North Sydney Council Green Roof and Wall Resource Manual

Central Park, Ultimo


Finger Wharf 11, Woolloomooloo

contents

A green roof has a dual function;

- it is a roof system designed to promote the growth of various forms of vegetation on the top of buildings.

- It is also designed to support various forms of renewable energy and water collection technology to assist in supplying power and water to the occupants of the building.

Although a green roof is only one element of a building, it is extremely important when considering the long-term sustainability of our buildings and their impact on the environment.

The environmental advantages of installing green roofs are widely known and include;

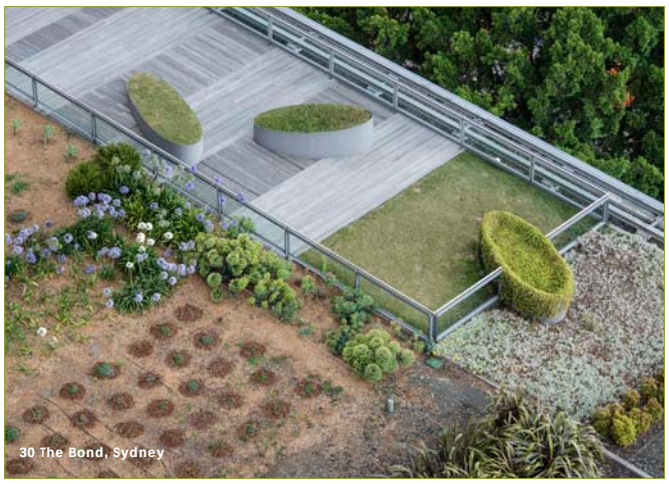
- thermal insulation,
- increasing the life span of the roof structure,
- minimizing surface run-off,
- reducing the cities heat-island effect,
- producing renewable/no emissions energy which is fed into the electricity grid,
- collecting and supplying rainwater to minimize the burden on town water and reducing emissions through minimizing the need for heating and cooling.

Every green roof has a series of components that aid in either protecting the building, assisting the growth of vegetation, collecting/harvesting rainwater or generating energy.

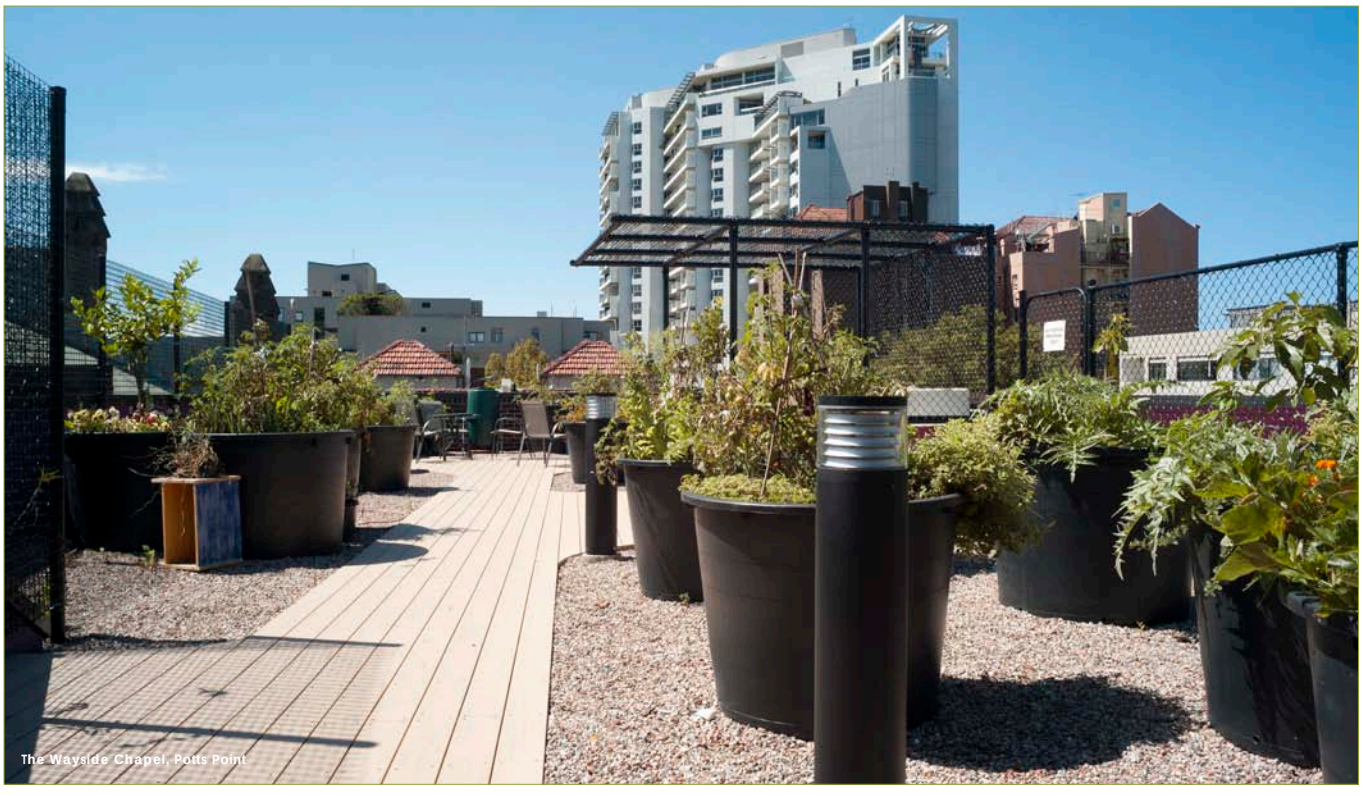
These components include;

- a root protection layer,
- waterproof membrane,
- drainage layer,
- substrate or soil layer and finally,
- a layer of vegetation.

Green roofs also host technology such as photovoltaic cells, wind turbines and water tanks.


30 The Bond, Sydney


Finger Wharf 11, Woolloomooloo

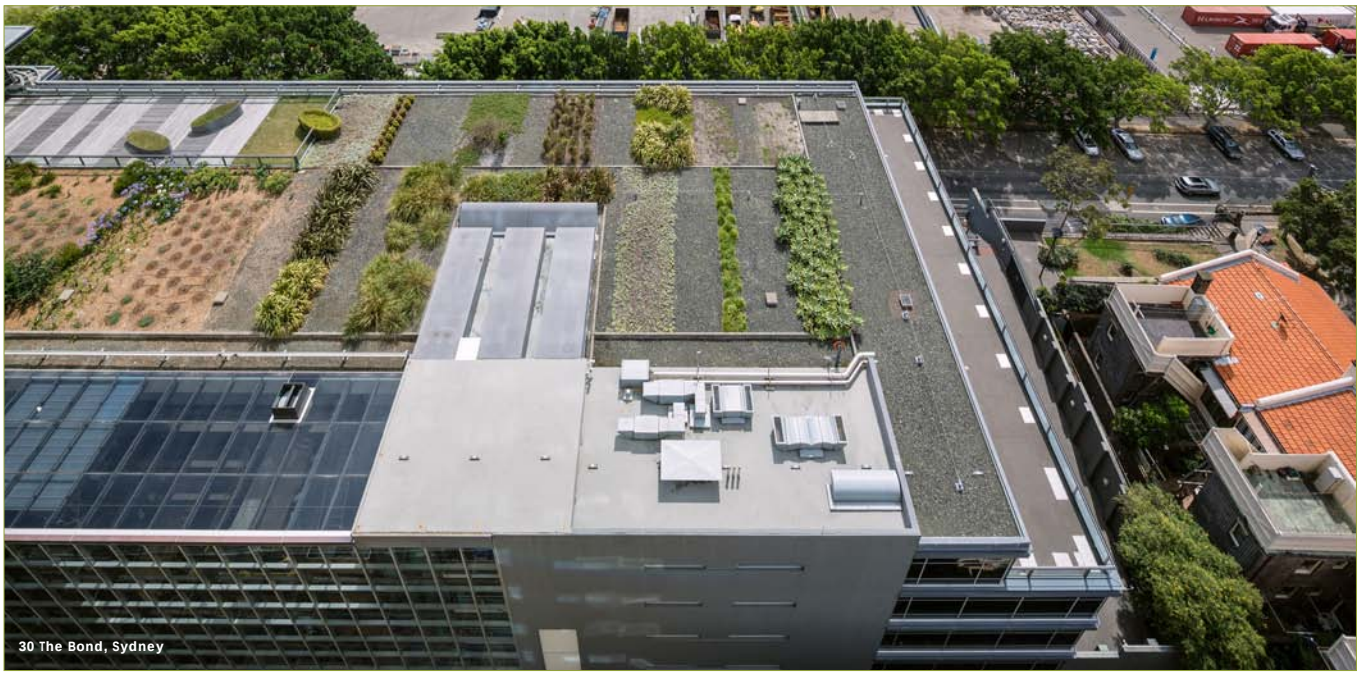

The Wayside Chapel, Potts Point

how is a green roof different to a roof garden ?

Green roofs are distinct from traditional rooftop gardens because they promote proven sustainable concepts. Typically rooftop gardens have been purely an aesthetic feature of a buildings 'roofscape'.

Whilst green roofs still pay attention to aesthetic considerations, their main objective is to minimize the buildings impact on the environment in an economically viable way.

Green roofs maximize the potential of having vegetation on the roof by collecting and harvesting storm water via a well-designed drainage system and the use of materials that have been specifically developed to significantly minimize the waste of any valuable resource such as water. Additionally, green roofs take advantage of the relatively cooler environment by supporting photovoltaic cells (PV), which operate more efficiently in cooler environments.



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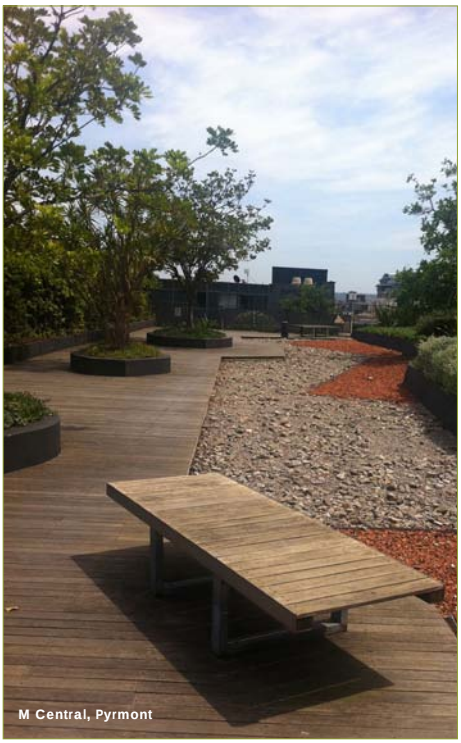
M Central, Pyrmont



M Central, Pyrmont

what are extensive green roofs ?

An extensive green roof is the most basic form of green roof. Like all green roofs, an extensive roof comprises of the following components;

- A water proof membrane,
- a root protection layer (although typically this can be combined with the membrane in an extensive roof system),
- a drainage layer,
- a filter mat,
- growing medium,
- vegetation.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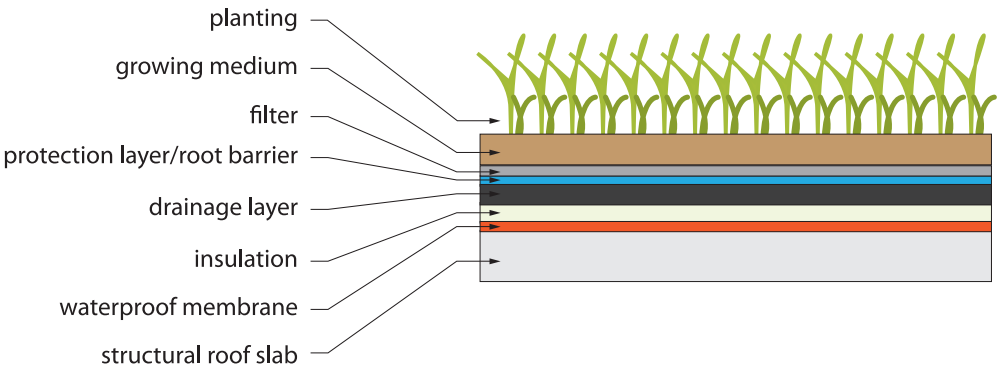

It is typically found to have a soil/substrate of no more than 15cm in depth. As a result of the shallow substrate depth, the range of vegetation is limited to low growing vegetation types including; grasses, moss and sedlums. The composition of the growing medium is crucial in an extensive green roof system. It is important to avoid an overly fertile substrate as this will encourage competition amongst vegetation species and may result in an uneven coverage of vegetation. The ideal scenario is to have a moderately fertile substrate that maintains a constant coverage yearlong.

An extensive green roof system is commonly used in situations where no additional structural support is desired. Typically, an existing roof will be able to support an extensive system that can weigh up to 100kg/m^2. However, it is essential to seek advice from a structural engineer before installing a green roof.

Extensive green roofs are not design to be accessed on a regular basis. This minimises the structural demand for the roof. However it is important to have some degree of access for maintenance.

Extensive green roofs require maintenance in the first 2 years to ensure that the vegetation has stabilised and there are no competing weeds. Beyond the first 2 years, maintenance is minimal and may only be required once or twice annually.


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Domain car park roof top, Sydney

what are semi extensive green roofs ?

A semi-extensive green roof is a hybrid of the two systems (extensive and intensive). A semi-extensive roof system is appropriate when the possibility for access is limited and the structural capacity of the roof deck could not support an intensive green roof, but a higher level of planting is desired for visual or environmental reasons.

A semi-extensive green roof allows for a slightly deeper substrate depth than a traditional extensive green roof but it still enjoys the relatively minimal maintenance that an extensive green roof system has. The deeper substrate can support a greater variety of vegetation which allows the architect or landscape architect flexibility in design.

The selection of vegetation on the roof is important as it will directly determine the level of maintenance required to keep the green roof functioning properly.

A semi-extensive green roof applies an extra load to the building. Generally the semi-extensive green roofs can weigh up to 630kg/m^2 depending on the selection of materials.


Conservatorium of Music, Sydney


Conservatorium of Music, Sydney


M Central, Pyrmont

what are intensive green roofs ?

Intensive green roofs are the most comprehensive roofing system. It is generally designed to maximise the environmental benefits that can be achieved from a green roof whilst also providing for public amenity. An intensive green roof can also support the production of food produce.

The components of an intensive green roof are the same as all other green roofs, however each component requires much more consideration with regards to its form and materiality due to the sensitive relationship between vegetation types, water harvesting and growing medium.

An intensive green roof needs to balance the quantity of water harvested, the fertility of its substrate and the varieties of vegetation chosen. Other considerations that are important are the load capacity of the roof deck, accessibility and other roof top structures.

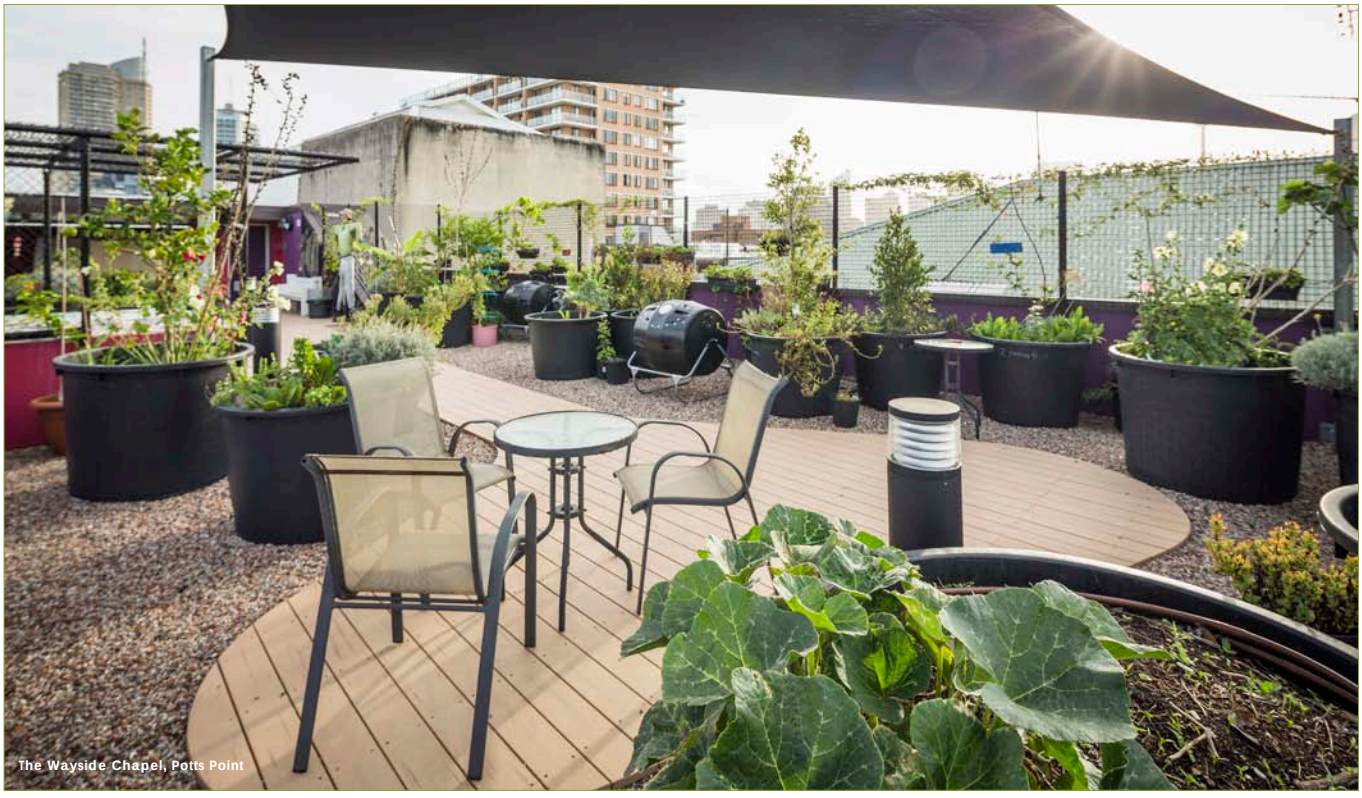
Intensive green roofs offer greater substrate depths, typically greater than 15cm. The greater soil depth allows a larger variety of vegetation to grow.

The use of large scale planters for intensive planting allows lighter loads, less waterproofing and easier maintenance.

However, different plant types have different requirements with regard to growing medium, nutrients and water needs, which will ultimately affect the selection of materials to be used in the green roof system. Therefore it is important to realise that extra consideration should be given to the selection of plant species when there are a large variety of plants to chose from.

Similarly to any green roof, consideration needs to be given to the structural capacity of the roof deck to compensate for the extra load. It is essential to obtain the advice from a structural engineer on each individual roof. An intensive green roof can have a saturated weight of up to 1000kg/m^2.

Maintenance for intensive green roof systems is the most involved and depends on the type of vegetation that is grown.



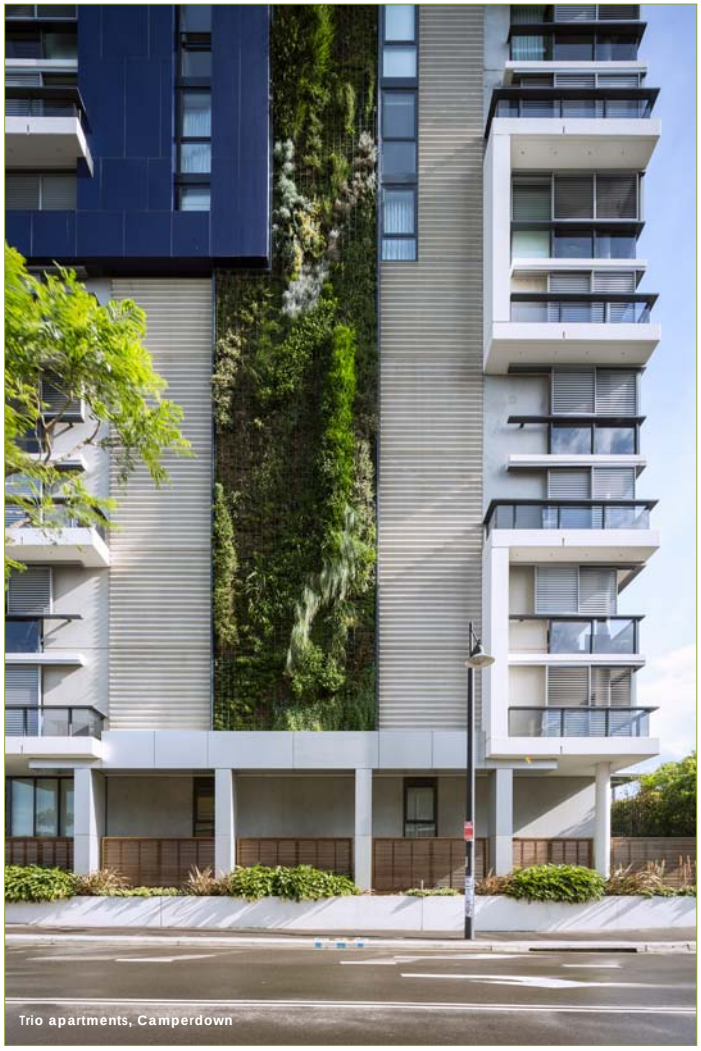
external

Sometimes called living walls or vertical gardens, green walls use minimal floor space and still provide a high volume of foliage.

A Green Wall acts as a biofilter, enhancing air quality by breaking down harmful airborne contaminants and transforming them into clean oxygen. Like a green roof, a green wall absorbs carbon dioxide and releases oxygen and therefore reduces green house gases in the atmosphere. It retains rain water that would otherwise run off the side of the building and overflow sewer and stormwater systems.

Green Walls reduce energy consumption by providing a layer of insulation around the building. This keeps the building cooler in summer, reducing the reliance on air conditioning and protecting the building from the cold in winter. This layer of insulation also protects the building's facade from harmful UV rays and other damaging weather conditions, as well as creating a sound barrier.

A green wall is a vertical garden that is pre-planted in panels and then attached to the facade of the building. Plants stay intact in their vertical positions because their root structures are anchored in 2-4 inches of soil kept within the panel. Sedums are the most common plant used in living wall applications, displaying beautiful succulent leaves and blossoms in spring and summer. You can also grow vegetables and native plants depending on your soil depth.



Trio apartments, Camperdown

internal

Green Walls can be interior and exterior. In exterior green walls sedums turn a shade of maroon in the winter and then turn back to green the following spring. Indoor living walls use tropical plants that stay the same colour the year around.

how is it different from a green facade?

Green facades like ivy walls are different to green walls. They are made up of climbing plants growing directly onto a wall or a specifically designed supporting structure. The plants are still rooted in the ground and receive their water and nutrients that way, where as in green walls the plants root in a structural support which is attached to the wall itself and receive all of their nutrients and water from the structure.

types of green walls

There are many different systems on the market. In general they contain some or all of the following components:

- Frame
- Waterproof panels
- Automatic irrigation system
- Lights
- Growing medium:
  - Loose media (susceptible to wind erosion so should not be used in applications above 2.5 meters, unless is included a media erosion system)
  - Mat media (suited to internal or small installations only)
  - Structural Media (more expensive to install but lower cost to maintain)

Hydroponic Green walls can weigh less than 20kg per m2, as the growing medium is replaced with a light weight porous material.

advantages of a green wall

In addition to the same benefits of green roofs as such as:

- Reduction in urban heat island effect
- Reduction in the overall tempurature of buildings
- Increased biodiversity
- Urban agriculture
- Aesthetic advantage
- Give an immediate solution to the spatial challenge in commercial areas.

the layer of air between the building and the panels enables the building to 'breath' and adds beneficial insulating properties whilst also protecting the building envelop from UV rays and other damaging weather conditions as well as creating a sound barrier.

Also, used internally the health of building occupants has been shown to improve. (Sage Journals, Fjeld T et al, 1998).

Bligh Street, Sydney

what the advantages for the community of green roofs/walls ?

reduction in urban heat island effect

The greater incidence of green roofs the greater the environmental effect. This is of particular importance with respect to the urban heat island effect. This phenomenon occurs because of the density of hard, heat absorbent materials in urban areas, which cause an increase in the average urban temperature.

Green roofs replace heat absorbent and reflective materials and therefore lower the temperature on top of roofs. If this is duplicated over many rooftops it can reduce the urban heat island effect.

increased biodiversity

Green roofs and walls can replace habitats that have been lost due to development. It is therefore important to choose the variety of vegetation that suits the local environment to maximize the effect of the green roof on biodiversity. Green roofs offer a safe place for birds, insect and other plants to grow.

improving air quality

Vegetation also has the ability to improve the air quality in the local environment. Predominantly larger types of vegetation such as shrubs and trees can capture air borne particles on their foliage, which eventually get washed into the substrate. However, any plant converts carbon dioxide into oxygen through a process of photosynthesis therefore improving the quality of air in the local environment.

Vegetation used internally such as in green walls have been shown to improve the health of building occupants. (Sage Journals, Fjeld T et al, 1998).

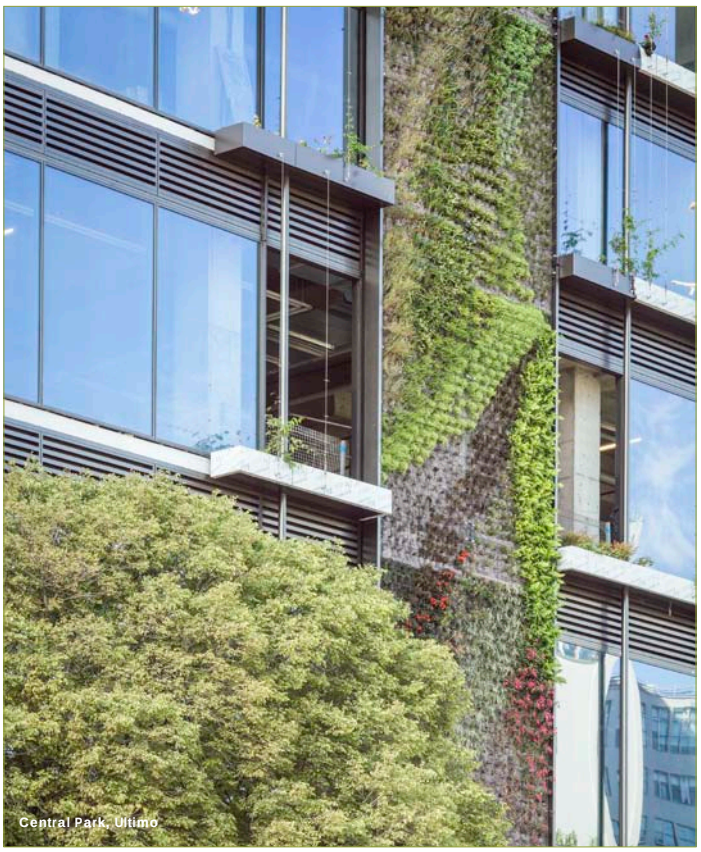
water management

Sydney's annual rainfall is typically approximately 1600mm of rain per annum. Recent rainfalls indicate that this amount of water can vary widely from year to year, in line with climate change, weather patterns and drought conditions.

Storm periods with intense rainfall can create difficulties for the urban stormwater systems. Conventional roofs and walls shed water, green roofs and walls on the other hand can help control water runoff through absorption, storage and then slow release of the excess that slowly moves through the layers of vegetation, growing mediums, fillers, geotextiles etc before even reaching a drainage outlet.

Installation of detention or retention tanks within the building can also slow down the water flow and reduce the impact on the stormwater system. For a storage system to be effective in reducing flow to the stormwater system, the tank has to be sized to provide sufficient storage for this maximum rain-flow event. In this case the water storage required is greatly in excess of that needed for the supply of water for the green roof and other uses within the building.

The water is collected along the roofing membrane and is usually directed to a series of down pipes. Where retrofit is taking place, the existing down pipe system can be used provided it can be connected to a storage system. In the case of a new building the down pipes can be located so that they feed directly to a storage system on the floor below the green roof or the water can be directed to the basement of the building where the water storage takes place.



Central Park, Ultimo

M Central, Pyrmont

Conservatorium of Music, Sydney

what are the advantages for owners of green roofs/walls ?

economic advantages

One of the major reasons for building a green roof are the economic advantages. Real savings can be accounted for immediately after a green roof is installed.

The main economic advantages include;

- Prolonged lifespan of the roof membrane and building envelope:

  An exposed roof deck without a layer of vegetation protecting it, is exposed to extreme heat, wind and ultra violet radiation. All of these elements deploy varying degrees of mechanical and chemical degradation, which places a large amount of stress on the roof material. Ultimately, the roof deck wears down and ages at a much faster rate than a protected roof.

  A green roof, on the other hand, provides direct shading and protection to the roof membrane and therefore greatly reduces the amount of exposure to harsh environmental conditions. Not only does this keep the membrane cool irrespective of the outside temperature, but it also keeps the temperature constant, avoiding major fluctuations which can impose stress on the membrane. This means that the expected lifespan of the roof is much longer than a traditional roof deck, which amounts to real long-term savings. It has been suggested that a green roof can last 20 years longer than a traditional roof.

  With green walls the layer of air between the building and the panels enables the building to 'breath' and adds beneficial insulating properties whilst also protecting the building envelop from UV rays and other damaging weather conditions as well as creating a sound barrier.

- Reducing heating and cooling costs:

  In the short-term, savings can be achieved in heating and cooling costs because the layer of vegetation provides excellent insulation to the building. The green roof acts as thermal mass keeping the internal temperature of the building relatively constant. It keeps the building cool in the hotter months and warm in the cooler months minimizing the dependence on HVAC systems.

- The production of food:

  On specifically designed green roofs there is the opportunity to develop rooftop farms, which promote the growth of food produce.

  Depending on the size of the devoted rooftop farm, owners can sell fresh produce to local businesses and restaurants, Alternatively, on smaller projects the rooftop farm can satisfy the needs of the building occupants.

  This could make the green roof a viably profitable and lettable space.

  The Fairmont Hotel, Vancouver, is a good example of a rooftop farm that supplies its restaurant with fresh produce that has been harvested(195m^2). It is estimated that this saves the company up to $30,000 per year on fresh produce. Earth Pledge in New York is a smaller venture that operates in a similar fashion by providing the restaurant below with fresh produce.

- Increased lettable space.

reduction in noise pollution

Green roofs and walls can markedly reduce noise pollution in urban environments. The layer of substrate and the layer of vegetation work in combination to minimize lower and higher frequencies respectively.

The Wayside Chapel, Potts Point

increased amenities

Rooftops are generally an underutilised space, often reserved for exhausts, air conditioning units and other plant equipment. If designed effectively, green roofs can provide for public amenity for owners, occupants and/or the public.

Being well above the noisy street the addition of roof top structures mean these spaces can provide an additional shaded recreational space and can become excellent spaces to hold meetings, have a quiet lunch or hold a function.

It is not possible to provide amenity to every green roof. In some instances the structural capabilities of the roof deck are not designed to support the extra live load associated with having people walking on its surface.

Readers Digest, Surry Hills

Readers Digest, Surry Hills

aesthetics

Green roofs and walls are more pleasant to experience or view from other buildings. Traditional roof structures are quite bleak and ugly to look at, often cluttered with HVAC equipment, exhausts and a bitumen or gravel protective layer.

Green walls also give an immediate solution to the spatial challenge in commercial areas.

reduction in fire risk

Green roofs in some circumstance can slow the rate that a fire will spread through a building so long as the substrate has a level of moisture in it. A saturated substrate will have more of an effect in slowing the rate in which a fire spreads.

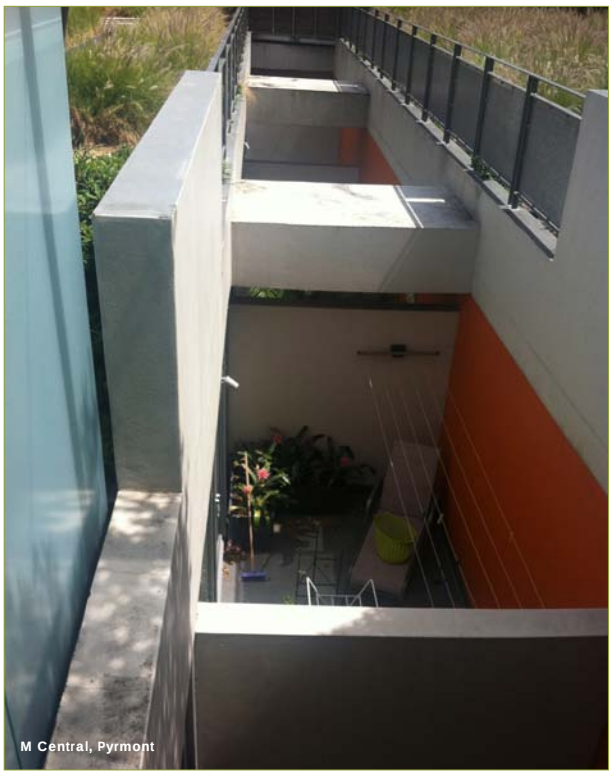
what are the roof top architectural considerations ?

deciding on a green roof

When deciding to install a green roof on a building, one of the first and most important decisions is to choose the appropriate type of green roof; extensive, intensive or anywhere in between.

In retrofit situations the structural capability of the roof deck is the most fundamental determinant that will influence the type of green roof chosen. In a new development however, the extra load of a green roof can be accounted for if it is factored in at the early stages of the design process.

Another determinant that assists in selecting the correct green roof type is an understanding of the functional requirements that are desired from the green roof. If for instance, the sole objective of the green roof is to achieve environmental benefits then there is no point installing an intensive green roof. In contrast if it were desired to provide public amenity for the building occupants or to grow food produce, then an intensive green roof would be the correct system to choose.



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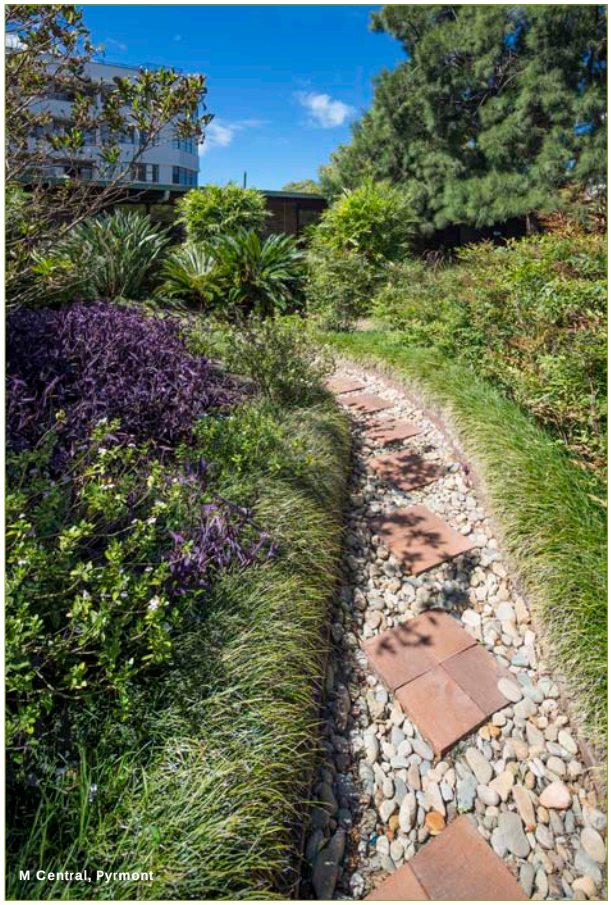

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Harris St, Pyrmont

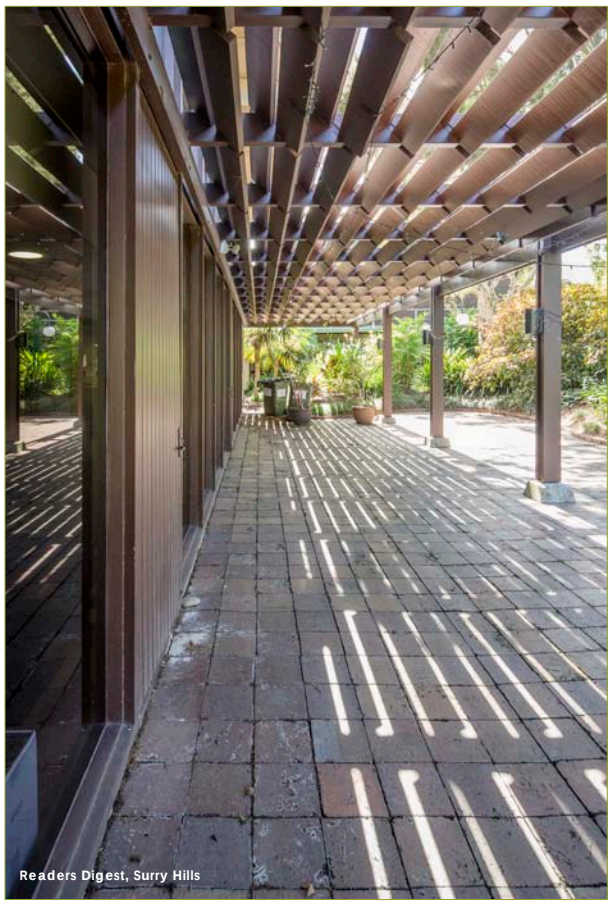
plant rooms

Where plant rooms are required for services to the building two approaches can be taken.

The area of plant room can be reduced to a series of storage areas on the roof, surrounded by the green roof technologies and green planting. In this instance, the intention is to use the walls of the plant roofs for green walls for further plant growth and to mount green technologies to the roof of the green room.

The second approach is to incorporate all the plant room activities into an additional floor at the top of the building and then cover the entire plant room with a green roof. This approach has the advantage of allowing for additional space for green technologies to be stored in the plant room, in particular the use of solar thermal and solar air conditioning and the plant equipment required for that. In addition, on low rise buildings, water storage can be maintained at the top of the building to provide a header, or supply, to the rest of the building which can also be incorporated into the plant room.

what are the roof top architectural considerations ?


Readers Digest, Surry Hills

shading and shelter

One of the main considerations to take into account when designing a green roof is the increased exposure to sun and daylight at the upper level of a building. On any rooftop, but particularly rooftops that are higher than surrounding buildings, there will be increased sunlight and a lack of shadow to reduce the intensity of the sun. Under such conditions it is important to provide shade, particularly in summer, for any occupation on the roof. Designers should consider the use of shade structures offering either 100% or a reduced amount of shade to substantial areas of the roof.

The roof area can be treated as a single storey building in regard to passive solar design where the orientation, form and shape of the shading structure can influence the access to winter sun and the provision of summer shade. The orientation of the rooftop structures may also be oriented towards the sun and principle wind directions independent of the form of the building below.

The design of shading structures needs to take account of the increased wind pressures at the higher levels of a building and be engineered to withstand the increased uplift forces and the likelihood of severe storm events, including hail.

rooftop rooms / meeting places

Part of the intention in developing an intensive or semi intensive green roof, is to increase access to the roof areas for both the occupiers of the building and the general public. This access to the roof can allow for a number of activities to occur, including:

- Access to the green garden areas for maintenance
- Access to green gardens for education and teaching
- Access to the green technologies for service and maintenance
- Provision of a meeting place for educational activities
- Access to areas for cultural activities such as religious or spiritual meetings
- Access to spaces for general meetings (eg: of the body corporate)

Such meeting places can take one of two forms, which we may characterise as "Roofless Walls" and "Wall-less Roofs".

Roofless Walls take the form of courtyards, where extending the walls of the building or creating new walls can deflect the increased wind pressures that are found at the rooftop. Such structures provide protection for not only people but also the planting from particular wind directions. It should be noted that the wind pressures on roof tops are significantly increased over those found at ground level. These walls can take various forms; a celebrated example is the use of the curved wall on the roof of the Villa Savoye by Le Corbusier, near Paris.

Wall-less roofs may take the form of a "veranda" where shade is provided from the roof above which is supported essentially on posts or columns. This form of rooftop structure can provide shade and can provide rain protection for outdoor areas to provide a suitable place for meetings.

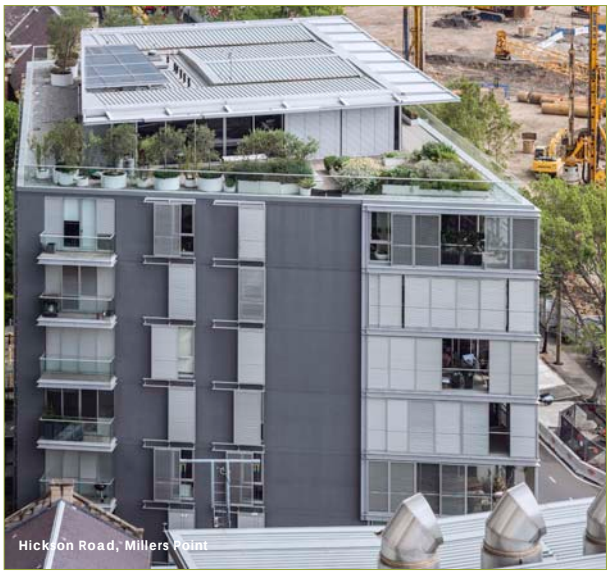

Readers Digest, Surry Hills


M Central, Pyrmont

sustainable technologies

Green roofs and walls provide the space and opportunity to incoporporate sustainable/renewable technologies. These can supplement the energy requirements and in some cases provide the power generation for the entire building.

Currently through the Commonwealth Government Small-scale Renewable Energy Scheme (SRES) there is a financial incentive provided through the Small-scale Technology Certificates (STCs).



Hickson Road, Millers Point

solar thermal

Solar thermal as a renewable energy source is different from photovoltaic cells in that it does not convert the suns energy directly into electricity. Solar thermal technology concentrates the suns energy via a series of specifically directed reflectors or mirrors onto a receiver, which stores the collected heat. This heat can then be stored and used both day and night. Although most commonly used in large-scale solar energy plants, there are opportunities to use this technology on green roofs.

A common application for solar thermal technology on a green roof would be solar hot water systems (see below).

The Wayside Chapel, Potts Point.

solar photovoltaic cells (PV)

Rooftops by nature are the perfect place to install PV cells because of their unimpeded access to solar energy.

PV cells come in two different varieties (flat-plate systems & concentrator systems) and a multitude of different sizes depending on the functional requirements of the system.

Testing on the efficiency of photovoltaic cells in combination with green roofs has found that due to the significantly lower temperatures on green roofs, photovoltaic cells run up to 25% more efficiently. Cooler conditions also improve the life span of the PV cells because constant high temperatures can threaten the long-term stability of the cells.

solar water heating

Solar water heating is an excellent and reliable alternative to electric water heating. Not only does it use free renewable energy that converts to real savings but also it reduces greenhouse emissions of up to 7 tonne P/A when used in a domestic situation (Aussie Solar).

Solar hot water systems come in a variety of different types but can be categorized into two main groups; active solar hot water systems and passive solar hot water systems. The difference between the two types is that active systems have pumps and circulators whilst passive systems do not.

Every solar hot water system has two main components, a tank and a solar collector.

Another advantage of installing a solar hot water system on a green roof is that a government rebate is paid for the installation of all new solar hot water systems. This makes the installation and payback period more affordable.

The Wayside Chapel, Potts Point.

wind power

Rooftops are typically a windy environment, especially on taller buildings in urban environments. This provides opportunity to install wind power generators on rooftops to supplement other renewable energy technologies.

When considering putting a wind power turbine on a green roof, special consideration needs to be paid to its location and the safety of any users that might be accessing the green roof space.

waterproof membranes

Waterproofing is fundamental in a successful green roof design. When retrofitting an existing building with a green roof, an audit of the existing membrane must be undertaken.

There are several choices of waterproof membranes:

- Thermoplastic membranes
- Elastomeric membranes
- Liquid-applied membranes

Some membranes consist of built up sheets/layers of 3 or more.

drainage

Standing water in the soil profile has risk implications in terms of increasing the potential of moisture breaching the waterproofing membrane. If the water drains freely through the profile and is collected and drained away, the risk is reduced. In addition, most plant material requires an aerated, non water-logged soil profile for healthy growth.

Water stored in the profile can also reduce irrigation demands. A balance should be found between the storage of water in the soil profile and the drainage of storm water on green roofs.

The drainage course materials and dimensions will depend upon construction requirements and objectives for vegetation.

Examples of drainage course materials:

- Mineral Aggregates
- Re-cycled Aggregates
- Drainage Matting
- Drainage Modules
- Drainage Boards
- Drainage and substrate boards

filter course

A geotextile layer is used to separate the drainage layer from the growing medium, preventing the fine particles present in the growing medium layer working through the profile vertically and ending up in the drainage layer and thus blocking the drainage layer or, in turn the stormwater system. An additional advantage is protecting the membrane.

Filter courses are now typically non-woven geotextiles. These filters need to be tough to withstand abuse while other layers are installed, while being open enough to provide good flow for water into the drainage layer.

The filter may be :

- a separate layer independent of the drainage layer or
- an integral part of the geo-composite drainage mat/ board.

modular systems

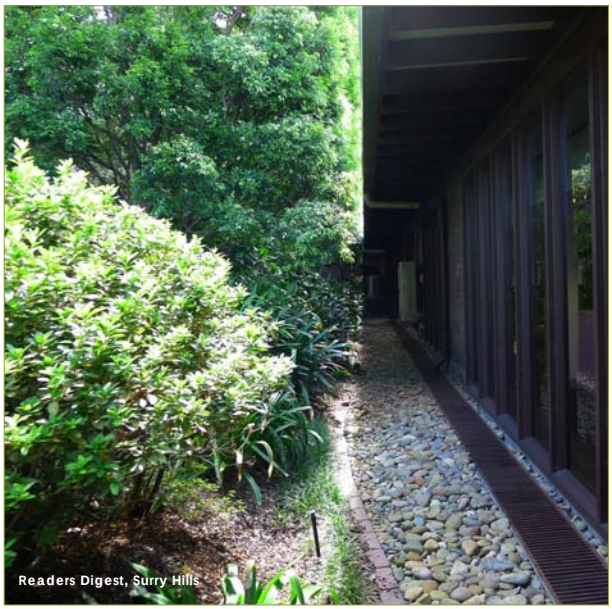
The drainage, filter, soil substrate or growing medium, and the plants are self-contained within a lightweight plastic module, of varying dimensions. In effect, these three main components of a greenroof are replaced by a fully planted module. When inter-locked they offer continuous roof drainage and coverage. (Linda Velaquez, 2003)

Advantages:

- rigid enough to support media/plants;
- capable of storing water and incorporating irrigation;
- create a free flowing drainage layer beneath
- removable in sections to allow repair to membranes.

The Wayside Chapel, Potts Point

Bligh Street, Sydney



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types of growing medium

By using a mixture of native soil upgraded with organic or mineral additives (peat, humus, wood chips lava or expanded clay), it is possible to achieve optimum water retention, permeability, density and erosion control necessary to support the green roof vegetation. It is not advisable to use ordinary garden soil, as degeneration often results from compacting and acidification.

The lesser the depth of the substrate, the higher the physical demands on the plants, resulting in root damage from heat and frost fluctuations.

One local example of a similar environment to a rooftop is the Robertson Plateau beyond Wollongong. Its growing media is derived from Hawkesbury sandstone which is poor in mineral plant food and often shallow, however it does contain particles of weathered mud and clay, enriched by decaying plant matter and bushfires add ash with valuable minerals. The plant communities which grow in this soil would also thrive on high-rise rooftops in Sydney.


The Wayside Chapel, Potts Point.

planting

Compatibility issues of green roof type, anticipated use, temperature, humidity, rainfall and sun/shade exposure are important elements for successful plantings of any kind. Most importantly for the artificial environment of a green roof, native and culturally adaptable plants need to be reviewed for heat and drought tolerance, as most systems are designed to be low maintenance.

City high-rise green roof plants experience extreme conditions so it is important to recognise the nature of such plants to ensure survival. The most important factors to consider include the levels of sunlight or shade required, growing media, heat/cold tolerance, periodic fluctuations in moisture and tolerance of windy conditions (sea-salt content).

The chances of creating a self-maintaining plant community are increased when a wide mix of species is used; hence, best practice is to avoid swaths of one species. Planting methods include seeding, hydro-seeding, spreading of sedum sprigs, planting of plugs or container plants and installing pre-cultivated vegetation mats.

Plant species endemic to the Sydney area range in variety due to the topography. The aim is to choose an endemic species which will grow in a rooftop environment. Ideally, choosing a variety of species from one plant community will simplify the execution and management of a green roof: i.e. same growing media, same drainage system etc.

Suitable plants for Australian intenseive green roofs:

- Woody Prostate perennials
- Small low shrubs and herbs
- Tuffed perennials

Suitable plants for Australian extensive green roofs:

- Grasses and Tussoaks
- Succulent ground creepers
- Ground creepers
- Climbers

agriculture

Amongst their numerous ecological, social and economic benefits, green roof infrastructure and even some green walls provide significant potential for increasing production of food through urban agriculture.


M Central, Pyrmont


The Wayside Chapel, Potts Point.


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