and 2005 projects focused on SEQ as that is the growth area in Australia. While these results are expected to be directly relevant in the other warm weather states of the Northern Territory and Western Australia, the Project

Agreement requires that the lot-rating methodology be relevant to all Australian states. As all climates zones throughout Australia have the potential for passive cooling through natural ventilation in the warmer months, the findings from this project will be examined in this wider context. As a first step, the capital city wind roses for Sydney, Melbourne, Adelaide and Perth are at Appendix F - . Similar data can be obtained from the BoM for Darwin. A subsequent report will provide an overview of current sub-divisional practices as they relate to designing to maximise passive heating and cooling in each state.

6.2.2 Linking to 2004-003-B Micro-climatic Impacts on the Built Environment

Researchers are liaising with those engaged in the 2004-003-B Microclimatic Impacts on the Built Environment Project. The aim of this project is to quantify and model the potential microclimatic influences and impacts of a building, within a precinct of buildings through assessment of a 3D CAD model to enable planners, developers or designers to model this interaction at a conceptual level. The outcome will be the ability for the BCC and QDPW staff to undertake assessment of microclimatic impacts of the design in relation to operational energy performance of a proposed new building design, based on its surrounding microclimatic impact as well as building boundary conditions for wind and rainfall. The relationship between these projects will be examined in further detail in the next report.

6.2.3 Linking to other GIS systems

The existing lot-rating methodology was a paper based process and it is expected that the enhanced version will be similar. However one of the barriers to effective utilization of analysis and evaluation tools is the additional time and effort that is required to extract data requirements and enter the information into the tools. Automatically linking such tools to other software systems already containing much of the data requirements can be a highly effective method of encouraging the use of analysis tools.

Land sub-division nowadays is aided by the use of sophisticated tools such as Geographic Information Systems (GIS). GIS data used for land sub-division would usually contain the vast majority of information required to perform a lot-rating using the methodology described above. Linking such as assessment tool to a developer's existing GIS software would enable quick and easy assessments to be made at the design stage.

6.2.4 Acknowledgements

Researchers would like to acknowledge the Project participants as without their generous support and willing participation, this research would not be possible. The researchers would also like to thank Robert Hilan for his ingenuity and thoughtful contributions throughout the equipment installation phase.

7. REFERENCES

AGO (1999). Australian Residential Building Sector Greenhouse Gas Emissions 1990-2010: Executive Summary Report 1999. Canberra, Australian Greenhouse Office.

Commonwealth Department of Housing and Regional Development (1995). *AMCORD 95: A National Resource Document for Residential Development*. Canberra, AGPS.

Delfin Springfield Pty Limited. (2004). "Springfield Lakes - Fact File." http://www.springfieldlakes.com.au/llweb/springfieldlakes/main.nsf/all/pl_factfile.

DLGP (2001). Queensland living: housing trends 2001. Brisbane, The State of Queensland (Queensland Department of Local Government and Planning).

Loder & Bayly Consulting Group with Sustainable Solutions Pty Ltd (1991). Energy Smart Lots: A Study of Solar Efficient Residential Subdivision. Melbourne, Energy Victoria.

Mickel, J. (2004). Media release: Queensland Minister calls for more economical cooling. 27/10/04.

Miller, A. and M. Ambrose (2005). Sustainable Subdivisions: Energy Efficient Design - Report to Industry. CRC-CI. Brisbane, Icon Net Pty Ltd.

O'Hare, D., R. Kennedy, N. Demirbilek and G. Strong (2006). The Role of Natural Ventilation: Building Sustainable Subdivisions in SEQ - Phase One: Consultative Phase G. Strong. Brisbane CRC CI.

Office of Urban Management. (2004). "Draft South East Queensland Regional Plan: For Consultation." Queensland Government. Accessed 20 December 2004, http://www.oum.qld.gov.au/Docs/draftplan/Draft_Regional_Plan.pdf.

OUM (2005). South East Queensland Regional Plan. Q. Government. Brisbane, Office of Urban Management.

Planning Information & Forecasting Unit, Q. A. B. C. C. (2003). "A Statistical Portrait of Brisbane: incorporating data from the 2001 census." BCC, 2005, http://wic001lc.server-web.com/statistical_portrait/download/pdf/brisbanes_regions.pdf.

PIFU. (2003). "A Statistical Portrait of Brisbane: incorporating data from the 2001 census." BCC, 2005, http://wic001lc.server-web.com/statistical_portrait/download/pdf/brisbanes_regions.pdf.

Queensland Conservation Council. (2004). "Queensland Household Energy Use." Accessed Mar 2004, http://www.qccqld.org.au/.

Queensland Government (2004). Towards Sustainable Housing in Queensland: Discussion Paper. Brisbane, Local Government and Planning and Environmental Protection Agency

Reardon, C. (2001, 1 March 2004). "Your Home: Technical Manual: Design for Lifestyle and the Future: 1:10 Rating Tools." Commonwealth of Australia, 3 November 2004, http://www.greenhouse.gov.au/yourhome/technical/fs110.htm.

SEDA (2003). Energy Smart Homes Model Policy. Sydney, Sustainable Energy Development Authority.

Szokolay, S. V. (1988). *Climatic data and its use in design*. Red Hill, Australia, RAIA Education Division.

Appendix A - Current lot-rating methodology

Energy Smart Homes Model Policy

Solutions for the future SEDA

Sustainable Energy Development Authority's Energy Smart Homes Model Policy for adaptation and implementation by Councils

table of contents

SOLAR ACCESS FOR LOTS

Guidelines for Solar Efficient Residential Subdivision in New South Wales

WHAT IS SOLAR ACCESS?

Solar access is a measure of how much solar energy (sunshine) is available to assist with the heating of a building.

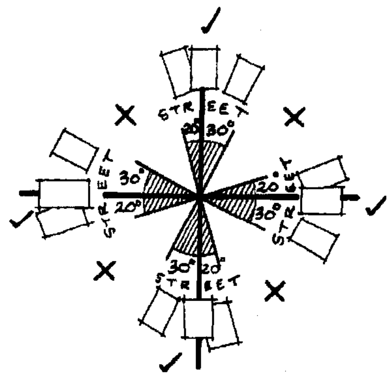
In Winter north facing windows gain heat from the sun thereby helping to heat the home. In Summer, they have the advantage of being able to be easily shaded to keep the house cool. By ensuring the windows to heated parts of the house face north, occupants can benefit from free solar heating which reduces energy bills and helps the environment. If the sun cannot shine on these north windows due to overshadowing (e.g. by surrounding buildings) then the free solar heating is lost.

SUBDIVIDING FOR SOLAR ACCESS

This brochure provides information about how to design subdivisions to minimise the overshadowing of neighbouring north windows. It incorporates information on:

- how to maximise solar access through the careful design of the orientation and size of house lots;
- how to site each house to ensure that it has solar access; and
- how to measure solar access on a scale from 1 to 5 stars.

DESIGN GUIDELINES FOR SOLAR ACCESS



To maximise solar access the design of residential subdivisions should be based on the following principles:

1 Street layout

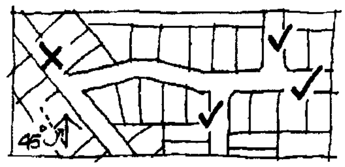
- Align streets east-west and north-south wherever possible.
- Aim for north south streets within 20° west and 30° east of true north.
- Aim for east-west streets within 30° south and 20° north of true east.

2 Land uses and densities

- Concentrate smaller lots on north slopes or adjacent to lightly treed open space.
- Locate larger lots, non-residential uses or public open space where solar access is poor.

3 Laying out the lots

Lot shape and orientation

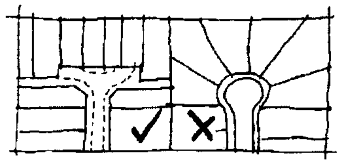


- Where streets are within the acceptable orientation range use rectangular lots.
- Locate as many long lot boundaries as possible within the permissible orientation range.
- Where the street is not within the orientation range use skewed lots.

Use the Solar Lot Width Guidelines

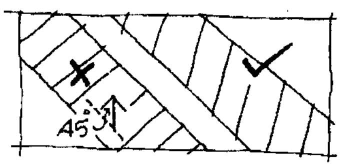
Select the appropriate lot width from Tables 1 and 2 .

Show the setback on the lot plan



Help builders, designers and home buyers to make best use of the sun by showing the preferred setback line for each lot on the subdivision plan.

Street orientation, lot width and rating



- Locate the narrowest lots on the north side of east-west streets.
- Lots on the south side of east-west streets need to be wider to accommodate car access.
- East-west lots need to be wider unless two storey construction is to be restricted.
- East west lots can be narrower if there is road or open space to the north (eg. a corner lot).

Adjust the lot ratings to reflect the impact of the slope

Lots on south facing slopes need more open space to the north to protect solar access while lots on north facing slopes need less open space (see Table 3).

4 Additional Controls

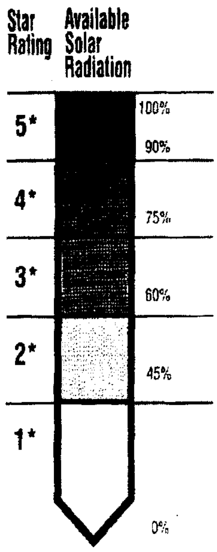
Where narrow lot widths are involved limiting the height of buildings relative to the south boundaries provides additional protection of solar access.

5 Matching the House to the Lot

An energy efficient house can still be built on a lot with poor solar access. By raising window sill heights or using clerestory windows actual overshadowing of windows can be minimised. Where solar access is limited insulate to higher levels, minimise air leakage, and keep glass areas to moderate sizes.

RATING SOLAR ACCESS

SOLAR ENERGY & RATINGS TABLE



△ Sun on wall on Solar Opportunity Line June 21, 9am - 3pm.

Solar Access Star Ratings

The Solar Access 5 star rating provides a measure of the amount of solar radiation available to assist in the heating of a house. The adjacent chart shows the rating thresholds as a percent of the solar radiation which would enter a house through north windows with no overshadowing.

Applicability of the rating

This rating system only applies to separate lots which are 300 - 1000 m² in area. For smaller lots solar access must more closely integrated with building design and siting. Lots larger than 1000 m² have a greater opportunity to achieve good solar access, however, buildings should still be set back the recommended distance from the north boundary.

Various lots receive only a 1 star rating. These are:

- Lots with all their long boundaries outside the permissible orientation range. This may not stop the house being correctly oriented. However, as most houses are built parallel to boundaries, in order to achieve good solar access, clear guidelines for house siting will need to be provided.
- Lots with a slope of 20% or more (1:5). Such lots should be avoided through better subdivision layout and are therefore only given a 1 star rating.

⇨ Step 1 Determining Lot Orientation

Tables 1 and 2 on the next page show how lot rating depends on the lot's predominant orientation and width. This orientation is determined by the bearing of the longer boundaries on the lot, and the general orientation of the lot to the street. (see also Figure 2)

Lot Width

Lot width is measured at right angles to the long boundary of the lot which falls within the acceptable orientation range.

For East/West facing lots the required lot width is determined by taking into account:

- the minimum setback of buildings sited to the north,
- the distance between buildings required to achieve the rated solar access, and
- an allowance for a minimum building width and setback from the south boundary of the lot.

For North/South lots the required lot width is determined by taking into account:

- the amount of northern facing wall available for north facing windows, and
- the distance required between buildings to the east and the west to minimise their overshadowing of northern windows and to achieve the rated solar access.

⇨ Step 2 Determining the Star Rating

Lots are rated on their ability to accommodate a house with good solar access. The width of the lot is an indicator of its ability to provide sufficient open space to the north of the house to ensure that surrounding buildings will not block out the sun. The tables below show the minimum lot width required to achieve the various star ratings depending on the orientation of the street frontage.

Table 1 Determining the star rating

Lot orientation	Minimum lot width (metres) Star Rating ★★★★★	★★★★	★★★	★★	★
East/West					
(Coastal NSW)	> 16.2	15.1-16.2	14.2-15.0	13.4-14.1	< 13.4
(Inland NSW)	> 16.8	15.6-16.8	14.4-15.5	13.8-14.3	< 13.8
North					
(Coastal NSW)	>13.5	11.7-13.5	10.9-11.6	10.5-10.8	< 10.5
(Inland NSW)	>14.1	12.2-14.1	11.1-12.1	10.5-11.0	<10.5
South					
(Coastal NSW)	>15.5	13.7-15.5	12.9-13.6	12.5-12.8	< 12.5
(Inland NSW)	>16.1	14.2-16.1	13.1-14.1	12.5-13.0	<12.5

TABLE 1

USE THIS TABLE IF THE HEIGHT OF BUILDINGS TO THE NORTH IS NOT LIMITED.

Definitions

East / West: Bearing of one long side within 250 and 300°, street on east or west side
North: Bearing of one long side within 340 and 30°, street on southern side
South: Bearing of one long side within 340 and 30°, street on northern side, note that greater lot widths are to allow for car access to north.

It will be noted from Table1 that reducing lot width results in a reduction in the solar access star rating. This need not be the case. Lot width can be reduced without impacting on the solar access rating by placing height restrictions to houses on the north boundaries.

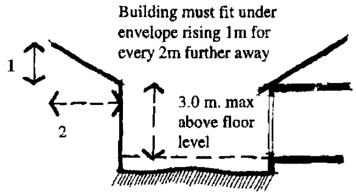
Table 2 below shows the ratings of lot widths were the height of buildings on the lot to the north are known to be one storey (as shown in the diagram opposite).

TABLE 2

USE THIS TABLE IF IT'S KNOWN THAT BUILDINGS TO THE NORTH WILL BE LIMITED.

Table 2 Determining the star rating (dwellings to the north one storey high)

Lot orientation	Minimum lot width (metres) Star Rating ★★★★★	★★★★	★★★	★★	★
East/West					
(Coastal NSW)	>12.7	11.7-12.7	11.0-11.6	10.4-10.9	< 10.4
(Inland NSW)	>12.9	11.8-12.9	10.9-11.7	10.4-10.8	<10.4
North					
(Coastal NSW)	>13.1	11.6-13.1	10.8-11.5	10.3-10.7	< 10.3
(Inland NSW)	>13.3	11.7-13.3	10.7-11.6	10.4-10.6	<10.4
South					
(Coastal NSW)	>15.1	13.6-15.1	12.8-13.5	12.3-12.7	< 12.3
(Inland NSW)	>15.3	13.7-15.3	12.7-13.6	12.4-12.6	<12.4



Height limits assumed for table 2

⇨ Step 3 Allowing for easements, public open space & road reserves

Where there is guaranteed open space to the north of the lot the lot width and required setback (shown below) may be reduced accordingly. For example if the lot to the north has a 3 m. easement on its south boundary the lot width and setback may be reduced by 2.1 m. as a 0.9 m. setback has already been assumed.

⇨ Step 4 Siting Your House To Achieve Solar Access

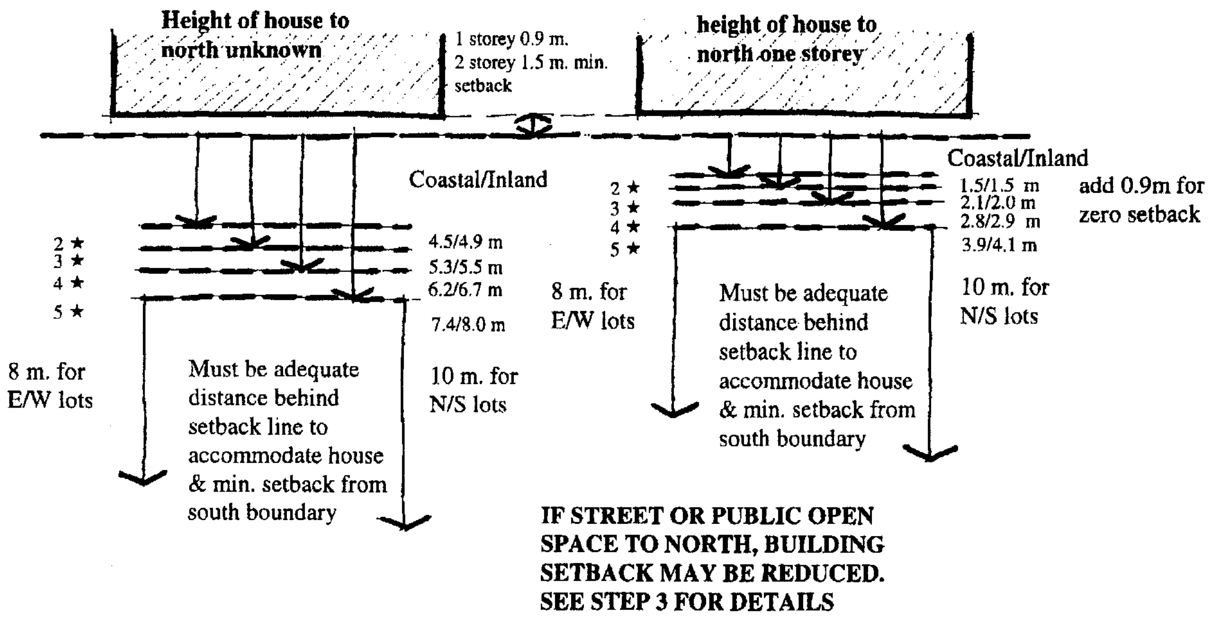
Setback from the north boundary

Having sufficient lot width alone will not guarantee solar access. A house must be sited so that its north facing windows are sufficiently set back from the north boundary of the lot to ensure they will not be overshadowed by surrounding houses. Figure 1 shows the setbacks required to achieve solar access potential at each star rating given the height of buildings to the north. The minimum building size and setback of adjacent buildings and the minimum building dimensions in the lot width tables assumed are also shown.

Showing setback lines on subdivision plans

It is suggested that subdivision plans show the setback line for the maximum rating obtainable - allowing for building height on lots to the north after allowance is made for the minimum building width and setback from the south boundary. Note that only those heated areas of the house need be setback to this line.

Figure 1 Building setback from north boundaries required to achieve various star ratings



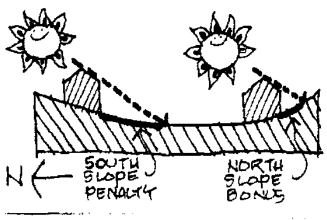
What about slope?

The setback (and lot width for East/West lots) required can be adjusted to allow for the slope of the land. South facing slopes will need larger setbacks to protect solar access while north facing slopes can have reduced setbacks. Add the figures below for south slopes and subtract for north slopes to obtain the appropriate setback from the north boundary.

Table 3 Slope Adjustments to lot width (metres)

Degree of Slope	Star Rating ★★★★★		★★★★ or less	
	1 storey	2 storey	1 storey	2 storey
5 < 10% (1:20 , 1:10) All zones	0.8	0.8	0.6	0.6
10 < 15 % (1:10 , 1:6.7) All zones	1.0	1.5	0.8	1.2
15 < 20% (1:6.7 , 1:5) All zones	1.4	2.1	1.1	1.7

East/West slopes reduce the amount of solar radiation available to north windows in the morning and afternoon. As the radiation is much less at these times such slopes are ignored. Note that with extreme East/West slopes this may not be true and detailed calculations would be required to determine actual solar access.



⇨ Step 5 Design an Energy Efficient House

After following the above steps to provide good solar access to a dwelling, the next step to consider is the design of the actual house.

Height of windows above ground

Prior to undertaking the house design, the sill height of overshadowed windows can have an impact upon the setback.

The information on setbacks and lot widths required to maintain solar access in these guidelines assume that the window sill is positioned at ground floor level. Overshadowing is greater on the portions of the window closest to the ground. The Solar Access of the house can be improved on poorly rated lots by raising the sill level to eliminate the most overshadowed sections of the windows. The table opposite shows the reduction in setback allowable if sill levels are raised. Clerestory windows and upper floor windows can be rated construction to the north where 2 storey construction is allowed on the lot to the north.

Reduction in setback allowed for increasing sill height Coastal Zone

sill height above floor	★★★★ or more	★★★ or less
300	0.4	0.4
600	0.9	0.7
900	1.5	1.0

Reduction in setback allowed for increasing sill height Inland Zone

sill height above floor	Star Rating ★★★★ or more	★★★ or less
300	0.5	0.4
600	0.9	0.7
900	1.5	1.0

HOW TO USE THE SYSTEM

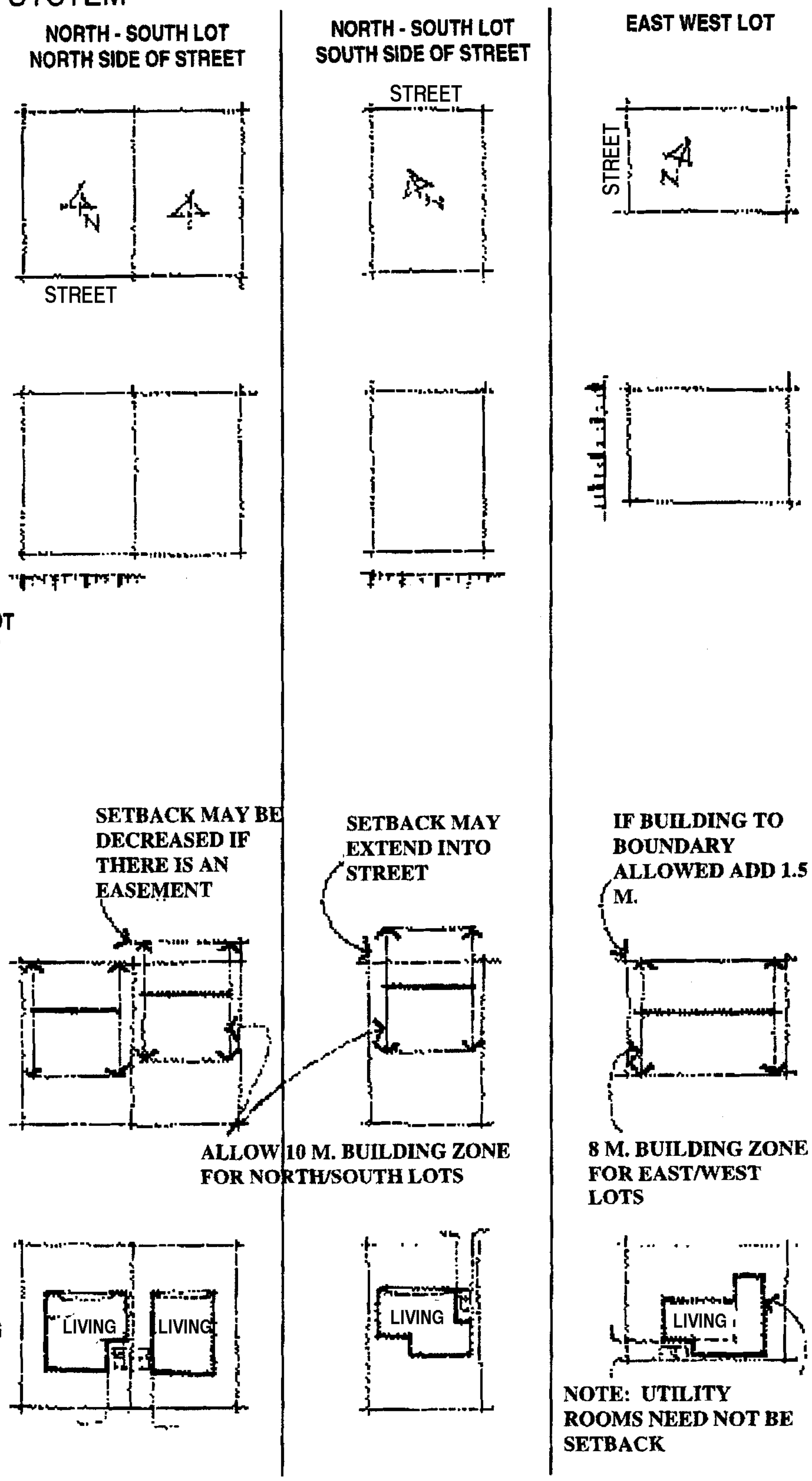
1 CHECK THAT LONG BOUNDARY IS WITHIN PERMISSIBLE ORIENTATION. (P.1)
CHECK PREDOMINANT ORIENTATION. (P.2)

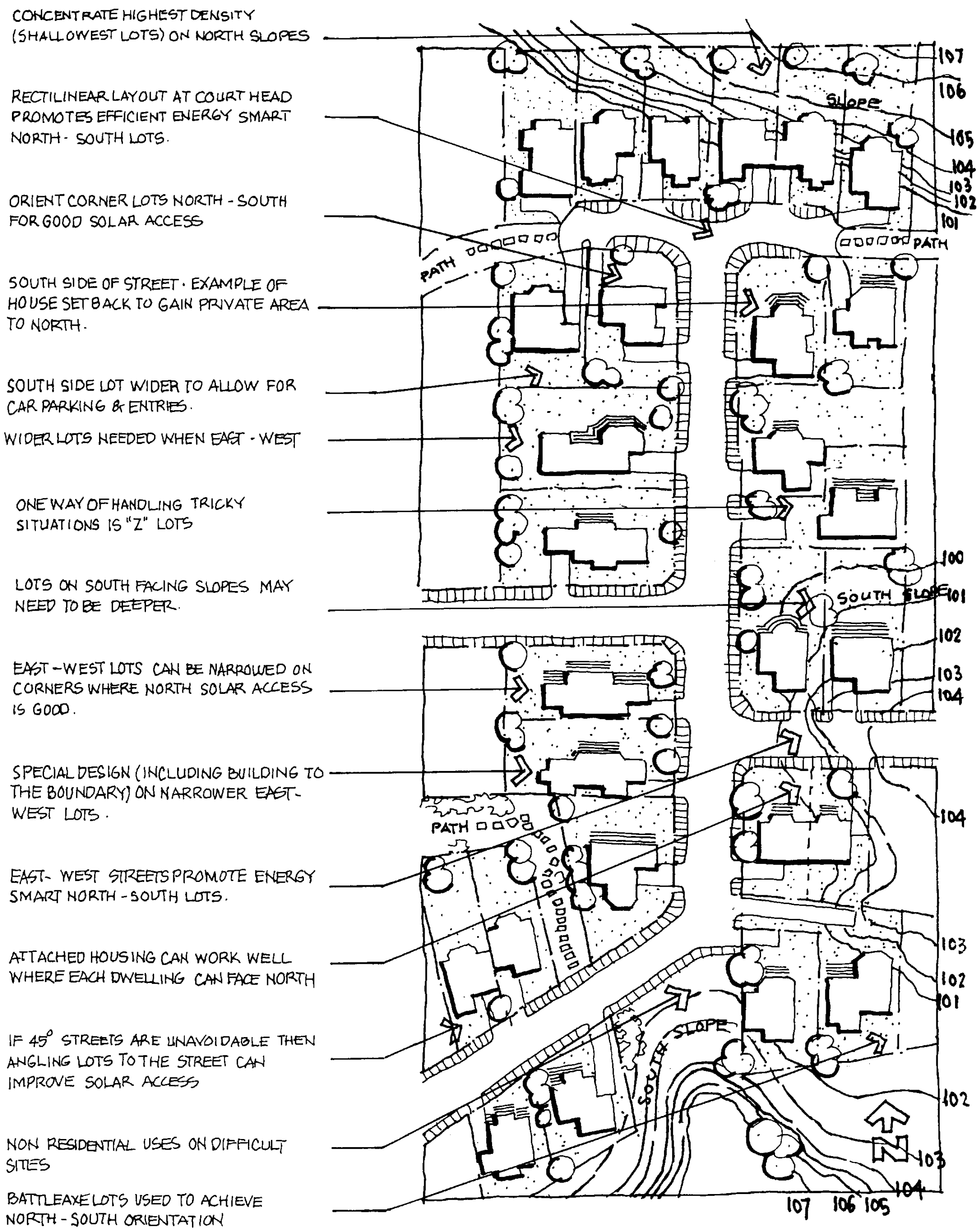
2 MEASURE LOT WIDTH AND DETERMINE RATING. (TABLE 1)

3 IF DESIRED, MODIFY LOT WIDTH OR USE HEIGHT LIMIT ON LOT TO THE NORTH (TABLE 2) TO IMPROVE RATING.

4 SHOW THE SETBACK REQUIRED TO ACHIEVE THE RATING ON THE PLAN OF SUBDIVISION.

5 THE SETBACK CAN THEN BE USED AS A STARTING POINT TO SITING AND SELECTING AN ENERGY EFFICIENT HOUSE




CONCENTRATE HIGHEST DENSITY (SHALLOWEST LOTS) ON NORTH SLOPES
RECTILINEAR LAYOUT AT COURT HEAD PROMOTES EFFICIENT ENERGY SMART NORTH - SOUTH LOTS.
ORIENT CORNER LOTS NORTH - SOUTH FOR GOOD SOLAR ACCESS
SOUTH SIDE OF STREET · EXAMPLE OF HOUSE SET BACK TO GAIN PRIVATE AREA TO NORTH.
SOUTH SIDE LOT WIDER TO ALLOW FOR CAR PARKING & ENTRIES.
WIDER LOTS NEEDED WHEN EAST - WEST
ONE WAY OF HANDLING TRICKY SITUATIONS IS "Z" LOTS
LOTS ON SOUTH FACING SLOPES MAY NEED TO BE DEEPER.
EAST - WEST LOTS CAN BE NARROWED ON CORNERS WHERE NORTH SOLAR ACCESS IS GOOD.
SPECIAL DESIGN (INCLUDING BUILDING TO THE BOUNDARY) ON NARROWER EAST-WEST LOTS.
EAST - WEST STREETS PROMOTE ENERGY SMART NORTH - SOUTH LOTS.
ATTACHED HOUSING CAN WORK WELL WHERE EACH DWELLING CAN FACE NORTH
IF 45° STREETS ARE UNAVOIDABLE THEN ANGLING LOTS TO THE STREET CAN IMPROVE SOLAR ACCESS
NON RESIDENTIAL USES ON DIFFICULT SITES
BATTLEAXE LOTS USED TO ACHIEVE NORTH - SOUTH ORIENTATION
SLOPE
PATH
PATH
SOUTH SLOPE
PATH
SOUTH SLOPE
107
106
105
104
103
102
101
100
101
102
103
104
104
103
102
101
102
103
104
107 106 105

references

Baulkham Hills Council, Environmental Services Division, 1994. Kellyville/Rouse Hill Residential Development Control Plan. Sydney.

Commonwealth of Australia, National Strategy for Ecologically Sustainable Development, 1992

Commonwealth Department of Housing and Regional Development, 1995. AMCORD: A national resource document for residential development. AGPS, Canberra.

Department Planning (NSW) and Office of Energy, Sydney, 1991. Energy Guidelines for Local Planning. Technical Bulletin No. 20. Sydney.

Department of Primary Industries and Energy, 1992. (Ballinger, Prasad & Rudder). Energy Efficient Australian Housing (2nd Ed.). National Solar Architecture Research Unit, University of New South Wales. AGPS, Canberra.

Energy Victoria, 1996. Solar Access for Lots. Energy Victoria, Melbourne.

Leichhardt Council, 1994. Development Control Plan No. 17, Energy Efficient Housing.

Loder & Bayly Consulting Group with Sustainable Solutions Pty Ltd and Isaacs, T, 1991. Energy Smart Lots. A study of Solar Efficient Residential Subdivision. Energy Victoria, Melbourne.

S. King, D. Rudder, D. Prasad & J. Ballinger, 1996. Site Planning in Australia: Strategies for energy efficient residential planning. An initiative of the National Energy Efficiency Program. Department of Primary Industries and Energy. AGPS, Canberra.

Phillips, R.O. 1992. Sunshine and Shade in Australasia. Technical Report 92/2. CSIRO Division of Building Construction and Engineering (available CSIRO Publishing Telephone: (03) 9662 7666, Facsimile: (03) 9662 7555).

SOLARCH, 1996. Water Heating Suitability Review. Report prepared on behalf of Unisearch Limited, UNSW, for Department of Housing. Sydney.

SOLECTA, 1997. Council Energy Efficient Housing Policy (Class I Buildings only). Gareth Cole and Associates Architects Pty Ltd.

State Projects, NSW Public Works Department, 1993. Building Energy Manual. Prepared for the Office of Energy, NSW Government. Sydney.

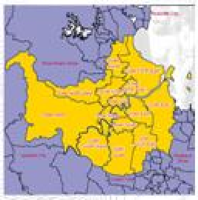
Appendix B - Call for case study homes

Sustainable Subdivisions: Ventilation Project

CRC Construction Innovation — Building our future

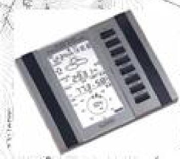
WANTED – HOME OWNERS to volunteer their homes for a research project that will verify and quantify the role that natural ventilation has in cooling residences in sub-tropical South East Queensland.

Twelve typical homes located in a range of typical suburban settings will be monitored for twelve months to determine the impact increasingly dense suburban settings may have in reducing the amount of breeze available to cool homes.



We will need your permission to:

- enter your property and install a monitor (similar to that shown on the left) on the outside of your home
- connect a data logger (similar to that shown on the right) to a powerpoint inside your home
- photograph the outside of your home to record significant barriers to natural ventilation such as high fences, dense foliage or adjoining structures
- remove the monitor and data logger at the end of the monitoring period, in February 2007



An information sheet will be provided when the equipment is installed.

We may ask you to assist with the data collection by either:

- allowing us to collect it on a periodic basis, or
- if you have a home computer, we may ask that you download the data and send an email, or a CD (provided)
- or we may be able to automate data collection

We will ask you to:

- sign a letter of involvement in the project and on the understanding that you can withdraw at any time

This research will inform the development of a lot rating methodology for SEQ and may also recommend that methodologies in use in other parts of Australia be modified to include the impact of ventilation.

CSIRO QUT Queensland Government Department of Public Works Brisbane City Bovis Lend Lease

So if you would like to volunteer your home to be part of this research project, please contact Anne Miller at CSIRO on 3327 4082 or via email on Anne.Miller@csiro.au before Friday 10th February.

Appendix C - Letter of Involvement

CRC Construction Innovation
BUILDING OUR FUTURE

CRC Construction Innovation
9th Floor, L Block
QUT Gardens Point Campus
2 George Street
BRISBANE QLD 4000
t: (07) 3864 1393
f: (07) 3864 9151
www.construction-innovation.info

Xx XXXXXXXXXX 2006

XX XXXXXXXXX
XXXXXXXXXXX
Brisbane QLD 4001

Dear XXXXX

Letter of Involvement in CRC CI Sustainable Sub-divisions: Ventilation Project

My name is Anne Miller and I am the Project Leader of a research project entitled "Sustainable Sub Divisions: Ventilation" on behalf of the (Cooperative Research Centre for Construction Innovation, CRC CI see http://www.construction-innovation.info/) – headquartered at Queensland University of Technology.

The research will verify and quantify the role natural ventilation has in cooling residences in sub tropical climates, inform the development of a lot-rating methodology for SEQ and may also make a recommendation that the existing lot-rating methodology in use in other parts of Australia, be modified to allow for the impact of ventilation.

Wind speed and direction will be monitored in 12 existing privately owned dwellings, representing a range of lot characteristics such as width, size, slope and location in relation to other buildings and vegetation. These dwellings will be owned and occupied by staff from the project participants, who will agree to equipment installation, and to assist in the transmission of the data for up to a year.

The offer of your dwelling for this project is deeply appreciated. The monitoring period is likely to start in February 2006 and end in February 2007. Wind speed and direction monitors similar to that pictured below (left) will be affixed to the outside of the dwelling. This solar powered and wireless monitor will transmit data to a data logger similar to that pictured below (right). The data logger will need to be connected to a power point inside your home for the duration of the project.

The data collection system is yet to be finalised. So depending on the equipment that is purchased, you may be asked to forward the data on a periodic basis e.g. fortnightly or monthly. If this is requested, CD's, and the like will be provided. If you have a home computer, we may be able to automate data collection. An information sheet will be provided when the monitor is installed.

To support the documentation of this project, it would be informative to include copies of photographs (and possibly plans) of the selected dwellings. The photographs will be de-identified where this is possible, as it is the context of the dwelling, rather than the specific dwelling, that is being examined.

However, the specific dwellings may be identifiable as the project will focus on identified locations within SEQ.

The photographs (and plans) sourced may be used in any of the Project Deliverables some of which will be publicly available. This includes project reports, presentations, conference papers and a variety of other publications including industry booklets, educational tools and media releases.

Your participation is voluntary and you are free to withdraw at any time. All monitoring equipment will be installed, maintained and removed by an appropriately qualified technician and will not require any attention from the volunteer. The CRC CI will not be responsible for claims related to property damage or occupant injury.

If you agree with the conditions of participation, please sign below and return by facsimile to 07 3864 9151 or hardcopy to the address provided above. If you would like to discuss this issue, please don't hesitate to contact me on telephone 3327 4082, or via email a.miller@construction-innovation.info

Your prompt assistance is very much appreciated.

Yours sincerely

Anne Miller

I ____ of _____________________________ agree to participate in the CRC CI Sustainable Sub-divisions: Ventilation Project and give permission for the wind speed monitor to be attached to my dwelling. I also give permission for the use of the plans and photographs for the purposes of the project as described. I warrant that I have the delegated authority to give this permission. I understand that my participation is voluntary and that I can withdraw at any time. I also agree that the equipment will be removed at the conclusion of the project. I accept the CRC CI will not be responsible for any claims related to property damage or occupant injury arising from my voluntary participation in this project.

Name Signature Date

----------------------- -------------------------- -------------------------------

Appendix D - Case Study Lots

D.1 Introduction

The aim of this section is to introduce;

- The selected lots (and dwellings)
- Positioning of the equipment
- Some homeowner ventilation anecdotes

Description and analysis of these case studies will be developed further in the subsequent reports. For now, case study presentations will include

Lot

In the Energy Project, the key informants commonly described both the lots and dwellings according to the lot size with a small lot being defined as less than 450m², or less than 15 metres wide, and large lots as over 560m². The case studies are listed in increasing order of lot sizes and include;

- Contour plan with the selected lot outlined in red
- Lot-rating based on current methodology
- Context - aerial photograph introduces the barriers/opportunities for natural ventilation.
- Indication of the location of the monitoring equipment (red arrow)

Dwelling

The main focus is on the mass of the house in relation to the lot, rather than on the individual dwelling types;

- External photographs of the dwelling with location monitoring equipment indicated
- Where provided, plans, elevations may be included in this Appendix and in subsequent reports as a tool for further examination of the relationship between the site and the dwelling.

Barriers/opportunities for passive ventilation

- This portion will be developed in subsequent reports

Ventilation anecdotes

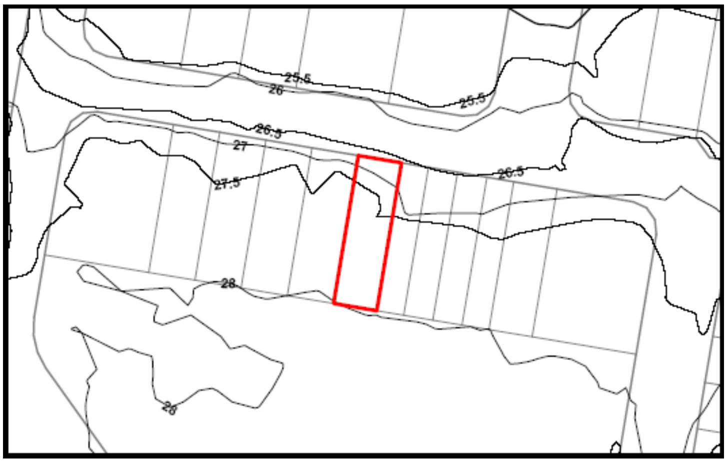
- Homeowner anecdotes regarding dwelling heating/ventilation. These may be developed in subsequent reports, but this aspect is outside the project agreement.

The images have been proportionally reduced to suit page layout and are not to scale. Dimensions have not been included.

D.1.1 Case study 1

One of only two very small (300m²) lots offered.

Figure 7-1 Lot case study 1



- Small lot 300m² - outer south
- Lot-rating - 1 star (width)

Figure 7-2 Suburban context case study 1

- North facing lot located in a brownfield development
- Open space to the south (rear) and a street to the north
- Equipment located to north of main living area in a reasonably clear space in the dense perimeter plantings within an enclosed courtyard

Figure 7-3 Dwelling case study 1

- Double storey brick veneer on slab freehold terrace dwelling
- 1990's double storey b/v on slab terrace house (freehold)
- 3 bedroom (including SOHO), 3 pedestals.

Homeowner anecdotes

- 2 adult occupants, one of whom works at home (WAH) part time
- Passive cooling preferred
- Owners expect dwelling to be hot at peak periods, but enjoy exceptional natural ventilation for most of the year
- Location of attached double storey dwellings adjacent to parkland allows passive surveillance and provides these zero lot dwellings with the benefit of breezes across the parkland.

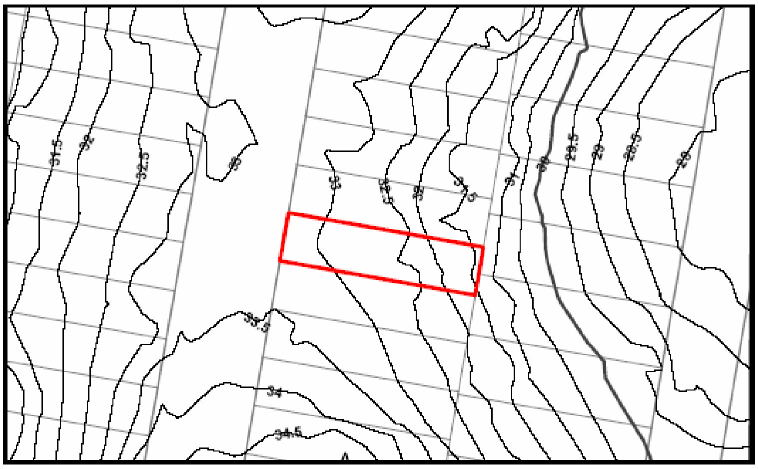
Barriers/opportunities for passive ventilation

- To be developed in the next report

D.1.2 Case study 2

Elevated lightweight dwelling typical of older suburbs pre-war, these dwellings are now being impacted by encroaching medium density developments. They are also being altered extensively with partial (as here) or complete sub-floor construction.

Figure 7-4 Lot case study 2



- Small lot 405m² - inner city
- 1 star (width) lot-rating

Figure 7-5 Suburban context case study 2

- West facing, flat lot
- Well vegetated lot made locating the equipment problematic
- Equipment located to east of main living area and closer to the dwelling than ideal to capture any breezes flowing over the high and dense boundary vegetation on the north eastern boundary

Figure 7-6 Dwelling case study 2

- Lightweight elevated dwelling (120m^2)with partial sub floor construction (60m^2)
- 4 bedroom, 2 pedestals
- Adjoining dwellings in close proximity

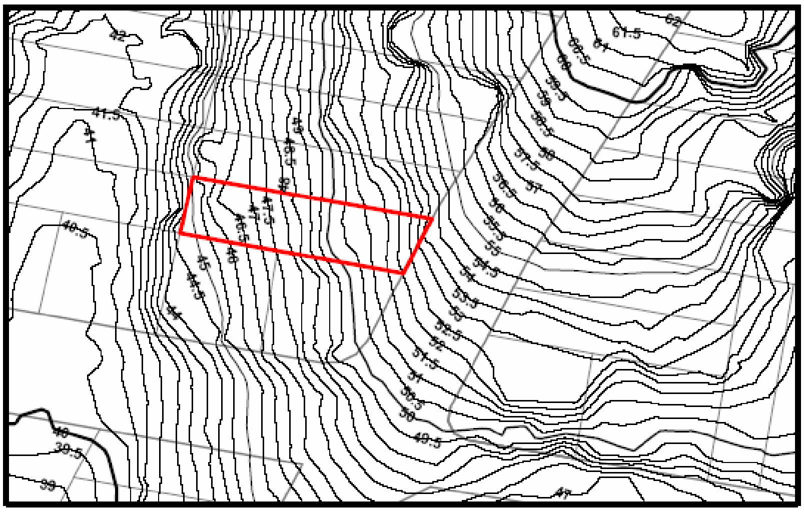
Homeowner anecdotes

- 2 adult occupants – both WAH periodically
- Lot and dwelling well ventilated
- No air-conditioning by choice
- Owners have added a wide verandah to rear with bi-fold doors to capture prevailing north-easterly breezes.

D.1.3 Case study 3

Urban infill development on a very steep slope

Figure 7-7 Lot case study 3



- Medium lot 476m² - inner west
- 1 star (width and slope) lot-rating

Figure 7-8 Suburban context case study 3

- East facing, very steep lot
- Limited sites for equipment to be installed owing to steepness of site, location services etc
- Equipment located to west of the main living areas, but below given steepness of site and constraints imposed by swimming pool, services etc
- Is expected to capture breezes flowing up the gully toward the living areas

Figure 7-9 Dwelling case study 3

- 2005 dwelling,
- 3 level dwelling, 4 bedrooms, 3 pedestals

Homeowner anecdotes

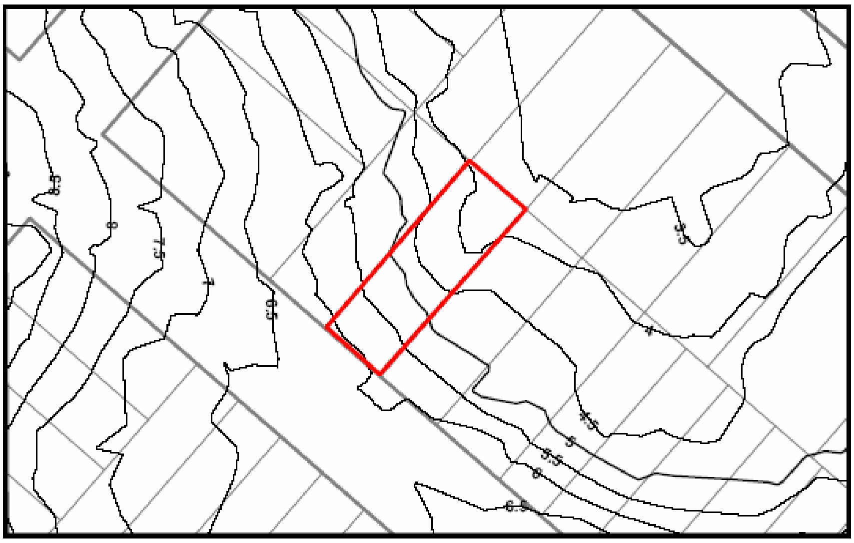
- 2 occupants, 1 WAH frequently and usually in the afternoon
- Lot and dwelling well ventilated
- Dwelling designed with passive ventilation in mind
- Air-conditioning rarely used

  Love our louvres, they are a very valuable feature – they catch the breezes, but also mean there is control over breezes, as well as control over rain. Sliding or double hung windows don't give such control. We frequently leave the louvres open a bit during the day to allow air movement through the house (either summer or winter).

D.1.4 Case study 4

Traditional Queenslander with clear sub storey

Figure 7-10 Lot case study 4



- 539m2 – inner city
- 5 star lot-rating

Figure 7-11 Suburban context case study 4

- South facing lot in a mature suburb
- Equipment located to north east of main living areas

Figure 7-12 Dwelling case study 4

- Elevated lightweight with clear sub floor
- 2 bedroom, 1 pedestal

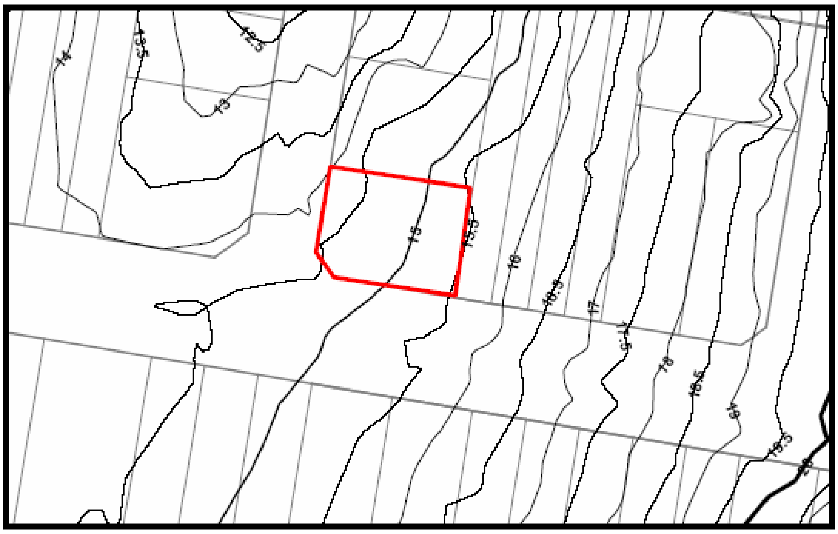
Homeowner anecdotes

- Occupants – 2 adults, I child
- Lot well ventilated, but dwelling is poorly ventilated

D.1.5 Case study 5

Only cavity (double) brick dwelling offered for the project.

Figure 7-13 Lot case study 5



- Small 541m2 – inner east
- 5 star lot-rating

Figure 7-14 Suburban context case study 5

- South facing lot in a mature suburb
- Breezes blocked by hill to north-east, by adjacent buildings and perimeter plantings
- Dwelling to north has been extended extensively over the past twenty years
- Chain wire fences replaced with 1.8 timber for privacy
- Equipment located to north east of the dwelling as security considerations prevented its location adjacent to the south facing main living areas

- High, dense perimeter plantings restricted location equipment to a relatively lightly vegetated area on the northern side to capture the prevailing north-easterly breezes

Figure 7-15 Dwelling case study 5

- 1930's cavity brick on piers with cavity brick on slab extension
- 3 bedrooms (including SOHO), 1 pedestal

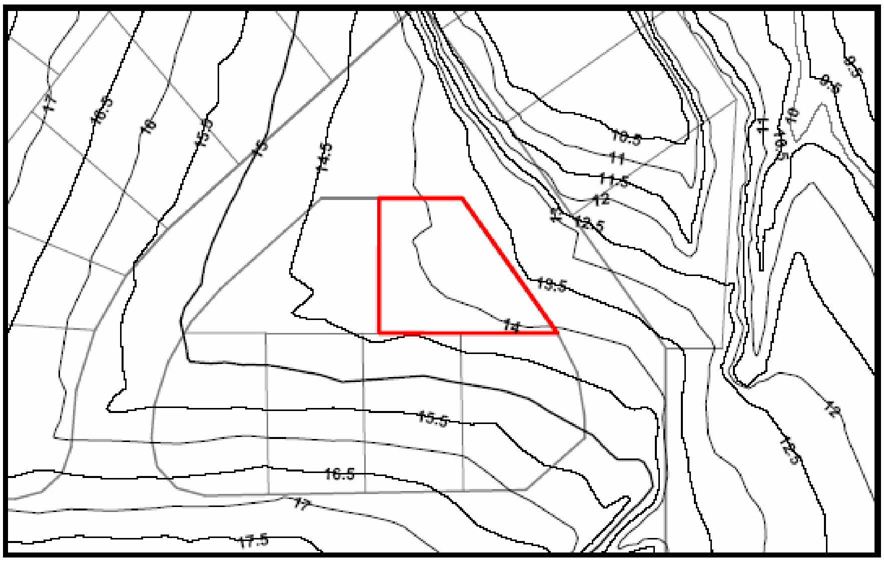
Homeowner anecdotes

- Occupant – I adult - WAH regularly
- Dwelling is warm in winter and cool in summer – provided the windows are closed before the temperature rises
- However noise in the neighbourhood prevents the windows being left open at night to shed internal heat
- This causes a build up of internal heat during prolonged periods of high temperatures
- Result - bedroom air-conditioned in 2004

D.1.6 Case study 6

One of two Greenfield residences offered for the study, this dwelling is located at the bottom of a steep rise in a new development

Figure 7-16 Lot case study 6



- 544m2 – outer south-west
- 5 star lot-rating

Figure 7-17 Suburban context case study 6

- North facing lot
- Equipment located to north east of main living area
- Clear space to north-east is currently a vacant building lot that has potential to block breezes in future

Figure 7-18 Dwelling case study 6

- 2005 constructed single storey brick veneer on slab
- 4 bedroom (including SOHO), 2 pedestal

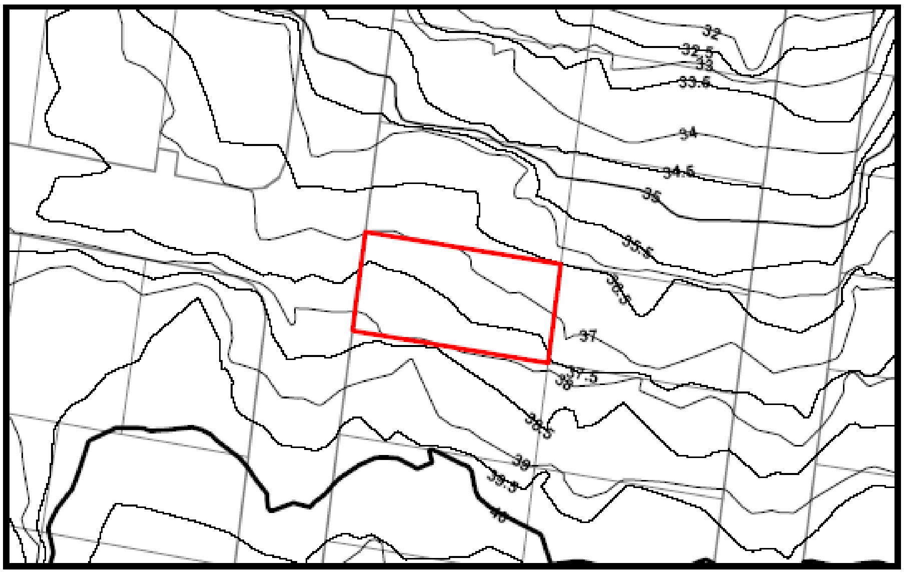
Homeowner anecdotes

- 2 adults – no WAH
- Air-conditioned throughout and 'during summer the air-conditioning would be on extensively'
- Winter use is an hour in the mornings before work for about a month or a month and a half
- Prefer to use air-conditioning to adjust internal temperature

D.1.7 Case study 7

Typical 1980's dwelling and sub-division

Figure 7-19 Lot case study 7



- 608m2 – outer south-west
- 5 star lot-rating

Figure 7-20 Suburban context case study 7

- West facing lot on a rise that slopes down toward north
- Equipment located to north of main living area in a secured area adjacent to the swimming pool

Figure 7-21 Dwelling case study 7

- 1980’s dwelling – 1 level b/v on slab
- Single storey brick veneer on slab

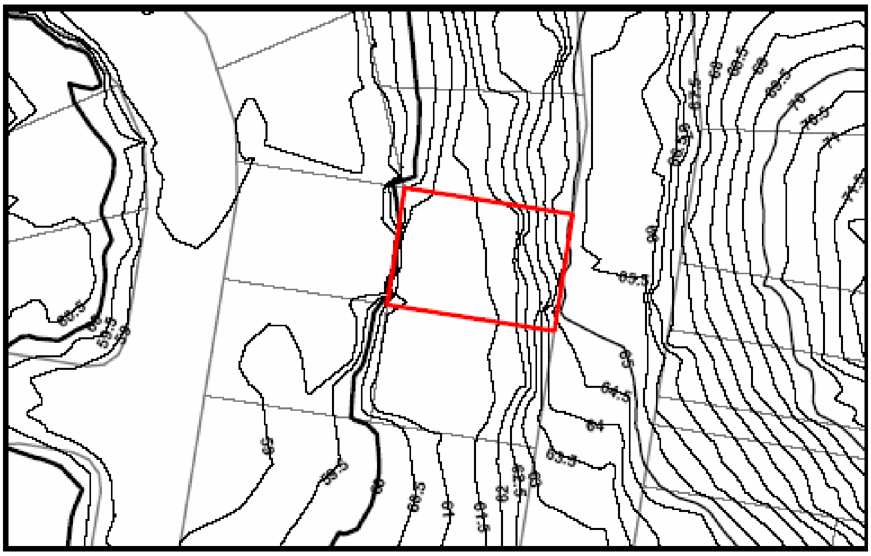
Homeowner anecdotes

- Occupants – 2 adults, 1 child
- Site reported to be well ventilated with clear access to north east
- Dwelling is not well ventilated - north facing clerestory is currently sealed, attracting and trapping heat
- Air-conditioning added in 2005 and used extensively in summer

D.1.8 Case study 8

One of the few poorly ventilated dwellings offered.

Figure 7-22 Lot case study 8



- 630m2 – outer north-west
- 1 star (slope) lot-rating

Figure 7-23 Suburban context case study 8

- East facing lot located on western side steep sloping hillside
- Breezes blocked by hill to north east and by steepness of site from street level
- System could not be located on north-eastern side due to steep slope, dense vegetation and driveway
- Main living areas are on western side and equipment is located on the south-western corner where it can be expected to capture breezes from the east and those flowing from the parkland to the south

- System monitors ground level this dwelling and level two of dwelling to its west

Figure 7-24 Dwelling case study 8

- 1980's dwelling
- 2 level brick veneer on slab
- 4 bedroom (SOHO), 3 pedestal

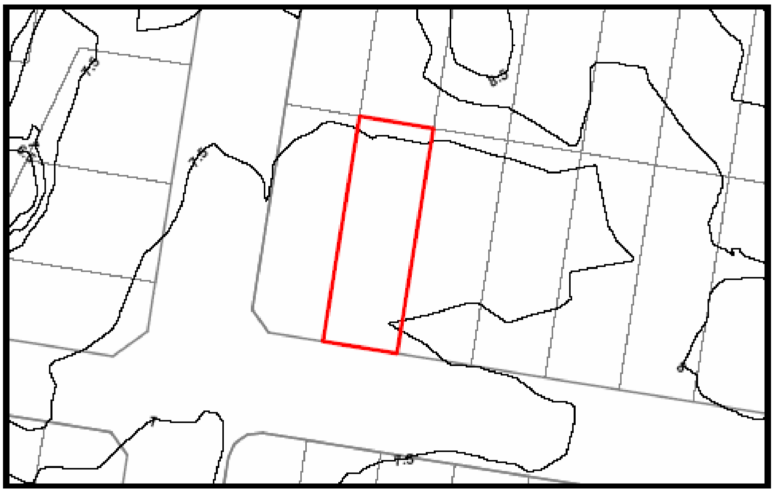
Homeowner anecdotes

- Occupants – 2 adults, 1 child
- Site and dwelling reported to be very poorly ventilated
- Owner has replaced sealed clerestory with operable windows, improving internal ventilation
- Also added a wide awning to rear of dwelling to shield west facing living area windows
- Air-conditioned throughout and used to heat in winter and cool in summer.

D.1.9 Case study 9

One of the few contemporary elevated lightweight dwellings offered for the study. The home-owners had removed the existing dwelling and built its replacement with passive cooling in mind.

Figure 7-25 Lot case study 9



- 703m² - outer south-west
- 4 star (width) lot-rating

Figure 7-26 Suburban context case study 9

- South facing lot in mature suburb
- Mature vegetation retained when former house removed and new dwelling constructed
- Open wire fences typical of earlier suburbs in Brisbane
- Equipment located in relatively clear area to north of the main living area

Figure 7-27 Dwelling case study 9

- 2005 construction elevated lightweight construction

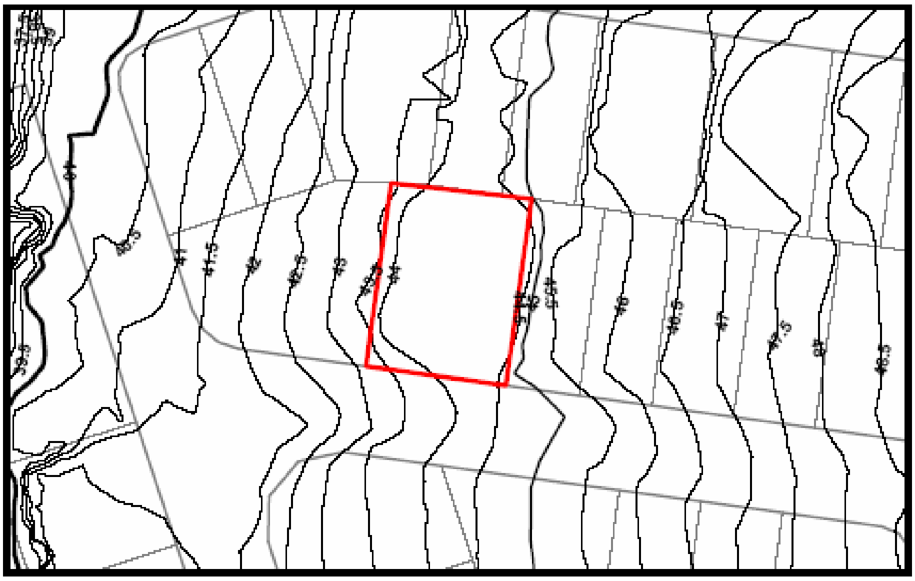
Homeowner anecdotes

- Occupants – 2 adults, 2 children
- Both lot and dwelling are well ventilated

D.1.10 Case study 10

One of the few Greenfield homes offered.

Figure 7-28 Lot case study 10



- 766m2 – outer south-west
- 5 star lot-rating

Figure 7-29 Suburban context case study 10

- Flat, south facing lot with retaining wall on eastern boundary
- Minimum vegetation in lot and in area due to newness of the development
- Equipment located to north-east of main living area

Figure 7-30 Dwelling case study 10

- Single level brick veneer on slab
- Air conditioned throughout

Homeowner anecdotes

- Occupants 2 adults 2 children
- Lot and dwelling are well ventilated

D.1.11 Case study 11

Dwelling was designed to maximise north easterly access, which were subsequently blocked by a dwelling being built at ground level, rather than cut into the hillside.

Figure 7-31 Lot case study 10

Not available at present

- 860m2 – northern corridor
- 5 star lot-rating

Figure 7-32 Suburban context case study 11

- West facing slightly sloping lot in mature sub-division
- Mature perimeter vegetation limited siting options
- Equipment located to north east of main living area
- System monitoring ground floor this dwelling and level two dwellings behind

Figure 7-33 Dwelling case study 11

- Single level brick veneer on slab
- 4 bedrooms (including SOHO), 2 pedestals
- Roof insulation R1.5 roof insulation and walls are sarked

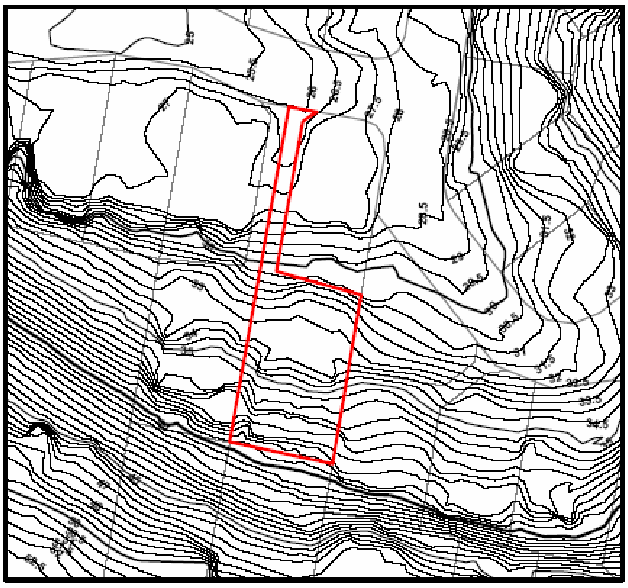
Homeowner anecdotes

- Occupants - 3 adults
- Lot and home poorly ventilated
- Fans used in preference to air-conditioning

D.1.12 Case study 12

Selected as representative of the steeply sloping sites that developers increasingly have to contend with.

Figure 7-34 Lot case study 12



Please note – lot is left of that outlined in this plan

- 1000m2 (and 200m2 easement) – outer west
- 1 star lot-rating

Figure 7-35 Suburban context case study 12

- North facing in-fill sub-division in area settled 20-25 years ago
- Equipment installed on north-western side dwelling (driveway on north-eastern side) and below main living areas on second level
- System monitoring ground floor this dwelling and level two of the dwellings to its north

Figure 7-36 Dwelling case study 12

- 1990's dwelling
- 3 bedroom, separate SOHO, 2 pedestal
- 2 story brick veneer on slab

Homeowner anecdotes

- Occupants 2 adults
- Lot and dwelling are well ventilated

Figure 7-37 Lot slope

Image reproduced permission homeowner, 2006

Appendix E - Selection of the monitoring equipment

E.1 Selection process

A number of researchers involved in various aspects of recording and analysing weather data were contacted for advice/recommendations; including

- Dr Heber Sugo from the University of Newcastle
- Mark Luther from Deakin University and director of Mobile Architecture & Built Environment Laboratory (MABEL)
- Mark Hayne from QUT (CRC CI Microclimates Project) and
- Wayne Ganther from CSIRO.

Based on these discussions, the following four systems were examined.

- WS 2310 from Lacrosse Technology
- WS-3512U from Lacrosse Technology
- Ultimeter 100 from Peet Bros Company, Inc; and
- Vantage Pro2™ from Davisnet.

A brief description follows with an overview of the perceived advantages and disadvantages of each system for this project, leading to the selection of the Vantage Pro2™ weather station.

E.1.1 System 1

The La Crosse WS-2310 has three sensors and a console to display the data recorded. The console has a large LCD touch screen and shows the wind direction on a compass rose. Price $AU $350 (approximately)

Figure 7-38 System 1

Console | Wind sensor | Themo Hygro sensor | Rain sensor

This system was considered for price and availability, but was subsequently rejected for this project for the following reasons;

- The console could only hold 175 sets of data, meaning that the system would need to be uploaded approximately every day (24 hours with data recording at 15 minute intervals results in 96 data sets per day)
- The receiver and the wind sensors are powered with alkaline batteries which meant that the participants would need to monitor the system carefully. Loss of power and data seemed inevitable over the monitoring period

- The signal from the wind sensor travels in a straight line and electrical appliances in that line may cause interference. These included computer monitors, TV sets, headphone, or speakers in the vicinity

The data limitations were not a concern initially as it had been hoped that the data upload procedure would be automated. Once this process proved impractical and it became apparent that the Participants would need to be relied on to upload the data, the focus shifted to systems that could store more data.

E.1.2 System 2

The La Crosse WS-3512U has two sensors to measure wind speed and direction, and a console to display the data recorded. The console has a large LCD touch screen and shows the wind direction on a compass rose. The receiver and the wind sensors are powered with alkaline batteries.

The wind speed can be displayed and recorded in different units (mph, km/s, m/s, Knots, Beaufort). The recorded wind speed is instantaneous at the time of record.

Data is uploaded from the receiver to a PC and it is possible to record 1750 sets of weather data (or approximately two weeks) with Heavy Weather PRO PC software.

Price - available from the US mid-October 2005, at AU$190

Figure 7-39 System 2

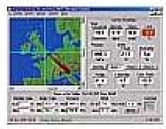
This was the cheapest system examined and it seemed possible that a number could be installed per dwelling. But further investigation revealed that the system is not designed for this use. As the frequencies of the individual units cannot be changed, it seemed likely that the installation of multiple units would cause interference and lead to data loss. Additionally;

- There are no suppliers in Australia and few suppliers in the US as this is a new product
- The values recorded to the computer are instantaneous values at the time of record, not averaged on the recording period
- Use of alkaline batteries could be problematic over the recording period.

E.1.3 System 3

The Peet Bros Ultimeter 100 Weather Station records wind speed and direction, wind chill, as well as outdoor/indoor temperature and date, time. The processor/display console features an LCD display that shows the wind direction on a compass rose to 16 points and other functions in large numerals in the user's choice of metric or imperial units. This system can be either wireless or wired.

Figure 7-40 System 3



The weather data can be tracked on the computer and data can be selected for any time period, then output as graphs or tables on the screen or printed - but to record data over a long period of time a DataPak data logger (above right) is required.

The data logger stores the data output from the weather station and can be downloaded to a PC. It can be collect data for up to 3 years and can be configured to either stop logging or to continue logging and overwrite old data when the memory is full. It can handle remote modem operation and can even be removed from the weather station altogether to be downloaded and/or configured independently. This Cost - AU$1046.80. Unfortunately none of the researchers contacted were familiar with this system.

E.1.4 System 4

The DavisNet Vantage Pro2 weather station contains a console to display the measured data and an integrated sensor suite that combines an anemometer, a rain collector, and temperature and humidity sensors into one package. The anemometer measures wind direction and wind speed.

Figure 7-41 System 4

- The weather station transmits and receives data up to 300 m line of sight
- A data logger stores data for uploading to a PC
- The displayed wind speed on the console is the observed average over the past 2.5 seconds. The software will record this and the 15 minute average on the PC
- The PC will give a more adjustable "window" to review the wind data so that it is possible to have average wind speed for any other period of time. This can be done by taking one minute snapshot and dividing the required number of them over the desired period of time.

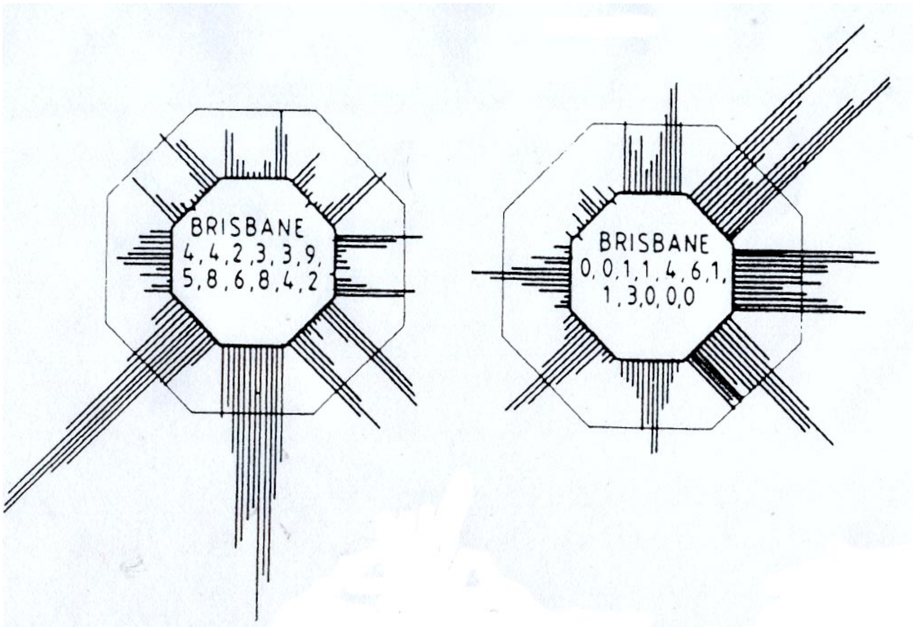
Many of the researchers contacted have been successfully using this system. Other advantages included

- The data is displayed on a user-friendly screen which allows the participants to follow the weather conditions and have a greater interest in the project
- Any error or dysfunction in the recording can be detected quickly as the data would stop being displayed on the screen, whereas with the data logger, there is nothing is to show what is happening with the data and its completeness can only be checked when downloaded

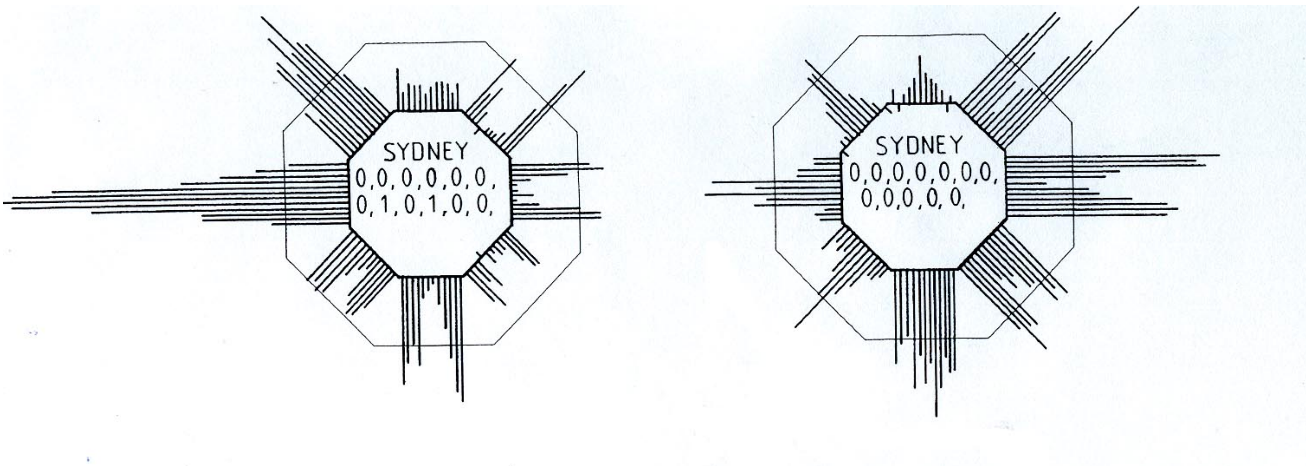
Appendix F - Capital City Wind Roses

The following images are reproduced courtesy Szokolay, 2006

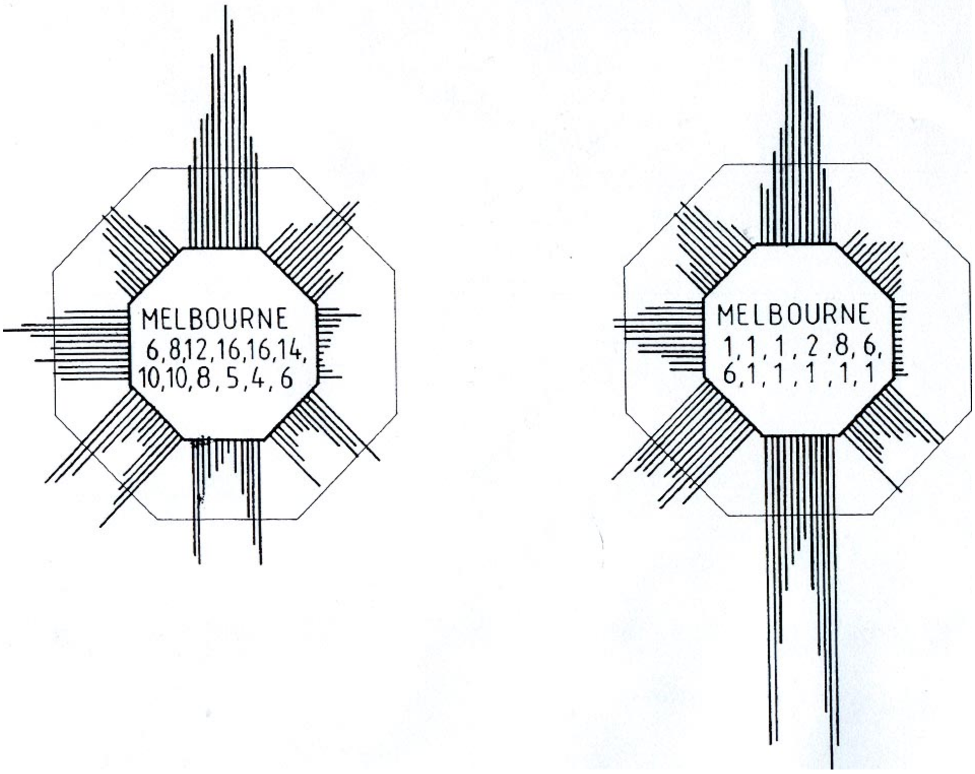
F.1 Brisbane



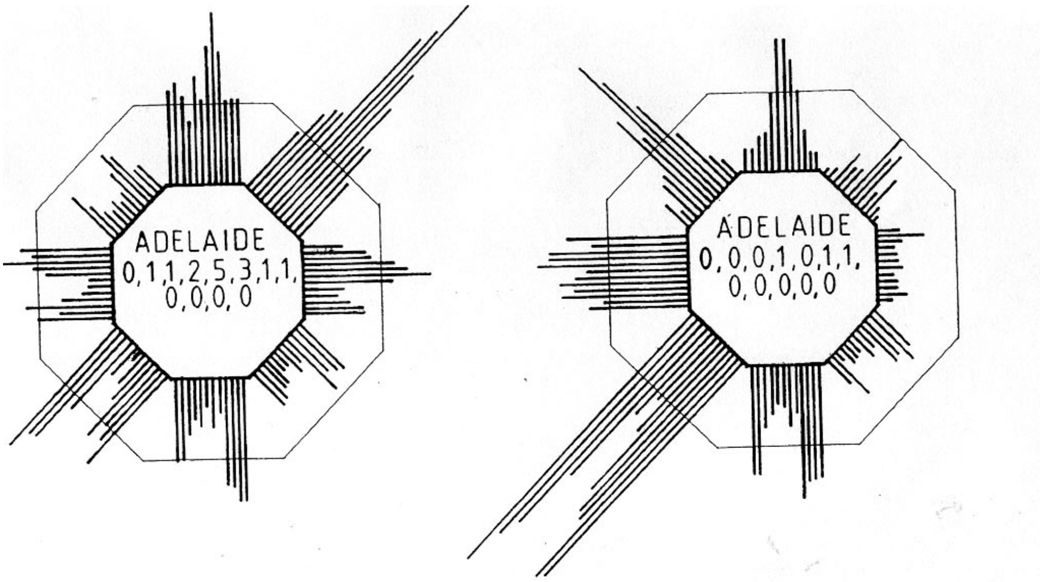
F.2 Sydney



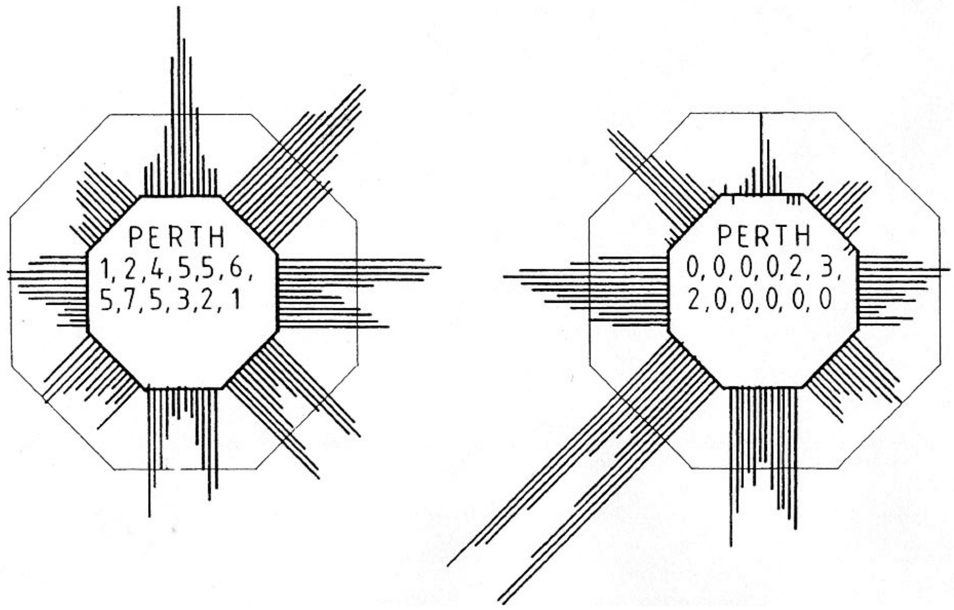
F.3 Melbourne



F.4 Adelaide



F.5 Perth



(Szokolay 1988)

Appendix G - Project Deliverables

G.1 Project Reports

G.1.1 2002-077-B-01

O'Hare, D, Kennedy, R, Demirbilek, N. and Strong, G. (2006) The Role of Natural Ventilation in Building Sustainable Sub-divisions in SEQ

Report from Phase One that examines the role natural ventilation plays in the sub-division design process in SEQ. The Centre for Subtropical Design at QUT coordinated this phase to assess current understandings and practices among a range of stakeholders including developers, land surveyors, urban designers and regulators and to gauge the degree of acceptance within the development industry of the proposed lot-rating methodology.

G.2 Refereed Conference Papers

G.2.1 CRC CI Conference

Miller, A. Ball, M and Ambrose, A. (2006) Benchmarking Sustainable Residential Dwellings, Proc of CRC CI 2nd Int. Conf. Moving Ideas into Practice, Gold Coast, Australia, 12-14th March.

ABSTRACT
This paper will summarise the findings from a study that explored the link between dwelling design, or type, and energy efficiencies in sub-tropical climates. An increasing number of government and private sector development companies are initiating projects that aim to deliver enhanced environmental outcomes at both sub-divisional and dwelling levels. The study used AccuRate, a new thermal modelling tool developed by CSIRO that responds to the need to improve ventilation modelling. The study found that dwellings developed in conjunction with the Departments of Housing and Public Works have set the benchmark. It provides a snapshot of the energy efficiency of a range of dwelling types found in recent sub-divisions. However, the trend toward increasing urban densities may reduce the likelihood that cooling breezes will be available to cool dwellings. The findings are relevant to regulators, designers and industry in all states interested in reducing the energy used to cool dwellings in summer.

Keywords: Sustainable, ventilation, energy-efficiency, density, benchmarking

Paper - available at http://www.2006conference.crcci.info/docs/CDProceedings/

Presentation - available http://www.2006conference.crcci.info/ppt%20presentations.html

G.2.2 Subtropical Cities 2006 Conference

O'Hare, D. Miller, A and Ambrose, M. (2006) Towards a Lot-rating Methodology for Sub-tropical Climates, Subtropical Cities 2006 Conference, Brisbane, Australia, 27-29 September.

ABSTRACT
What role can climatically appropriate sub-division design play in decreasing the use of energy required to cool premises by maximising access to natural ventilation? How can this design be achieved? The sub-division design stage is critical to urban and suburban sustainability outcomes, as significant changes after development are

constrained by the configuration of the sub-division, and then by the construction of the dwellings. Existing Australian lot-rating methodologies for energy efficiency, such as that by the Sustainable Energy Development Authority (SEDA), focus on reducing heating needs by increasing solar access, a key need in Australia's temperate zone. A recent CRC CI project, Sustainable Sub-divisions: Energy (Miller and Ambrose 2005) examined these guidelines to see if they could be adapted for use in subtropical South East Queensland (SEQ). Correlating the lot-ratings with dwelling ratings, the project found that the current guidelines would need to be modified for use to make allowance for natural ventilation. In SEQ, solar access for heating is less important than access to natural ventilation, and there is a need to reduce energy used to cool dwellings. In Queensland, the incidence of residential air-conditioning was predicted to reach 50 per cent by the end of 2005 (Mickel 2004).

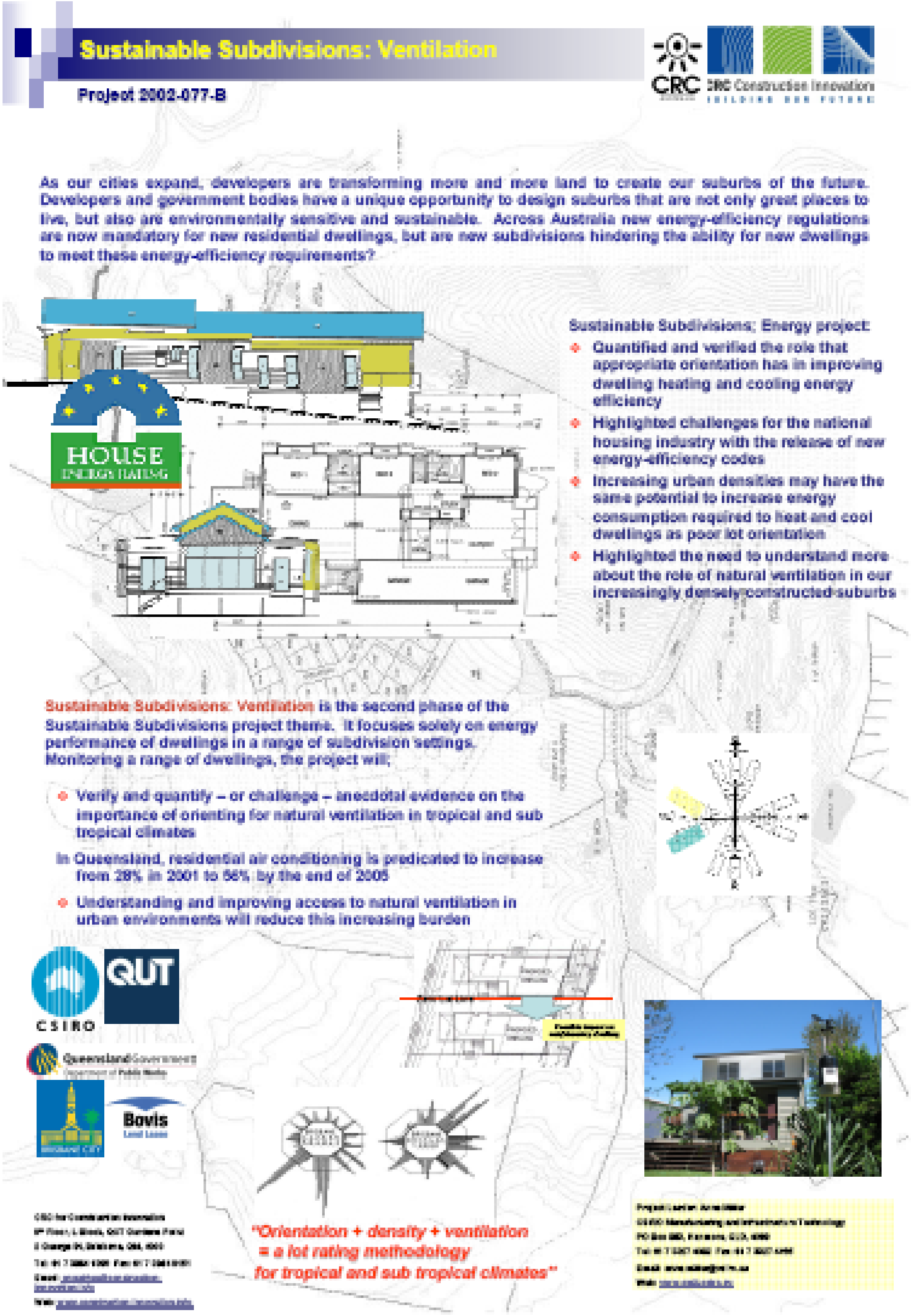
The CRC CI, Sustainable Sub-divisions: Ventilation Project (CRC CI, in progress), aims to verify and quantify the role natural ventilation has in cooling residences in subtropical climates and develop a lot-rating methodology for SEQ. This paper reviews results from an industry workshop that explored the current attitudes and methodologies used by a range of professionals involved in sub-division design and development in SEQ. Analysis of the workshop reveals that a key challenge for sustainability is that land development in subtropical SEQ is commonly a separate process from house design and siting. Finally, the paper highlights some of the issues that regulators and industry face in adopting a lot-rating methodology for sub-divisions offering improved ventilation access, including continuing disagreement between professionals over the desirability of rating tools.

Keywords: Sub-division, subtropical design, sustainable development, lot, lot-rating methodology, ventilation, energy-efficiency.

Paper available at: http://www.subtropicalcities2006.qut.edu.au/Papers.html

Presentation available at: http://www.subtropicalcities2006.qut.edu.au/Papers.html

G.3 Promotional Poster



8. AUTHOR BIOGRAPHIES

8.1 Anne Miller

Anne Miller is a researcher with the CSIRO Sustainable Ecosystems Division where she has been employed since 2004. She is the Project Leader and researcher for this project.

Anne undertook the research, analysis and reporting of the case studies and prepared the report for the preceding project Sustainable Sub-divisions: Energy Project and developed the proposal for this project.

Before joining CSIRO in April 2004, Anne was a researcher with the Australian Housing and Urban Research Institute Queensland Centre. She undertook research in various projects on social policy issues associated with urban development, design and associated social issues and from a national and international perspective.

Anne has a Bachelor of Built Environment (2000) and a Graduate Diploma [Interior Architecture] (2001) from the QUT. Prior to this recent re-training and career period, Anne's had more than twenty years experience with the Australian Government focusing in a range of property related areas including project management, commercial property management and construction administration.

8.2 Fanny Boulaire

Fanny Boulaire is a scientist with CSIRO Sustainable Ecosystems where she has been employed since 2003. She holds an engineering degree / Masters in Mathematics and Modelling, from the Grande Ecole CUST, located in Clermont-Ferrand, France.

Since she started at CSIRO, Fanny has been involved in many CRC CI projects such as DesignCheck, DesignSpec, the AutomatedSchedulor where she applied advanced engineering and mathematical skills in the development of computer software. All these software have in common a common data definition exchange, which allows interoperability and easy transfers between CAD systems.

Lately she has been involved in the CRC CI 'Microclimatic Impact on the Built Environment' project that consists in evaluating and predicting the distinct changes in the microclimate, the immediate surroundings of a building or built environment. She was responsible for the development of a software module that predicts the thermal behaviour of outdoor spaces under some climatic conditions, as well as the incorporation of all the other environmental analyses within the software.

Her interest in the impact of urban development on the environment has led her to be part of this project in which she analysed the environmental data.

8.3 Michael Ambrose

Michael Ambrose is an environmental scientist with CSIRO Sustainable Ecosystems where he has been employed for the last 13 years. Michael holds a degree in architecture from Deakin University and has a graduate diploma in building project management. He is currently involved in the CRC CI Your Building project which is developing sustainability guidelines for commercial buildings where he is leading the energy and water sustainability sections and is a member of the Your Development project, an Australian Greenhouse Office funded project developing sustainability guidelines for subdivisions. Michael was the leader of the original CRC CI Sustainable Subdivisions: Energy project and has also managed a CSIRO project, developing sophisticated long-term life cycle analysis software for water authorities.

Michael's other recent projects include the analysis of energy embodied in buildings, material and cost estimating and the utilisation of CAD systems for environmental analysis. These have included projects for the Australian Greenhouse Office looking at energy efficiency of commonwealth housing and several embodied energy analysis projects for commercial, residential and infrastructure projects including an analysis of several urban water infrastructure options for a large residential sub-division. He also developed and managed environmental specifications for a Greensmart residential village recently opened in Brisbane, Australia.

Michael's background in architecture has been utilised in the LCADesign project and he has been responsible for developing the prototype CAD models and the interface between the 3D CAD software and LCADesign.