ENVIRONMENT DESIGN GUIDE

INVERLEIGH PRIMARY SCHOOL – INVERLEIGH, VICTORIA

Libby Chaplin
Arcadian Solutions

The redevelopment of the Inverleigh Primary School has delivered a unique blending of historical, environmental and social ideals within the limited budget of the Victorian government. The application of the 'H' shape design along with the careful selection of materials created a more functional and comfortable space in which to empower and motivate students. This classic plan was enhanced by the overlay of ecologically sustainable principles into the building design and operational requirements. After two years experience utilising the space the Principal Peter Kirby believes that the new building fosters education and has provided teachers, students and parents with very a positive experience.

1.0 PROJECT OUTLINE

1.1 Project details

Client
Inverleigh Primary School Council

Architects
Cowland North Pty Ltd

Consultants

Structural consultant
JP Hawkins Pty Ltd

Landscape architect
Living Exteriors Garden Design

Interior designers
Cowland North Pty Ltd

Builder
AP van Dort & Sons Building Contractors

Year of completion
1999

Project type
Educational institution

Activity undertaken
Design and construct

Floor area
350 square meters. Decks and ramps 176 square metres

Number of storeys
1

Cost at completion
The total cost of the project was $432,600 including site works, sewage system, furniture and computers. This translates into a cost of $645/m² for the structure (excluding non-building elements).

Number of people in occupancy
Approximately 120.

Occupancy rates
40 hrs per week.

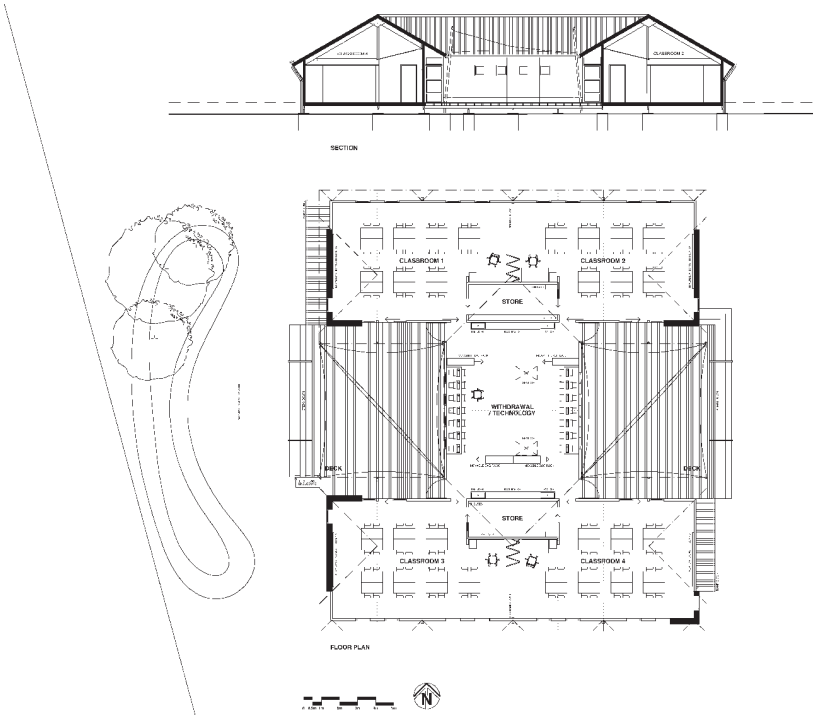

Figure 1. The 'H' shape plan has been used to transform auxiliary spaces into flexible learning areas

1.2 Location and climate

Inverleigh Primary School is located 100km west of Melbourne in the Western Plains region of Victoria. This region experiences a moderate rainfall of between 600–800mm annually. Situated in a flood plain at the confluence of two rivers, the school is subject to flooding and is exposed to hot winds prevailing from the northwest in summer, and cold winds prevailing from west-southwest in winter. Summer time daily maximums are mild to warm and range from 22–27°C while winter daily maximums are cool and range from 12°C –16°C[1]. Winter mornings are often brittle and foggy with regular occurrences of frost.

1.3 Background to project

The original Inverleigh Primary School House is a historic building constructed in the 1870s of bluestone and timber beams. This one-classroom school was augmented over time with an assortment of relocatable buildings that were not meeting the growing needs of the school community. The School Council successfully applied to Department of Education Training (DET) for funding to construct an additional four classrooms plus ancillary areas. Cowland North were appointed as architects for the redevelopment.

2.0 DESIGN PHILOSOPHY

2.1 Design intentions

The primary design intentions articulated by the Cowland North team were to create a building that would:

- afford a creative, interactive and social environment for children to learn in
- interpret the DET standards to make the most effective use of available space
- link with the local environment and site heritage; and
- deliver a sustainable outcome for current and future occupants of the school.

Figure 2. The existing bluestone building became an important aspect in the design of the redevelopment

[1] Thomas, M, *Climate and Weather Atlas of Australia* (http://home.iprimus.com.au/ozthunder/oz/front.html)

The DET standards for the construction of school facilities are outlined in the DET *Building Quality and Standards Handbook*. According to Judith North, the traditional solution to these standards has been ribbon style classrooms constructed from concrete slabs and brick walls. This conventional design solution makes it extremely difficult to deliver energy efficiency and thermal comfort because one side faces north while the other faces south. As a result it is almost impossible to maintain a comfortable environment that is conducive to scholarship.

3.0 SUSTAINABILITY OBJECTIVES

Environmental performance was not a criteria specified in the original design brief. However, Cowland North was able to clearly demonstrate the benefits of integrating sustainable design principles into the new building. These key objectives were to:

- provide a healthy learning facility that was energy efficient and offered thermal comfort
- enhance the psychological comfort for everyone using the building
- enable good cross ventilation during the heat of the summer
- ensure maximum access to natural light
- conserve water which is a scarce resource during the summer months
- foster positive learning and social interactions between students, teachers and visitors; and
- use efficient and sustainable building materials.

4.0 DESIGN PROCESS

Cowland North refined their design by working closely with the School Council and liaising with the Department of Education Training *Project Review and Evaluation Panel* (PREP) that was chaired by Janet Mattiske. The panel was most concerned to ensure that the DET standards were complied with and that the building met its educational function requirements. The rational for all environmental initiatives had to be fully considered and the panel convinced of their efficacy.

Since the traditional design for DET projects were of concrete slab construction, it was necessary for the architects to demonstrate the benefits of elevating the building above the ground. Historical records were used to show that the Leigh River periodically inundates the school grounds. These records demonstrated that expensive submersible pumps had to be installed at the corners of the bluestone buildings to pump away floodwaters when they inundated the building.

A full area and cost analysis was prepared in order to assure the panel that the project met the set criteria. The results of this analysis demonstrated that the sustainability criteria could also be implemented within budget. A minimal annual cost of $360 was estimated to maintain the cladding, however this was thought to

be conservative as it was based on the assumption that the alternative brick cladding would not crack and would not be vandalised. In the likely event that either of those assumptions were incorrect then the Cowland North design would actually be more cost effective.

Three-dimensional models were provided to the panel to show the building with the roof removed and enable a 'virtual' tour of the internal spaces. These models also allowed the panel to explore how the internal spaces including furniture, windows and doors would be laid out and to consider how it would operate in an educational context. Full 3D CADD modelling is used as a key design tool in all Cowland North projects as it allows the designers to:

- refine building and site aesthetics
- undertake full solar modelling necessary for evaluating exposure and shading of windows; and
- carry out solid modelling to assess mass for proportioning thermal mass and selecting the most efficient materials.

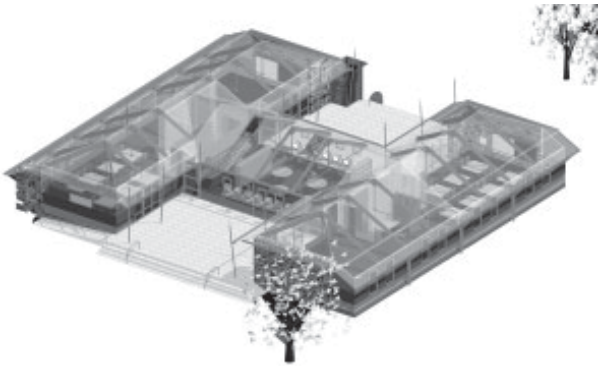

Figure 3. Example of three-dimensional model of the Inverleigh Primary School

4.1 Consultation

The Cowland North team demonstrated a strong commitment to ensuring that the final design reflected the desires and practical requirements of the school community. The aim of this process was to seek views and gather ideas for creating the most functional and enjoyable space possible. The main activities included:

- consultation with the School Council at the beginning of the design process
- presentation of the preliminary design at a public meeting for the community and parents in order to seek their input and suggestions.

Peter Kirby believes that this was an important part of the process as 'at the end of the day, people were very happy with the outcome and feel that their input was taken seriously and incorporated in the design where possible'. While it was not possible to implement all suggestions within the constraints of the DET budget, the process ensured that everyone understood the reasons for the decisions that were made.

4.2 Social implications

In a town the size of Inverleigh, with a population of 283 (ABS, 1996[2]), the school provides an important focal point in the lives of students, teachers, parents and the local community. Peter Kirby believes that this project has had important social implications as it has lead to 'a happier more relaxed environment where children, teachers and parents feel inspired to learn and interact'. In particular:

- it has created a space that is more comfortable, feels safer and is aesthetically much more pleasing
- parents are appreciative that their children spend the school day in a positive and productive environment
- it has added a new dimension to the townscape which people find appealing
- the new building has provided an educational experience for students who are learning the benefits of designing spaces that are environmentally friendly and responsive.

Figure 4. Clean lines and gentle spaces provide a positive experience for students

For Cowland North, projects like these provide an important opportunity to educate people that sustainable buildings are attainable and affordable. This project has demonstrated that buildings designed for sustainability can provide a far better outcome within tight budgetary constraints.

4.3 Procurement process

The School Council invited a number of organisations to tender for the project and short-listed six architectural firms to be interviewed. The interview panel was comprised of the Principal, Peter Kirby, two School Councillors and a representative from DET Regional Facilities. Each of the architectural firms was invited to present their vision in verbal, written and pictorial formats. The panel was aware that this opportunity was a one-off and therefore it was critical that the design integrate well with other school activities and make the most of the available space.

---

2 Australian Bureau of Statistics (1996) *Census of Populations and Housing – Basic Community Profiles Australia*

Peter Kirby reported that the panel were impressed with the Cowland North presentation because they were able to convey a sense of a passion for delivering a unique educational facility, which not only complied with the DET schedule but also provided a unique interpretation of the standard in order to design a more flexible learning space. The visual presentation also demonstrated how the design would compliment the old school building and link into the historic nature of the site and the rural character of the town. The Cowland North proposal was exciting because it concentrated on delivering a high performance building, not only for education and community purposes, but also delivered environmental outcomes.

5.0 DESIGN AND CONSTRUCTION

5.1 Heritage values

The original bluestone school is an important landmark, which the school community was anxious to maintain. The consultation process highlighted the importance of linking the new with the old. Cowland North proposed that bluestone could be used in the new building in a modern reinterpretation to achieve this link and have the added environmental benefit of increasing the thermal mass. The response from the school was enthusiastic but, unfortunately, use of this material would exceed the DET allocation of funds. Determined to have the best possible outcome, the school was able to raise additional funds to purchase recycled bluestone and assist with the labour required to obtain the stone.

Figure 5. The blending of bluestone, double glazing, Ecoply and timber decking imbues a light restful ambiance that extends into the surrounding school grounds

5.2 Orientation, layout and site planning

The north south orientation of the new structure put it at a slight angle to the existing building. This provided a range of advantages, including the added benefit of framing the existing smaller building rather than over-powering it. The H shape ensured that each classroom is north and south facing which facilitates maximum solar penetration into each of the spaces. It also allowed for two external deck spaces, one facing west and the other facing east. Each of the decks provided a different climatic zone in which students and teachers can choose to spend their time depending on the weather conditions. The architects moderated the west face of the building with an earth berm, which acts to divert the prevailing winds. The berm protects the building and also transforms the western deck into an amphitheatre that can be used for stage performances. Unfortunately, landscaping of this area has been delayed due to the severe drought and water restrictions experienced in the region.

5.3 Building form and envelope

The DET standard requires allocation of spaces for classes, locker space, wet areas, withdrawal areas, storage, staff work areas, and travel. The traditional interpretation of this is to allocate separate rooms for each activity. The beauty of the Cowland North H shape design was in the re-interpretation of the required allocation for lockers, wet areas, withdrawal areas[3] and travel spaces into one linked multi function area.

The establishment of a multi purpose space delivered a number of advantages to the new space including:

- the ability to re-allocate funds from construction of internal partitions into more efficient external cladding
- the provision of better access between the classes and to reflect a sense of fluidity and exchange rather than control. Students experience a more cooperative learning environment that is quite different to the traditional congestion and fractious nature of school corridors. Teachers can better integrate different classes and age groups and encourage interactive small group work
- construction of two external courtyard decks that effectively provide an additional two teaching spaces, which can be used during recreational periods; and
- the creation of strong links between the building and the school grounds. Peter Kirby believes that this was further enhanced by the natural tones of timber decking combined with muted colour scheme, weathered downpipes and zincalume, which 'creates an impression of harmony with the surrounding environment'.

[3] Withdrawal areas are used by teachers to remove students to a special work area for discipline or special tasks and group work. The latest research suggests that isolation of students in withdrawal areas may not be as effective in achieving behavioural change as interaction and problem solving with other students.

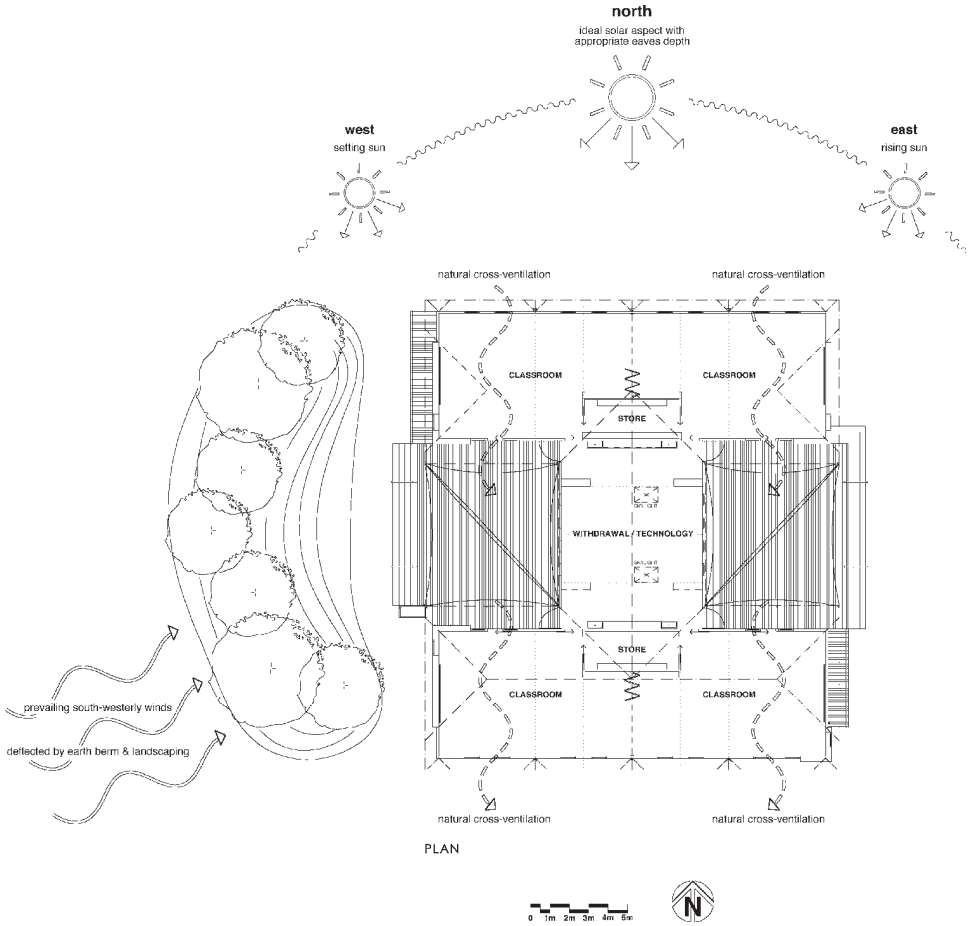

Figure 6. Orientation of the building provides maximum solar access and ventilation

Low emobied energy materials:

- recycled bluestone pitchers for thermal mass
- plantation pine plywood for cladding and bracing structure
- low maintenance zincalume and natural galvanised steel
- category 1 timber decking

Energy saving features:

- ideal summer and winter northern solar exposure to all classrooms
- appropriate eave projections for sunshading
- demountable shade cloth sails for addtional summer relief
- good natural light
- energy efficient fittings for artificial lighting
- double glazed windows
- high levels of insulation
- north-south natural cross-ventillation to each classroom
- protection from prevailing winds by landscaped mound to the west
- energy efficient heat-pump system on automated controls
- solar hot water service
- effluent treatment system discharges clean water to playing fields

5.4 Construction system

In response to the flood prone nature of the site and the difficulty of placing foundations on basaltic clay soils that swell and shrink as moisture content varies, it was decided to construct the floor 600mm above ground. This meant that lightweight materials had to be specified. Table 1. provides a summary of the products and materials used in the project and includes a list of the companies that supplied each one.

Walls were constructed from timber stud framing with EcoPly Texture 2000 plywood cladding fixed as panels with joints expressed to form a grid over the walls. Double glazed windows and sliding doors were framed in aluminium and designed to fit as modules into the cladding. Recycled bluestone was used in walls exposed to the weather, in order to increase thermal mass and emulate the historical nature of the existing school.

A steel subfloor system, DuraGal, was used to avoid termite damage, to allow greater spans and to reduce the need for footings. Roof loads were carried on composite trusses of timber, steel tube and stainless steel cable. This provided a contemporary reflection of the traditional king post trusses used in the old school house.

Steel columns were located in the walls to also reduce the need for footings. Spans were calculated to use minimum sized roof purlins (90mm x 45mm F17 at 600mm centres). These spans directly supported the steeply pitched corrugated zincalume roofing and the plasterboard lining. Fascia beams were eliminated by

providing small steel struts to reduce the eaves span and a processional axis of steel columns to support entry verandas along the perimeter of the decks (Cowland North, 2000[4]).

Application	Product	Supplier
Thermal comfort	SkyAir Heat Pump	Daikin Australia Pty Ltd
Effluent treatment	Clearwater Effluent Treatment System	Taylex Sales Pty Ltd
Roof	Corrugated zincalume	Stramit Metal Building Products
Ceiling linings	Plasterboard	Boral Plasterboard
Walls	EcoPly Texture 2000 Plywood	Carter Holt Harvey
Wall linings	Plasterboard Craftwood	Boral Plasterboard Laminex Industries
Insulation	Sisalation 430 Thermowool R2.5	ACI Insulation Thermowool
Windows	Double glazed, aluminium frames	Rylock Windows Geelong
Window treatment	Holland blinds	Moonee Furnishings
Doors	Solid core and double glazed sliding doors	Rylock Windows Geelong
Flooring	Steel floor frame Aquabar particleboard flooring	BHP DuraGal Laminex Industries
Floor finishes	Invermere Carpet	Northstate Carpet Mills

Table 1. Summary of products and materials used in the construction of Inverleigh Primary School project

5.5 Embodied energy

A primary consideration in the choice of materials for this project was that they be low in embodied energy. The bluestone used in exposed walls was sourced from salvaged paving stone. The manufacture of plywood used to clad walls normally uses 150 times less embodied energy than brick cladding, but since its use also allowed for a 30% reduction in timber framing, its efficiency in this case is even greater (Cowland North, 2000). The materials selected for this project were a deviation from the traditional materials of brick and concrete generally used in DET projects.

5.6 Landscape and land management

The site is dominated by trimmed local grasses and a number of ancient peppercorn trees. Cowland North decided early on that a key design constraint would be the conservation of the existing peppercorn trees. These trees were many years old and provided shade and an old-world charm to the site. The original master plan, which included a linear arrangement of classrooms, would have required the removal of the peppercorn trees.

5.7 Ventilation

The 'H' shape design facilitates excellent cross ventilation for all classrooms. Windows can be left slightly ajar in order to achieve good venting of the classrooms overnight and still ensure that security is maintained. Night-time purging is very important during summer evenings to enable maximum cooling to occur. Skylights were installed over the central space on the east roof and provide an additional opportunity for ventilation, particularly in the evenings. Traditionally schools are closed at 4pm and opened again the next morning, which means the classrooms remain hot and stuffy most of the summer.

5.8 Indoor air quality

The Cowland North team aimed to use minimal finishes in order to maintain air quality and reduce maintenance requirements. Materials such as the zincalume roofing, bluestone blocks and timber decking were not coated and created a weathered look that allows the building to blend in with its surroundings.

5.9 Thermal comfort

The climate of the Western Plains area provides an interesting challenge for achieving thermal comfort throughout the year, due to the extreme cold in winter and heat in summer. In order to minimise heat loss in winter and heat gain in summer, the architects chose to:

- maintain thermal mass with the use of bluestone in exposed walls
- insulate with Sisalation 430 and Thermowool R2.5 in both the ceiling and walls. It would also have been desirable to include additional insulation in the floor, however this was not possible in the tight budget. Even without floor insulation, the building is able to maintain a comfortable temperature during the warmer months; and
- double glazing of windows with low E[5] glass which has the added advantage of reducing noise between the different learning spaces. Windows have a partial thermal break and both the sashes and glass were fitted with double tubular rubber gaskets.

Heat is minimised during the summer months by:

- cooling the building with good cross ventilation and night-time purging
- use of eaves to ensure there is virtually no exposed glass in summer; and

4 Cowland North, 2000, *RAIA Architectural Awards Application*

5 Low E coating reduces heat loss in winter but also reduces heat gain in summer

- installation of sun-sails at the beginning of each summer to provide shade to the deck areas.

Specific measures used to maintain thermal comfort in winter include:

- the use of eaves to provide covered access to the classrooms; and
- the installation of an energy efficient SkyAir heat pump that operates on automatic or manual controls.

Figure 7. The heat pump is only required in the early morning and late afternoon

The SkyAir pump was found to be less expensive and more efficient than the traditional alternative. The school is particularly happy with this system as they also obtained an 'air cooler' that can be used on particularly hot days. Heat pump systems use a fan to extract energy from the atmosphere in a heat exchange process. Such systems offer 290% efficiency for every kilowatt of electricity they use and are able to provide up to 2.9 kilowatt of effective heating or cooling depending on the ambient outdoor temperature. According to Peter Kirby, the heat pumps are easy to use and are only required in the early mornings and late afternoons because of the efficiency of the passive heating systems. Given the high ceilings in the classrooms it does take some time for the rooms to warm up, however this was recognised in the project design with the installation of timers, which are used effectively to turn on the system at 7:30am each morning.

5.10 Day lighting and sun control

Particular attention was given to the provision of natural lighting with high ceilings, glass windows and glass doors. Floor to ceiling windows were installed on the north and south walls and small windows installed on the east and west walls. Skylights were installed over the central space on the east roof and provide excellent natural lighting in the central space. Removable shade sails that span both courtyards provide deep pools of shade in the summer and reduced the risk of radiant heat entering east and west elevations. The school has the option of removing the sun sails and storing them over the winter to maximise solar access to the classrooms.

5.11 Artificial lighting

Energy efficient fittings (58 watt fluorescent lights) were installed, however Peter Kirby reports that they are not needed except on overcast days. Installation of sensors for artificial lighting would have improved the efficiency of this system, however the budget was unable to extend that far.

5.12 Fire safety and access

The new building meets all the traditional requirements for fire alarms and extinguishers. Importantly, the 'H' shape design is extremely safe as it provides direct egress from all classrooms. In addition to the 'front' door to classrooms, each room also has a sliding door that faces the deck. This double access is also useful because students can exit classrooms without disturbing those working in the central area. Access between adjacent classrooms is also good, as it is possible to move through the adjoining storerooms if necessary.

Figure 8. Removable sun sails provide essential shade in summer

6.0 MANAGEMENT OF PROJECT IN USE

6.1 Retrofitting

The building has been designed to be as flexible as possible for future needs. Heavy walls between adjacent classrooms can be retracted to allow the rooms to be enlarged or sealed off to enhance small class activities and reduce noise. Plywood panelling and windows can be unbolted as separate modules for maintenance or adapted to changing requirements. This is particularly important in a school environment where the requirements for computer hardware is changing rapidly.

6.2 Water management

Water is particularly precious in the Western Plains region in summer where drought is not uncommon so, the existing septic tank was replaced with a Clearwater Effluent Treatment System. The system discharges clean recycled water from the toilets for use in a subsurface irrigation system underneath the school grounds. The system redirects the treated water by cycling it through a series of 20–25 lines until the entire area is irrigated. Each line is 15–20 metres long and once it is filled a valve shuts the line off and the water is diverted to the next line so that a very broad coverage can be achieved. After two years of operation this system has worked well and ensured water is used as wisely as possible. In winter when watering of the grounds is not required, the clean water discharged from the system can be diverted to the stormwater system. The design also specified the installation of a solar hot water system. This system has proven to work well since:

- it is space and cost effective
- very little hot water is required
- hot water is only needed for a short time each day during school hours; and
- the system can be set at lower temperatures to ensure there is no risk of scalding the students.

6.3 Waste management

Cowland North used computer analysis to ensure that standard sizes and modules were used wherever possible. The builder, AP van Dort & Sons Building Contractors, was also extremely aware of the need to minimise costs and waste, and so was very careful to order only what was needed. Peter Kirby reported that only half a length of timber was left over after construction of the decks and very little waste generated overall.

6.4 Building operation manual

A building operation manual was provided to the school that explained the use of the heat pump, solar hot water and sewage systems. The users were also briefed on the operation of those systems on handover and Peter Kirby reports that this was very helpful in assisting staff to learn how to use them.

7.0 POST OCCUPANCY EVALUATION

Two years of occupation has lead Peter Kirby to believe that this building far exceeds the School Council's expectations both in terms of comfort and operational performance. In particular, Peter noted that:

- although a technical assessment of the building performance had not been undertaken, a review of utility bills showed that the operating costs were about the same as they were four years ago. Since the floor area had increased by nearly one third, Peter believes this was a very good result, particularly as the building is much more comfortable to occupy
- in addition to reducing heating bills and providing a more comfortable temperature, double-glazing had also greatly reduced noise between classrooms and from the adjacent highway. This was a real bonus as it allows a calmer and more relaxing atmosphere for students, teachers and visitors
- the high degree of natural light reduced the need for artificial lighting and also provided a much more pleasant working environment for students and teachers
- the modular nature of the building allowed spaces to be reduced or enlarged for small group activities or joint projects; and
- the overall response from students and teachers was very positive as they felt that the new buildings were much more comfortable, safer and aesthetically pleasing. Parents are particularly appreciative that their children were able to spend time in a school environment that they believe provided a very positive educational experience.

8.0 CONCLUSION

8.1 Challenges and opportunities

The project was not without its challenges yet, in each case, the architects were able to transform these into opportunities for improving the functionality and comfort of the building. In particular, the architects were able to deliver:

- an environmentally sensitive building within an extremely tight budget and in compliance with the DET standards
- a multi-purpose central space made up of auxiliary spaces such as travel space, lockers and wet areas
- a solid flood free building on a flood prone unstable site
- a building that was cost effective to operate and maintain
- a water reuse system in a severe drought area
- a building that blended with both the local environment and heritage values of the site

- an outcome that protected site vegetation including an old peppercorn tree; and
- a comfortable and sun smart learning environment on a site exposed to extreme weather conditions.

8.2 Lessons learnt

After two years of occupation, both Cowland North and the school community are extremely happy with the performance of the building. In hindsight, Peter Kirby believes that placement of internal glass windows in the storeroom walls would improve teacher's ability to supervise students. In addition, he would locate the sinks externally and put all coat lockers along the back wall, as this would allow the central space to be opened up even more. There is every chance that these changes will be made in the future as the modular system makes such a task reasonably easy. For Peter Kirby, the real challenge is to 'make sure that the facilities that are now available are being utilised in the very best way to educate his students'.

BIOGRAPHY

Libby Chaplin is Director of Arcadian Solutions, an environmental consulting firm that has been delivering environmental solutions to government and industry for over three years. Her interest in the construction sector began ten years ago when she was employed as an environment officer to assess development applications at Brisbane City Council. More recently, Libby has worked with the Civil Contractors Federation developing a Model Environment Management System and delivering training to members and VicRoads contractors. Libby has worked with numerous construction and demolition companies to improve environmental performance and resource efficiency. She has published numerous case studies and more recently '*The Do's and Don'ts: Resourceful Construction and Demolition',* a pocket sized handbook for large and small sites in Victoria. Contact: libby.chaplin@arcadian.com.au.