R8 and R9 Residential, Barangaroo South

Sustainability Report – Project Application

September 2012

Lend Lease

Document History

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EXECUTIVE SUMMARY

This ESD summary report has been produced by Lend Lease design to describe the initiatives that are to be included within the R8 and R9 residential buildings proposed as part of the Baranagaroo South precinct. This project aims to deliver a sustainable residential building, with low operational energy consumption, reduced potable water use, minimisation of waste to landfill and appropriate materials selection while at the same time maintaining a high level of indoor environmental quality through appropriate mechanical design, façade configuration and materials selection.

The residential development will be committing to a 5 Star Design and As-Built Green Star ratings under the Green Star Multi-Unit Residential v1 tool. Initiatives targeted within this Green Star tool will ensure significant sustainability principles will be incorporated into the design, appropriate management practices are applied through the construction period and facilities and resources are provided to ensure the delivery and operation of the building achieves the sustainability objectives. The precinct initiatives in combination with those specifically related to the residential buildings enable the minimum NSW sustainability performance requirements set by BASIX to be comfortably met.

The proposed residential development will benefit from the Barangaroo precinct sustainability initiatives such as the district cooling plant, on-site renewables strategy and precinct recycled water plant. These initiatives are essential to ensure the precinct achieves the many sustainability targets such as:

- Minimal operational energy consumption off-set by offsite renewable energy to ensure a carbon neutral precinct.
- Exporting more water than importing of potable water to ensure a positive water impact.
- Zero waste
- 20% reduction in embodied carbon (cradle to gate) not including tenant fit outs.
- On site renewables of an amount to offset public realm and recycled water treatment plant energy use.
- Green Star design and As-Built ratings for all eligible buildings within the precinct.

With the precinct sustainability initiatives and building specific initiatives, the proposed residential development will achieve the sustainability aspirations set for the Barangaroo south precinct.

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1.0 INTRODUCTION

This report supports a Project Application submitted to the Minister for Planning pursuant to Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act). The Application seeks approval for construction of a residential development (known as R8 and R9) and associated works at Barangaroo South as described in the Project Description section of this report.

This Sustainability report has been produced by the Lend Lease Sustainable Design Team to describe the principles to be incorporated into the design, construction and ongoing operation phases of the project to minimise its impact on the environment.

This project aims to deliver a sustainable residential development, with low embodied and operational carbon emissions, reduced potable water use while at the same time maintaining a high level of indoor environmental quality through appropriate mechanical design and materials selection. As with other projects within the Barangaroo precinct the development is committing to independent third party certification of sustainability by targeting Green star ratings. The development will target a 5 Star Design and As-Built ratings under the Green Star Residential Tool v1

1.1 Site Location

Barangaroo is located on the north western edge of the Sydney Central Business District, bounded by Sydney Harbour to the west and north, the historic precinct of Millers Point (for the northern half), The Rocks and the Sydney Harbour Bridge approach to the east; and bounded to the south by a range of new development dominated by large CBD commercial tenants. The Barangaroo site has been divided into three distinct redevelopment areas (from north to south) – the Headland Park, Barangaroo Stage 2 (also known as Barangaroo Central) and Barangaroo South.

1.2 Project Description

This Project Application seeks approval for the construction of 2 buildings consisting of ground floor retail within each, 7 levels of residential apartments consisting of 77 apartments within the R9 building and 10 levels of residential apartments consisting of 84 apartments within the R8 building

1.3 Purpose of This Report

This report has been prepared to accompany the Project Application for the R8 and R9 residential buildings and associated works at Barangaroo South. It addresses the relevant Director-General Requirements for the project, outlines the targets proposed for the development and in particular demonstrates the compliance of the works with the relevant requirements from the Statement of Commitments included in the approved Concept Plan.

The ESD initiatives for the development aim to be world class, and will provide support for and complement work by the Council of the City of Sydney on its Sustainable Sydney 2030 plans. The overall Barangaroo South development aims to provide:

- Inspiring architecture with healthy, light filled homes and workplaces;
- Low energy buildings that respond to the environment and the people within;
- Transport links and options that make it easy to leave the car at home;
- A mixed use precinct with outdoor spaces that everyone can share and enjoy;
- Centralised precinct services that support a carbon neutral, water positive and zero waste outcome;

- A long term Governance structure that also delivers carbon reduction and community benefits;
- A focused approach on delivering social initiatives that will assist in establishing a healthy and happy community integrated into the Sydney CBD; and
- A broad based skill development program that will meet a wide range oflearning and skilling needs – from blue and white collar to green.

2.0 Referenced Documentation

2.1 Architectural

Project application drawings provided by PTW and FJMT dated September 2012, including plans and elevations provided.

2.2 Building Services

Information generally provided verbally and/or through services reports and schematics uploaded to the project web document library.

2.3 Limitations

This report is based on documentation supplied to Lend Lease design as of September 2012. This documentation is subject to change as the design progresses and specific outcomes may be substituted or omitted whilst still targeting the sustainability aspirations for the Barangaroo precinct.

3.0 Precinct Initiatives

The Barangaroo South precinct has established a range of significant sustainability targets that will be delivered progressively throughout the development phase. This short overview provides the context for considering the building C5 application against the aspirations of the broader project. The descriptions in the section below are provided for information only and will be subject to more detailed reports and approvals as part of the subsequent building works applications. The proposed precinct wide targets are:

Healthy Buildings:
- 5-Star Green Star Design and As-Built ratings for Multi-Unit Residential buildings;
- Tuned to Sydney's climate and connected to outdoors;
- Passive design, low energy buildings; and
- Use of some sustainable materials, including recycled content and low emissions.

Energy and Carbon:
- A carbon neutral outcome supported by the use of new offsite renewable energy generation;
- Significant reduction in building energy consumption , reflected in a base building equivalent to a 5 Star NABERS Energy + 30% improvement, subject to tenancy behaviour;
- 20% reduction in embodied carbon within the built form;
- Efficient precinct infrastructure using central cooling plant and harbour heat rejection; and
- Onsite photovoltaic generation sized for the public domain and blackwater treatment system.

Water Positive:
- A water positive outcome – where more water is exported than potable water is imported;
- Treatment and reuse of a proportion of on-site stormwater catchment;
- On-site waste water treatment and water recycling;
- Capacity to export recycled water allowing neighbours to reduce their potable water demands; and
- Sewer mining to reduce network demands.

Zero Waste:
- Greater than 90% diversion of construction waste from landfill.

Sustainable Transport:
- A new connection/entry point for the CBD (with provision for light rail, ferries, and the Baranagraoo Pedestrian Link);
- Car parking ratios resulting in less car parking spaces than normally provided for a CBD commercial building;
- Infrastructure and support for cyclists and pedestrians;
- Real-time commuter updates;
- Green travel plan to promote vehicle sharing, small cars and electric cars; and
- Safe, low-speed onsite environment.

Landscape and Biodiversity:
- Use of native flora and encourage habitats for fauna;
- Inclusion of water-sensitive urban design;
- Planning for climate change; and
- Landscaped public spaces and selected green roof features.

Many of these targets involve various third parties and authorities, and will need partnerships, and involve commitments to work with and toward these targets.

These world leading initiatives will be evaluated, measured and reviewed progressively throughout the project life.

4.0 R8 and R9 Residential and Sustainability Contribution

The proposed R8 and R9 Residential Project will address the sustainability requirements included in the Statement of Commitments of the approved Concept Plan. The table below summarises these requirements and confirms how the project will address each requirement.

Category	Clause	Approved Concept Plan	R8 and R9 Residential Commitment
General ESD	64	There is to be an environmental focus on strategies for Water, Energy, Micro-Climate, Environmental Quality / Amenity, Landscape, Transport, Waste and Materials for the development. Each building on site will achieve the primary benchmark of a "5 star" standard of : Green Star 5 star, and Residential: Green Star Residential score >60, and each development will be required to demonstrate how it satisfies each of the following Key Performance Indicators for each of the ESD focus areas referred to below.	The R8 and R9 development will be designed and constructed to achieve a 5 star Green Star Multi-Unit v1 Design and As-Built ratings.
Water	65	There is to be a 35% reduction in Potable Water Consumption compared to a standard practice development and a 40% reduction in flow to sewer compared to a standard practice development.	The proposed R8 and R9 development will consume approximately 70% less water average dwellings within NSW. This is calculated using the NSW Building Sustainability Index (BASIX). Refer to section 4.5 for details describing how this target is achieved.
Energy	66	There is to be a 35% reduction in Greenhouse Gas Emissions compared to a standard practice development. 20% of power is to be purchased from low impact, renewable sources or alternatively there should be a 20% reduction in GHG emissions through carbon offsets. The purchase of renewable energy should be at World Best Practice level.	The proposed R8 and R9 development will result in approximately 50% less greenhouse gas emissions average dwellings within NSW. This is calculated using the NSW Building Sustainability Index (BASIX). Refer to section 4.3 for details describing how this target is achieved.
Micro-Climate	67	Key public open spaces (parks and squares) are to receive direct sunlight in mid-winter.	This relates to public open spaces so is not applicable to this PA submission.
Landscape	68	Primarily non-invasive plant species are to be used on the site.	This requirement will be met through the choice of appropriate plant species.
Transport	69	Ensure that there is sufficient public transport to achieve points under the public transport credit for Green Star Rating Tools for buildings and a future Green Star Tool for	Proximity to Wynyard station trains and buses within short walking distances will ensure a high score in the Green Star public transport

Category	Clause	Approved Concept Plan	R8 and R9 Residential Commitment
		residential buildings.	credit.
Waste	70	Centralised recycling areas are to be provided in all buildings and 100% of waste bins for public use are to allow for waste separation.	Waste collection areas in the basement have been provided allowing for the streaming of waste and recyclables from R8 and R9.
Wind	71	Wind tunnel modelling and verification of proposed treatments will be carried out at the building design application stage due to the significant exposure of the site to the southerly and westerly winds. Any development proposal for the southern portion of the site should be subjected to a wind tunnel study, carried out in accordance with the procedures outlined in industry recognised guidelines such as the Australasian Wind Engineering Society Quality Assurance Manual.	This is addressed in a separate wind report so is not applicable to this report.

5.0 Green Star Multi-Unit Residential Tool

The Green Star rating scheme, a voluntary national sustainable design rating tool set up and managed by the Green Building Council of Australia (GBCA) is being used to guide the design process. The Green Star scheme is a comprehensive rating system that evaluates the environmental design and construction of buildings and communities - 4, 5 and 6 Star ratings can be awarded by the GBCA.

The Green Star Multi-Unit Residential Tool was first released as a Pilot scheme in mid 2008 and version 1 has since been released. The project is targeting a 5 star Green Star rating under Green Star Multi-Unit Residential v1which is considered to be Australian excellence.

Green Star is a holistic assessment scheme, which assesses the sustainability features of a development within 8 different categories.

- Management
- Indoor Environmental Quality
- Energy
- Transport
- Water
- Materials
- Land Use and Ecology
- Emissions

Credits are awarded based on meeting criteria in each of the categories and the credits are summed and weighted according to their environmental importance and totalled to give a star rating. There are 105 Credits available. A score of 45-59 Credits is equal to 4 Stars (Best Practice), a score of 60-74 Credits is equal to 5 Stars (Australian Excellence) and a score of 75 or more credits is equal to 6 Stars (World Leadership).

The following sections outline in some detail how the sustainability initiatives within R8 and R9 can be recognised under the Green Star tool.

5.1 Management

Lend Lease has a proven track record in the management of sustainability in its projects. Many credits relate to the way in which the project is delivered and Lend Lease Project Management and Construction (PMC) have in place the necessary controls and procedures to achieve the outcomes targeted.

MAN-1. Green Star Accredited Professional. The majority of Lend Lease's sustainable design personnel are Green Star Accredited Professionals and the ESD consultant on R8 and R9 has been accredited since 2005 and served in many Green Star working groups, assessments and peer reviews.

MAN-2. Commissioning Clauses. The design consultants will provide documentation that outlines the design intent and contractors will be required to ensure they commission systems in accordance with the appropriate CIBSE and ASHRAE standards.

MAN-3. Building Tuning. The contractors will be required, during the first 12 months post completion, to tune the base building (strata) systems that are sometimes left operating inefficiently. This may include systems such as common area lighting, hot water systems and car park ventilation.

MAN-4. Independent Commissioning Agent: An individual will be responsible for providing commissioning advice to the building owner and the design team and to monitor and verify the commissioning of all building systems.

MAN-5. Building User Guide. The design team will be responsible for producing a user guide that gives the residents important information about how the building works and how to use the facilities most efficiently. During construction the guide will be updated in collaboration with the construction team.

MAN-6. Environmental Management. The construction team will operate the site using a Site Environmental Management Plan which is accredited/recognised against industry best practice, such as the NSW Environmental Management System Guidelines 2007 and ISO 14001.

MAN-7. Waste Management. The construction team will aim to recycle at least 80% of construction and demolition waste using a waste contractor that can sort and direct waste for recycling. It is anticipated that this 80% target will be easily exceeded.

MAN-16. Metering. Sub-metering will be provided for all water, electricity and gas end-uses. In addition each dwelling will be individually metres for electricity, water, hot water and chilled water. An in-home display will be provided which will display consumption and financial cost information to tenants.

5.2 Indoor Environmental Quality (IEQ)

The overall planning and design of the apartments has been developed to maximise IEQ outcomes. This is a process of balancing good environmental outcomes with the contradicting issues of energy and materials efficiency. Increased daylight, air movement and the use of environmentally friendly materials has been encouraged wherever possible.

IEQ-8. Thermal comfort. Apartments will ensure that thermally comfortable conditions can be maintained with minimal heating and cooling energy.

IEQ-9. Internal Noise Levels. Apartments will be designed to minimise building services and external noise intrusion.

IEQ-10. Volatile Organic Compounds. Lend Lease engaged with its supply chain some time ago to deliver finishes products that were low VOC without significant cost impost. This includes paints, adhesives & sealants, floor coverings and wall & ceiling coverings.

IEQ-11. Formaldehyde Minimisation. The biggest challenge for residential developments will be sourcing kitchen and bathroom cabinetry that doesn't utilise formaldehyde based binding agents. These products are available and Lend Lease will continue to drive suppliers to deliver these products cost effectively.

IEQ-13. Electric Lighting Levels. The lighting design within the apartments delivers at least 300 lux levels at working surfaces such as the kitchen sink, cooktop and bathroom vanity.

IEQ-21. Dwelling Ventilation. Every apartment will have dedicated and separate kitchen exhaust systems which improve air quality within the apartment without unnecessarily expending central energy.

IEQ-22. Natural Ventilation. Approximately 74% of dwellings will achieve cross ventilation. While the specific requirements of the associated Green Star credit are not achieved, units will have good natural ventilation opportunity provided window operable areas are addressed during the next design phase.

5.3 Energy

The design of R8 and R9 prioritises energy efficient and cost effective solutions. The need for air conditioning will be minimised through good passive design and demonstrated through the use of the NatHERS Energy Star Ratings calculated for each apartment type. However, air conditioning will be provided in the form of energy efficient air cooled plant utilizing environmentally friendly refrigerants.

ENE-1. Conditional Requirement/Greenhouse Gas Emissions. Green Star and The Building Code of Australia all set minimum standards for NatHERS – the energy rating method for apartments. The apartments will

be designed with a high performance external façade which should result in a minimum average star rating of 7 Stars. As well as minimising heating and cooling loads the apartments will utilise chilled water from the precinct chilled water plant, have energy efficient lighting fittings and hot water will be delivered from a centralised gas fired storage system. Common area energy consumption will be reduced through providing natural ventilation to common areas where possible, efficient lighting and appropriate controls of lighting and any ventilation requirements. In addition to the energy efficiency initiatives, there is also a target to incorporate 150kW of rooftop photovoltaics (75kW per building) within the development as part of the precinct wide renewable energy strategy. This will significantly lower grid supplied electricity and therefore significantly reduce the operational greenhouse gas emissions associated with the development.

ENE-7. Unoccupied Areas. Each apartment will have a hotel-style entry/exit switch that can isolate the power used by lighting and air conditioning. All public areas and car parks include motion sensing controls to minimise energy consumption associated with lighting and ventilation/air conditioning as well as time schedule and day lighting control where appropriate.

ENE-8. Energy Efficient Appliances: Clothes washers and dishwasher to be provided will have the highest energy rating available. In addition clothes lines will be provided for each apartment.

ENE-11. Peak Electricity Demand Reduction This is achieved through the minimisation of cooling loads and the provision of gas heating.

5.4 Transport

R8 and R9 benefit from an ideal location adjacent to Sydney's CBD and within the Baranagaroo South precinct. All commercial and residential buildings, including R8 and R9, within the precinct will include a portion of retail tenancies giving residents access to a variety of services. Public transport facilities including trains, buses and ferries will also be readily accessible.

TRA-3. Cyclist Facilities. Bicycle storage will be provided for residents via storage cages as required. Visitors to the building will also be able to access external bike parking via racks to be located on the ground level.

TRA-4. Commuting Mass Transport. The Barangaroo precinct has good access to public transport including the Wynyard station trains, buses within the CBD and ferries.

TRA-5. Trip Reduction - Mixed Use. Given the significant retail components of the Barangaroo precinct, occupants will have access to a wide range of amenities.

5.5 Water

R8 and R9 will be targeting a high level of reduction in potable water through the use of the precinct recycled water plant for use in flushing toilets, laundries and irrigation. Fixtures and fittings will also be selected to be as low flow as reasonably possible.

WAT-1. Occupant Amenity Water. This credit relates to the efficiency of the water fittings provided and the availability of any non-potable water sources. The development will be provided with highly water efficient fittings including dual flush toilets and low-flow taps and showerheads. Recycled water from the precinct recycled water plant will be pumped to the building to the apartments via a third-pipe supply network for flushing toilets, use in washing machines and irrigation.

WAT-3. Landscape Irrigation. The communal landscaped areas will be designed to minimise water consumption. Water to be supplied for irrigation purposes will be recycled water from the precinct plant. It is also proposed to provide recycled water to laundry taps within apartments to enable any private balcony landscape to be irrigated using recycled water.

WAT-4. Heat Rejection Water. Cooling to apartments will be provided by the district central cooling plant. This cooling plant utilises harbour heat rejection and therefore does not rely on any water based heat rejection technologies..

WAT-5. Fire System Water. The fire hydrant pumps have been located and arranged so that water used in monthly pump and hydrant tests can be directed to the precinct fire water tanks located within the basement.

5.6 Materials

In addition to providing waste recycling facilities, materials will be specified and selected to ensure minimal environmental impact.. Alternative materials will be investigated for all constructions and these alternatives employed wherever practical.

MAT-1. Recycling Waste Storage. Waste handling within R8 and R9 follows best practice principles regarding facilities to be provided to tenants for recycling of waste. Each building has four core lifts. Next to each is a chute that services each level. The chutes feed into four separate waste rooms located in basement level 2. Lend Lease are currently reviewing the e-diverter chute system that allows tenants to easily divert their general waste and recycling to the appropriate bins. This system ensures that recycling is as easy to use as the general waste system. Cleaners will monitor the waste rooms and transport full bins to the combined precinct waste room as required. Oversized items, including expanded polystyrene packaging, will be stored within the precinct combined waste room for diversion to re-use centres or for recycling as appropriate. Tenants will be required to book a collection with the building management for such items to be collected and transported to the waste area. This area will be managed by the cleaners, allowing separation of items to be maintained.

MAT-3. Concrete. Initiatives targeted regarding concrete include the reduction of Portland cement, use of reclaimed water within the concrete mixes and use of alternative materials within aggregate.

MAT-4. Steel. Steel will be sourced from 'responsible steel makers' in accordance with GBCA requirements. In addition reinforcement steel will be procured from a supplier who produces steel using energy reducing processes during its manufacture and a proportion of reinforcement steel will be pre-fabricated off-site.

MAT-5. PVC. Revised credit criteria have been developed by the GBCA to recognise environmental improvements in PVC manufacture. R8 and R9 will utilise PVC that complies with the Green Building Council Best Practice guidelines, or alternatively use alternatives to PVC.

5.7 Land Use and Ecology

The R8 and R9 site benefits from Barangaroo's position as a brownfield district with potential for land re-use rather than developing new land. The history of the district as a working dock also leads to the requirement for land remediation and minimising in-ground works. For these reasons the site meets the conditional requirement that it has not been of prime agricultural value, contained old growth forest and has not been a wetland.

ECO-2. Re-use of Land. The site was previously developed as part of the working dock. Redeveloping the site for apartments is a clear re-use of land.

ECO-3. Reclaimed Contaminated Land. Significant contamination exists on the Baranagaroo site and therefore significant works are required to ensure the site is appropriately decontaminated which will entitle all buildings developed within the precinct to achieve this Green star criteria.

ECO-4. Change of Ecological Value. The predevelopment condition of the site was bare ground (hard standing). While there will be some communal rooftop landscaping it will will not be sufficient to significantly raise the ecological value of the site. However, the post development condition is no worse than the pre development condition and is eligible for 1 point for maintaining the same biodiversity.

5.8 Emissions

Emissions from R8 and R9 will be minimised as far as possible. By using environmentally friendly refrigerants and insulation and eliminating light spill and cooling tower emissions any negative impact of the building can be significantly reduced.

EMI-1. Refrigerant ODP. The air-conditioning units will utilise refrigerants with zero ozone depleting potential. These HFC based gases are controlled substances which, if accidentally leaked, will not damage the ozone layer. The refrigerants associated with the project are located within the district cooling plant.

EMI-4. Insulant ODP. The fabric and services insulation specified at R8 and R9 will be of a type that does not use any material with Ozone Depleting Potential in its manufacture or composition.

EMI-5. Stormwater. Stormwater run-off from the site will be treated as part of the precinct wide stormwater strategy.

EMI-7. Light Pollution. The design of the external lighting system will ensure that light does not spill upwards to the sky or beyond the boundary. This can be a nuisance to adjacent properties, particularly residential neighbours.

EMI-8. Legionella. The district cooling plant will utilise harbour heat rejection and therefore there are no cooling towers associated with R8 and R9. This eliminates any risk of legionella.

5.9 Innovation

The proposed design currently incorporates initiatives which are not recognised under the Green star tool. These include precinct sustainability initiatives such as the reduction in embodied carbon targeted by the project, the centralisation of infrastructure which minimises materials and the carbon neutral, positive water and zero waste operational commitments.

As these are not rewarded by existing Green star credits, these initiatives may be eligible to contribute towards the project's Green star rating through innovation credits. Given the uncertainty of innovation credits they cannot be relied upon to ensure a targeted rating is achieved. Therefore the current 5 star strategy does rely on any of the potential innovation credits which the project may be eligible for.

6.0 Regulatory Compliance – BASIX

The Building Sustainability Index (BASIX) sets energy reduction, thermal comfort and water reduction targets for new residential developments based on the average energy and water consumption of dwellings in NSW. Achievement of the BASIX targets is the minimum regulatory sustainability requirement for residential dwellings in NSW. The reduction targets range from 20 to 40%, depending on the type and location of the development. For buildings with 6 or more stories such as the R8 and R9 developments, a 20% reduction in energy, and a 40% reduction in water use is required to pass.

For Thermal Comfort, BASIX requires a "pass" score based on heating and cooling "caps" set by BASIX; however the thermal performance of a development will affect its energy score. For example, a development that has excellent thermal performance reduces its reliance upon air conditioning, and is therefore awarded in BASIX with a positive contribution to its energy score.

The following table summarises the BASIX targets required to be achieved for the R8 and R9 development and also the BASIX scores achieved. As seen below, given the sustainability initiatives to be included within the project, the BASIX targets for both energy and water are comfortably exceeded.

Category	Requirement	Score Achieved
Water	40% reduction	68% reduction
Thermal Comfort	Pass	Pass
Energy	20% reduction	48% reduction

The BASIX summary report which includes the design initiatives resulting in the above scores has been attached as an appendix.

7.0 Conclusion

The proposed R8 and R9 residential development will achieve the sustainability aspirations set for the Barangaroo south precinct. The project will benefit from the precinct wide sustainability initiatives such as the district cooling plant, on-site renewables strategy and precinct recycled water plant. These initiatives are essential to ensure the precinct achieves the many sustainability objectives.

This project aims to deliver a sustainable residential building, with low operational energy consumption, reduced potable water use, minimisation of waste to landfill and appropriate materials selection while at the same time maintaining a high level of indoor environmental quality through appropriate mechanical design, façade configuration and materials selection.

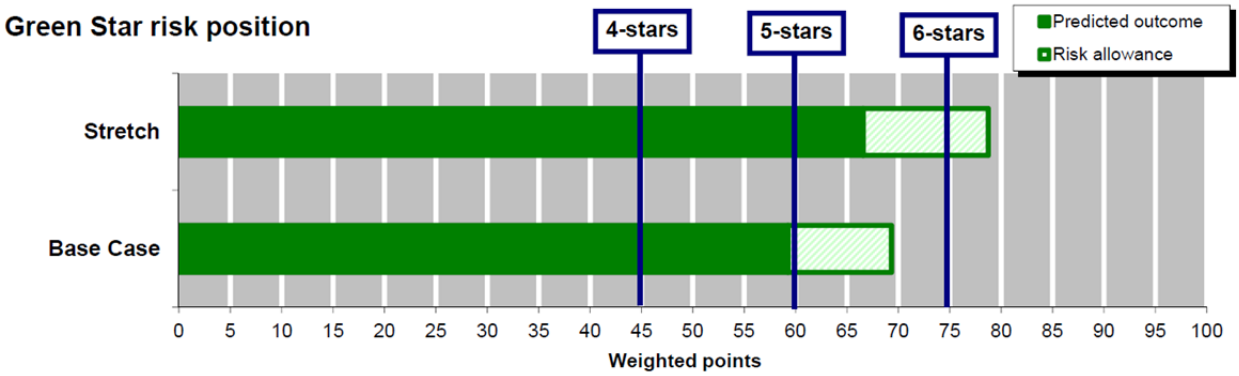
The residential development will be committing to a 5 Star Design and As-Built Green Star ratings under the Green Star Multi-Unit Residential v1 tool. Initiatives targeted within this Green Star tool will ensure significant sustainability principles will be incorporated into the design, appropriate management practices are applied through the construction period and facilities and resources are provided to ensure the delivery and operation of the building achieves the sustainability objectives. The precinct initiatives in combination with those specifically related to the residential buildings enable the minimum NSW sustainability performance requirements set by BASIX to be comfortably met.

A) Appendix – Green Star Strategy

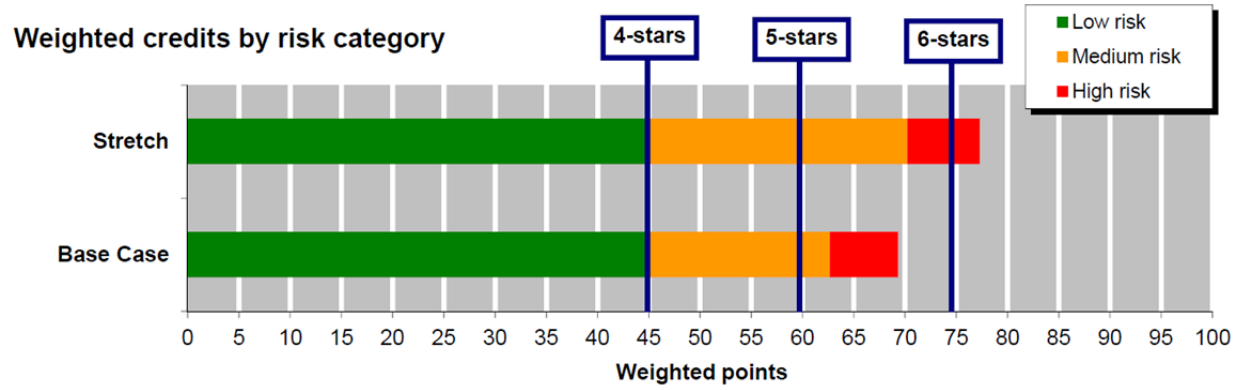
The following summarises the current strategy to achieve a 5 Star rating under the Green Star Multi-Unit Residential v1 tool. All credits have been reviewed and those appropriate to be incorporated into the design have been classified as follows:

- Low Risk: 95% of Low Risk credits are assumed to be achieved
- Medium Risk: 75% of Medium risk credits are assumed to be achieved
- High Risk: 50% of High risk credits are assumed to be achieved

As seen in the chart below, with the above risk weightings, the targeted credits should ensure a 5 star rating is achieved. The 'Base Case' displayed below is what is representative of the current strategy. The 'Stretch' strategy indicated below includes initiatives which would be required to be investigated if a 6 star rating was desired.



The chart below displays the total targeted credits by risk category. As seen below, the 5 star strategy requires the majority of the medium risk credits to be confirmed through design development. The 69 credits targeted should however ensure that there is a sufficient buffer to ensure the 5 star rating is achieved. A significant buffer is recommended early in the design phase given uncertainty regarding many of the design details surrounding the services design.



The following table details the risk associated with each targeted credit and includes a brief description of requirements.

Green Star Risk Matrix

Barangaroo Residential

High	Risk factor = 50%	High
Medium	Risk factor = 25%	Medium
Low	Risk factor = 5%	Low

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These credits are typically low risk and we cannot perceive any reason to not achieve credit. However, GBCA have been unpredictable in the past and have been known to disallow credits due to minor technicalities, hence the 5% contingency

Cat.	Credit description	Ref	Available	Base Case	Risk category	Stretch Case	Risk category	Notes
Management								
	Green Star Accredited Professional	Man-1	2	2	Low	2	Low	Included in ESD fees
	Commissioning - Clauses	Man-2	2	2	Low	2	Low	Required for residential above ground, basement by others
	Commissioning - Building Tuning	Man-3	1	1	Low	1	Low	Requires 12 months of building tuning of building services post occupancy
	Commissioning - Commissioning Agent	Man-4	1	1	Low	1	Low	Need to engaged from beginning of services schematic design through to operation - does not have to be the same party as the basement
	Building Users' Guide	Man-5	1	1	Low	1	Low	User guide which contains information relevant to building residents and management. Included in ESD fess.
	Environmental Management	Man-6	3	3	Low	3	Low	BAU. Achieved through implementation of EH&S plan and PM&C ISO14001 accreditation.
	Waste Management	Man-7	2	2	Low	2	Low	Requires 80% of demolition and construiction waste to be diverted from landfill
	Metering	Man-16	4	4	Low	4	Low	Requires sub-metering of water (potable and recycled), electricity and hot water for each apartment. While not required by th credit criteria CHW thermal meters and HHW thermal meters will also be required to enable billing of CHW and HHW to tenants. Smart metering must also be included for each dwelling which displays consumption data as well as financial cost information.
	Metering	Man-16	2	2	Low	2	Low	This requires sub-metering of all major water, electricity and gas base building end-uses.
		TOTAL	**18**	**18**		**18**		
Indoor Environment Quality								
	Daylight	IEQ-4	2	0	No risk	0	No risk	Requires a DF of 2% to >95% of kicthens and 1.5% to >60% of living areas. Will be very difficult.
	Thermal Comfort	IEQ-5	2	2	Low	2	Low	Review of the current design suggests a 7 star average can be achieved. Requires clear dbl gazing as a minimum and extensive shading (preferrably operable shading to west).
	Hazardous Materials	IEQ-6	NA	NA	No risk	NA	No risk	
	Internal Noise Levels	IEQ-7	2	1	Low	2	Medium	Advice from Acoustic consultant suggests that 1 point is achievable if targeting 'High' standard for acoustic performance and points is achievable if 'Premium' performance is targeted.
	Volatile Organic Compounds	IEQ-8	4	4	Medium	4	Medium	This applies to paints, adhesives and sealants, flooring, walls and ceilings.
	Formaldehyde Minimisation	IEQ-9	1	1	Medium	1	Medium	This is applicable to all composite wood products.
	Electric Lighting Levels	IEQ-13	1	1	Low	1	Low	A minimum of 300 lux is to be provided on the surface of kitchen sinks, cooktop or stoves and vanity basins.
	Private External Space	IEQ-20	1	0	No risk	0	No risk	Need all apt baclonies to be greater than 2x3m and >15% of living area. Will require operable shading to ensure solar access requirements are met.
	Ventilation Rates - Trickle Vent	IEQ-21	2	0	No risk	0	No risk	Need to incorporate something into glazing design for ease of repeatabilityThis requires each room to have a trickle ventilato Not targeted.
	Ventilation Rates - Kitchen Exhaust	IEQ-21	1	1	Low	1	Low	Kitchens to be ventilated with dedicated and separated extract fans.
	Natural Ventilation	IEQ-21	2	1	High	1	High	70% of units requiered to achieve cross-flow for 1 point and 90% for 2 points. While current design achieves cross ventilation to 74% of units, specific requirements required by Green Star are not achieved and therefore compliance with this credit will need to be confirmed with tjhe GBCA.
	Natural Ventilation	IEQ-22	1	0	No risk	0	No risk	Common areas must be naturally ventilated with 5% openable area on floor-by-floor basis.Assumed this can be achieved.
		TOTAL	**19**	**11**		**12**		
Energy								
	Energy	Ene-0	:ond Req't					
	Energy Improvement	Ene-1	17	8	Low	10	Low	Without modelling, this is uncertain, however a min of 8 points anticpiated. Will require an efficient lighting design.
	Energy Improvement	Ene-1	3	5	Medium	5	Medium	These additional points should be confirmed during detailed design. In addition to more certain assumptions, PV and cogeneration will make a significant contribution..
	Unoccupied Space	Ene-7	2	2	Low	2	Low	Dwelling kill switch near the main entry door of each dwelling for 1 point. Additional point achieved if all common areas include automated controls to common area lighting and ventilation. Controls can include motion sensors, timers, push button timers or daylight sensors.
	Energy Efficient Appliances	Ene-11	2	1	Low	2	Medium	For 1 point clothes dryers and dishwashers with highest rating available AND internal or external clothes lines with min of 7.5m/apartment. For 2 points a complete appliance package (clothes dryers, dishwashers, refrigerators and clothes washers) will be required with the highest energy rating possible.
	Peak Energy Demand Reduction	Ene-12	2	2	Low	2	Low	Non-electric heating (HHW provided to FCUs) and 2 points under IEQ-5 will ensure this is achieved.
		TOTAL	**26**	**18**		**21**		
Transport								
	Car Parking Minimisation	Tra-1	2	0	No risk	2	No risk	Assuming less than council requirements will be provided.
	Fuel Efficient Transport	Tra-2	2	0	No risk	0	No risk	Small cars and car share may be hard to implement. Client desire is not to include these.
	Cyclist Facilities	Tra-3	3	3	Low	3	Low	Individual cages provided in basement for each dwelling for 2 points. Additional point achieved by providing visitor bike racks near major entries which are protected from the elements.
	Commuting Public Transport	Tra-4	5	5	Low	5	Low	Good CBD Services
	Trip Reduction - Mixed Use	Tra-5	2	1	Medium	2	Medium	Retail within precinct should result in a significant number of services. Timing may be an issue and may require a CIR.
		TOTAL	**14**	**9**		**12**		
Water								
	Occupant Amenity Potable Water Efficiency	Wat-1	2	2	Low	2	Low	Achieve 2 points with 3.5l/flush toilets; 4.5l/s/ taps; 7.5l/s showers
	Occupant Amenity Potable Water Efficiency	Wat-1	3	2	High	2	High	2 points for using recyled water in clothes washers and toilets. High risk given that occupants will have the option of potable and non-potable supplies to clothes washers. Will require discussion with the GBCA.
	Landscape Irrigation Water Efficiency	Wat-3	1	1	Medium	1	Medium	Irrigation to green roofs will be recycled water. Recycled water can be reticulated to laundry taps to enable recycled water to be used for planter boxes on balconies.
	Heat Rejection Water	Wat-4	2	2	Low	2	Low	Achieved with harbour heat rejection associated with DCP.
	Fire System Water Consumption	Wat-5	1	1	Low	1	Low	The sprinkler / hydrant test drain will drain to the Precinct Fire Tanks for re-use.
	Water Efficient Appliances	Wat-7	1	0	No risk	1	Medium	Would require dishwashers and clothes washers to be installed and be within 1 point of highest WELS rating.
	Swimming Pool/Spa Water Efficiency	Wat-8	NA	NA	No risk	NA	No risk	No pool provided
		TOTAL	**10**	**8**		**9**		
Materials								
	Recycling Waste Storage	Mat-1	2	2	Medium	2	Medium	Waste chutes for general waste and recycling provided on each floor. In addition spatials for storage of recyclables, compost facilities and an area for over-sized items is to be provided in the basement. Medium risk is associated with re-use of compos off-site and potnetial on-line portal for re-use of household items.
	Building Re-Use	Mat-2	NA	NA	No risk	NA	No risk	
	Recycled Content & Reused Products & Materials	Mat-3	1	0	No risk	1	High	Difficult to achieve
	Concrete	Mat-4	3	2	Medium	2	Medium	Target 3 points as per precinct strategy; 2 likely and 1 high risk. Part of precinct embodied carbon strategy.
	Concrete	Mat-5	3	1	High	1	High	
	Steel	Mat-5	2	2	Low	2	Low	This assumes that greater than 60% of steel is reo. 1 point should be standard practice. Additional point achieved for pre-fab of 15% of reo.
	PVC Minimisation	Mat-6	2	2	Medium	2	Medium	Requires PVC supplied to the project to be compliant with the GBCA's Best Practice Guidelines. Hydraulic pipework should not be an issue, however electrical cabling may be more difficult. Can substitute with non-PVC products however this may ad cost.
	Sustainable Timber	Mat-7	2	1	Medium	1	Medium	Risk associated with this credit is associated with demonstrating Chain of Custody for certified products.
	Design for Disassembly	Mat-8	1	0	No risk	0	No risk	With in-situ construction this will not be achievable.
	Dematerialisation	Mat-9	2	1	High	1	High	Investigate initiatives as part of precinct strategy.
	Floor Coverings	Mat-11	1	1	High	1	High	This requires careful selection of products. Products certified by schemes such as GECA or Ecospecifier to be favoured.
	Joinery	Mat-12	1	1	High	1	High	This requires careful selection of products. Products certified by schemes such as GECA or Ecospecifier to be favoured.
	Internal Walls	Mat-14	2	2	High	2	High	This requires careful selection of products. Products certified by schemes such as GECA or Ecospecifier to be favoured.
	Universal Design	Mat-15	1	1	Low	1	Low	Would require 10% of dwellings to comply with the Class A, B or C requirements of AS4299-1995 'Adaptable Housing'.
		TOTAL	**23**	**16**		**17**		

Green Star Risk Matrix

Cat.	Credit description	Ref	Available	Base Case	Risk category	Stretch Case	Risk category	Notes
Land Use & Ecology								
	Conditional Requirement	Eco-0	:ond Req't					
	Topsoil	Eco-1	na	na	No risk	NA	No risk	No topsoil as currently concrete base -*CIR for commercial*
	Reuse of Land	Eco-2	1	1	Low	1	Low	Was a working dock
	Reclaimed Contaminated Land	Eco-3	2	2	Medium	2	Medium	Achived as part of precinct remediation works. Risk associated with timing of remediation.
	Change of Ecological Value	Eco-4	4	1	Low	1	Low	Standard practice
	Communal Garden Facilities	Eco-5	3	0	No risk	2	Medium	Potential to introduce some facilities; BBQ, seating, play area, outdoor drying, veggie patch etc. Would require 25% of the site area to be dedicated to communal facilities.
		TOTAL	**10**	**4**		**6**		
Emissions								
	Refrigerant ODP	Emi-1	1	1	Low	1	Low	Achieved through district cooling plant
	Refrigerant GWP	Emi-2	2	0	No risk	0	No risk	Unlikely to achieve without exclusively absorption chillers
	Refrigerant Leak Detection	Emi-3	1	1	Low	1	Low	Achieved through district cooling plant
	Insulant ODP	Emi-4	1	1	Low	1	Low	Insulants to be specified as having zero ODP in manufacture and composition
	Watercourse Pollution	Emi-5	2	2	Medium	2	Medium	As per precinct strategy.
	Reduced Flow to Sewer	Emi-6	4	4	Low	4	Low	Achieved through precinct recycled water plant.
	Light Pollution	Emi-7	1	1	Medium	1	Medium	Requires light spill to be minimised to negligible levels at the site boundary.
	Legionella	Emi-8	1	1	Low	1	Low	Achieved with harbour heat rejection as part of DCP.
		TOTAL	**13**	**11**		**11**		
Innovation								
	Innovative Strategies and Technologies	Inn-1	5 points in total for Inn-	0	No risk	0	No risk	Reduction in embodied carbon, daylit and visible stairs minimising lift energy.
	Exceeding Green Star Benchmarks	Inn-2		0	No risk	0	No risk	
	Environmental Design Initiatives	Inn-3		0	No risk	0	No risk	
		Total	**5**	**0**		**0**		
TOTAL CREDITS (UNWEIGHTED)				95		106		
TOTAL CREDITS (WEIGHTED)				**69.3**		**78.7**		
TOTAL CREDITS (INCLUDING RISK ALLOWANCE)				**59.3**		**66.6**		

B) Appendix – BASIX Summary Report

Barangaroo Residential R8/R9
BASIX Assessment Assumptions

Introduction

This report summarises the assumptions made for the BASIX assessment of the R8/R9 development at Barangaroo.

The Building Sustainability Index (BASIX) sets energy reduction, thermal comfort and water reduction targets for new residential developments based on the average energy and water consumption of dwellings in NSW. The reduction targets range from 20 to 40%, depending on the type and location of the development. For buildings with 6 or more stories such as the R8 and R9 developments, a 20% reduction in energy consumption, and a 40% reduction in water use is required to pass.

For Thermal Comfort, BASIX requires a "pass" score based on heating and cooling "caps" set by BASIX; however the thermal performance of a development will affect its energy score. For example, a development that has excellent thermal performance reduces its reliance upon air conditioning, and is therefore awarded in BASIX with a positive contribution to its energy score.

To complete a preliminary assessment of the project using BASIX, certain assumptions have been made. Based on the assumptions listed in this report result, the development receives the following scores:

Category	Requirement	Score Achieved
Water	40% reduction	68% reduction
Thermal Comfort	Pass	Pass
Energy	20% reduction	48% reduction

The assumptions included within this summary should be reviewed in detail as they can have a significant impact on the overall BASIX score.

Assumptions

Project Areas

The following areas have been measured from drawings issued in September 2012 by project architects; Francis-Jones Morehen Thorp for R8, and PTW Architects for R9. The basement and back of house areas have been provided by the basement design team.

Site Details		
Site area	m^2	3,178
Total roof area (for all buildings)	m^2	1,174
Non-residential floor area	m^2	1,023
Residential car spaces	No.	160
Non-residential car spaces	No.	0

Common Areas			
Space Type	Location	R8 Areas (m²)	R9 Areas (m²)
Ground floor lobby	Ground floor	107	122
Residential floor hallways	North module	162	428
	South module	243	
Other internal common area (e.g. store rooms, FCR, garbage chutes)	Ground floor	26	23
	North module	28	40
	South module	60	
Undercover car park	Basement	4,350	
Lift shafts	Basement	113	
Switch rooms	Basement	58	
Garbage rooms	Basement	96	
Comms rooms	Basement	44	
Water meter rooms	Basement	50	
Heat exchanger rooms	Basement	15	
Sewer tank/ pump rooms	Basement	114	
Grease arrestors	Basement	168	

There is no communal swimming pool, spa or gymnasium in the development.

Please refer to the Appendix for a reference to the unit codes assigned to each typical apartment.

Dwelling Details – R8					
Unit Code	Levels	Quantity	No. Of bedrooms	Conditioned floor area (m²)	Area of garden and lawn (m²)
1A	1 – 5	5	1	59	0
1B	6 – 7	2	1	59	0
2	1 – 7	7	2	102	0
3	1 – 8	8	2	96	0
4	8	1	3	127	0
5	9	1	4	363	0
6A	1 – 5	10	1	57	0
7A	1 – 6	16	2	98	0
7B	1 – 5	10	2	98	0
8	1 – 6	6	1	59	0
9A	6	2	3	126	0
9B	6	2	3	126	0
10A	7	5	3	167	0
10B	7	1	3	154	0
11	1 – 7	6	2	105	0

Dwelling Details – R9					
Unit Code	Levels	Quantity	No. Of bedrooms	Conditioned floor area (m^2)	Area of garden and lawn (m^2)
1A	1 – 6	24	1	56	3
2A	1 – 6	36	2	97	0
2B	1 – 6	6	2	90	0
2C	1 – 6	6	2	86	0
2D	7	4	2	116	11
2E	7	1	2	104	57

Central Systems

Summary

Central systems refer to components of the development which service numerous dwellings. The inputs for these systems contribute to the estimated water and energy consumption which determine the BASIX score for the development.

Central Systems Summary			
System	R8	R9	Notes
Swimming pools, Spas, Saunas	0	0	No swimming pools, spas or saunas.
Number of residential lifts	4	4	One lift per lift core.
Central on-site recycled/alternative water supply	Yes	Yes	Connected to the Barangaroo precinct recycled water treatment plant.
Central domestic hot water systems	Yes	Yes	A single gas-fired boiler is assumed for each building.
Central cooling system	Yes	Yes	Connected to the Barangaroo precinct chilled water system.
Central heating system	Yes	Yes	A single gas-fired boiler is assumed for each building.
Fire sprinkler system	Yes	Yes	Test water will be reticulated back to the Precinct Fire Tanks for re-use.

Water

This section outlines the assumptions made for the water consumption and water supplied by the central systems. The drawings indicate that there are no common landscape areas in R8, and a common rooftop area on level 7 of R9. It has been assumed that all planter boxes in the common landscaped areas will be planted with exotic plant species, and that all non-planter box areas will be hard surface. While native or endemic species should be targeted to minimise water consumption, exotic species has been assumed as part of the PA submission to enable maximum flexibility as the design progresses.

Alternative Water Supply

The R8/R9 development will be connected to the Barangaroo precinct blackwater treatment plant for landscape irrigation, toilet flushing, and clothes washing as an alternative water supply. Since the blackwater treatment plant is a precinct wide system, the supply of the system is very likely to meet the demands of the

R8/R9 development. As such, the water supply from the precinct recycled water system has been assumed to meet all of the anticipated demands within the buildings.

Common Area Water Consumption

It has been assumed that the common barbeque areas on the level 7 terrace of R9 are fitted with water efficient kitchen taps as per the table below. The fire sprinkler systems will be tested in a closed system, where the test water will be reticulated through the basement and drained to the precinct fire tanks.

Common Area – Water Consumption			
Water Use	Units	R8	R9
Common Landscape			
Common area lawn	m^2	0	176
Common area garden	m^2	0	73
Area of indigenous or low water use species[1]	m^2	0	0
Other common area water uses			
Kitchen taps	L/min WELS rating	None	4.5 6 star
Car washing bays	no.	0	
Sprinkler test system	-	Closed system	

1) Given landscape design has not been progressed all species have been assumed to be exotic to permit some flexibility in design. Indigenous or low water species should be maximised.

Dwellings Water Consumption

The assumptions listed below have been made for the water fixtures and fittings installed for all dwellings in both the R8 and R9 developments. The Green Building Council of Australia awards appliances that have a WELS rating within one star of the highest rating available. The highest available rating for dishwashers is 5.5 stars. The BASIX tool only provides full star rating options, so the WELS rating for dishwashers has been input as 5 stars. Clothes washers will not be installed in the dwellings; however laundries will be fitted with a connection to the blackwater plant for clothes washers.

As planter boxes will be provided on the balconies of the one bedroom apartments and the penthouse apartments in R8, it is proposed that the laundry basin taps be provided with recycled water from the precinct blackwater treatment plant to give residents the ability to water their plants with non-potable water.

Dwellings – Water Consumption			
Fittings and Fixtures	Water supply	L/min	WELS rating
Showerheads	Potable mains	7.5	4 star (> 6 L/min and ≤7.5 /min)
Toilets	Blackwater plant	3.5	4 star
Kitchen taps	Potable mains	4.5	6 star
Bathroom taps	Potable mains	4.5	6 star
Dishwashers	Potable mains	-	5 star
Landscape Irrigation	Blackwater plant	n/a	n/a

Thermal Comfort

The thermal comfort section of BASIX takes the heating and cooling loads calculated in AccuRate and compares it against the maximum allowable load. The average loads for the development then determines whether the development is awarded a pass or fail, rather than a percentage improvement.

For this BASIX assessment, the assumptions and results are the same as the Preliminary Thermal Performance Assessments for R8 and R9. A summary of the constructions assumptions are summarised in the table below.

Constructions		
Building Element	**Construction**	**Detail / Properties**
Windows	Clear single low e glazing with aluminum frames throughout.	▪ U Value[1] = 4.08 W/m2.K; SHGC = 0.64; VLT = 79% ▪ Windows assumed to be operable to permit natural ventilation. Operable areas of windows are assumed to be equal to 10% of the total area of glazing[2]. Operable areas of doors to balconies have been taken as per the plans are therefore generally 50-67% of the total glazed areas. ▪ Glazing heights are as per elevations.
External Shading	Varies throughout	R8: ▪ Western balconies on levels 1 – 6 are shaded with bi-fold louvred screens. ▪ Western balconies on level 7 are shaded by retractable drop-arm and combination awnings. ▪ Western balconies on level 8 are shaded by deep, fixed horizontal shades. ▪ Northern module balconies are shaded by operable bi-fold vertical metal perforated screens. ▪ East windows have fixed horizontal shades which are vertically stacked. R9: ▪ Western balconies on levels 1 – 6 are shaded by bi-fold operable screens. ▪ Western balconies on level 7 are shaded by drop down venetian blinds. ▪ Northern living/kitchen room windows on levels 1 – 6 are shaded by horizontally sliding metal perforated screens. ▪ Northern living/kitchen room windows on level 7 are shaded by drop down venetian blinds. ▪ Eastern windows have horizontally sliding perforated screens. ▪ Northern glazed pop out boxes have no shading currently proposed.
External walls	Internally insulated insitu concrete panel (200mm)	▪ R 2.0 added internal insulation ▪ Medium colour with solar absorptance of approximately 0.5.
Internal walls – within units	Plasterboard on studs	
Internal walls –	Uninsulated insitu concrete	

Constructions		
Building Element	Construction	Detail / Properties
between units	panel (150mm)	
Floors	Concrete	▪ Tiles in bathrooms, laundries, carpet in bedrooms; timber covering in all other spaces
Ceilings	Plasterboard	▪ Suspended plasterboard ceiling ▪ Floor to ceiling height assume to be 2.7m
Roof	Concrete	▪ R3.0 added internal insulation; ▪ Medium colour with solar absorptance of 0.5.

Based on the heating and cooling loads extracted from the AccuRate preliminary thermal simulation, all the apartments receive a pass mark.

Thermal Comfort Inputs and Results – R8					
Unit Code	Levels	Quantity	Area adjusted heating load (MJ/m².annum)	Area adjusted cooling load (MJ/m².annum)	Pass/fail
1A	1 – 5	5	18	13	Pass
1B	6 – 7	2	23	14	Pass
2	1 – 7	7	6	26	Pass
3	1 – 8	8	5	19	Pass
4	8	1	5	12	Pass
5	9	1	10	22	Pass
6A	1 – 5	10	6	19	Pass
7A	1 – 6	16	9	14	Pass
7B	1 – 5	10	9	14	Pass
8	1 – 6	6	8	18	Pass
9A	6	2	9	13	Pass
9B	6	2	9	13	Pass
10A	7	5	11	23	Pass
10B	7	1	17	32	Pass
11	1 – 7	6	9	26	Pass

Thermal Comfort Inputs and Results – R9					
Unit Code	Levels	Quantity	Area adjusted heating load (MJ/m².annum)	Area adjusted cooling load (MJ/m².annum)	Pass/fail
1A	1 – 6	24	10	20	Pass
2A	1 – 6	36	5	10	Pass
2B	1 – 6	6	13	19	Pass
2C	1 – 6	6	4	20	Pass
2D	7	4	30	19	Pass
2E	7	1	19	29	Pass

Energy

The energy section of BASIX calculates a percentage reduction in expected greenhouse gas emissions compared with an average NSW dwelling. As the R8/R9 development has over 6 storeys above ground, the project must achieve a BASIX energy reduction of at least 20%. It considers the energy demands of the central

systems, as well as the energy demands of the common areas and dwellings from the domestic hot water system, the HVAC system, lifts, lights and appliances.

Central Systems

Central Domestic Hot Water System

It has been assumed that a gas-fired boiler will be installed for each building to meet the domestic hot water and heating hot water demands. The hot water reticulation system will be continuous flow, eliminating the heat losses associated with storage systems. Insulation for both the external and internal hot water pipes has been provided with thermal resistance values as follows:

- Piping external to building: R 1.0 m^2K/W
- Piping internal to building: R 0.75 m^2K/W

Central Heating and Cooling System

The development will be connected to the Barangaroo precinct chilled water system which will use water from the adjacent harbour for heat rejection. The heating hot water will be provided by one gas fired boiler for each building. These systems will provide the heating and cooling via individual fan coil units to each apartment. No heating or cooling, only ventilation, is provided to the common areas of the development.

The following details have been input to the BASIX calculator for the precinct chilled water plant:

- Chiller energy source: Electric driven compressor
- Heat rejection method: Harbour heat rejection
- System COP: High – COP > 4.5

Photovoltaic System

The rated electrical output of the photovoltaic (PV) system has been input as 112 kW total over both buildings. The PV system associated with each building is an essential component of the current Green Star strategy as well as the wider precinct sustainability aspirations.

Lifts

The plans indicate that there are 4 lift shafts in each building, where all lifts are gearless traction lifts with Variable Voltage Variable Frequency Drive (VVVF) motors. Lifts will also service two basement levels in addition to any above ground levels. The number of levels each lift services has been interpreted from the plans and elevations. In the diagram below, the levels serviced by each lift shaft is shaded (where lift number 1 is the northernmost lift, and lift number 8 is the furthest south).

Lifts – Levels Serviced								
	R8				R9			
Lift number	1	2	3	4	5	6	7	8
Level								
10								
9								
8								
7								
6								
5								
4								
3								
2								
1								
G								
B1								
B2								

Other Central Systems

The following details of central systems are additional fields required by BASIX:

Other Central Systems	
Item	Details
Building Management System (BMCS)	To be installed
Active power factor correction (PFC)	Not installed
Common area clothes drying line	Not installed
Common area electric/gas clothes dryer	No common clothes dryer
Common area clothes washer	No common laundry facility

Common Areas

Common Area Ventilation

The majority of common areas in both R8 and R9 will be naturally ventilated through louvres and windows. The only exception to this is the northernmost core of R8 which will be mechanically ventilated. It is assumed that the ventilation of this area will be controlled via the BMCS using motion sensors, or alternatively by time clock, to ensure that mechanical ventilation energy is only consumed when there are zone occupants.

Unit Code	Ventilation System Type	Efficiency Measure
Car park	Ventilation (supply + exhaust)	CO monitors + VSD fan
Lift motor room	Ventilation exhaust only	Continuous
Switch room	Ventilation exhaust only	Continuous
Garbage room	Ventilation exhaust only	Continuous
Comms room	Ventilation exhaust only	Continuous
Water meter room	Ventilation exhaust only	Continuous
Heat exchanger room	Ventilation supply only	continuous
Sewer tank/pump	Ventilation exhaust only	Continuous
Grease trap	Ventilation exhaust only	Continuous
Ground floor common areas	No mechanical ventilation	Time clock or BMS controlled
Corridors (North module R8)	Ventilation (supply + exhaust)	Time clock or BMS controlled
Corridors (All other corridors)	No mechanical ventilation	Time clock or BMS controlled

Common Area Lighting

The BASIX tool requires inputs for the primary lighting type in each zone, where the primary lighting type is defined as the lamp type fitted to 80% or more of the light fittings to be installed. The following fittings have been assumed for the common areas:

Unit Code	Ventilation System Type	Efficiency Measure
Car park	Fluorescent	Time clock and motion sensors
Lift cars	LEDs	Connected to lift call button
Lift motor room	Fluorescent	Motion sensors
Switch room	Fluorescent	Motion sensors
Garbage room	Fluorescent	Motion sensors
Comms room	Fluorescent	Motion sensors
Water meter room	Fluorescent	Motion sensors
Heat exchanger room	Fluorescent	Motion sensors
Sewer tank/pump	Fluorescent	Motion sensors
Grease trap	Fluorescent	Motion sensors
Storage units	Fluorescent	Motion sensors
Ground floor common areas	Compact fluorescent	Time clock and motion sensors
Corridors (North module R8)	Compact fluorescent	Time clock and motion sensors
Corridors (All other corridors)	Compact fluorescent	Time clock and motion sensors

Similar to the common area mechanical ventilation system, it is assumed that a lighting control system or connection to the BMCS via motion sensors or a time clock will be installed as a controls mechanism to ensure that lighting energy is not consumed where there are no occupants. A lighting controls system will also be implemented in the basement BOH areas, by both motion sensors and time clocks. Furthermore, it is assumed that the lighting controls in the lifts are triggered by the lift call button to avoid wasting energy in these spaces.

Dwellings

Heating and Cooling

It has been assumed that all heating and cooling in the dwellings will be serviced by individual fan coil units. These fan coil units will receive chilled water from the precinct harbour-water cooled chilled water plant, and receive heating hot water from the gas fired boiler in the building. While it has been assumed that the air conditioning in the dwellings will not be day-night zoned between the bedrooms and living areas, this should be considered to reduce peak loads and overall energy consumption.

While not assumed in the BASIX analysis, consideration should be given to slab heating in particular for penthouse apartments where optimum comfort of occupants will be expected to be at an exceptional level.

Ventilation

Ventilation within dwellings is provided for bathrooms, kitchens and laundries. Each dwelling has an individual laundry and no common laundry facilities are provided.

Dwelling Ventilation		
Exhaust location	Exhaust system type	Operation Control
Bathroom	Individual motorised damper into central duct + VSD	Manual switch on/off
Kitchen	Individual motorised damper into central duct + VSD	Manual switch on/off
Laundry	Individual motorised damper into central duct + VSD	Manual switch on/off

Motorised dampers are essential to enable the central ventilation fans to be controlled to minimise ventilation energy consumption. The Green Star and operational energy targets for the project will be very difficult to achieve without these.

Lighting

The BASIX tool also takes into account energy consumption from lighting based on the lighting strategy. For each dwelling, the BASIX tool awards the number of bathrooms and kitchens that are naturally lit by either a window or skylight. BASIX awards the rooms which are primarily lit by fluorescent or LED lamps as these are more energy efficient lighting options; and further awards projects where these fittings cannot be replaced by alternatives.

It was assumed that for all rooms the primary lighting type is LEDs, and that these fittings will be specific to LEDs preventing occupants from replacing them with less efficient lamps. Kitchens are all assumed to have a direct line of sight to external windows and there are some bathrooms which have access to natural light.

Appliances

The current Green star strategy requires that all clothes dryers and dishwashers have the highest available energy rating under the Australian Government's 'Energy Rating' labelling scheme. The highest available ratings for dishwashers and clothes dryers are 4 stars and 6 stars respectively. However, the highest option in the BASIX tool for clothes dryers is 4.5 stars. As such, this rating has been input into the BASIX tool, although a 6

star rated clothes dryer will be required. Currently, no refrigerators or clothes washers are being provided to the dwellings.

Dwelling Appliances	
Appliance	Input
Stovetop	Gas
Oven	Gas
Dishwasher	4 star energy rating
Clothes dryer	4.5 star energy rating

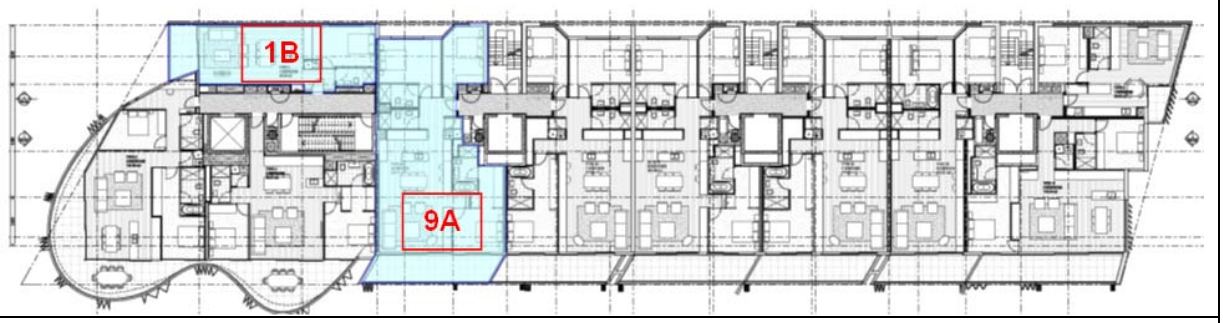
It has also been assumed that each dwelling will have a permanently installed clothes drying line that will be either indoors, or outdoors on a covered balcony where the clothes will be protected from rain.

Appendix A

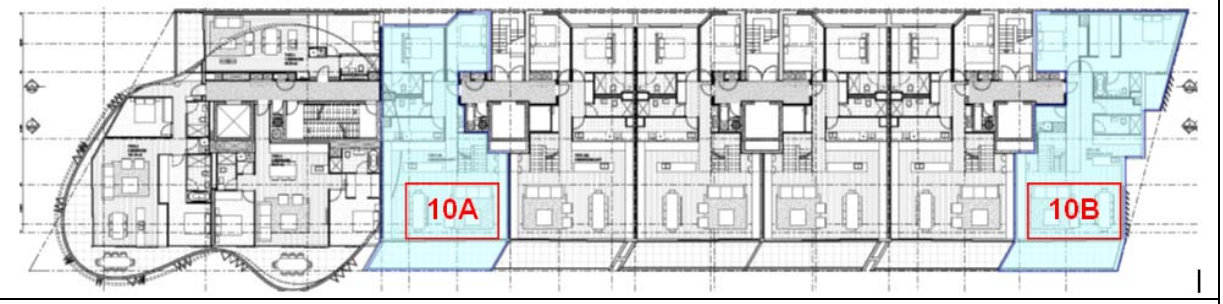
R8

Level 1 – 5

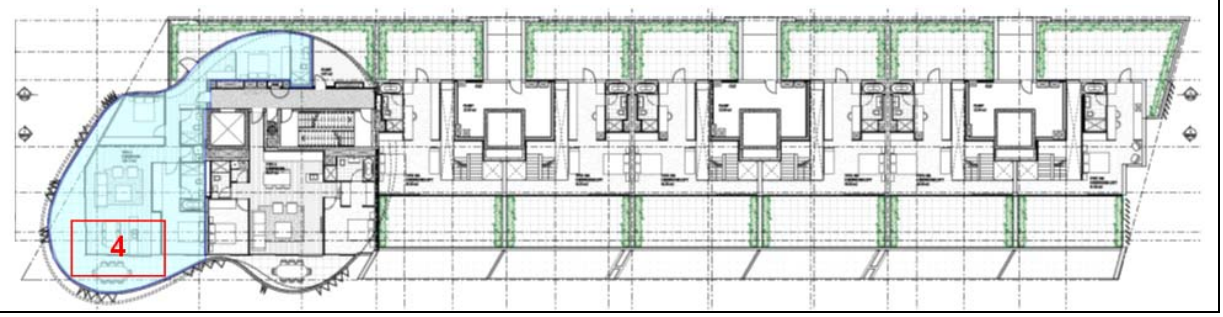
Level 6



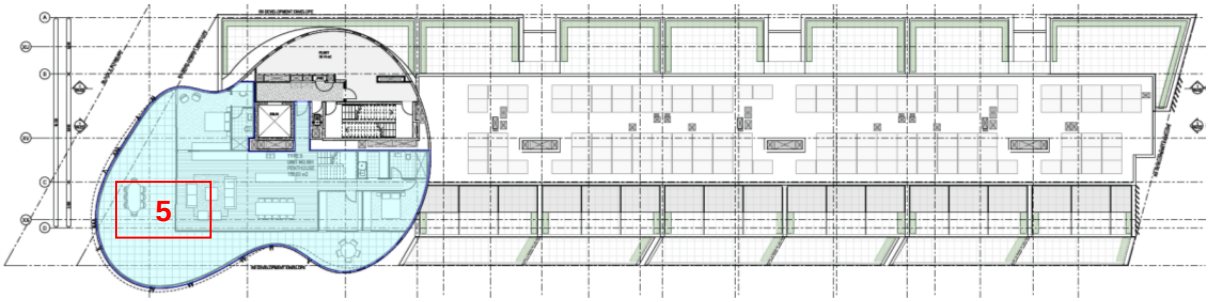
Level 7



Level 8



Level 9



R9

Level 1-6

Level 7

C) R9 Thermal Performance Summary Report

Barangaroo Residential R9
Preliminary Thermal Performance Assessment
October 2012

Introduction

A number of representative units within the residential R9 development at Barangaroo have been assessed to determine the ability of the development to achieve an average 7 star NatHERS rating. This targeted thermal performance is essential to ensure that:

- Green Star commitments for the project can be achieved;
- Operational heating and cooling energy can be minimised;
- A high level of thermal comfort can be provided;
- BASIX minimum thermal performance can be achieved.

The Accurate software package has been used to assess the expected thermal performance of the typical apartments to confirm that the design as currently proposed achieves the above requirements. Accurate is recognised software for evaluating thermal performance or residential dwellings within Australia and is suitable to assess the thermal performance requirements of BASIX and Green Star.

Previous studies have assessed different glazing and insulation values with proposed shading configurations. The studies discussed in this summary assess the design as currently documented for the Project Application and makes recommendations to optimise the design through the next design phase. Recommendations generally relate to the details of external shading which will require careful consideration.

The assumptions and recommendations described in this document require careful review to ensure they are consistent with design intent.

Model Assumptions

The energy simulation was performed using Sydney weather data preloaded in the software package.

Overshadowing from the commercial towers to the east of the development has been included in the model. The commercial towers are expected to be completed prior to completion of R8 and R9.

Four unique apartments on the typical floors (levels 1 – 6) and two unique apartments on the penthouse level (level 7) have been modelled as representative of the entire development. These units and their modelled areas are indicated below.

Figure 1: Modelled apartments - Typical floors (level 1 - 6).

Lend Lease Project Management & Construction (Australia) Pty Limited
ABN 97 000 098 162
30 The Bond, 30 Hickson Rd, Millers Point NSW 2000

Figure 2: Modelled apartments - Penthouse floor (level 7).

Table 1: Modelled areas and quantities of unique apartments simulated.

	1A	2A	2B	2C	2D	2E
Quantity	24	36	6	6	4	1
Area (m^2)	56	97	90	86	116	104

The following table includes base case construction assumptions for the calculations. This table should be reviewed carefully as variances may alter the predicted performance indicated in this report.

Table 2: Construction assumptions

Building Element	Construction	Detail / Properties
Windows	Clear double glazing with aluminum frames throughout.	- U Value[1] = 4.08 W/m2.K; SHGC = 0.64; VLT = 79% - Windows assumed to be operable to permit natural ventilation. Operable areas are assumed to be equal to 10% of the total area of glazing[2]. Operable areas of doors to balconies have been taken as per the plans are therefore generally 50-67% of the total glazed areas - Glazing heights are as per elevations.
External Shading		- Please refer to table 3 where assumed external shading properties are discussed.
External walls (inc walls adjacent to common areas)	Internally insulated insitu concrete panel (200mm)	- R 2.0 added internal insulation - Medium colour with solar absorptance of approximately 0.5.
Internal walls – within units	Plasterboard on studs	
Internal walls – between units	Uninsulated insitu concrete panel (150mm)	
Floors	Concrete	- Tiles in bathrooms, laundries, carpet in bedrooms; timber covering in all other spaces.
Ceilings	Plasterboard	- Suspended plasterboard ceiling - Floor to ceiling height assume to be 2.7m
Roof	Concrete	- R3.0 added internal insulation; - Medium colour with solar absorptance of approximately 0.5.

1) All U-Values stated are total system. i.e. inclusive of glazing and frame. Frame area for the analysis has assumed to be approximately 15% of the window area. A reduced frame will result in a lower U-value and higher SHGC. While the 15% assumption is thought to be conservative, actual window selections will need to be assessed during the next phase of design.

2) The operable area refers to the area of glazing which can be open for natural ventilation. The 10% assumption assumes awning windows. The operable area assumption is low given Lend Lease's GMRs (Global Minimum Requirements) for safety. These requirements may limit the operable areas which can be achieved where balconies are not present and the 10% assumption is intended to address this. If openings were to be reduced further, the potential for natural ventilation would be reduced resulting in a greater cooling demand to maintain thermally comfortable conditions and corresponding reduced Accurate ratings.

The following table provides details of external shading proposed throughout the building. These assumptions are based on PA drawings issued in September 2012 and discussions with PTW architects. These assumptions should be reviewed and confirmed as being consistent with the design intent as variations can have a significant impact on the predicted thermal performance. In addition to the assumptions stated, recommendations are provided regarding each shading type which can be investigated during the next phase of design. The results presented in this report do not consider any of these recommendations.

Table 3: External Shading Assumptions

Orientation	Proportion of Building	Description / Assumptions	Recommendation / Comment
East	All Levels	Perforated screens which can be moved horizontally. It is assumed that they can shade the extent of windows and that the screens are approximately 35% open as a result of the perforations when closed.	Given the extensive overshading provided by the 3 commercial towers to the east, the detail of these shades will only have a minimal effect on the thermal performance of units.
West	Levels 1 to 6	Bi-fold operable screens which can completely shade balconies. Screens are perforated and assumed to be approximately 30% open as a result of the perforations.	The size and frequency of perforations may need careful consideration given the potential for glare from direct solar penetration.
West	Level 7	Drop down venetian blinds are proposed. It is assumed that venetian blinds can be tilted to nearly block all low altitude western solar radiation. Only 20% of solar radiation is assumed to transmit through the blinds when closed.	In combination with the solid deep overhang, the proposed blinds will provide good solar control.
North	Levels 1 to 6	Perforated screens which can be moved horizontally to completely expose the windows if desired. It is assumed that they can shade about half of the extent of living room windows and that the screens are approximately 35% open as a result of the perforations when closed	The proposed blinds will provide good solar control.
North	Level 7	Drop down venetian blinds are proposed. It	The proposed blinds will provide

Orientation	Proportion of Building	Description / Assumptions	Recommendation / Comment
		is assumed that venetian blinds can be tilted to nearly block all low altitude western solar radiation. Only 20% of solar radiation is assumed to transmit through the blinds when closed.	good solar control.
North	Popout Boxes on All Levels	No shading currently proposed	Consideration should be given to operable external shading to minimise summer solar gain, enable winter gain and eliminate glare when necessary.

Results

The table below details the area-adjusted heating and cooling loads and corresponding star ratings as calculated using Accurate for each unique apartment type. From these results, an area weighted average star rating was calculated as follows.

Table 4: Results summary

	1A	2A	2B	2C	2D	2E
Heating	10	5	13	4	30	19
Cooling (sens.)	12	5	11	14	11	21
Cooling (lat.)	8	5	7	7	8	8
Stars	6.9	8.7	6.9	7.8	5	5.2

The area-weighted average of the apartments modelled is 7.7 stars and therefore achieves the minimum requirements for the project given the assumptions made.

Discussion

The proposed architectural response to the thermal performance of units appears to be generally appropriate given the site limitations and aspirations for the development. While a predominant east and west orientated building normally results in significant heating and cooling loads, the proposed design which incorporates large balcony overhangs, operable external shading and appropriate levels of glazing will assist in the maintenance of thermal comfort without excessive energy consumption. Operable shading is ideal for west and eastern orientations as occupants can retract shading in cooler months to enable any limited solar gain and maximise daylight. In the warmer months, shading can be when there is direct solar gain to minimise heat load and can also be retracted in diffuse sky conditions and at times where there is no direct solar load to maximise daylight for longer periods. While the details of proposed shading may not be optimum in all areas, recommendations are provided in Table 3 which can be investigated in the next phase of design.

The current proposed design achieves an area-weighted average rating of 7.7 stars. As the majority of apartments are represented by 1A and 2A, changes that affect the ratings of theses apartments are expected to have the largest impact on the area-weighted average rating of the development.

Apartments 1A and 2A on the typical floors have few external walls and 2A in particular has a low glazing to conditioned floor area ratio (< 24%). Furthermore, all glazed areas are shaded by deep balcony overhangs of the level above and/or operable shading devices as currently proposed. The majority of internal walls are shared with conditioned spaces.

The northernmost apartment 2C and the southernmost apartment 2B on the typical floors have larger areas of glazing and external walls than the apartments discussed above. These exposed surfaces facilitate a higher rate of heat transfer, resulting in greater annual energy demands for both heating and cooling. The north apartment, 2C, has a slightly higher rating as some lower low altitude sun may penetrate into the unit during cooler months reducing the heating load while cooling load can be reduced by the proposed operable shading and balcony overhangs.

Similarly, the representative internal penthouse apartment (2D) has a higher rating than the apartment with external walls exposed to the north (2E). The southern penthouse apartment rating will be slightly lower than 2D as there is more exposed external wall area associated with this unit.

Recommendations

The following recommendations are made with respect to the building envelope:

External Shading

- Apartments are generally well shaded, however the detail of proposed shading can be optimised in the next phase of design. Table 3 can be referred to for recommendations and comments regarding each different shading type. In particular the size and extent of perforations in proposed screens needs careful consideration to ensure that solar load is minimised to a suitable level and that there are no glare and/or comfort issues for occupants.
- Advice from the mechanical consultant suggests that peak cooling loads must be calculated by assuming that operable external shading remains open. Glazing requirements should be reviewed by mechanical to ensure that peak cooling load requirements can be achieved and are within any limits of the district cooling plant. The opportunity to calculate peak loads with shading closed should be investigated as this would significantly lower the peak loads, reducing mechanical capacity required. This opportunity should be discussed with the mechanical designer and the client. It should be noted that thermal comfort will not be able to be maintained if occupants do not close shades in summer afternoons despite the temperature which is maintained within the living area as discomfort will be caused by the direct solar radiation.

Glazing and Window Types

- While not presented in this summary, various glazing options have been presented in previous summaries. Given the extent of shading and operability proposed, glazing can remain clear to maximise natural lighting. While a single glazed low-e and a clear double glazing will result in a similar performance, a double glazing is recommended to ensure there are no localised comfort issues at areas close to the glass and that the risk of condensation is minimised.
- A high performance low-e double glazing would provide some operational energy benefits. If this option is desired, glazing should be selected with a visual light transmittance as high as possible to ensure amenity within the space is maintained.
- When selecting window types, operable areas are to be considered. Larger operable areas result in greater natural ventilation which will help to reduce cooling loads. For openings which do not open onto balconies, Lend Lease GMRs (Global Minimum Requirements) may restrict the operable areas to minimise operational safety risks. Low operable areas have therefore been assumed for these openings to allow these requirements to be achieved. The Lend Lease GMRs and potential ventilation impacts are therefore needed to be reviewed in the next phase of design.

Insulation

- As penthouse units are exposed to additional heat gains and losses through the roof, insulation beyond R3.0 could be investigated. Soil from roof top planting may assist in improving the insulation of the roof which has not been considered in this analysis. Alternatively a higher performance glass could be considered for penthouse units if it is desired to improve their performance.
- While not presented in this summary, the sensitivity of performance to external wall insulation values has been assessed and an added wall insulation of R2.0 is recommended (this includes walls adjacent to common areas). If spatial impacts are a concern this could be reduced without a significant impact on thermal performance, however this would have to be investigated.

D) R8 Thermal Performance Summary Report

Barangaroo Residential R8
Preliminary Thermal Performance Assessment
October 2012

Introduction

A number of representative units within the residential R8 development at Barangaroo have been assessed to determine the ability of the development to achieve an average 7 star NatHERS rating. This targeted thermal performance is essential to ensure that:

- Green Star commitments for the project can be achieved;
- Operational heating and cooling energy can be minimised;
- A high level of thermal comfort can be provided;
- BASIX minimum thermal performance can be achieved.

The Accurate software package has been used to assess the expected thermal performance of the typical apartments to confirm that the design as currently proposed achieves the above requirements. Accurate is recognised software for evaluating thermal performance or residential dwellings within Australia and is suitable to assess the thermal performance requirements of BASIX and Green Star.

Previous studies have assessed different glazing and insulation values with proposed shading configurations. The studies discussed in this summary assess the design as currently documented for the Project Application and makes recommendations to optimise the design through the next design phase. Recommendations generally relate to the details of external shading which will require careful consideration.

The assumptions and recommendations described in this document require careful review to ensure they are consistent with design intent.

Model Assumptions

The energy simulation was performed using Sydney weather data preloaded in the software package.

Overshadowing from the commercial towers to the east of the development has been included in the model. The commercial towers are expected to be completed prior to completion of R8 and R9.

The R8 development has a northern module with a curved facade and southern modules within a rectangular structure. The following describes the apartments which have been modelled:

- Three apartments associated with the northern module on level 1-7 (apartment types 1A, 1B, 2);
- An apartment associated with the northern module on level 1-8 (apartment type 3);
- The apartment associated with the northern module unique to level 8 (apartment type 4);
- The multi storey penthouse apartment associated with the northern module on level 9-10 (apartment type 5); Four apartments associated with the southern module on level 1-6 (apartment types 6A, 7A, 8, 11);
- Two multi storey loft apartments associated with the southern module (apartment types 10A, 10B);

These modelled units and their modelled areas are indicated below.

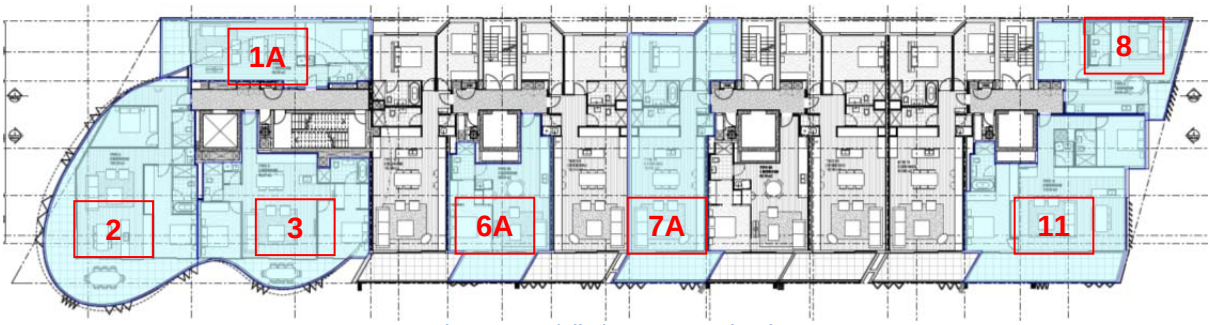


Figure 1: Modelled apartments; level 1-5

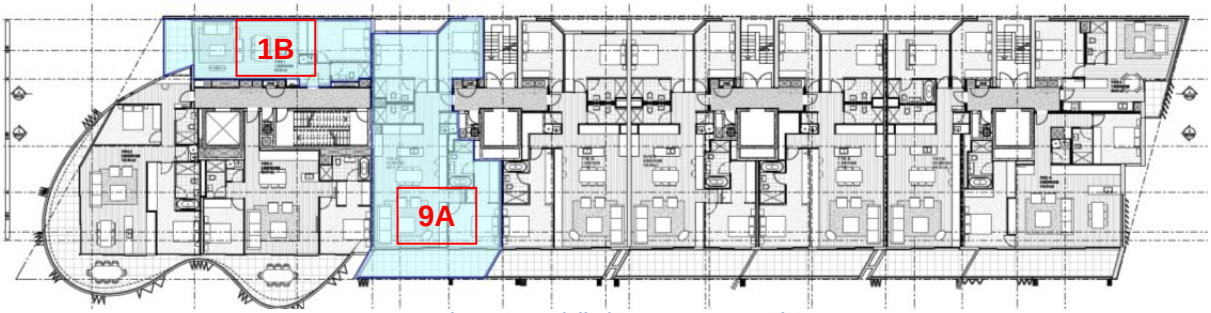


Figure 2: Modelled apartments; Level 6

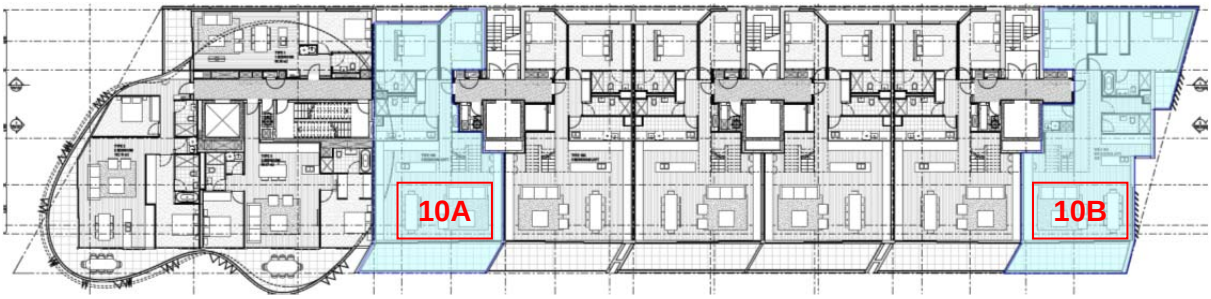


Figure 3: Modelled apartments; Level 7

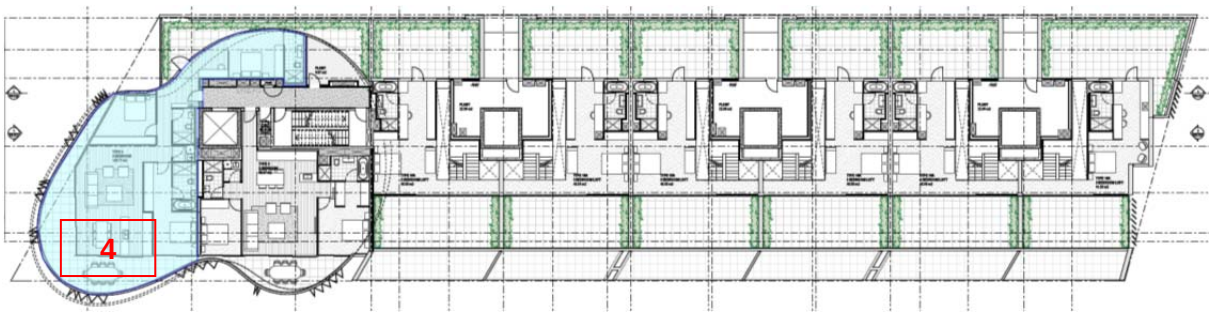


Figure 4: Modelled apartments; Level 8

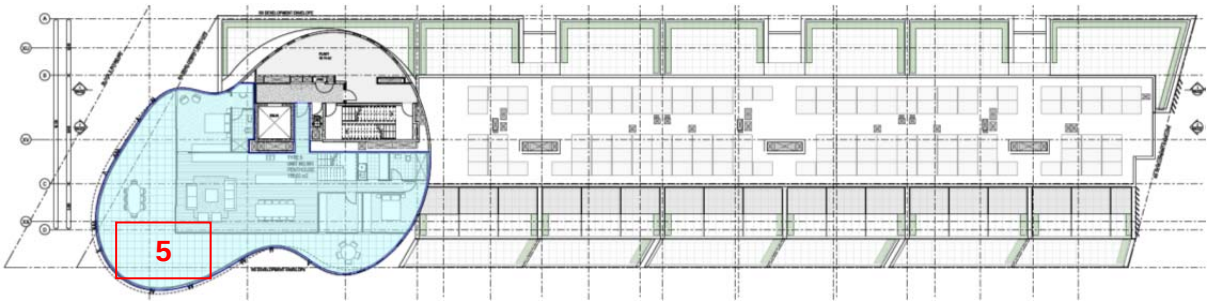


Figure 5: Modelled apartments; Level 9

Table 1: Modelled areas and quantities of unique apartments simulated.

LEVEL	1A	1B	2	3	4	5	6A	7A/7B	8	9A/9B	10A	10B	11
1 to 5	5		5	5			10	25	5				5
6		1	1	1				1	1	4			1
7		1	1	1							5	1	
8				1	1								
9						1							
Total	5	2	7	8	1	1	10	26	6	4	5	1	6
Area (m^2)	59	59	102	96	121	363	57	98	59	126	167	154	105

The following table includes base case construction assumptions for the calculations. This table should be reviewed carefully as variances may alter the predicted performance indicated in this report.

Table 2: Construction assumptions

Building Element	Construction	Detail / Properties
Windows	Clear double glazing with aluminum frames throughout.	- U Value[1] = 4.08 W/m2.K; SHGC = 0.64; VLT = 79% - Windows assumed to be operable to permit natural ventilation. Operable areas of windows are assumed to be equal to 10% of the total area of glazing[2]. Operable areas of doors to balconies have been taken as per the plans are therefore generally 50-67% of the total glazed areas. - Glazing heights are as per elevations.
External Shading		- Please refer to table 3 where assumed external shading properties are discussed.
External walls (inc walls adjacent to common areas)	Internally insulated concrete panel (200mm)	- R 2.0 added internal insulation - Medium colour with solar absorptance of approximately 0.5.
Internal walls – within units	Plasterboard on studs	
Internal walls – between units	Uninsulated concrete panel	

Building Element	Construction	Detail / Properties
	(150mm)	
Floors	Concrete	- Tiles in bathrooms, laundries, carpet in bedrooms; timber covering in all other spaces.
Ceilings	Plasterboard	- Suspended plasterboard ceiling - Floor to ceiling height assumed to be 2.7m
Roof	Concrete	- R3.0 added internal insulation; - Medium colour with solar absorptance of approximately 0.5.

1) All U-Values stated are total system. i.e. inclusive of glazing and frame. Frame area for the analysis has assumed to be approximately 15% of the window area. A reduced frame will result in a lower U-value and higher SHGC. While the 15% assumption is thought to be conservative, actual window selections will need to be assessed during the next phase of design.

2) The operable area refers to the area of glazing which can be open for natural ventilation. The 10% assumption assumes awning windows. The operable area assumption is low given Lend Lease's GMRs (Global Minimum Requirements) for safety. These requirements may limit the operable areas which can be achieved where balconies are not present and the 10% assumption is intended to address this. If openings were to be reduced further, the potential for natural ventilation would be reduced resulting in a greater cooling demand to maintain thermally comfortable conditions and corresponding reduced Accurate ratings.

The following table provides details of external shading proposed throughout the building. These assumptions are based on PA drawings issued in September 2012 and discussions with FJMT architects. These assumptions should be reviewed and confirmed as being consistent with the design intent as variations can have a significant impact on the predicted thermal performance. In addition to the assumptions stated, recommendations are provided regarding each shading type which can be investigated during the next phase of design. The results presented in this report do not consider any of these recommendations.

Table 3: External Shading Assumptions

Orientation	Proportion of Building	Description / Assumptions	Recommendation / Comment
West	Levels 1 to 6	Balconies are shaded by retractable louvre blades which can extend the length of the balcony. Louvre blades are spaced to maintain views when shading is closed. The approximate solar transmission of closed shades when the shades are likely to be required is estimated to be approximately 40% given the details currently provided.	To be completely effective, ideally louvre blades should be able to pivot to block all solar radiation. Louvres as currently detailed will allow significant solar penetration during late afternoon periods when the sun is at a low altitude and may cause comfort and glare issues for occupants. If louvres can not be operable, investigations into the depth and spacing of louvre blades will need to be undertaken during the next design phase. Alternatively bi-fold screens could be provided as per the northern module.
West	Level 7 and 8 Loft apartments	Level 7 is shaded by an adjustable drop-arm and combination awning. Informtation provided by FJMT suggest that the shade will be made of a semi-transparent canvas. It has been	Level 7 shading is to be reviewed during the next design phase to ensure a maximum amount of glazing can be shaded and that proposed material provides significant shade.

Orientation	Proportion of Building	Description / Assumptions	Recommendation / Comment
		assumed that the shade is capable of shading 50% of the vertical height of the associated glazing and that the proposed canvas is only 20% transmissive to solar radiation. Level 8 is shaded by very deep horizontal overhang shades. These shades have been assumed to be 100% opaque.	
North and West	Northern Module - All levels	Operable bi-fold perforated vertical screens are provided which can extend the entire length of balconies to provide complete shading. The extent of perforations is assumed to be minimised so that only 20% of the screen is open.	The size and frequency of perforations may need careful consideration given the potential for glare from direct solar penetration.
East	Levels 1 to 7	Fixed horizontal shades which are vertically stacked to cover glazing are provided to levels 1 to 7. Proposed details suggest shades will allow approximately 50% of solar to be transmitted at peak times.	Given the extensive overshading provided by the 3 commercial towers to the east, the detail of these shades will only have a minimal effect on the thermal performance of units.

Results

The table below details the area-adjusted heating and cooling loads and corresponding star ratings as calculated using Accurate for each unique apartment type. From these results, an area weighted average star rating was calculated as follows.

Table 4: Results summary; Heating and cooling loads given in MJ/m^2.annum.

	1A	1B	2	3	4	5	6A	7A/7B	8	9A/9B	10A	10B	11
Heating	18	23	6	5	5	10	6	9	9	9	11	17	9
Cooling (sens.)	8	9	19	12	8	15	11	8	12	8	16	23	18
Cooling (lat.)	5	5	6	7	5	7	8	6	6	5	7	9	8
Stars	6.9	6.3	6.8	7.8	8.4	6.8	7.6	7.8	7.4	8	6.6	5.2	6.6

The area-weighted average of the apartments modelled is 7.3 stars and therefore achieves the minimum requirements for the project given the assumptions made.

Discussion

The proposed architectural response to the thermal performance of units generally appears to be appropriate given the site limitations and aspirations for the development. While a predominant east and west orientated building normally results in significant heating and cooling loads, the proposed design which incorporates large balcony overhangs, operable external shading and appropriate levels of glazing will assist in the maintenance of thermal comfort without excessive energy consumption. Operable shading is ideal for west and eastern orientations as occupants can retract shading in cooler months to enable any limited solar gain and maximise daylight. In the warmer months, shading can be when there is direct solar gain to minimise heat load and can also be retracted in diffuse sky conditions and at times where there is no direct solar load to maximise daylight for longer periods. While the details of proposed shading may not be optimum in all areas, recommendations are provided in Table 3 which can be investigated in the next phase of design.

The current proposed design achieves an area-weighted average rating of 7.3 stars. As the majority of apartments are represented by the apartments 6A and 7A, changes that affect the ratings of these apartments are expected to have the largest impact on the area-weighted average rating of the development.

Apartments 6A and 7A on the typical floors have few external walls and low glazing to conditioned floor ratios. Furthermore, all glazed areas are shaded by deep balcony overhangs of the level above and/or operable shading devices as currently proposed. The majority of internal walls are shared with conditioned spaces. The southernmost apartments on the typical floors, apartments 8 and 11 have higher glazing to conditioned floor ratios than 6A and 7A and are fully exposed to ambient conditions at the south external walls allowing more heat loss to occur than for the internal apartments, resulting in a lower star rating.

The typical apartments in the northern module have larger glazing to conditioned floor ratios than the apartments discussed above. These exposed surfaces facilitate a higher rate of heat transfer, resulting in greater annual energy demands for both heating and cooling. The north apartment, 2, has a higher cooling load and lower heating load than the other apartments within the northern module. There is significant north oriented glazing allowing some lower low altitude sun to penetrate into the unit during cooler months reducing the heating load while the cooling load is reduced by the balcony overhang and the proposed operable shading

The south double storey loft apartments (9A and 9B) are the most exposed apartments. As these apartments are on the top floor, heat transfer can occur through the ceilings, as well as through the external walls. While there is no shading to the east facade of the top level in the penthouse apartments, there is minimal glazing and therefore this is not a significant impact and the commercial towers to the east will provide shading for the majority of the year. The south apartment (10B) is more exposed than the internal apartment (10A) therefore a poorer star rating.

The penthouse apartment on level 9 and 10 of the northern module is the apartment most exposed to ambient conditions. Similar to the loft apartments, significant heat transfer can occur through the roof areas and the external walls which face all four orientations. Furthermore, the apartment has a high glazing to floor area ratio, with the highest concentration of glazing on the north and west elevations. However, the glazed areas are well shaded by metal perforated operable external shading devices. The roof features a large void over the level 9 balcony, which allows more solar access to the space causing slightly higher cooling loads, offset by slightly lower heating loads.

Recommendations

The following recommendations are made with respect to the building envelope:

External shading

- Apartments are generally well shaded, however the detail of proposed shading can be optimised in the next phase of design. Table 3 can be referred to for recommendations and comments regarding each different shading type. In particular the following aspects of the proposed shading are to be investigated to ensure that solar load is minimised to a suitable level and that there are no glare and/or comfort issues for occupants:
  - Size and extent of perforations in proposed screens of the northern module;
  - Depth and spacing of louvre blades proposed for western shades;
  - Level 7 drop down canvas awnings.
- Advice from the mechanical consultant suggests that peak cooling loads must be calculated by assuming that operable external shading remains open. Glazing requirements should be reviewed by mechanical to ensure that peak cooling load requirements can be achieved and are within any limits of the district cooling plant. The opportunity to calculate peak loads with shading closed should be investigated as this would significantly lower the peak loads, reducing mechanical capacity required. This opportunity should be discussed with the mechanical designer and the client. It should be noted that thermal comfort will not be able to be maintained if occupants do not close shades in summer afternoons despite the temperature which is maintained within the living area as discomfort will be caused by the direct solar radiation.
- While all assumptions included within this summary are to be reviewed, it is particularly important to review the external shading assumptions given the large impact they can have on the predicted performance.

Glazing and Window Types

- While not presented in this summary, various glazing options have been presented in previous summaries. Given the extent of shading and operability proposed, glazing can remain clear to maximise natural lighting. While a single glazed low-e and a clear double glazing will result in a similar performance, a double glazing is recommended to ensure there are no localised comfort issues at areas close to the glass and that the risk of condensation is minimised.
- A high performance low-e double glazing would provide some operational energy benefits. If this option is desired, glazing should be selected with a visual light transmittance as high as possible to ensure amenity within the space is maintained.
- When selecting window types, operable areas are to be considered. Larger operable areas result in greater natural ventilation which will help to reduce cooling loads. For openings which do not open onto balconies, Lend Lease GMRs (Global Minimum Requirements) may restrict the operable areas to minimise operational safety risks. Low operable areas have therefore been assumed for these openings to allow these requirements to be achieved. The Lend Lease GMRs and potential ventilation impacts are therefore needed to be reviewed in the next phase of design.

Insulation

- As penthouse units are exposed to additional heat gains and losses through the roof, insulation beyond R3.0 could be investigated. Alternatively a higher performance glass could be considered for penthouse units if it is desired to improve their performance.

- While not presented in this summary, the sensitivity of performance to external wall insulation values has been assessed and an added wall insulation of R2.0 is recommended (this includes walls adjacent to common areas). If spatial impacts are a concern this could be reduced without a significant impact on thermal performance, however this would have to be reviewed.