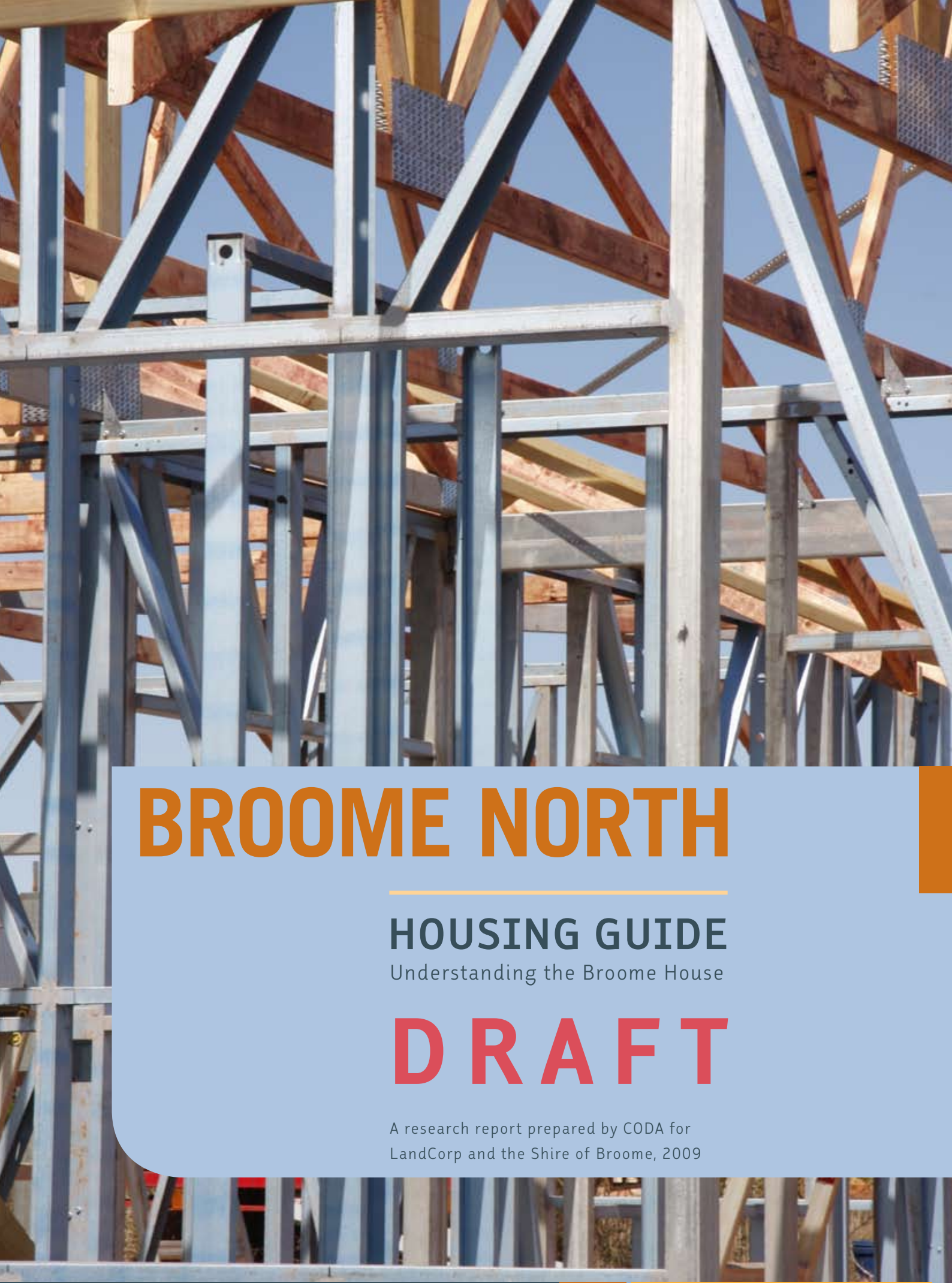

BROOME NORTH

HOUSING GUIDE

Understanding the Broome House

DRAFT

A research report prepared by CODA for
LandCorp and the Shire of Broome, 2009

CODA
www.coda-studio.com

LANDCORP

CONTENTS

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INTRODUCTION

IN JANUARY 2009 LANDCORP ENGAGED CODA TO DEVELOP A DESIGN STRATEGY FOR THE DELIVERY OF AFFORDABLE, SUSTAINABLE, CLIMATICALLY AND CULTURALLY SUITABLE HOUSING FOR THE BROOME NORTH DEVELOPMENT. CODA'S ROLE WAS TO UNDERSTAND THE LOCAL HOUSING MARKET, IT'S CONDITIONS AND CONSTRAINTS, AND PROPOSE DESIGN GUIDELINES AND URBAN DESIGN STRATEGIES TO ENABLE THE PROVISION OF SUITABLE HOUSING AS IDENTIFIED IN THE SHIRE OF BROOME, LOCAL HOUSING STRATEGY 2009 DOCUMENT.

This document sets out a Housing Design style as part of the vision for the new development of Broome North and in response to the Local Housing Strategy for Broome. The Strategy outlines three key issues that relate directly to house design:

Housing Affordability
High Land and Building Costs
Housing Mix

Other items listed as matters to be addressed include:

Public Housing
Heritage
The Broome Climate
State Government planning policies and the R-Codes

Our housing guide responds to each of these issues and in doing so develops strategies and approaches towards an urban design and a housing typology that can be implemented in the Development Plan for Broome North. This typology is based on the existing Broome character but brings both innovation and practicality to the mix, based on the latest developments in the theories of tropical urban design adapted to the particular nature of the Broome environment.

We begin with an understanding the site, the history, the culture and the natural environment in and around the Broome peninsula at both macro and micro scales. Numerous meetings were held in Broome with consultants, builders, planning departments, the Yawuru people and other local interested parties to provide invaluable contextual information. In addition historical and modern day printed material were sourced that add a depth of understanding of the local issues both from a human point of view as well as the physical qualities of the area. Our approach has been to try to learn from the past such that we can make appropriate and informed decisions regarding the future development and innovation of Broome North.

From an understanding of the history of Broome, the guide looks to establish the key urban design principles in order to set out a viable and sustainable development. Research shows that when evaluating potential for natural ventilation in both lot subdivision and house design the need for climatic data measured locally is essential. Many factors influence the readings such as the topography, landscape and any local obstructions. To this end six local weather stations were installed in and around the Broome peninsula in order to gather local climate information. This data will be used to inform the setting out of the subdivision taking into account the importance of all of the critical factors such as sun, wind, lot densities, landscape, drainage and economy. With all of these elements we can provide streetscapes and building designs that are responsive to the environment, climate, local character and community.

In the final sections we explore the detail of different housing typologies and focus on the house design principles. This section deals with a detail response to climate and capturing breezes within the individual house and lot as well as looking at the types of materials suitable to achieve the maximum building performance. The information is routed in affordability and investigations were made into the techniques , capacities and building costs of the existing house builders in Broome as well as exploring opportunities for introducing new sustainable technologies. In addition discussions with Department of Housing, Foundation Housing and GROH informed the diversity and adaptability of the housing types and mix in order to be able to respond to the needs of Broome now as well as in the future.

BACKGROUND AND HISTORY

KEY OBJECTIVE

To investigate the history and urban form of Broome and to establish the principles of the existing architecture both in terms of the urban design as well as the building form within the context of the existing community and local culture

BROOME'S HISTORY

ESTABLISHED IN THE LATE 19TH CENTURY ON THE TRADITIONAL LANDS OF THE JUNGUN AND YAWURU ABORIGINAL PEOPLE, BROOME IS A SMALL COASTAL TOWN WITH A VIBRANT HISTORY. IT IS THIS HISTORY, PRIMARILY AS A PEARLING TOWN INHABITED BY KOEPANGER, MALAY, CHINESE, JAPANESE, EUROPEAN AND ABORIGINAL PEOPLE, THAT HAS CREATED THE MULTICULTURAL TOWN THAT EXISTING TODAY.

Indigenous Australians

Indigenous Australians have lived and prospered in the Broome and Roebuck Bay area for 40,000 years. A new chapter of aboriginal history in Broome was opened with the arrival of William Dampier, the first European visitor, in 1688. His reports of the regions pearl beds, and the subsequent arrival of enthusiastic European settlers, was to be the beginning of a fractious relationship that "would forever change the lives of the regions aboriginal inhabitants". As the Broome Visitors centre notes, "The constant and fundamental cultural clashes between the two people eventually led to the exploitation of the regions original inhabitants, especially in the early days of the pearling industry when Aborigines were forced to become skin divers for pearl shell and work aboard the pearl luggers."

In 2006 the Yawuru people were awarded Native Title over an area in excess of 5000sq km around the Broome area.

"The Yawuru people are closely connected to country. This is perhaps best illustrated by their seasonal calendar. They recognize six climactic seasons throughout the year. The seasons are broken down according to prevailing winds, ecological cycles (such as when certain fruits are prevalent or when the dugong and kangaroo are fat) and temperature. The Yawuru people would undertake different practices relative to the season's riches." From http://www.broomecam.com/history.html.

European Discovery

Whilst briefly envisioned as a cattle-grazing area, Broome's modern history can be traced to the discovery of the pearl oyster Pinctada Maxima, the largest pearl shell in the world, in 1861. By the late 1870's there was a thriving harvest industry in the region that led to the proclamation of the township of Broome, named after the colony's Governor Frederick N. Broome, in 1883.

Pearling days

Using aboriginal, Chinese and Japanese divers, often working in horrendous conditions, the pearl industry in Broome quickly became the largest in the world. The pearl shells, not the pearls themselves, were valued for their wide use in such things as buttons and cutlery handles. As such, "By 1910, 400 pearl luggers worked the waters around Broome" (http://www.broomecam.com/history.html, 7/7/09) and the town had grown to around 4000 people from all over the world.

Notwithstanding the fortunes made in the pearling heydays by some entrepreneurs, the history of pearling in the area is one marked by danger and death. Hundreds of headstones in Broome cemetery attest to the dangers of drowning, the 'bends' and sharks that divers bravely endured in the search for pearls.

Concurrent to the pearling industry's growth was the laying of the communication cable that gave Cable beach its name and connected Australia to the rest of the world.

The War Years

The first and second world wars dramatically altered the township. World War One and the following economic depression devastated the pearling economy, whilst the development of cheap plastics simultaneously ended the market for pearl shells. The Second World War, in which Broome found itself briefly on the frontline, brought yet more disruption to the industry as Japanese people, the primary work force, were interned or deported and the lugger fleet was used to evacuate residents to Perth.

Post-1950's Broome

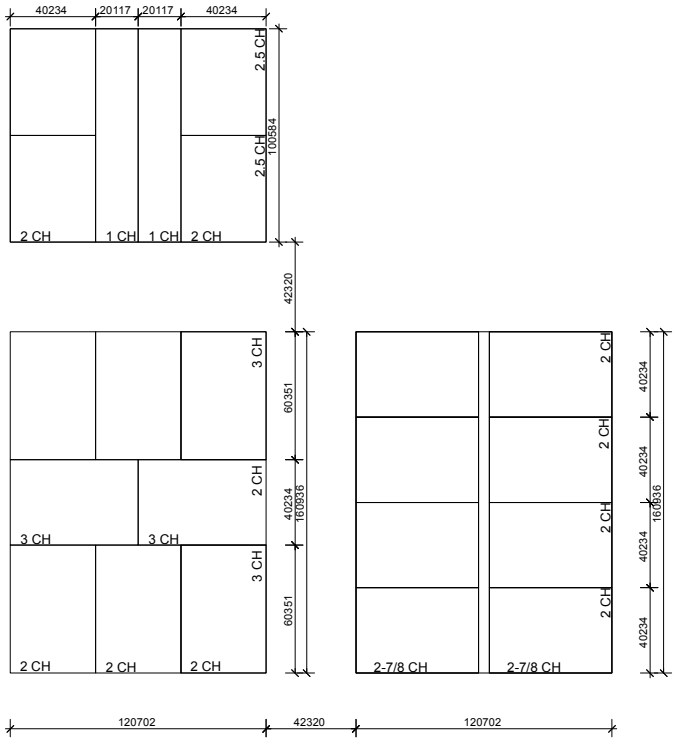
If the world wars almost destroyed the town, both figuratively and literally, the subsequent years have seen Broome return to health through the twin industries of tourism and the farmed pearl.

THE BROOME GRID

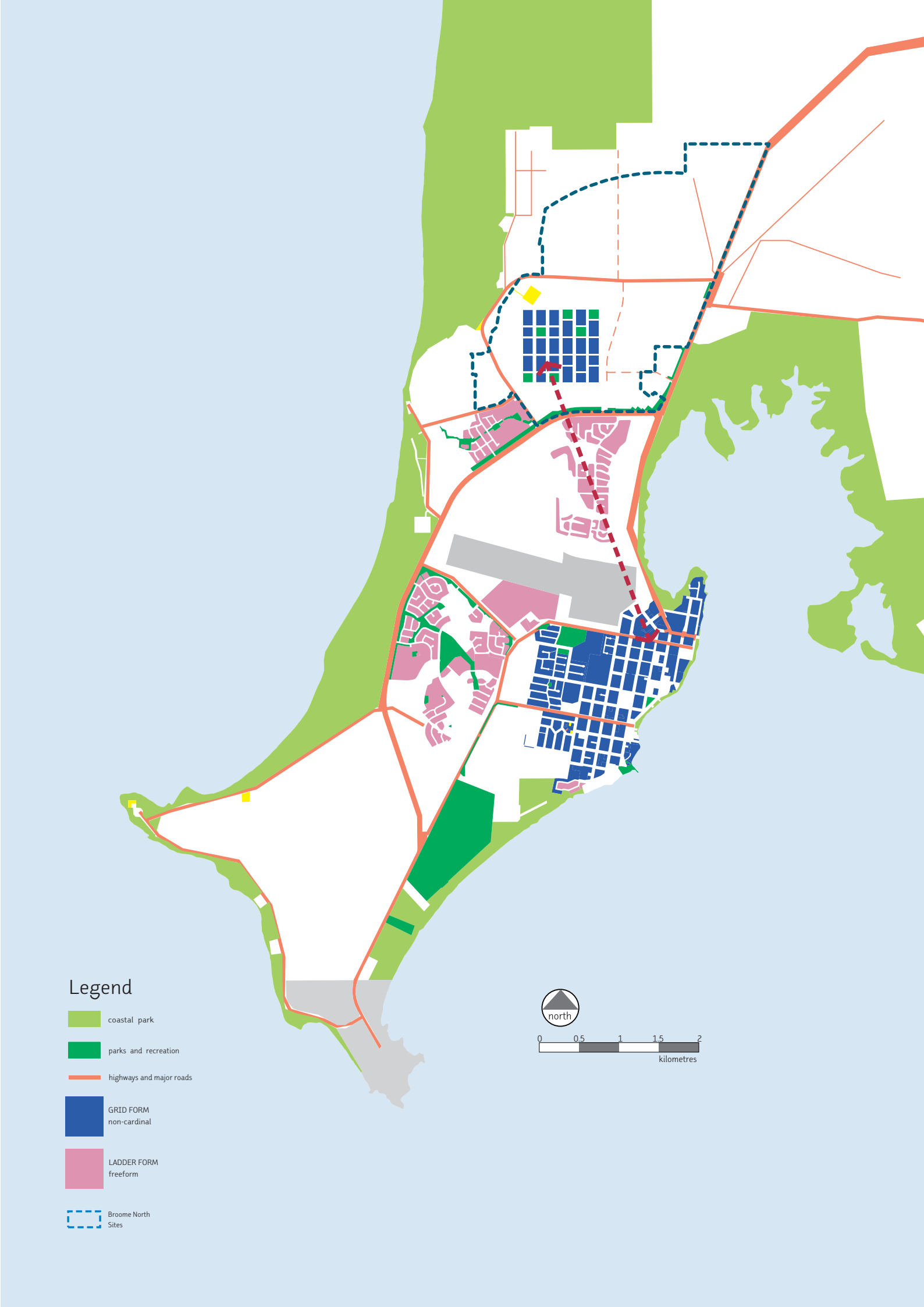
BROOME NORTH'S HOUSING WILL REFLECT AND ADAPT TO IT'S CULTURAL AND SOCIAL DIVERSITY. NEW HOUSING, WHETHER SINGLE RESIDENTIAL OR MULTI-RESIDENTIAL, MUST BE ADAPTABLE TO THE DIFFERENT PEOPLE AND FAMILIES THAT LIVE IN BROOME.

As part of the research for the Housing Guide we have looked into the history of the town of Broome from its early beginnings at the end of the 19th Century on the lands of the Jungun and Yawaru aboriginal people through to the present day. We have looked in detail at the town planning development and the urban form of the town centre as well as the characteristics of the lot distribution and development densities. In collaboration with the Shire and through other reports, we have looked in particular at Broome from an early 1920's lot diagram as well as aerial photography since 1949. These provide traces of the mode of development across the Broome Peninsula, the various urban design strategies that have been developed over the decades since WWII, and offer a clue to what the future development of the town should look like.

The character of the Broome grid offers a clearly legible, permeable and easily defined quality that many locals and tourists regards as the defining characteristic of the town. We wanted to know what qualities could be replicated, understood and modified to suit a very different requirement for drainage, streetscape and most importantly for the project, affordability and sustainability.



Old Broome Town Grid
CH = chain
1 chain = 20.1168m approx.


Legend
coastal park
parks and recreation
highways and major roads
GRID FORM
non-cardinal
LADDER FORM
freeform
Broome North
Sites
north
0
0.5
1
1.5
2
kilometres

BROOME GROWTH

As a starting point for our investigations we researched the changing demographics and urban growth of the town from it's earliest recorded statistics. There were various subdivision stages over Broome's history which where each unique in their form. Broome's urban form had its beginning in a grid, the grid has site-lines and inter connectedness naturally in built. The road layout also allows for breezepaths through the town. Some of the larger lots where gradually subdivided and a diverse mix of lot sizes now exist in the Old Broome area. A contrast to this original grid form are the new developments in Cable Beach which where an organic form with a cul-de-sac type arrangement. Site-lines and breezepaths are lost in such subdivisions and they seem to be a departure from the old Broome style. (Refer to Appendix C for full size aerials)

1910 POPULATION DISTRIBUTION

257 Europeans

2038 Indentured Asians

183 mixed-race residents

(Aboriginal residents were not included in population count)

2478 TOTAL non-indigenous population

1979 DWELLING STATISTICS	**NUMBER**	**PERCENTAGE**
Private Occupied Dwellings	576	90.0
Private Unoccupied Dwellings	38	5.9
Non-private Dwellings	26	4.1
TOTAL DWELLINGS	**640**	**100**

1991 POPULATION + NO. OF DWELLINGS

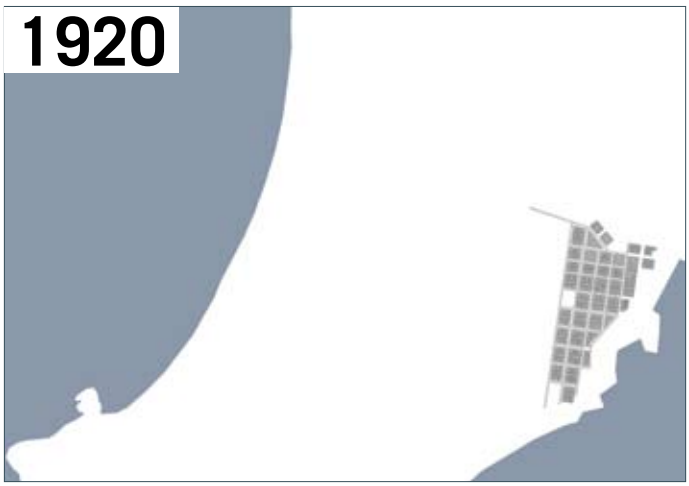
7887 Shire Population

2102 Number of Dwellings

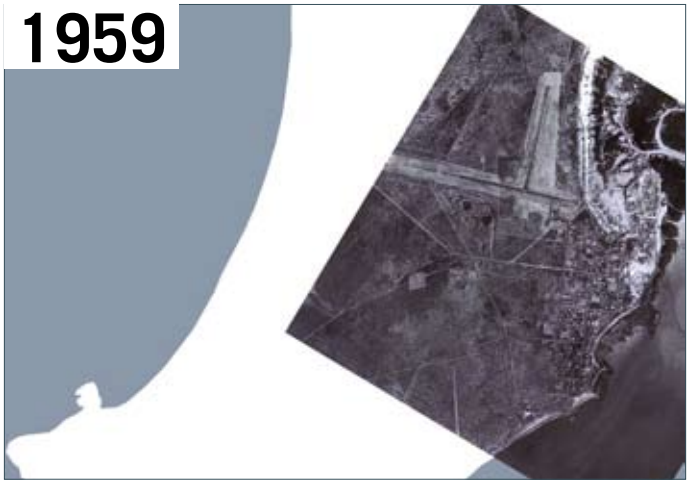
1997 POPULATION + NO. OF DWELLINGS

9768 Shire Population

2773 Number of Dwellings


1920


1949


1959


1967


1981


1990


1995


2003


2007

?

2030

BROOME'S STREETS

TO UNDERSTAND THE NATURE OF BROOME'S STREETS WE LOOKED AT THE RELATIONSHIP BETWEEN THE STREET, THE VERGE AND THE VEGETATION IN RESPECT TO THE ELEMENTS OF SHADE, PROTECTION AND PRIVACY TO OCCUPANTS AS WELL AS PASSERS BY.

To maintain a harmonious urban environment we are conscious of the effect the street design has on a community. The way each house 'addresses' the street has an effect upon the whole community. When people spoke to us about the Broome character, the wide streets of Old Broome featured prominently.

What is it about these streets that people are so connected to? Their width alone was probably not the only defining characteristic that people mentioned. We looked at streets all over Broome, and noted the differences in width, treatment of verges, planting, footpaths, curbing and more.

One of the most noticeable factors in newer parts of Broome is the houses proximity to the street, but also it's elevation about street level. Often this disconnects the house from the street, and from passers by. A lack of space on the verge and in front of houses also means limited garden area with smaller trees and shrubs. The old Broome street conceals most of the house structure behind a thick canopy of vegetation. This provides shade to the house, and privacy to the occupants inside.

an intersection in old Broome
vegetation conceals most housing, footpath on one side only.

a street in Old Broome
large stands of white gums. No footpath

Large verges in old Broome used for parking.
no footpath.

A house in Old Broome - photo taken 1967.
pindan verge, no footpath, no curbing

A stretch along Robinson St.
White gums shade the footpath enabling comfortable pedestrian access.

A cul-de-sac in post 1969's Broome, west of old Broome.
Road widths and reserve approximately 22m.
Established vegetation conceal most housing.

A road in post 1990's Broome.
Footpath on the edge of road, houses set back approx 6 m from lot boundary.

New estates of Broome.
Elevated blocks draining to street. No footpath.

Footpath on the road edge, minimal verge.
Broome style housing approx 4m from kerb edge. House is close to road level.

Smaller corner lots - approx 350m2
Exotic and fencing limits interaction with street.
Footpath on road edge. 18m road reserve

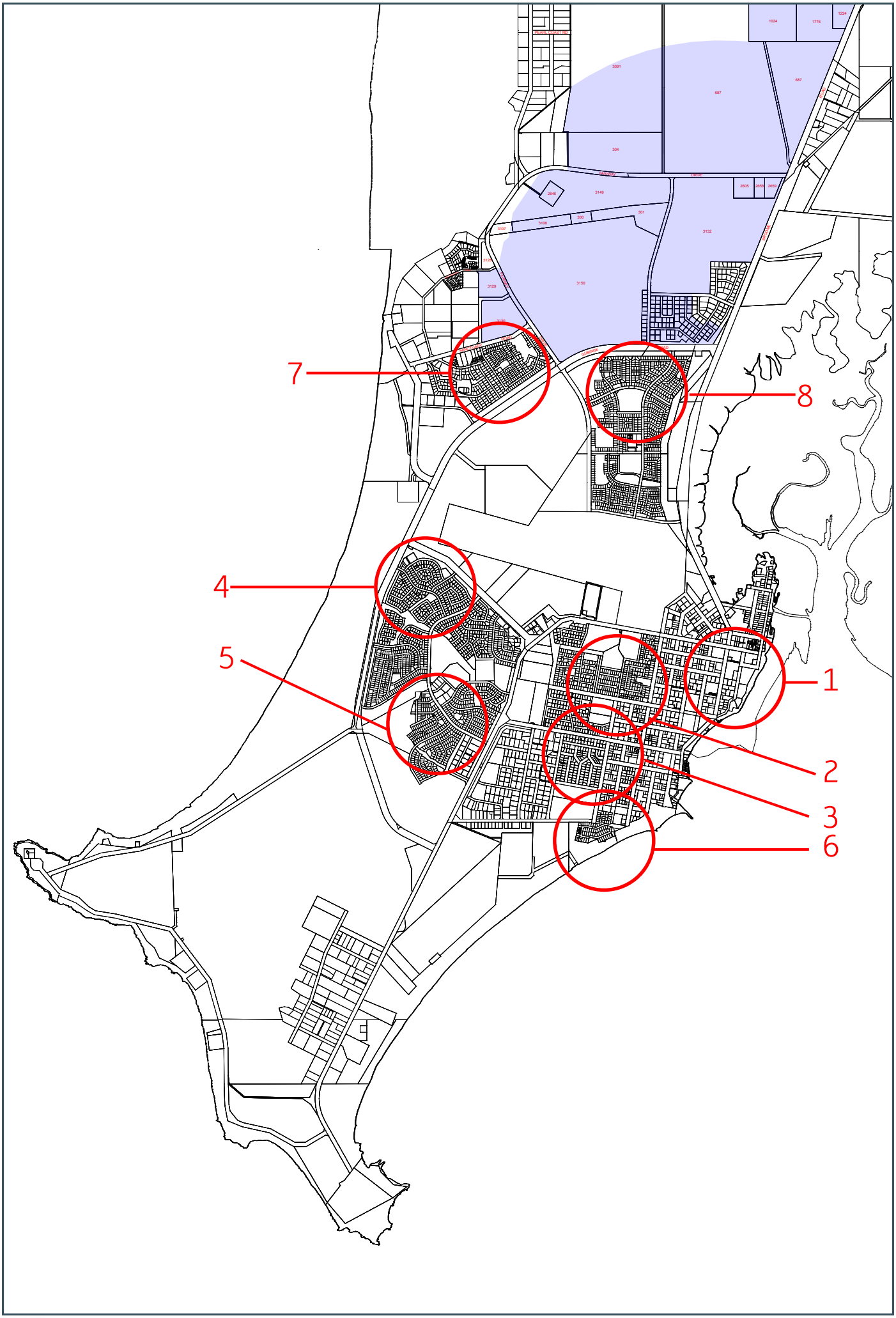
Side fencing limits interaction with street.
May impact on breeze access.

Janubaru Six Seasons. typical street layout with raised blocks, mountable kerb and no footpath. House typically 4-6 m from street edge.

Corner street lots have difficulty access due to slope and drainage requirements. retaining walls often result limiting access and interaction with the street. 4-6 m verge. Footpath on road edge.

Corner street lots have difficulty access due to slope and drainage requirements. retaining walls often result limiting access and interaction with the street. 4-6 m verge. Footpath on road edge.

Fairway Drive in New Broome - what kind of street will this become?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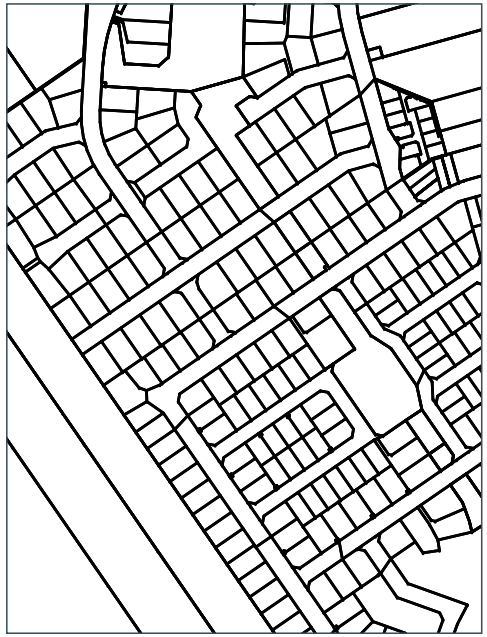
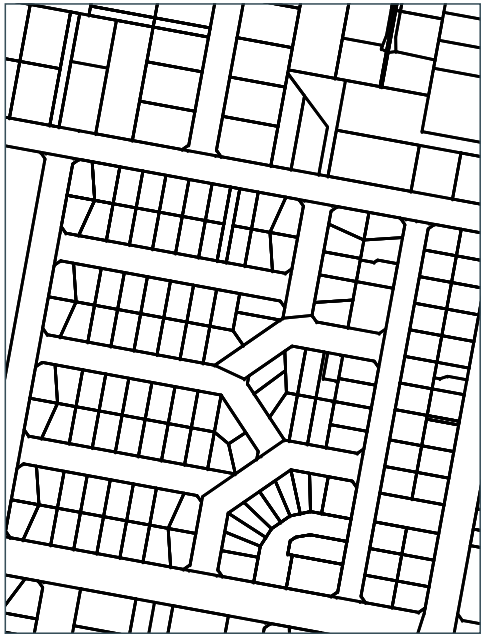
7. Sunset Rise

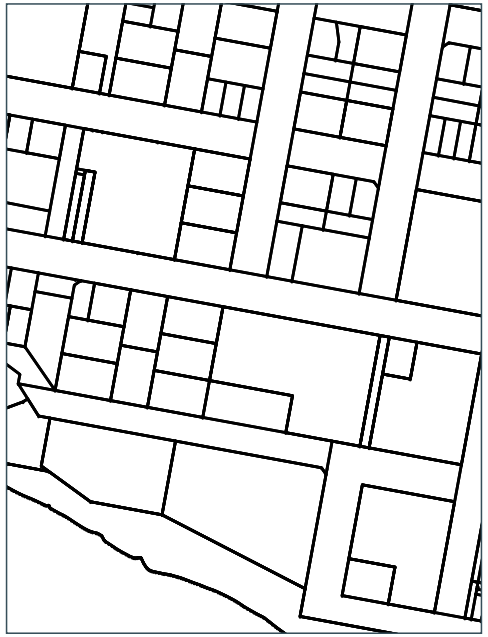


5. Janubaru Six Seasons

3. Broome

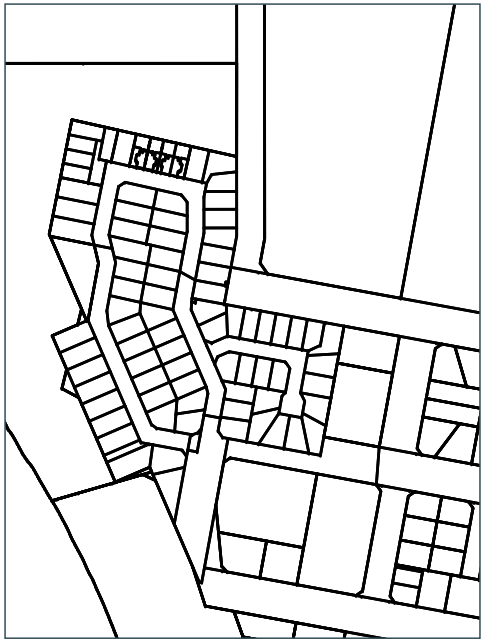


1. Old Broome

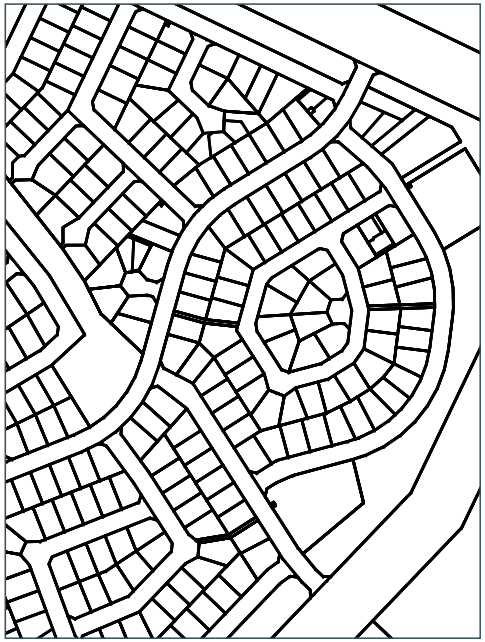


8. Roebuck Estate

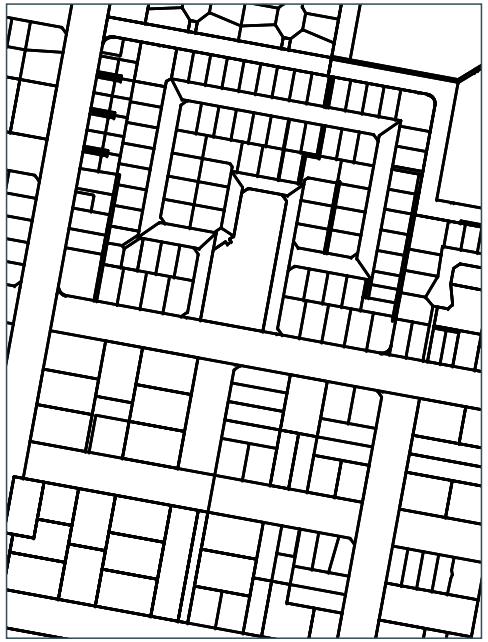
6. Broome



4. Cable Beach



2. Broome



THE BROOME HOUSE

DEVELOPING LAND ON THE BROOME PENINSULA REQUIRES PARTICULAR DESIGN SOLUTIONS. THE SOIL TYPE, CLIMATE AND LOCATION MAKE THE DESIGN OF RESIDENTIAL LOTS RADICALLY DIFFERENT TO LOTS IN WESTERN AUSTRALIA'S SOUTH-WEST.

As a starting point for our investigations we sought to study the historical architecture of Broome. We looked at the history of Broome's buildings since its establishment in the late C19th.

Upon examination it is evident that Broome's unique style of architecture developed out of innovative responses to existing conditions. It was during the early years of the town in the late 1800s and early 1900s that the formation of distinct architectural types began. The remoteness of its location meant a lack of local building materials, builders had to be innovative with what was available. The harsh subtropical climate determined, to an extent, the type of building constructed as natural cooling was essential. The economic status of the occupant decided the complexity of the building. There were also innovations of building techniques using the knowledge of Japanese craftsmen and Asian shipwrights. A combination of all these elements formed what we now know as 'Broome-style'.

However, it is important to recognise that currently two different Broome-styles are present, old Broome and new Broome. New-Broome style encompasses the buildings post WWII and the buildings of the 60s until current day. This style came about due to the introduction of new technologies for cooling and construction and the availability of a greater palette of materials. The new buildings became less responsive to climate and relied upon air-conditioning, the permeability of the building skin became lost as well as the strong connection between indoors and outdoors. Due to the economy of construction buildings were no longer on stumps but instead on concrete slabs. The Broome-style of the 1900s became translated simply through the collaging of its iconic elements such as corrugated iron and lattice.

MATERIALS

Typical materials used for construction in Broome included:

- Custom orb
- Queen Anne corrugated iron
- Timber lattice
- Fly-wire
- Cheesecloth
- Timber decking
- Wood-panelled walls
- Pressed metal
- Tin shutters
- Louvres

CLIMATE

Elements of Broome architecture that responded to climate included:

- Wind scoops and vents
- Shutters & Screens operable to capture breezes
- Vegetation
- Hip Roof, pitch of 30-33° promoted air-circulation
- Stump footings

LANDSCAPE

A distinct characteristic of Broome is the variety of exotic trees planted in the gardens of residences. Within the yard of a typical Broome house you would find gardens planted with some of the following trees:

- African mahogany
- Mango
- Royal Poinciana (Delonix regia)
- Lots of different palms (such as Foxtail Palms, Carpentaria palms)
- Ixora
- Ginger
- Alamandas
- Mock Orange
- Hibiscus
- Bouganvilleas
- Oleanders
- Frangipanis
- Duranta
- Golden cane
- Coconuts
- Exotic gum trees eg. Maculata

COLOUR

In the 1900s in Broome most houses would be painted with a tellurite whitewash, it was the most economical method of covering the red stain of the Pindan soil. Others painted their houses pale green or beige; the choice of colours was limited. Red, green and black where often used as to paint gutters, window and door trims; the colours were also used due to availability. Lugger timber preservative was the green paint and lead antifouling paint was the red, these colours where adopted into the new Broome-style and can be found as highlights on many recent projects in Broome.








SOURCE: Kerry Hill

PEARLER'S BUNGALOWS

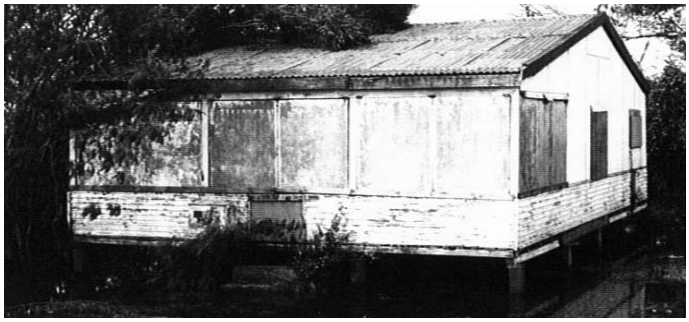
These houses were predominantly British Colonial architecture built for the pearlers and their families. The residences were located in the European residential quarter with large spacious gardens and generous road verges. Raised on 4 foot stumps for termite protection. All had four hipped roofs with 30-33° roof pitch, this pitch promoted air circulation and has the minimum resistance to cyclonic winds and air flow. Materials for these cottages were corrugated iron roof with white-washed wall lining sometimes pale green or beige paint. The buildings uses single skin construction with exposed studs on the verandah side. Timber-framed structures, jarrah posts. Jarrah tongue and groove boards for flooring. Dividing walls were often tongue and groove oregon boards, sometimes pressed metal or corrugated. The planning was usually based around a central rectangular house cell, generally 2 bedrooms and a small lounge with a wide surrounding verandah, on average 12 feet wide. The laundry, bathroom and kitchen were located separately. Uses the skills of Japanese craftsmen in the timber joinery. Storm shutters were a common feature and allowed operability to capture breezes. Other permeable linings were used such as cheesecloth or fly-screen enclosures, canvas shutters. Rainwater tanks were essential due to the condition of the bore water.

SOURCE: Battye Library 28044P

SEA SHANTIES

The sea shanties were working-class architecture located on the edge of town or on the foreshore. They offered the most basic form of shelter for their impoverished occupants. Built using the most simplified building methods, they were usually single-storey, unlined, timber-frame and corrugated iron clad. Some were raised on 600mm masonry stumps to capture cooling breezes for termite protection and safeguard against flooding. Others they were on concrete slabs or simply dirt floors. These shacks had no running water, no insulation and little shade. Laundries and Bathrooms were located outdoors.

SOURCE: National Australian Archives K1212/1, Broome, Box 19



SOURCE: Beyond the Lattice, Sickert, S, 2004

SOURCE: 1967 Report

CABLE STATION

Reminiscent of tropical colonial architecture. The design had a central core plan with surrounding verandah and is said to have influenced the planning of the bungalows. The building had some obvious differences, it was raised on stumps 3 times higher than the Bungalow style and had a double layered corrugated iron roof with complex vent as a cooling system. It used teak wall and ceiling panelling and is clad with corrugated iron. It is an iron-framed, prefabricated building designed in Britain, shipped via Singapoore where teak timber joinery and tradesmen where brought on board. The wrought iron frame was imported as well as the corrugated iron sheets and roofing, cast iron verandah posts, balustrade and steps, these were unavailable in Australia at the time.

SOURCE: 1967 Report

TOWN CENTRE

The three main streets in town were Dampier Terrace, Carnarvon Street and Napier Terrace. Behind the main streets were small buildings that only had narrow laneway access this was necessary due to the dense arrangement of lots. Several long narrow lots were divided in eight sections that were leased to different tenants. The Laneway arrangement fostered the density of the area that is now Broome's Town Centre. John Chi Lane and Sheba Lane would have been the two principle laneways both in existence since the mid 1890s. The buildings of Broome town centre were influenced by the architecture found in fishing villages of China and Japan. Buildings faced directly onto the street or lane. No front fences or footpaths. These buildings were one or two storey with a gabled roof, symmetrical facade and small windows. They also used glassless windows, instead screened by bars and shaded by pressed metal window awnings which allowed for breezes. Another innovation was the wind scoop. Rainwater tanks were integral to the houses in town. The kitchen & bathroom were located at the back of the house, it kept the heat and damp away from living areas, seperate outhouse for toilet. The planning of the houses made them easily extendable and their style drew it's heritage from buildings commonly found in fishing villages in China and Japan whitewashed corrugated iron cladding. The flooring was usually Jarrah or pine tongue and groove boards.

SOURCE: CODA

ASIAN INFLUENCE

Asian shipwrights were employed to build dwellings for the pearlers during periods of inactivity on the foreshore. This explains why some construction methods usually only found in boat-building were found in the bungalows. Scarf joints were found on the verandah beams. The stud was joined to the bottom plate by a mortise and tenon joint that went right through the bottom plate to the stump adding strength. The use of mortise and tenon joints in wood joinery is believed to go back at least seven thousand years in China. This technique allowed the most complex structures to be held together entirely without the use of nails, bolts or any other metal fasteners.

SOURCE: CODA

SOURCE: CODA

SOURCE: 1967 Report

NEW BROOME STYLE

Due to the economy of construction buildings were no longer on stumps but on concrete slabs. The Broome-style of the 1900s became translated simply through the collaging of its iconic elements such as corrugated iron and lattice. The new buildings became less responsive to climate and relied upon air-conditioning, the permeability of the building skin became lost as well as the strong connection between indoors and outdoors.

Several notable examples have been built recently that represent direct responsiveness and inventiveness to the local climate. Iredale Pederson Hooks' Kapang St house is perhaps the best example of this modern take on a broome house. Contractors who worked on the hand over of the building on Christmas Eve commented on the house's amazing ability to stay cool in the hottest parts of the day.

SOURCE: IPH Copyright Shannon McGrath

SOURCE: CODA

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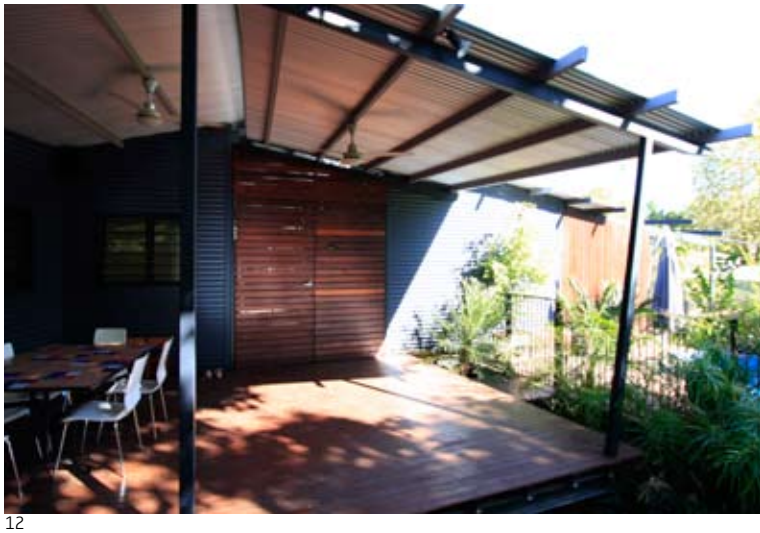


12

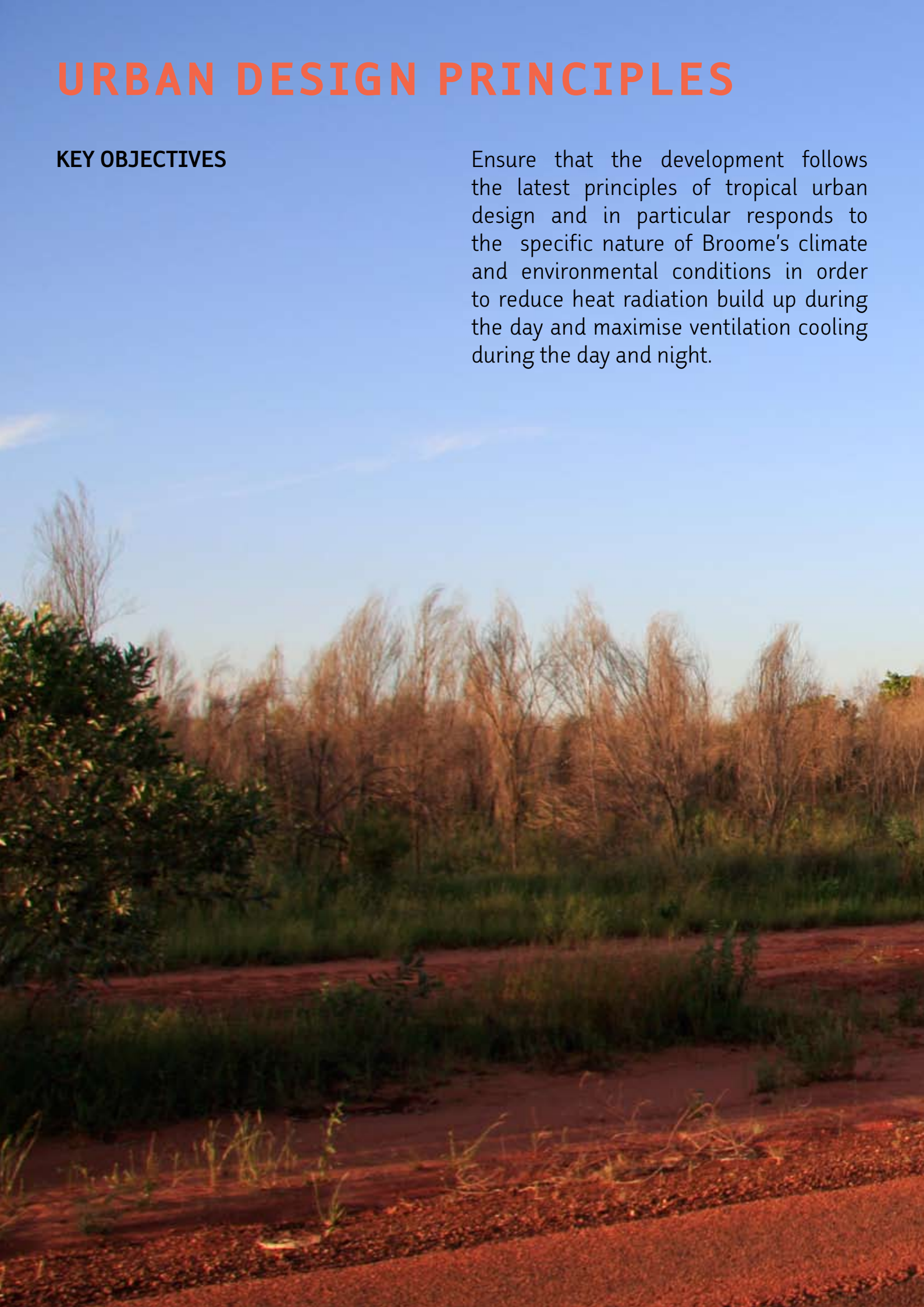
15

1 Cable Station, 1967 Report
2 Multi-residential Development, CODA
3 Old Broome House, CODA
4 Kapang House, CODA
5 Cable Beach House, CODA
6 Januburu House, CODA
7 Multi-residential, CODA
8 Januburu House, CODA
9 ANZ Bank, CODA
10 Old Broome House, CODA
11 Short Street Gallery, CODA
12 Rear Deck, CODA
13 Japanese CLub, 1967 Report
14 Januburu House, CODA
15 Pearler's House, 1967 Report

URBAN DESIGN PRINCIPLES

KEY OBJECTIVES

Ensure that the development follows the latest principles of tropical urban design and in particular responds to the specific nature of Broome's climate and environmental conditions in order to reduce heat radiation build up during the day and maximise ventilation cooling during the day and night.



BROOME'S CLIMATE

Temperature
Broome is classified under the BCA as a Zone 1 - Tropical Climate Zone that is characterised by high temperatures year round, moderate diurnal (day/night) temperature range and high humidity. The summers are particularly hot and humid while the winters are warm. Understanding the two main seasons - the 'wet' and the 'dry' is essential to design a comfortable, climate sensitive house and enjoy the Broome lifestyle all year round.

From October to April maximum temperatures average over 33°C while overnight minima are a typically 26°C. The highest temperature ever recorded is 44.8°C however the temperature seldom rises above 40°C with cooling afternoon breezes coming in off the ocean in the afternoon, the coastal location offering the moderating effect of the ocean on temperature extremes. By contrast winters are mild, with July average maximum and minimum temperatures being 26.9°C and 12.0°C respectively. Overnight temperatures rarely fall below 5.0°C and only fall below 10°C about once a week during July.

Rainfall
The median annual rainfall is 603mm per year on an average 47 days. The majority of rain falls between December and March in thunderstorms and cyclones. A warm dry season occurs from April to November.
For much of the year this a general southeasterly wind regime but reliable afternoon sea breezes arrive from the northwest to southwest during the warmer months.

Humidity
Evaporation is high. In November the average daily rate is 9.5 mm per day. The relative humidity is generally uniform from month to month averaging about 60 - 70 % at 9 a.m., while at 3 p.m. values range from about 35 % in the cooler months to about 60 % in the wettest month

Temperature

Summer Range	26.0°C	-	33.0°C
Winter Range	12.0°C	-	26.9°C

Rainfall

Mean Annual Rainfall	603mm
Mean No. of Days of Rain	47 days

Humidity

Mean 9am Relative Humidity	57%
Mean 3pm Relative Humidity	50%

SOURCE: Bureau of Meteorology: Climate Data
Broome Airport Weather Station

The Yawuru community, also known as Rubibi, are the traditional owners of the Broome area. The table below outlines the natural divisions in the year into six seasons according to the Yawuru calendar.

SEASON	LOCAL CONDITIONS	BUSH FOOD, FLOWERS & FRUIT
Wirralburu		
March to Mid May	High tides; Light south easterly winds	Bush honey is abundant; Grass turns brown Stingrays are not fat; Mosquitoes
Barrgana		
Mid May to August	Dust storms; Moderate South easterly winds	Joongoon is fruiting; Pandanus gaamba nuts are red Fish are fat; Kangaroos are fat
Wirl Buru		
August to September	Low spring tides	Melaleuca is in flower; Jigal tree is flowering Stingrays are fat; Lizards are thin
Larja		
September to November	Build up to wet season; Strong north westerly winds	Gunurru white gum is in flower Turtles are mating
Manggala		
December to March	Wet season - cyclones	Gubinge tree is fruiting; Bush banana in fruit Kangaroos are thin; Turtles are laying eggs
Marul		
February to April	Hot after the wet; Light winds	No fruit in season; Pandanus gaamba nuts are ripening Fish are thin; Lizards are fat


vegetation buffer
afternoon breezes
B
A
A
morning
breezes
over land
vegetation buffer
cool morning
breezes over sea
north
0
0.5
1
1.5
2
kilometres

BROOME'S CLIMATE

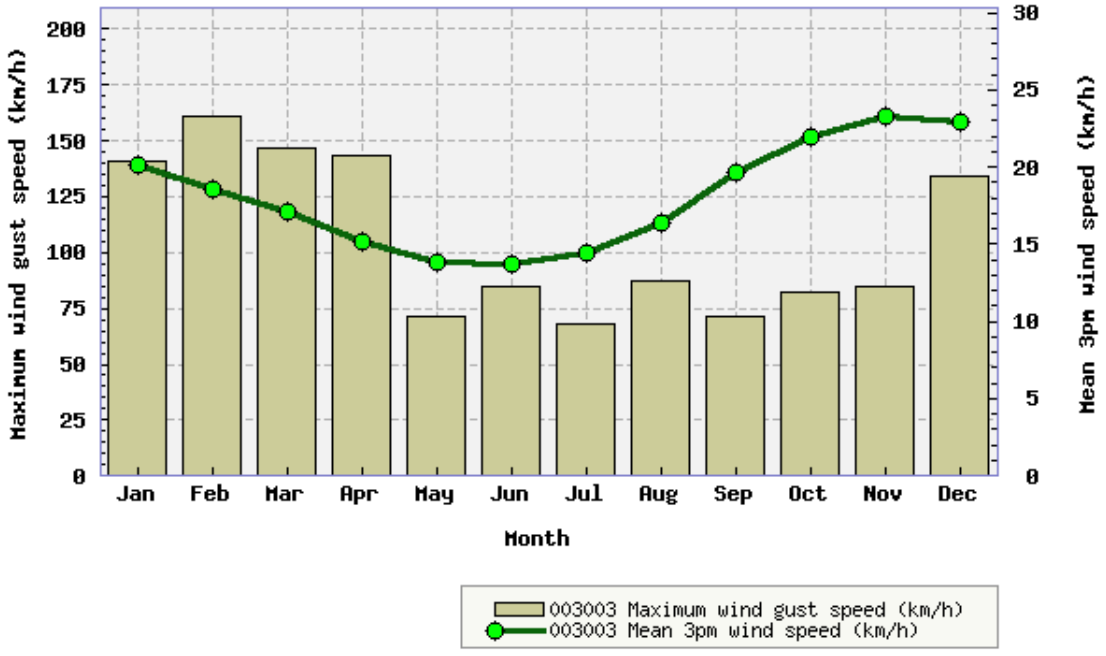
Wind

Understanding the direction and speed of the prevailing winds is critical to building in any tropical region and no less so in Broome. Established data collected since 1939 by the Bureau of Meteorology at Broome Airport shows that a general southeasterly wind regime exists for much of the year however afternoon sea breezes arrive from the northwest to southwest during the warmest months.

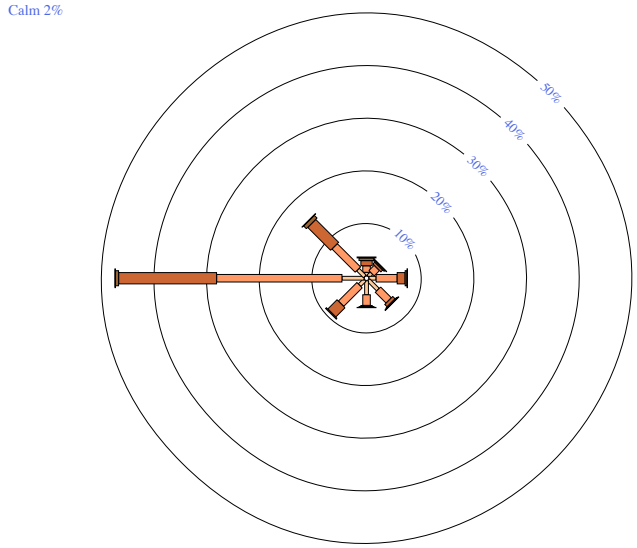
In addition to this tropical cyclones capable of strong winds, high seas and heavy rain can be experienced during the months from November to April, but are most common in January and February. 11 cyclones have been experienced within 50km of Broome over the past 70years. Cyclone rosita in 2000 caused the most severe damage.

The following detailed deductions can be made regarding the direction and speeds of the prevailing winds in Broome:

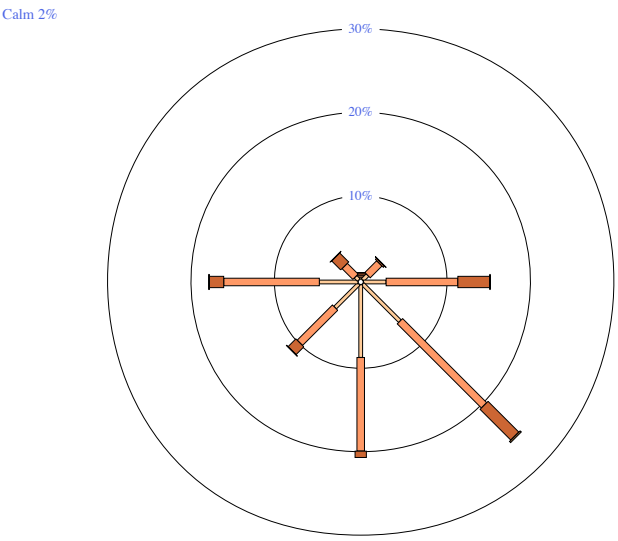
At 3pm >40% of the winds come from the West at speeds up to 30 km/h
At 3pm 15% of winds come from the Northwest at speeds of 20 to 30 km/h
At 3pm 10% winds come from the Southwest at speeds of 20 to 30 km/h



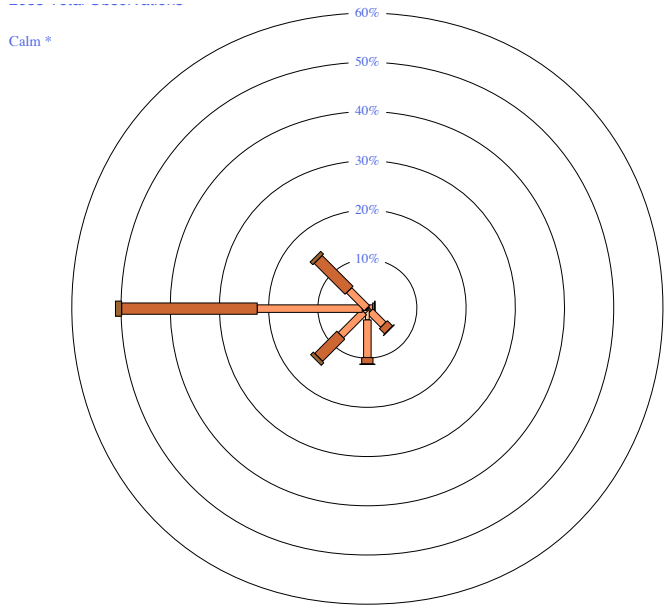
Broome Airport
Maximum wind speeds and maximum wind gust speeds
SOURCE: Bureau of Meteorology: Climate Data



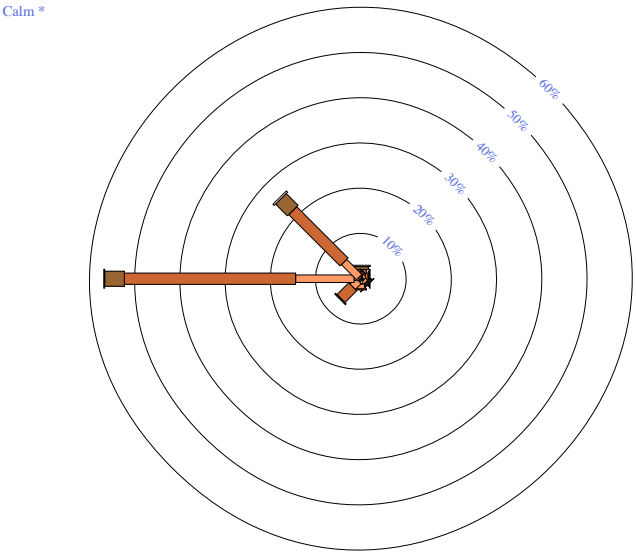
Broome Airport
Wind Rose for March at 3pm
SOURCE: Bureau of Meteorology: Climate Data



Broome Airport
Wind Rose for June at 3pm
SOURCE: Bureau of Meteorology: Climate Data



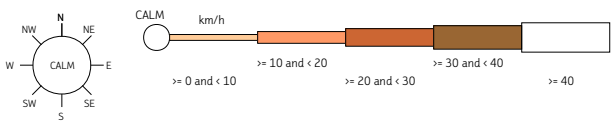
Broome Airport
Wind Rose for September at 3pm
SOURCE: Bureau of Meteorology: Climate Data



Broome Airport
Wind Rose for December at 3pm
SOURCE: Bureau of Meteorology: Climate Data

BROOME AIRPORT

Site No: 003003 · Opened Jan 1939 · Still Open · Latitude: -17.9475° · Longitude: 122.2353° · Elevation 7.4m



THE WEATHER STATIONS

DESIGNING FOR CLIMATE IS ONE OF THE MOST IMPORTANT ASPECTS FOR ANY CONSTRUCTION AND DEVELOPMENT PROJECT AND IS FUNDAMENTAL TO THE SUCCESS OF THE FINAL OUTCOME. IN ORDER TO ACHIEVE THIS WE NEEDED TO UNDERSTAND THE EXISTING CONDITIONS ON THE SITE SO THAT WE CAN WORK WITH AND NOT AGAINST THE NATURAL ENVIRONMENT CONDITIONS IN AND AROUND THE BROOME NORTH SITE.

Following initial investigations into availability of climatic data on the site we undertook to obtain more detailed site-specific data that was not available from the local meteorological stations in order to track breezes and gather in depth temperature and humidity information. The data so far has revealed key differences in wind direction and temperature on our site from the published data.

We are interested in this data as a way of refining the project design to ensure that all residents of Broome North have the best possible chance to access breezes throughout the development.

BROOME NORTH: WEATHER STATION

LandCorp commissioned CODA and ENGAWA Architects to install, monitor and report on findings of local micro-climate using carefully calibrated weather stations. This unique and detailed research component to the project will enable the design team to understand the micro-climatic patterns across the whole site, and the implications of designs of street networks and on houses on the prevailing breeze paths. Careful consideration of local temperature, humidity and wind speed and direction are being recorded.

Bureau of Meteorology staff calibrating units for temperature, humidity and dew point.

CALIBRATION:

To ensure reliability of data collected, and to compare the information to the Broome Airport observatory, all Kestrel weather station units were calibrated by Bureau of Meteorology staff prior to be installed in the field.
During the data collection stage, the units will undergo random calibration testing to ensure that the data collected is reliable and robust.

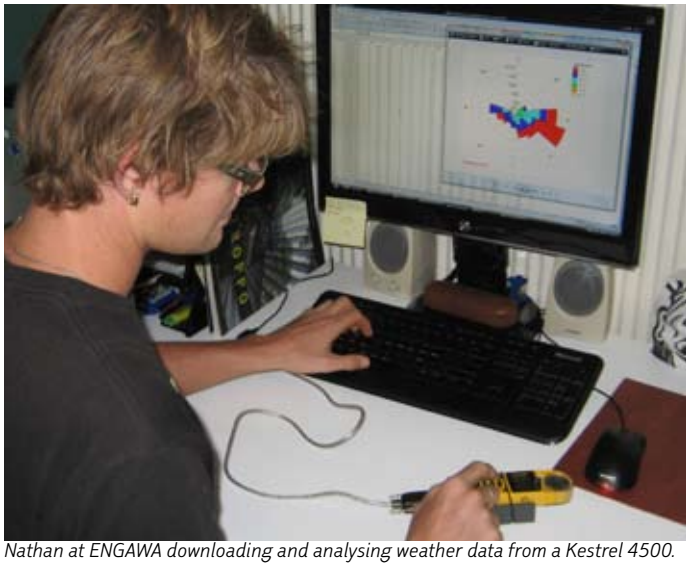
Sue from ENGAWA with Bureau of Meteorology staff calibrating units for wind direction and speed

Nathan setting up a data log

Nathan from ENGAWA installing a unit in a field site

Several units were installed at existing house sites to compare weather patterns in other parts of Broome

Nathan from ENGAWA installing another unit



Nathan at ENGAWA downloading and analysing weather data from a Kestrel 4500.

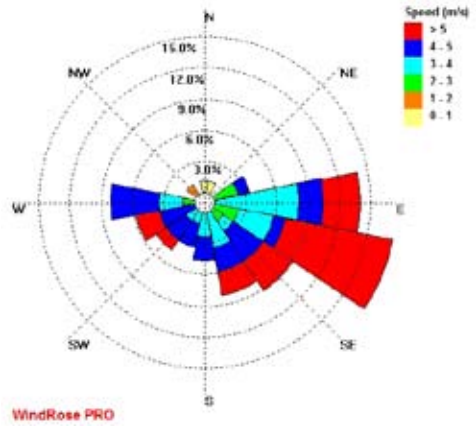
AERIAL VIEW OF BROOME SHOWING APPROXIMATE LOCATION OF THE WEATHER STATIONS

EARLY FINDINGS:

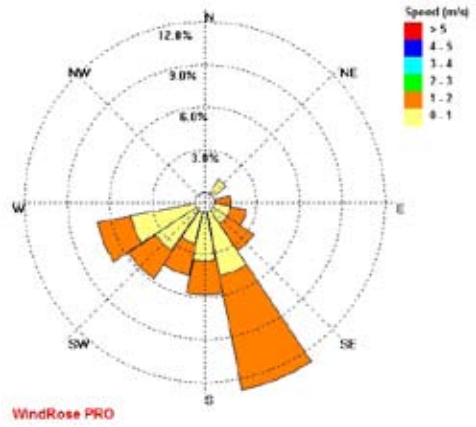
The units have been in the field for two separate one week sessions collecting wind speed, direction, temperature, humidity at 30sec intervals for a period of 7 days. These results are then downloaded at the ENGAWA office and graphed using excel. Wind Rose Pro software is also used to deliver graphical wind rose data. BOM spreadsheets are also being supplied by the local bureau office as a baseline, and these are also fed into our system for analysis.

Table 1 shows the week results for wind speeds at the stations in the field during the week of 17th July, 2009.
Table 2 shows the Dry bulb temperatures for all six stations in the field during the week of 17th July 2009

Clearly wind speeds are significantly reduced, and wind directions are also affected due to factors such as ground disturbance, vegetation, built form (roof and house mass) and dunal systems.



The Bureau of Meteorology Wind Rose for 17th July 2009.
Broome Airport, station at 10m above ground level



Weather Station THREE: Wind Rose for 17th July 2009.
Station at 2.2m above ground level

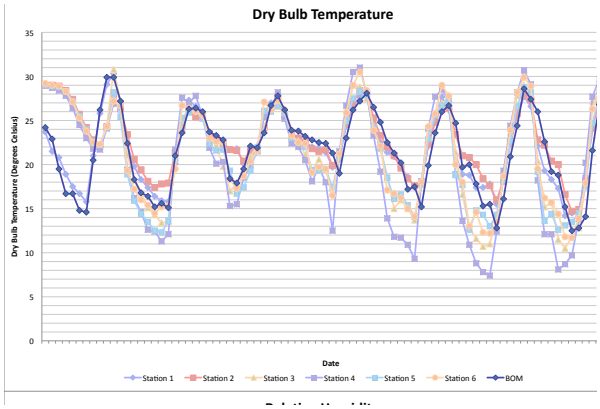
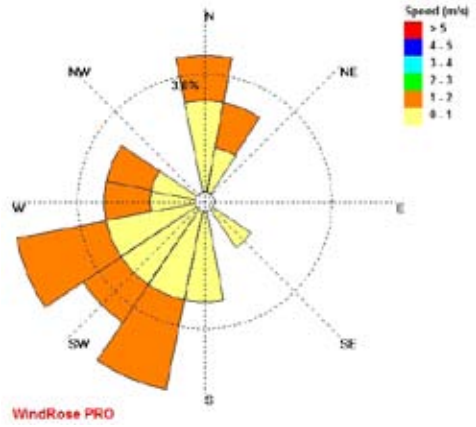


Table 2



Weather Station FOUR: Wind Rose for 17th July 2009.
Station at 2.2m above ground level

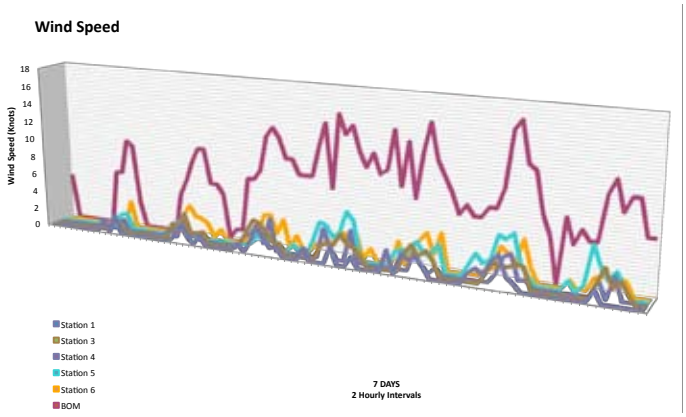
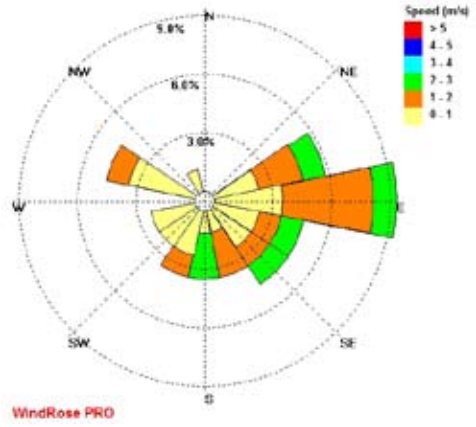


Table 1



Weather Station FIVE: Wind Rose for 17th July 2009.
Station at 2.2m above ground level

SUN SHADE AND WIND

Sun and Shade

In order prioritise 'passive' urban design in any tropical subdivision layout the key is to minimise the exposure to direct sunshine and to ensure adequate airflow through the entire development. The first can be dealt with in establishing the direction of the development grid and the second in establishing the orientation of the main roads and blocks.

Solar orientation is a critical factor in Broome, in particular to provide sun shading from the punishing western sun . In order to enable standard eaves projections for effective shading, the ideal lot orientation should be cardinal. Walls that are not aligned to the cardinal direction will be difficult to shade since it is difficult to protect wall and external openings from slanting sun angles at certain times of the year.

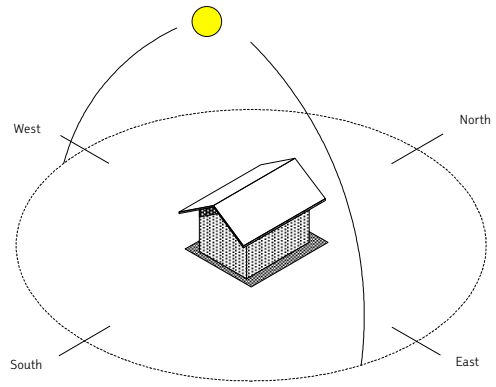
Orientating the lots in a cardinal direction has been shown to reduce radiant solar gains through all wall areas.
(Source 'Assessment of Climate Responsive Design' for Thuringowa City Council in Queensland by Richard Aynsley B.Arch (Hons I, MS (Arch Eng, PhD)

The wind factor

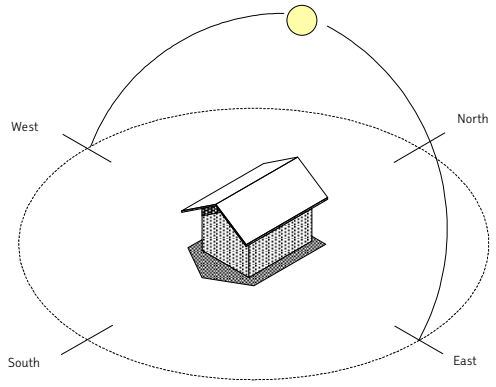
Ventilation of subdivisions and houses is required for two key reasons- in order to remove air contaminants such as CO2 and to provide cooling, Studies show that an air speed of 0.5m/s equates to a 3 degree drop in temperature at relative humidity of 50 % (Source 'Your Home Design for Lifestyle and the Future' Third edition)

In order to look at the effect of wind over the subdivision we looked at existing data to establish the prevailing wind direction. Wind direction changes constantly up to 20degrees of the prevailing direction however it is some pattern of prevailing wind can be established statistically over a number of years. Data taken from the BOM weather station at Broome airport shows that the most cooling winds come from the West and from the Northwest during the hottest period of the day. This presents the most challenging situation with regards to lot orientation since the direction of the cooling winds is the same as the hot western sun.

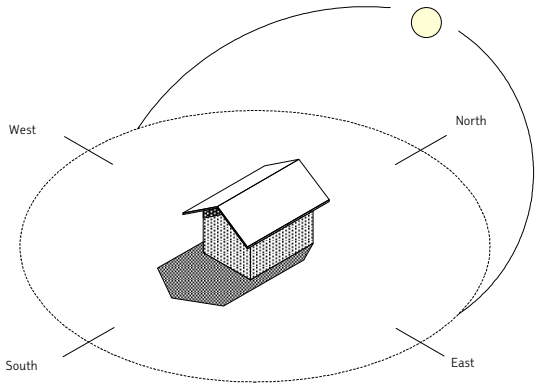
The latest principles for block layouts suggest that with north westerly through to south westerly breezes the direction of the major streets should run north south with the long axis of the lots running East West. The main reason for this is that at subdivision level the cooling breezes will best be able flow through the subdivision if the houses are parallel to the wind with generous breezepaths identified on the south or east side of the lot so that these areas are shaded from the hottest sun paths.
(Source 'Assessment of Climate Responsive Design' for Thuringowa City Council in Queensland by Richard Aynsley B.Arch (Hons I, MS (Arch Eng, PhD)



December



March and September



June

Seasonal sun paths

The situation is particularly challenging for smaller lots of less than 15m width. However solar orientation should be considered more important since there are techniques that enable the capture of prevailing breezes. Smaller lots can be orientated with the long axis in the North South direction since in these situations the long western walls can be shaded by the neighbouring building.

Studies in the report by Dr. Richard Aynsley 'Assessment of Climate Responsive Design' show that high level wind speeds slow down considerably over urban developments. In order to look at this in detail and its effect on air flow around groups of houses there has been considerable testing in particular by Lee et al (1980). This study looked at air flow around groups of similar sized objects in order to assess the reduction on wind pressure difference between windward and leeward walls giving measures of the natural ventilation potential. This potential was shown to decrease with the distance between the objects (Sc) to the height of the object (h). This ratio correlated with the density of the objects in plan and identified three regimes:

Isolated roughness regime: air flows over an object and descends back to ground level

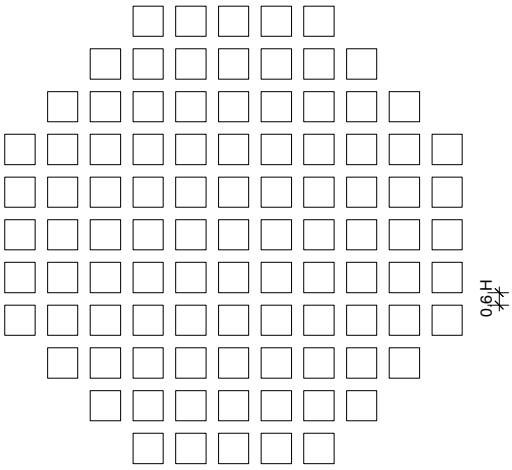
Wake interference regime: air flows over the first object and impact the upper portion of the downwind object to create an eddy between the two

Skimming flow regime: where the air flows over an object and passes over the top of the downwind object

The table opposite shows the relationship between height and distance between objects in order to achieve the desired isolated roughness flow regime. This indicates that the buildings should be well spaced and staggered where possible to enhance airflow through the subdivision.

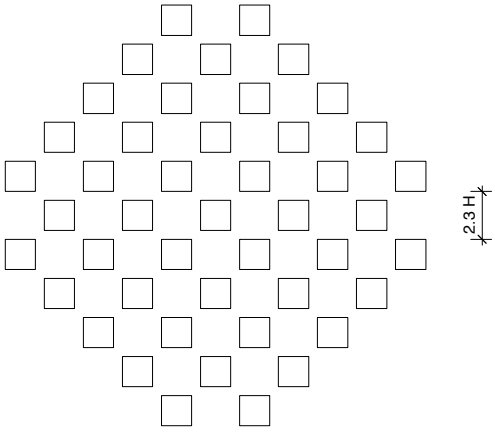
Number of storeys	Height to ridge (m)	Sc / H ratio	Minimum spacing for IR air flow regime (m)
1 (flat roof)	3.5	2.6	9.1
1 (pitch roof)	5.0	2.6	13.0
2 (pitch roof)	7.8	2.6	20.3

Back to back spacing of houses to achieve isolated roughness air flows



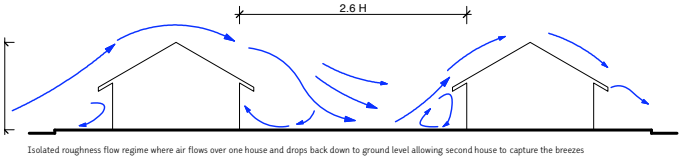
Airflow studies: normal configuration density 40%

Source Lee at al 1980

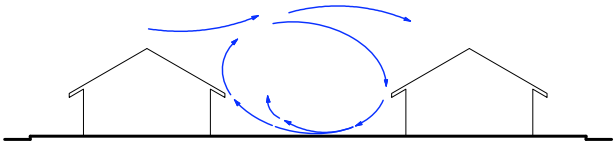


Airflow studies: staggered configuration density 20%

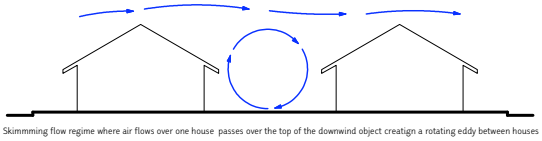
Source Lee at al 1980



Isolated roughness flow regime where air flows over one house and drops back down to ground level allowing second house to capture the breezes



Wake interference flow regime where air flows over one house and the downwind catches the second house creating a rotating eddy between houses



Skimmming flow regime where air flows over one house passes over the top of the downwind object creatign a rotating eddy between houses

Air flow regimes

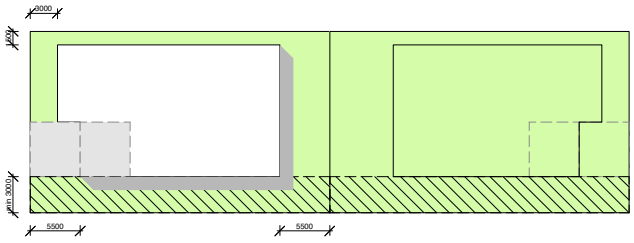
Source Lee et al 1980

LOT DENSITY AND DIVERSITY

Housing density

In order to be able to improve cost and resource efficiency of the development as a whole, the density of the number of people per hectare will be carefully controlled and managed. Higher densities can be achieved through:

1. the organisation of the streets
2. the provision of smaller lots
3. the provision of 0 lot lines on the smallest lots
4. encouraging two storey developments with an integrated housing solution
5. reducing dwelling footprints by introducing maximum lot coverage of 50%

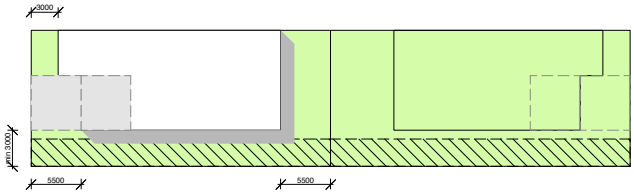


Wide frontage lots

Lot diversity and housing mix

The size and shape of the lots is critical to the subdivision layout. In order to standardise the road grid for economies of construction the majority of lots will have the same depth but will have varying widths for single dwellings with larger lots up to 35m wide for multiple dwellings.

In order to give flexibility and allow for diversity in the housing mix we have looked at combining different widths within one block as well as having some blocks with a combination of east west lots and north south lots at the ends of the blocks. In this way we can accommodate variety in the mix as well as the desired staggering effect of the lots.



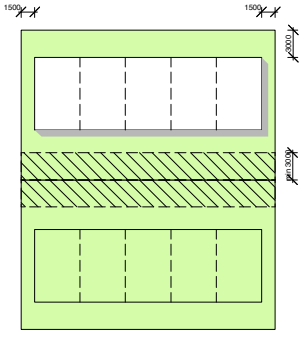
Narrow frontage individual lots

Lot set backs

The set backs set out in other guidances will be reconsidered in this development. Following the studies identified in the earlier sections the requirement for a breezeway through the lot will be clearly identified for each lot. The breezeway should be at least 3m wide and should cover 20% of the lot. On east west lots the breezeway should be located on the south side and on north south lots on the east side.

Rear set backs will look to adopt the principles of the airflow studies and as such the rear set backs should be no less than 5.5m for a single storey building and increasing to 10m for two storey.

In addition to this the front set backs can be reduced to 3m for the house and 5.5m for any carport structure in order to increase the building presence on the street.



Row houses

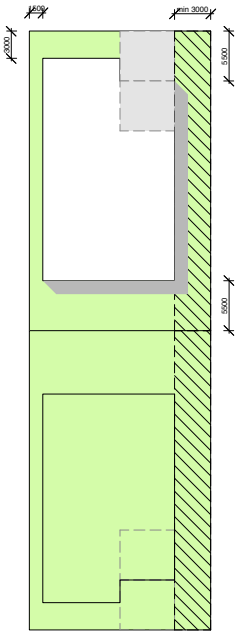
EAST WEST FACING LOTS

Row houses

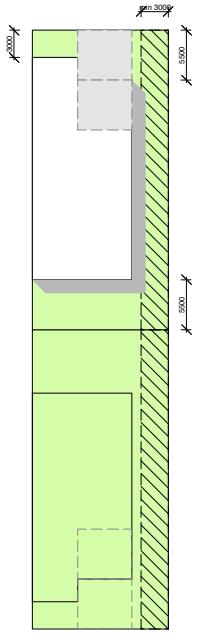
With narrow lots of less than 15m wide the ability to provide effective ventilation thought the subdivision becomes more challenging. For these lots we will look to orientate the buildings north south in a zero lot arrangement. In this way one building can provide shade over the western wall of the neighbouring property.

In even narrower lots in order to alleviate the heat build up between buildings the solution may go further and provide continuous row development, building to the boundary on both sides of the lot with shared party walls. This eliminates one west facing wall for a two house developments and two west walls eliminated for three houses in a row. Eliminating west facing walls will provide greater efficiency for natural ventilation. It will be important to provide the wide rear set backs in accordance with the Sc/H ratio for these developments in order to restore the downstream airflows.

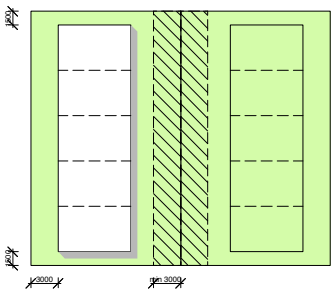
In addition this solution will require fire and acoustically rated separating walls and provide an effective barrier to noise transmission from one property to another.



Wide frontage lots



Narrow frontage individual lots



Row houses

NORTH SOUTH FACING LOTS

LANDSCAPE AND STREETSCAPE

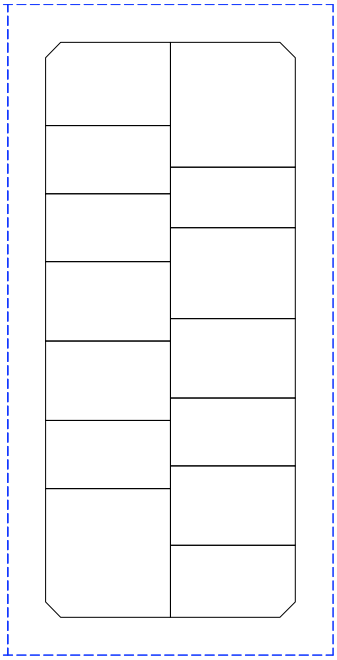
Landscape and Heat sinks

As the sun's radiation is absorbed by roofs, walls and any paved surfaces these elements heat up the earths atmosphere via conduction and convection. During periods of calm in sub-divisions when the air close to the ground is not carried away by ventilating breezes there is a risk of this heat building up in particular in narrow areas between enclosed structures.

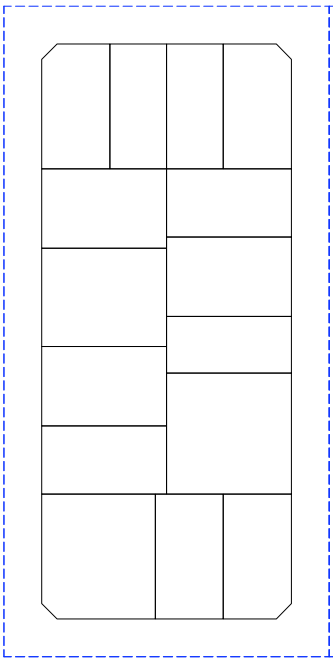
This effect can be reduced using shading of surfaces to prevent solar absorption. Some effective ways to do this include the planting of shade and rain trees as well as ground cover. By limiting the areas of hard ground surfaces and introducing shaded parks to act as heat sinks at strategic locations within the development, some of the heat build up can be mitigated. These parks should be planted with ground cover and trees to provide cool comfortable micro climates throughout the precinct. All vegetation should be selected for robustness and survival in cyclonic conditions as well as an ability to provide shade.

Wide areas of bitumen avenues should be aligned with wind where possible so that any heat build up can be dissipated once the breezes arrive. Where possible consideration will be given to lighter coloured bitumen for paving. Also the use of permeable paving will be considered as alternative to bitumen. In addition awnings can be used to provide shade to areas of hard paving.

Other ways to prevent heat build up within built up areas include the use of light coloured finishes for the buildings and reduce the use of materials with high thermal mass that will tend to store heat and increase the overall ambient temperature. Lightweight construction such as fiber cement clad timber and metal frame buildings are possible alternatives to masonry walls.



Typical block with east west facing lots



Typical block with a mix of east west and north south lots

Streetscape

The design if the street will be important at subdivision level. The way each house 'addresses' the street has an effect upon the whole community. In setting out the grid we have considered different hierarchies of streets and verges. Size and shape of the lots is critical to the subdivision layout.

Verandahs facing the street that are actively inhabited provide opportunity for interaction with passers-by and casual street surveillance. Street facing verandahs need to be carefully designed to enable a comfortable environment in terms of privacy and shelter from the sun and wind.

Street width

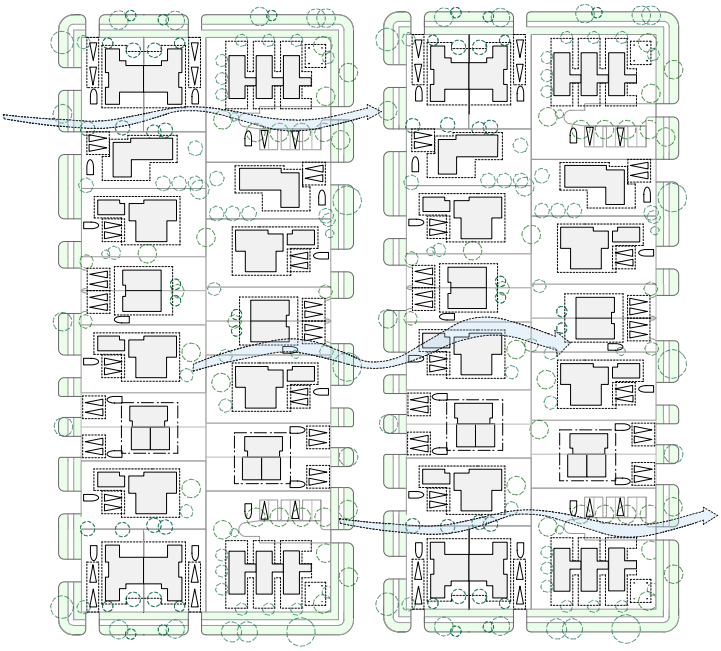
The adopted for Broome North allows for a 20m wide overall block to block distance including the street, any cycle lanes, the verges and any footpaths. Depending on the allocation of each of these a typical street could have a 6m street with 1m cycle lanes on either side and still allow 6m on wither side of the street for verges and footpaths.

Street height

Housing will be no more than two storeys in any residential area, unless specifically noted as Local Activity Centres in the overall subdivision development plan.

Security / Social

All houses should have open and shade outdoor areas that can interact with the street. These may be front verandahs, or outdoor living areas. Both of these solutions may require ceiling fans to aid in air movement and ensure comfort can be achieved when living outside.



Possible subdivision showing staggered lots with streets and verges

Corner Sites

Corner lots are visually prominent within the neighbourhood and dwellings on such lots will be required to be designed to address both the primary and secondary street frontages.

Crossovers & Access

The design of driveways plays an important role in the appearance of the house and their appeal of the street environment. To assist in the achievement of attractive, pedestrian friendly environments, driveway crossovers will be limited in width. Design criteria and setback requirements for all homes as well as associated structures, such as carports, boat ports, garages and other outbuildings will be considered to assist with the achievement of a high quality of residential design and streetscape.

Possible subdivision arrangement with east west lots and distribution of heat sinks

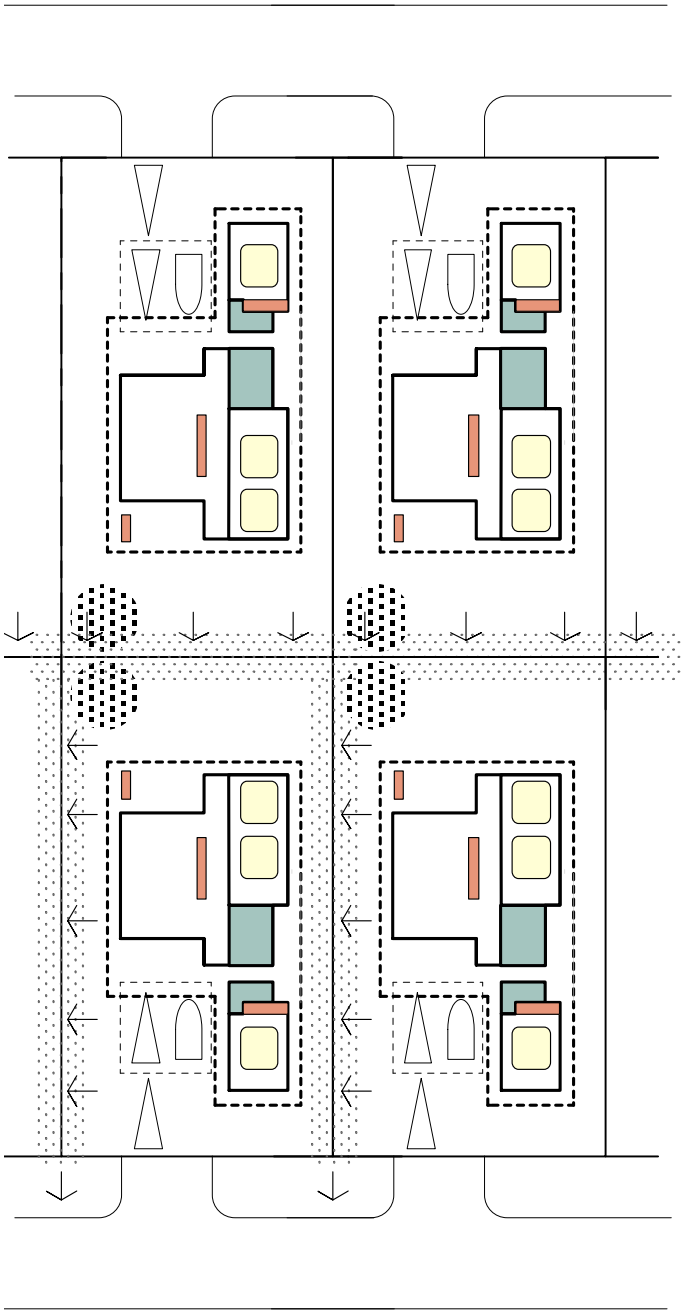
LOT DRAINAGE

Subdivision drainage principles

Primary amongst the site specifics of the Broome peninsula is drainage for the incredible wet season condition experienced. At subdivision level it will be difficult to deal with the sudden increases in water volumes that result from the sudden rains. As such a strategy needs to be developed to deal with water run off at an overall subdivision level as well as the individual lot level.

The drainage principles adopted by the team as a whole follow the standards adopted in Queensland with importance placed on minimal earthworks and an emphasis on above ground drainage, easements on each lot and designing for the 100 year event. On the individual lots excavation and retaining walls will be avoided wherever possible in line with the desire to reduce carbon foot print of the development, retain natural vegetation and minimise costs.

A cardinal block arrangement for Broome North means that the natural slope of the land will be approximately 45 degrees across the most lots, with the highest point in the north west corner falling to lowest point in the south east corner. With the strategy adopted the lot drainage will fall to the rear or side of each lot and either through to the neighbouring lot or out onto the street. Each lot will be mandated with a minimum 3m wide easement and a requirement that 3% of the lot is given to a rain garden. The latter will act as a soakwell in the case of an unusual amount of rainfall at any one time.



LOT DRAINAGE
Drainage of subdivision follows land gradient wherever possible
Each lot required to have 3% of lot area allocated as a rain garden
Drainage of lot falls to side or rear before discharging to road system
Drainage aligns with breezepaths where possible

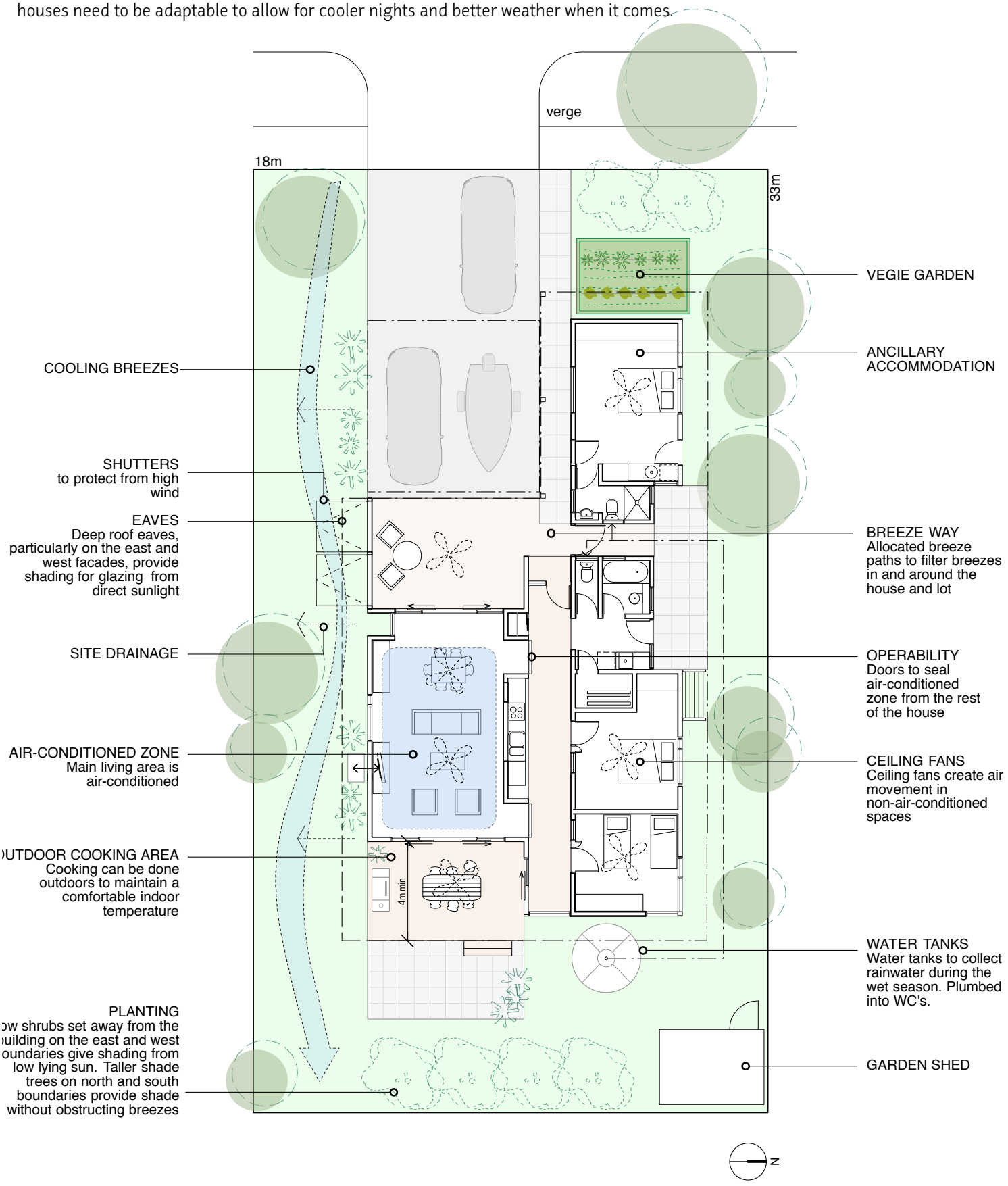
HOUSING DESIGN PRINCIPLES

KEY OBJECTIVE

To investigate the principles for sustainable and affordable house designs in Broome that respond to the climate and are adapted to the local environment

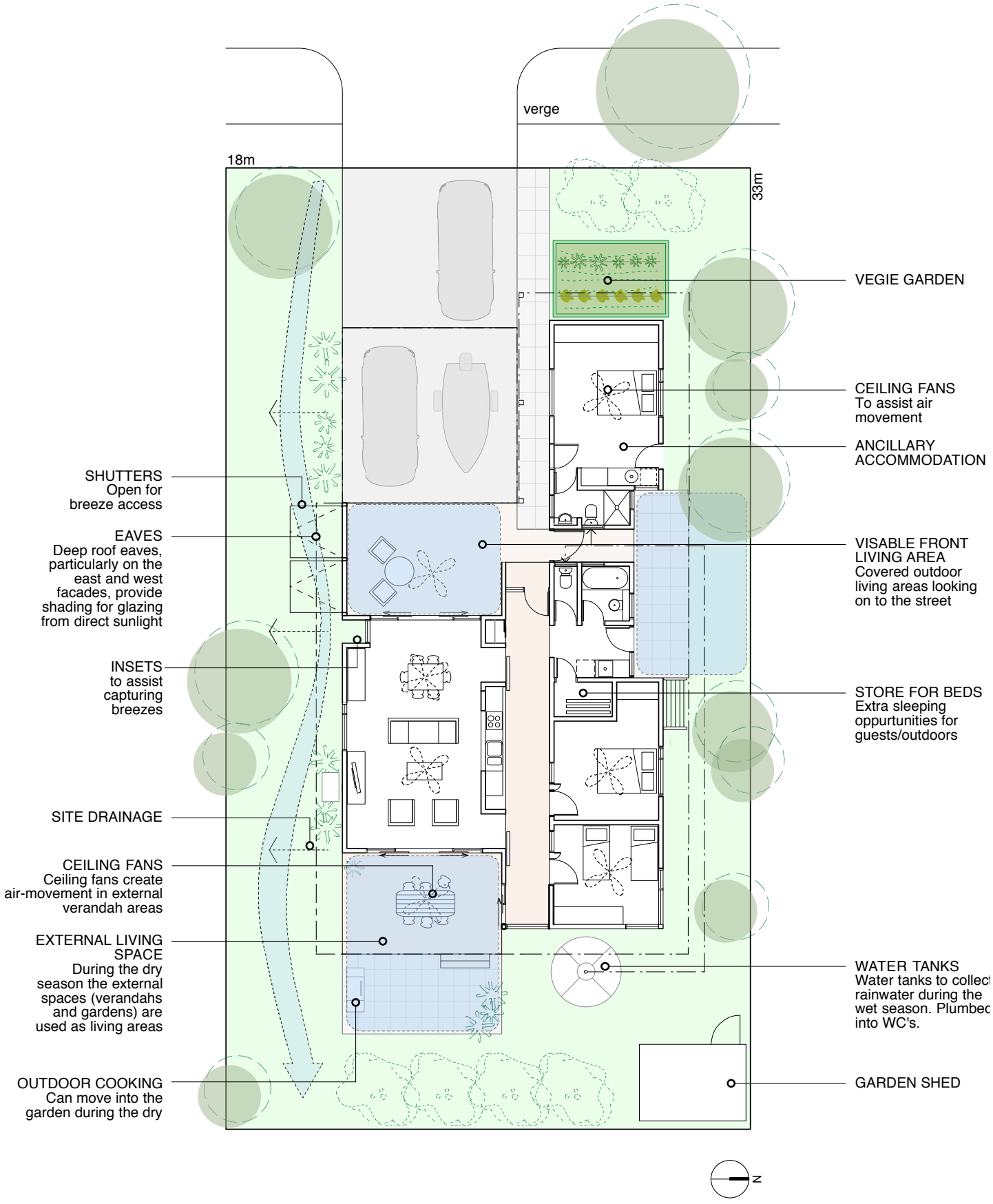
THE WET SEASON HOUSE

During the wet season (August/September to March) the interior of the house is used as the primary living spaces during the hottest and most humid parts of the day. Air conditioning is often the only method to achieve human comfort for periods of time. However, Broome's location does allow breezes and some cooling effects to occur in the evenings during these months, and houses need to be adaptable to allow for cooler nights and better weather when it comes.



THE DRY SEASON HOUSE

During the dry season (April to July) the exterior spaces are used as the primary living spaces. There is no need for air-conditioning as the temperature is generally cooler with afternoon breezes.

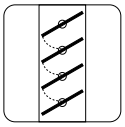


CLIMATIC DESIGN PRINCIPLES

THE KEY TO HOUSE DESIGN IN THE BROOME REGION LIES IN THE USAGE OF A SERIES OF SIMPLE ARCHITECTURAL AND LANDSCAPING PRINCIPLES AND COMPONENTS.

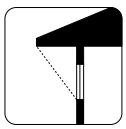
BREEZEWAYS

The provision of an open, or openable, clearway through a house that allows for the passage of breezes and the aeration of interior spaces.



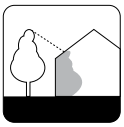
LOUVRES

Louvered windows, when combined with intelligent planning, allow for cross-ventilation of the interior, particularly when the house is sited to accommodate prevailing winds. .



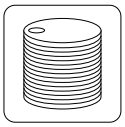
ROOF EAVES

Deep eaves and verandahs shade the sun from windows and openings, significantly reducing the solar gain.



SHADING

Shading of the house by trees prevents solar gain during the day.



WATER CATCHMENT

Rainwater catchment during the 'wet' months has economic benefits for households (by decreasing their water bills) whilst simultaneously decreasing the strain on the towns piped water supply.

FENCING

Front fences shall be no higher than 1.6 metres high and minimum 50% open.

SOLAR ORIENTATION + SHADING

IN THE TROPICS THERE IS NO SUCH THING AS TOO MUCH SHADE. THE SOLAR ORIENTATION OF A HOUSE IN TROPICAL REGIONS IS IMPORTANT AND CAN SIGNIFICANTLY REDUCE INTERNAL SOLAR HEAT GAIN. DUE TO THE SUN ANGLE NORTH AND SOUTH WALLS CAN BE SHADED QUITE SIMPLY BY EAVE OVERHANGS. THE AREA OF GLAZING TO EAST OR WEST FACING WALLS SHOULD BE MINIMISED AS THEY ARE HARD TO SHADE, MINIMISING THE GENERAL WALL AREA ALSO REDUCES RADIANT HEAT GAIN. THE SOLAR ORIENTATION OF A DWELLING TAKES PRECEDENCE OVER ORIENTATION TOWARD PREVAILING WIND DIRECTION AS THERE ARE A VARIETY OF WAYS TO CAPTURE BREEZES.

OVERHANGS + SHADING DEVICES

- All windows should have a shading device (e.g. eaves, exterior blinds, awnings, louvers)
- Sides of the houses that have no verandah should have an eave of at least 900mm wide. Horizontal overhangs shade and also enhance natural ventilation as they encourage air flow through the house.
- Where a house is double story, the ground floor windows must be shaded by an awning of at least 900mm wide.
- Use deep verandahs with a low eaves line and adjustable awnings or blinds to provide protection for walls and windows from western sun where there are desirable views to the west.
- Try to shade all doors and windows from direct sunshine with awnings or sunscreens.
- Recess windows about 600 mm back into external walls facing into prevailing breezes to improve shading and air flow.
- Fit lattice screens over windows increase privacy and provide some sun shading.
- Paint sheet metal surfaces of sun shading components with white paint to reduce their temperature when exposed to solar radiation by reducing absorption and increasing heat loss by infrared radiation.
- Further reduce solar heat gain through external glazing by the use of light coloured drapes to reflect solar radiation back out through the glass.

PLANNING

- Location of verandahs and carports should be considered to provide shading to the east and west of the dwelling.
- Locate living areas on the north to north-east side of the house to allow sun-shading with eaves overhangs, covered decks or verandahs.
- Locate utility spaces e.g. Laundries, store rooms, garages, carports, covered outdoor areas along western façade.

SHADING WALLS OF NATURALLY VENTILATED HOUSES

- Fully shade south facing walls 2.4 m high between 10 AM and 2 PM by eaves overhangs for the most southern summer sun path on December 22.
- Fully shade north facing walls between 11 AM and 1 PM from May 15 through to July 29 with eaves overhangs. This will allow warming during cooler months at latitudes greater than 15°.
- Two storey walls are much more difficult to shade from solar radiation although providing greater potential for natural ventilation.
- Try to orientate the longest walls to face North and South. This orientation allows the walls and windows to be shaded by simple eaves overhangs which do not obstruct breezes.
- Shade walls facing west or east by trees and shrubs to protect them from the sun when it is low in the sky during the morning and late afternoon.
- Reduce indoor heat gains from solar radiation by up to 10% with appropriate eaves overhangs.

A typical awning, perforations allow breezes to pass through it.

VERTICAL SHADING ELEMENTS

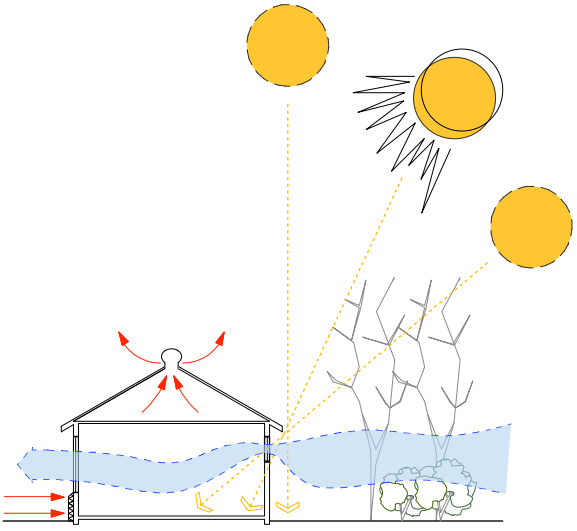
- Vertical shading elements can be used for Sunshine from the East and West.
- Eaves overhangs on north and south facing walls cannot provide sun shading near the ends of walls during low sun angles in the mornings and afternoons.
- By supplementing eaves overhangs on north and south facing walls, with vertical sunshade panels can shade walls and windows without compromising natural ventilation.

WINDOWS

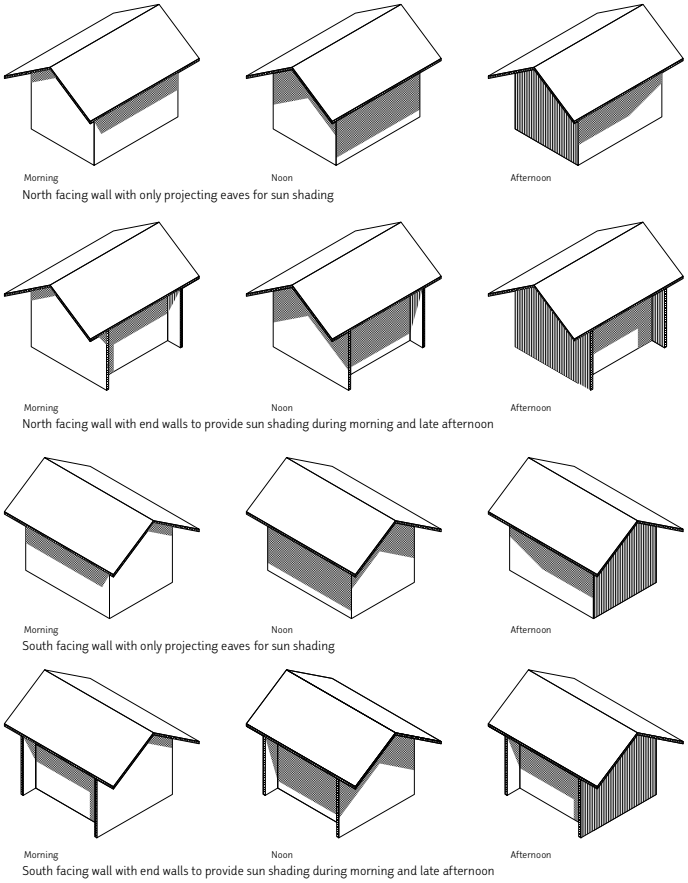
- Apply tinting film to glass exposed to eastern and particularly western sunshine and where there are difficulties in fitting sunscreens to windows or glazed doors to control solar radiation.
- Replace glass where visual transparency is not critical, with light coloured metal, plastic or timber louvres or shutters.
- Reduce window sizes but maximise openable area, particularly in bedrooms, to reduce heat gains while retaining air flow potential.
- West facing glazing should be kept below 2% of the floor area of the room, or preferably eliminated.
- East facing glazing should be below 8% of the floor area of the room.

OUTDOOR LIVING

- Homes should have a shaded habitable outdoor space adjacent to the main living area, located to take advantage of westerly coastal breezes.
- Outdoor Living in the Humid Tropics During the warmer months, the most comfortable space is usually a shaded outdoor living space that catches the prevailing breeze.
- In many ways this space can improve thermal comfort and energy efficiency in houses in humid tropical climates more than any other feature of house design.
- It is important that roofing over such space be insulated to stop heat radiating downward from the hot roof.
- During the evening, breezes often subside and ceiling height should be sufficient to allow ceiling fans to be installed to improve thermal comfort and deter flying insects.



SHADING + VENTILATION
(Source 'Your Home Design for Lifestyle and the Future' Third edition)



VERTICAL SHADING ELEMENTS
SOURCE Guidelines for Sustainable Housing in the Humid Tropics, Richard M. Aynsley

DESIGN FOR BREEZES

AIR VENTILATION CAN OFFSET HIGH INDOOR AIR TEMPERATURE BY THE COOLING EFFECT OF AIR MOVEMENT THEREFORE CONSIDERATION SHOULD BE TAKEN FOR THE LOCATION OF PRINCIPAL LIVING AREAS WITHIN YOUR HOME IN RESPECT TO PREVAILING WESTERLY, NORTH-WESTERLY AND SOUTH WESTERLY BREEZES.

NATURAL VENTILATION

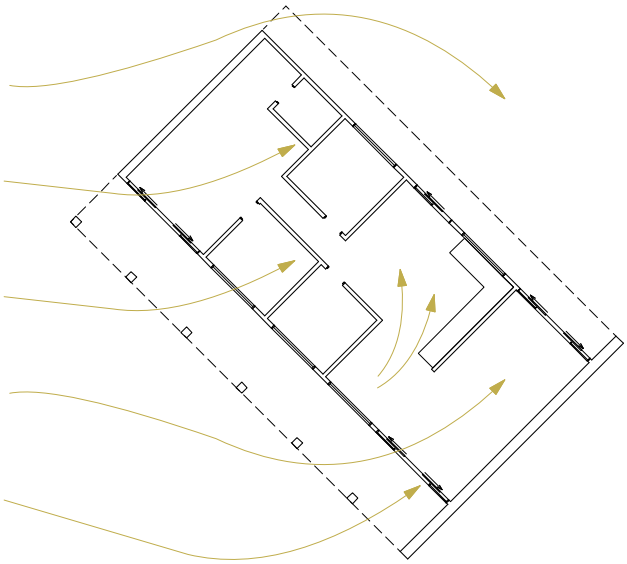
The comfort and energy efficiency of a home is increased when there is extensive shade and indoor air flow. Airflow provides fresh supply of outdoor air. Air movement enhances summer thermal comfort. Provide ventilation paths/breezeways to all internal and external areas and maximise openings to allow for good air flow. Narrower house floor plans assist with breeze path access and cross ventilation. The longest wall of the house should not be inclined by more than 45° to the prevailing direction of summer breezes. Maximum average wind pressure difference across a house with a rectangular plan shape is achieved when the diagonal of the plan is across the approaching breeze.

INDOOR AIR FLOW

Provide a minimum of two external openings on separate walls of all rooms to provide sufficient cross ventilation and air circulation to achieve thermal comfort. For maximum potential for air flow through a house, the air flow should enter and exit a room through openings in opposite walls. Orientate one of the openings to the prevailing breeze direction and where possible place the second external opening diagonally on the opposite side of room. The openings can be above door height. Use screens and wall openings in lieu of solid walls between internal living areas to encourage good ventilation flow. Minimise the indoor resistance to air flow between windward and leeward walls by limiting the number of openings through which the air flow has to pass from windward to leeward openings. Avoid hallways which force indoor air flow to change direction abruptly thereby increasing resistance to air flow. Having bedrooms open directly off a family room is a common means of avoiding hallways. Provide ceiling fans fitted to all habitable rooms. Provide natural ventilation for all truss roofs and other roof cavities by use of energy efficient ventilators e.g. wind, solar or provision of sufficient eaves/gable ventilation openings. Ventilation grilles above door frames to ceiling level in naturally ventilated houses, allow hotter air near ceilings to flow through the house to vent through the ceiling into a ventilated roof space with an exhaust fan or wind powered vent.

OUTDOOR AIR FLOW

To reduce obstruction of breezes fencing should be a maximum of 1.6m high with 50% permeability. Benefits of cooling summer breezes can be substantially reduced by dense foliage close to the windward side of a house. When shading west and east facing walls with vegetation consider a setback from the building and low bushy vegetation to reduce obscuring breeze paths. Extend leeward end wall as a 'wing wall' to capture breezes . (Refer diagram)
L-shaped or U-shaped windward walls to capture breezes, with overhanging eaves, trap prevailing breezes, increasing potential for air flow through the houses. Benefits of cooling summer breezes can be substantially reduced by adjacent buildings within six building heights of the windward side of a house. Large leeward openings encourage more air to be drawn through the house.



BREEZE PATHS
SOURCE Guidelines for Sustainable Housing in the Humid Tropics, Richard M. Aynsley

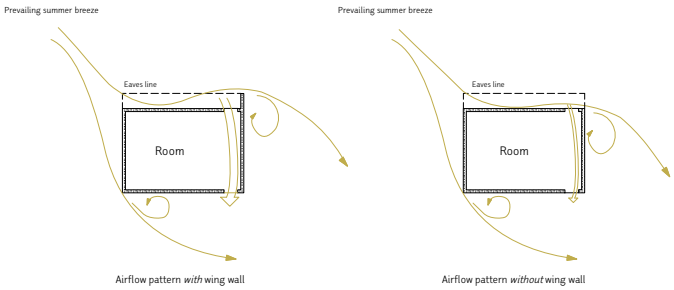
OPENINGS

Replace existing sliding windows with louvres or casement sashes, hinged on the side that will enable the sash to catch the prevailing summer breeze to improve air flow. Replace sliding doors with hinged or folding doors to improve air flow. Extend window openings as close to ceiling level as possible to encourage venting of hot indoor air. Avoid bay windows unless they are well shaded. Use casement sash windows or hinged french doors hinged on the downwind side of window opening and doorways. Recessing windows or doors into windward walls can improve the air flow efficiency of these openings and increase the effectiveness of eaves overhang for sunshading.

DISPLACEMENT VENTILATION

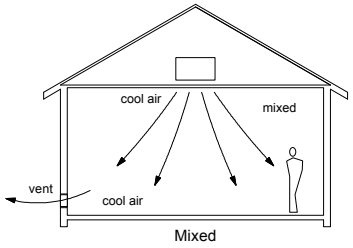
All enclosed buildings require ventilation to provide fresh air and remove stale air. A recent development in energy efficiency in cooling of buildings is displacement ventilation. In the past, air conditioned air was distributed with sufficient velocity through outlets in ceilings to mix with the general air in a room before returning near floor level for filtering, re-cooling and recirculation. Displacement ventilation delivers the filtered and cooled air at lower velocities below window sill level. This fresh air displaces warmed air which rises naturally toward the ceiling from where it is returned to the system for filtering and cooling, leaving the freshest and coolest air in the occupied region within the first 2 metres above floor level. This accumulation of warm air at ceiling level reduces the temperature difference between the heated roof space and air under the ceiling reducing heat entry into the room. This thermal stratification of indoor air in cooled buildings has been shown to save up to 26% of cooling system energy. If displacement ventilation is adopted ceiling fans should not be operated. (Refer to diagram)

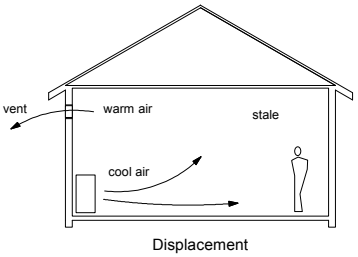
SOURCE Guidelines for Sustainable Housing in the Humid Tropics, Richard M. Aynsley



Airflow with and without wing walls

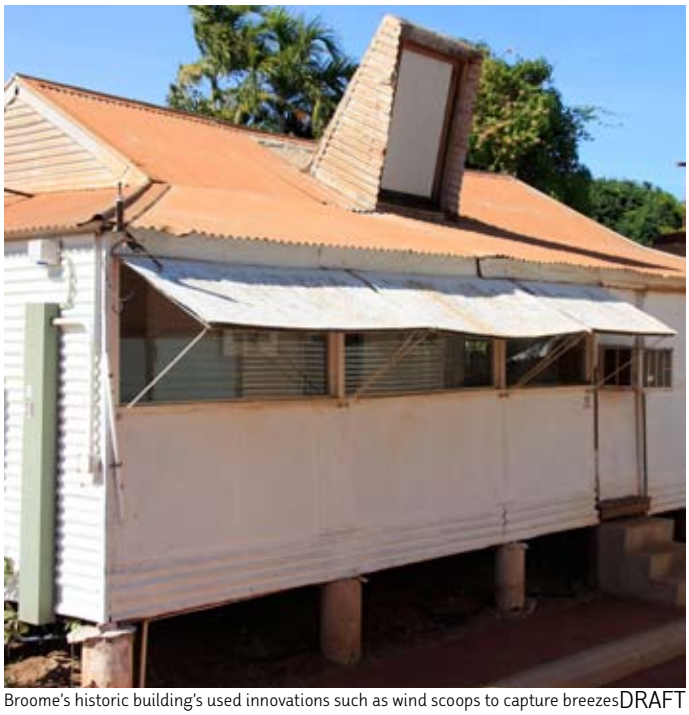
WING WALLS
SOURCE Guidelines for Sustainable Housing in the Humid Tropics, Richard M. Aynsley





DISPLACEMENT VENTILATION
SOURCE Guidelines for Sustainable Housing in the Humid Tropics, Richard M. Aynsley

Iredale Pederson Hooks' Kapang St house is a modern take on a broome house breezeway.

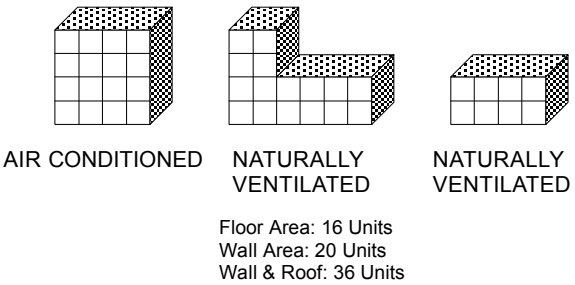


Broome's historic building's used innovations such as wind scoops to capture breezes

HOUSE FORM

THE OPTIMUM SHAPE OF AN ENERGY EFFICIENT, NATURALLY VENTILATED HOUSE IN THE HOT HUMID TROPICS IS AN ELONGATED BUILDING IN THE RATIO OF APPROXIMATELY 1:1.7 (OLGYAY, 1992)

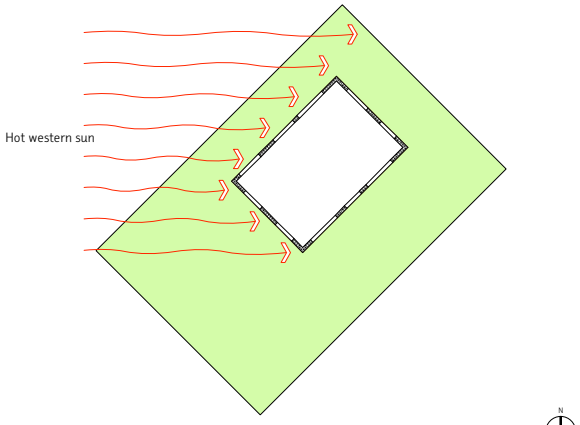
When choosing how your house is going to look, residents are encouraged to keep the building and roof forms as simple as possible. The Broome house is a simple and direct formal response to the climate - large roof forms, deep shading via verandahs or eaves. The form of your home should also be conducive to shading and breeze principals.



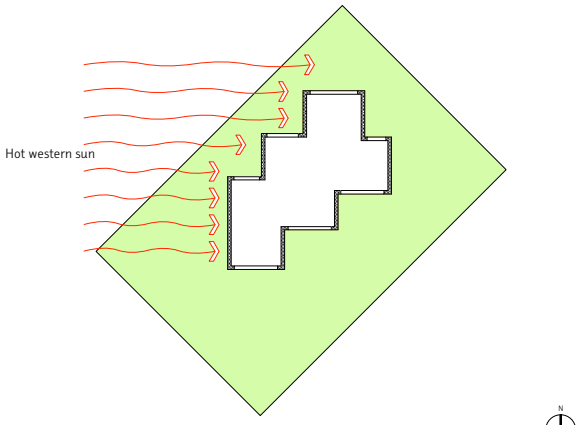
PLAN SHAPES
SOURCE Guidelines for Sustainable Housing in the Humid Tropics, Richard M. Aynsley

DESIGN RECOMMENDATIONS

- Narrower house floor plans assist with breeze path access and cross ventilation.
- External walls inclined to the east or west can be stepped to allow windows to face north or south so they are protected from the low angles of the afternoon or morning sun. (Refer diagram)
- Air flow can be significantly increased by steps in the wall line, recessing windows or doors, or projecting wing walls, below eaves overhangs, which deflect air flow into the openings.
- Air conditioned houses in humid tropical locations, should have plan shapes approaching a square to minimize external surface area,
- Where feasible, plans of naturally ventilated houses should be two storeys. This minimises site coverage relative to the internal floor area allowing less obstruction to air flow through residential subdivisions. Shading is more difficult however.
- Locate outdoor shaded living space with ceiling fans on the East to Northeast sides of the house. Another critical consideration is plan area density. For effective natural ventilated residential development plan area density should not be greater than 8%.
- Many current residential subdivisions have greater than 30% plan area density.



Windows inclined to the west are difficult to shade from the sun



North or South facing windows can be shaded using standard eaves overhangs

STEPPED PLAN
SOURCE Guidelines for Sustainable Housing in the Humid Tropics, Richard M. Aynsley

MATERIALS-THERMAL MASS

THIS SECTION IDENTIFIES APPROPRIATE BUILDING MATERIALS TO HELP LIMIT HIGH ENERGY CONSUMPTION IN THE HOME BY REDUCING HEAT GAIN. WHEN IMPLEMENTED CORRECTLY, ONGOING ENERGY COSTS WILL BE REDUCED AND THE COMFORT OF THE

MATERIALS

- Light-weight construction, with timber framing clad with timber or fibre-cement and metal roofing has the advantage of cooling quickly in less than 1 hour after sundown. If this type of construction has effective roof insulation, shading of walls and windows, and cross ventilation, then indoor air temperatures are rarely more than one or two degrees Celsius above outdoor shade temperature.
- Concrete slab floors on the ground will rarely exceed 30°C if kept shaded. As long as they are not covered with insulating material such as carpet, they help cool interiors. Ensure western walls are insulated and/or fully shaded. For concrete masonry construction, alternative walling materials may be more appropriate for western walls.
- The use of cavity brick and brick veneer to external walls is discouraged. Where thermal mass such as concrete block, cavity brick and brick veneer to external walls is used, it must be demonstrated that 80% shading is achieved at the summer solstice.
- Provide a light coloured roof and light coloured wall finishes.
- Continuous concrete or bitumen should be avoided in favour of mulch and ground covers, light-covered gravel or block or brick paving.
- Phase change materials were suggested as an alternative wall lining for cooling.
- The use of prefabricated components is encouraged. The benefits of off-site construction include reduced construction times.
- Supervision and administration costs, and improved material/ waste efficiencies.

THERMAL ENERGY STORAGE

- The capacity of building materials to store thermal energy depends on their weight and thermal conductivity. Thin metal building components absorb heat quickly, from solar radiation or hot air and distribute it quickly throughout the material. They also lose heat just as quickly, usually a matter of minutes when the source of heat such as sunshine is removed.
- Concrete and masonry materials are relatively heavy materials but are poorer thermal conductors than metal sheeting. Thick slabs or walls absorb heat from solar radiation and hot air and distribute the heat slowly through the material. They lose this heat slowly when the surrounding environment cools, usually over a number of hours. This means that heat absorbed during the hottest time of the day is still being released late at night.
- In locations where night time air temperatures regularly fall more than 7°C from daytime temperatures to night time temperatures, the coolness of the night air can be used to cool concrete or masonry by night time ventilation. The storage of coolness or coolth can be used to maintain lower morning indoor temperatures for at least a few hours if windows and doors are closed at sunrise.
- When indoor air temperatures reach outdoor air temperatures windows and doors should be opened to benefit from ventilation and air movement.

New Broome houses are typically slab on ground.

LANDSCAPING

RESIDENTIAL GARDENS WITHIN PUBLIC VIEW MAKE A SIGNIFICANT CONTRIBUTION TO THE LOOK AND FEEL OF THE AREA. TREES AND PLANTS IN THE FRONT GARDENS CAN ALSO CONTRIBUTE POSITIVELY TO THE MICROCLIMATE OF THE STREET. TREES AND SHRUBS PROVIDE WELCOME SHADE, ACCESS TO COOLING BREEZES OR WINDBREAKS AND HABITAT FOR LOCAL BIRDLIFE. GARDENS ALSO HELP TO CONTROL DUST AND SAND MOVEMENT FROM WIND IN AND AROUND YOUR HOME. LANDSCAPING CAN PLAY AN IMPORTANT ROLE IN ACHIEVING ENERGY EFFICIENT HOUSES IN TROPICAL REGIONS.

This section identifies landscape design elements that reduce maintenance and water consumption with respect given to the Broome climate, in an attempt to contribute to water conservation and the desired character of Broome North. The Broome North plant list is the key component in maximizing water efficiency, plant growth, and consequently minimizing your water bill. Effective landscape design can improve access to cooling breezes to the residence, reduce maintenance, support biodiversity and water consumption.

LANDSCAPING

A common issue for homeowners is the lack of time available to spend on garden maintenance. The implementation of maintenance reducing measures such as 100% mulch (stone encouraged) coverage to garden beds for weed prevention, minimising lawn coverage, automated irrigation systems and shade tree planting can all contribute to spending less time caring for your garden and more time enjoying it.

SOFT LANDSCAPE

Soft landscape is required to compliment and soften hard landscape elements such as walls, fencing, and paving. The buyer is required to landscape the zone between the building façade and the front property boundary to reflect the existing streetscape of Broome.

HARD LANDSCAPE

Hard landscape elements should be durable, able to handle exposure to strong winds, salt, dust and sun. They should compliment the elements of the architecture in material, texture and colour. All hard surfacing such as paving should be permeable to surface water infiltration. Shaded paving is good looking, cool and waterwise.

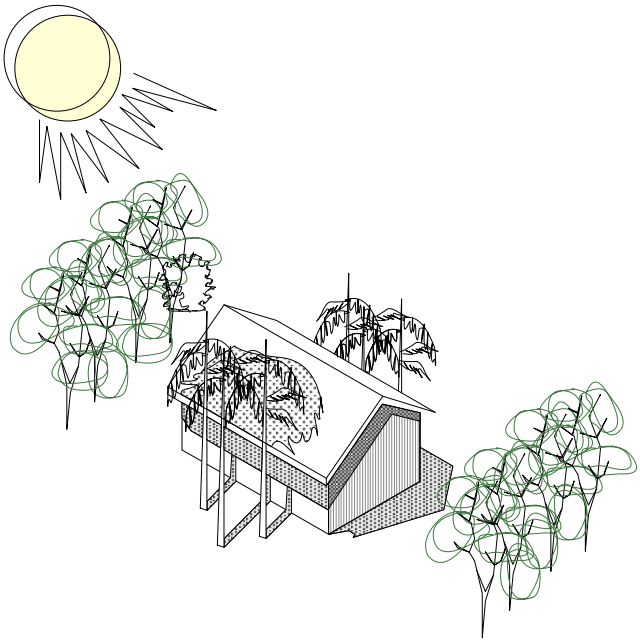
FENCING

This section aims to achieve a fencing approach, which assists with the achievement of a high quality of residential design and streetscape to protect your investment and the estate. In doing so, it is also the intention to maximise surveillance of parks, footpaths, schools and drains to reduce the opportunity for crime and to avoid restricting air flow to the home and outdoor living areas.

DESIGN RECOMMENDATIONS

- Front fences shall be no higher than 1.6 metres high and minimum 50% open.
- Side fences (within the front setback of the house) should be no higher than 1.6 metres and be constructed of the same or matching materials as those used in the front fences.
- Fencing to those lots where the side fence abuts a street may have a fence to screen and provide security to rear yards. However, should houses overlook secondary streets (corner lots) it is strongly encouraged that such fencing not enclose the side of the house and be largely open and visually permeable above one metre in height.
- All boundary fences should allow airflow.
- Utilise vegetation as an additional form of shade for dwellings and outdoor areas to reduce radiant heat. When shading west and east facing walls with vegetation consider setback and type to reduce obscuring breezepaths. (Refer diagram)
- Consider planting or using existing trees and shrubs along the East and West sides of the house for sunshading.
- Consider a shade cloth covered orchid house or fernery between the house and Western boundary fence. Avoid continuous concrete or bitumen in favour of mulch and ground covers, light-coloured gravel or block or brick paving to allow.

- Permeable paving allows evaporative moisture exchange between the ground and the air that minimises surface temperatures of ground exposed to sun. Reduce solar reflection from ground surfaces by shading, planting ground cover or lawn.
- Reduce solar reflection from adjacent walls and roofs by shading with trees.



Tall shade trees close to the North and South of the house provide shade at midday without obstructing breezes.
Lower trees and bushes to the East and West set further back from the house provide shade in the morning and afternoon when the sun is low in the sky.

LANDSCAPING FOR SHADING + VENTILATION
SOURCE Guidelines for Sustainable Housing in the Humid Tropics, Richard M. Aynsley

The Landscaping of houses in Broome has long been a feature, often so luscious visibility of the house is lost.

AFFORDABILITY

AFTER MEETING WITH CONTRACTORS IN THE BROOME BUILDING INDUSTRY THE FOLLOWING RECOMMENDATIONS WERE SUGGESTED TO DEVELOP COST COMPETITIVE DWELLING TYPES FOR TROPICAL CLIMATES. OWNERS AND BUILDERS SHOULD BE AWARE OF, AND SEEK TO MINIMISE, FACTORS THAT INCREASE THE COST OF THE BUILDING COMPONENT OF NEW HOUSING.

DESIGN RECOMMENDATIONS

- The choice of finishes can significantly impact the affordability of a building. From our conversations the range of square metre rates varied from $1800-4000/m2 (2009) depending on wall height, finishes and complexity. These rates are inclusive of everything except landscaping this option is preferred by clients as it is quicker and easier.
- In Broome external living areas are typically finished with Batu decking, an area for possible cost reductions is to use concrete deck as an alternative. Eaves are often lined in ply or villaboard and painted, using colorbond eaves can reduce painting areas and bring down costs. Carpet is the cheapest floor covering, $40/m2 and tiles are also more affordable at $110/m2. (2009)
- Polished concrete has potential as an affordable alternative floor finish and could be pushed but it is hard to get a good finish.
- There is potential to employ modular building techniques to meet affordability for certain segments of the market. Steel components could be pre-fabricated in Perth in mass and transported to Broome. Potentially builders could use a combination of prefabricated buildings with local construction. Builders would have to determine the right balance in terms of sustainability, embedded energy, local labour & training.
- Provide dwellings sized to achieve affordable price points
- Reduce the size (square meterage) of dwellings through compact, flexible housing designs.
- Use construction methods where availability of trade skills is not a constraint
- Prioritise inclusion of sustainability features that do not add additional upfront cost
- To achieve the most cost effective external wall framing, use prefabricated plantation timber framing (cheapest option in volume) then plantation timber frame using traditional construction techniques, then steel framing. Note: The use of plantation timbers is standard industry practice for timber framing.
- For affordability, reduce the ratio of wall length to floor areas, i.e. prefer square floor plates over rectangular or shapes which increase wall lengths.
- Consider the cost efficiencies provided by single storey over double storey housing designs. Note: Higher costs associated with double storey buildings can be minimised by reduced land area and/or utilising shared walls.
- Construct internal partitions from steel e.g. stud'n'track in preference to timber to reduce trade/labour costs.
- Provide a better quality and higher cost wall finish to facades (e.g. painted, rendered finish or painted accent cladding materials to highly visible areas).For sides and rear of dwelling to minimise costs use more affordable alternatives.
- Use slab on ground construction in recognition that raised floors have higher construction costs. Use waffle-pod (preferred) or raft concrete slab forms due to lower construction costs in preference to strip footings. Note: Waffle-pod concrete slabs reduce the volume of concrete and/or fill required.
- On sloping sites, achieve cost efficiencies by using cut and fill practices to allow slab on ground construction. Note: This choice conflicts with desire to minimise sediment erosion from sloping sites.
- Use timber joists with a steel sub-frame (posts and bearers) to achieve a cost-effective raised floor. Alternately, achieve a cost effective raised floor using an elevated concrete slab (i.e. over fill) for raised floors up to a maximum height of 800mm.
- A timber sub-floor is a cost effective option for two-storey dwellings with lightweight construction to the upper-storey. Preferentially provide external living areas at ground level e.g. external paved areas as this is cheaper than providing a raised deck.
- Design decks less than 1m above the ground to avoid incurring increased costs due to requirement for handrails + balustrades.
- Seek to incorporate soft landscaping (lower cost) where possible to reduce spending on provision of hard shading.
- Locate existing housing inclusions e.g. soft landscaping e.g. trellises, carports, utility spaces, and breezeways wisely e.g. along west facing walls to achieve more cost effective external shading of walls and windows.

- Minimise the total capacity of air-conditioning installed in dwellings.
- Avoid installing oversized air-conditioning systems.
- Design homes with smaller internal floor areas offset by larger areas of usable outdoor living spaces thereby reducing the internal floor areas required to be air-conditioned.
- Investigate the feasibility of providing air-conditioning to only some parts of the house, rather than the full house (i.e. design some internal space as a non-air-conditioned zone).
- Implement offsets, to justify the additional expense of providing inverter airconditioners.

Refer To Apendix A For Builder's Report On Affordability and Environmetal Responsiveness

Small one/two bed units provide affordable price points to enter the housing market

BUILDING PERFORMANCE RECOMENDATIONS

AIR CONDITIONING

- Air-condition discrete areas to reduce load.
- Use of energy efficient systems such as inverter.
- Implement offsets, to justify the additional expense of providing inverter airconditioners.
- Minimise the total capacity of air-conditioning installed in dwellings.
- Avoid installing oversized air-conditioning systems. Design homes with smaller internal floor areas offset by larger areas of usable outdoor living spaces thereby reducing the internal floor areas required to be air-conditioned.
- Investigate the feasibility of providing air-conditioning to only some parts of the house, rather than the full house (i.e. design some internal space as a non-air-conditioned zone).
- Many houses in humid tropical regions have some cooled spaces and some naturally ventilated spaces in the same house.
- Living areas tend to be naturally ventilated spaces with ceiling fans and sleeping areas the cooled areas.
- The design of naturally ventilated spaces of such houses should follow the naturally ventilated house guidelines
- Cooled spaces should follow guidelines for cooled and warmed houses.
- Walls separating the naturally ventilated and cooled spaces should be insulated and have doors to limit loss of cooled air.

INSULATION

- Provide insulation to roof and/or ceilings of internal and external spaces. Ideally insulate to 3.5 R-value or better.
- For non air-conditioned living spaces and outdoor areas use reflective roof insulation with a low thermal resistance to upward heat flow to promoterapid cooling of the house after sundown.
- Ensure western walls are insulated and/or fully shaded. For concretemasonry construction, alternative walling materials may be more appropriate for western walls.

WATER

- Use demand management approaches to reduce water consumption across the project as a whole and of individual dwellings.
- Supply or facilitate installation of water efficient landscaping and irrigation.
- Provide for reuse (or future reuse) of greywater.
- Consider the use of non-potable water for irrigation purposes.
- Ensure water recycling efforts are justifiable considering embodied energy.
- Consider rainwater reuse but ensure benefits justify the cost.

ENERGY

- Include smart meters including in-home energy use displays.
- Provide for automatic/remote switching off of electricity using devices.
- Design housing to minimise electricity use by air-conditioning
- Choose high-efficiency air-conditioners and install for maximum energy efficiency.
- Choose energy efficient hot water heating. Locate refrigerators in well-ventilated locations.
- Install vents above and below refrigerators (as practicable); and provide ample space on all sides if built into kitchen cabinetry.
- Ensure that all appliances pre-installed or otherwise achieve an energy efficiency rating of minimum 4-stars.
- Provide external clothes lines to all dwellings
- Provide areas of north facing roof for present or future installation
- of photo-voltaic (PV) panels for solar electricity generation.
- Review material selection and choose materials for reduced. embodied energy and lifecycle impacts.
- Seek carbon credits or have a goal of creating a carbon neutral development.

SOLAR POWER

- Install energy efficient hot water heating systems. Note: Solar water heating is considered the most preferable, although heat pump systems and instantaneous gas also significantly reduce greenhouse emissions compared to electric storage hot water systems.
- In choosing the type of hot water system, consider synergies e.g. availability of gas infrastructure, cooling effect of heat pumps, etc
- Install shared water heating facilities, especially for higher dwelling densities which make the sharing of facilities more attractive.


Solahart

ELASTICITY

BROOME NORTH'S HOUSING WILL REFLECT AND ADAPT TO IT'S CULTURAL AND SOCIAL DIVERSITY. NEW HOUSING, WHETHER SINGLE RESIDENTIAL OR MULTI-RESIDENTIAL, MUST BE ADAPTABLE TO THE DIFFERENT PEOPLE AND FAMILIES THAT LIVE IN BROOME.

ELASTICITY

Broome has a unique confluence of several demographic factors that have made the provision of affordable and appropriate housing difficult since the town was established. Its remote location has always meant housing costs have been high, labour shortages, limited materials and an economy driven by fluctuations in pearl prices have also meant a staggered approach to the development of housing. Concurrent with this is the difficulty of the indigenous population to be adequately housed in dwellings that are robust, suitable and affordable.
A concept which should be considered is that of housing elasticity - whereby the occupation needs of a single dwelling can stretch and contract within tight time frames - visitors staying, friends, seasonal work=forces, tourism and high level of shared accommodation all add to a need for any housing in Broome to be capable of rapid and easy adaptation to a different occupation model.

CULTURAL AND SOCIAL DIVERSITY

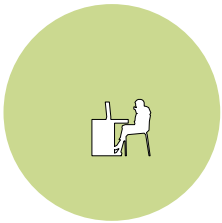
Famed for its cultural diversity during the early pearling decades, the historical ethnic diversity of Broome manifests today as a town in which a varied population lives. This diversity is both cultural and social, with a mix of both ethnic groups and household types.

BROOME DEMOGRAPHICS

The 2006 Australian Bureau of Statistics census, the most resent available information on Broome's demographics, identifies 3,833 households in the area with 2,666 (69.5%) identified as family households. A further 252 identify (6.5%) as group households whilst the remaining 919 (24%) are single person households. The census indicates that family households within the region are varied, with 1,022 (37.1%) couple families without children; 1,081 (39.2%) couple families with children under 15; and the rest divided between single parent families, couples with non-dependant children. The total population, as of 2006, was 14,436 people. 11% of the population is overseas born whilst 31.8% are indigenous Australians.

what kinds of families?
how many kids?
where do they live now?

FAMILY WITH CHILDREN



work and live from home?
mixed use, shop houses

HOME OFFICE

young working couples,
retirees?
who provides the business backbone to broome?

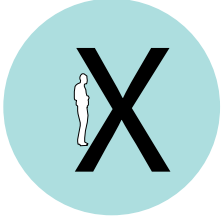
COUPLES

work and live from home?
mixed use, shop houses
key / service workers

SHARED HOUSING

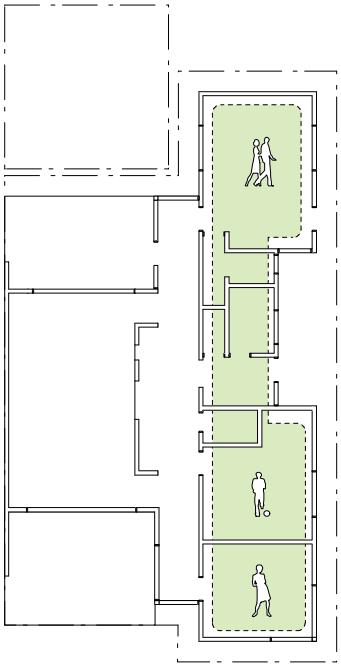
indigenous needs
elasticity in housing demand, one house, one block?

MULTI-FAMILIALGROUPS



sleeping rough
placeless
boarding houses / hostels

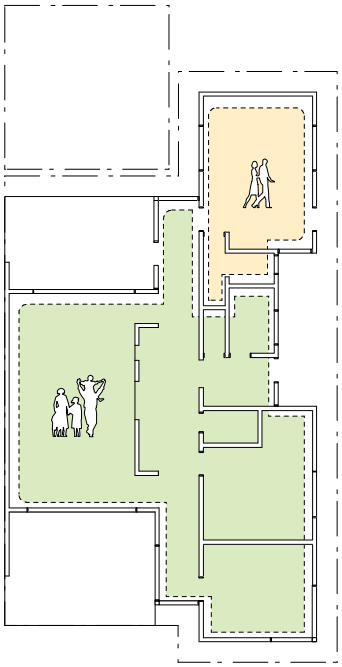
HOMELESS



ADAPTABILITY 1

Family Home

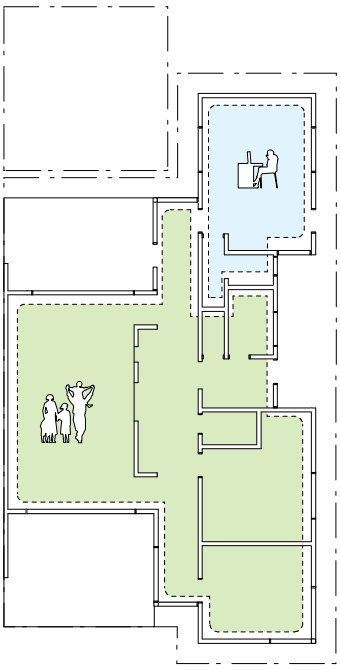
Three bedroom House with extensive outdoor living. Large master bedroom at front includes ensuite, kitchenette and adjacent outdoor living area.



ADAPTABILITY 2

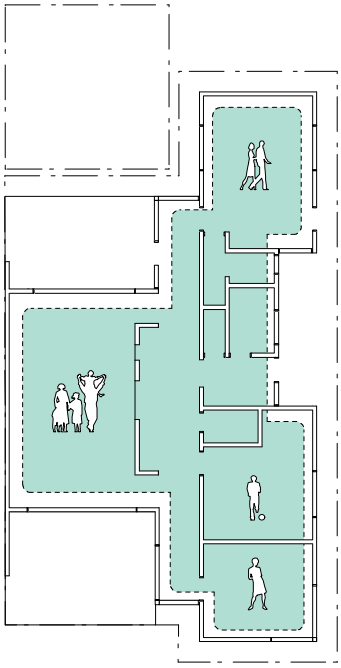
Shared house/Cultural

Self contained room at the front of the house with a separate entry and outdoor space. House responds to shared households and cultural rules by allowing for independence of occupant groups



ADAPTABILITY 3
Live/Work

Fully contained home office at the front of the house with a separate entry, allowing for complete separation of home and work environments.



ADAPTABILITY 4
Extended Family

Mattresses can be taken from the store room and used in the living space (and outdoor decks) when extended family come to stay.

CONVERSATIONS WITH BUILDERS

CODA HAS BEEN TALKING WITH LOCAL BUILDERS, DEVELOPERS, MATERIAL SUPPLIERS AND PRODUCT REPRESENTATIVES TO ESTABLISH THE PREDOMINANT MODES OF CONSTRUCTION, AND GAIN VALUABLE PRACTICAL EXPERIENCE IN DEALING WITH ISSUES OF AFFORDABILITY AND CLIMATE SENSITIVE DESIGN. WE HAVE RECORDED THE PROCESS OF A STANDARD HOUSE CONSTRUCTION, AND NOTED WHAT ELEMENTS CONTRIBUTE TO THE VARIOUS ROADBLOCKS TO BOTH SUSTAINABLE DESIGN PRINCIPLES AND AFFORDABLE HOUSING.

Simple building techniques, along with better house and land integration, a greater awareness of technical know how and an understanding of the Broome lifestyle are all important factors in the design and construction of new housing. Effective, clear and robust design guidelines to help steer pragmatic construction solutions will be required to ensure affordability is met within LandCorp's sustainable vision for Broome North.

In the lead up to the Broome North Planning Forum, CODA visited Broome several times to consult with local builders on a range of topics. The questions were framed in a questionnaire which asked builder to list their experience in relation to :

affordable housing design
roadblcoks to construction
the broome market
materials, techniques and labour
climate response
lot design and type

These responses were minuted and are tabled in Appendix A.

The Shire of Broome require all lots to grade (slope) to the street. This ensures storm water runoff is directed away from the lot, into the road network which acts as the drainage path during rainfall events. The Shire also require that the finished floor level of a house is raised a minimum of 500mm above the crown (high-point) of the adjacent road. These two policies affect the design and delivery of the lot for developers, resulting in removal of vegetation, retaining walls often being required, and a volume of fill being brought in by builders to elevate the concrete pad of the house.

What are the opportunities for leaving vegetation in place on a block? Soil run off and site tops oil erosion could be minimised, but at what cost?
Should the Shire require a deposit to ensure that site's are protected from extensive erosion during construction?
What costs would be involved in building around existing vegetation if it was to be kept to one side of the site?

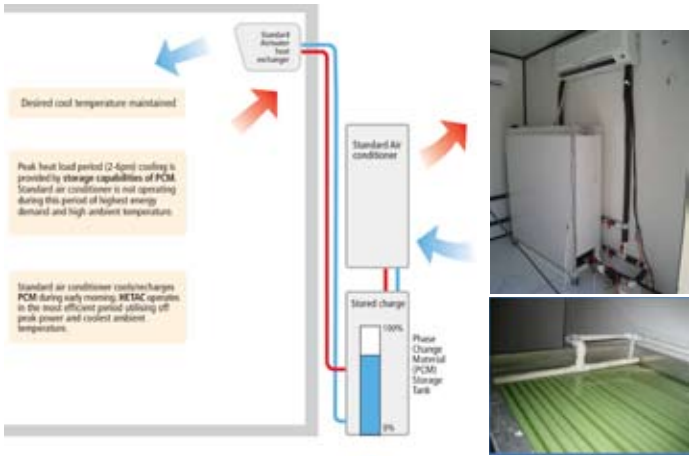
The raised pad can have other effects - the floor level can often be higher than 500mm above 'natural ground' resulting in overlooking issues to neighbouring properties. The disconnection from the garden means stairs are required (adding expense) and universal and disabled access can be compromised. The floor also acts as a large heat sink, and its exposed edges can absorb heat during the day, releasing it slowly at night.

There is potential to employ modular building techniques to meet affordability for certain segments of the market. Steel components could be pre-fabricated in Perth in mass and transported to Broome. Potentially builders could use a combination of prefabricated buildings with local construction. Builders would have to determine the right balance in terms of sustainability, embedded energy, local labour & training. The proportion will inevitably come down to cost. Broome has a natural advantage because the labour force likes living there; construction costs per dwelling are $100,000 less than Karratha.

Typically the walls and roof are pre-fabricated in components off site and brought onto the lot in parts. They are assembled and erected by carpenters. Timber trusses are favoured by most builders for roofing, whilst wall frames are usually steel. This has benefits for termite protection, cyclonic rating and strength, however the thin gauge wall frame cannot be effectively insulated using bulk insulation, and the steel frame requires a thermal break material between the cladding to ensure that heat isn't transferred inside during the hottest parts of the day. The thinner wall also reduces acoustic separation possibilities between rooms, and other neighbouring houses.

The existing labour base of Broome means that this form of construction is by far the most economical system in single residential construction. Recently the supply of wall and roof trusses was stretched to capacity and any growth in the sector may require additional suppliers, or systems to be introduced.

What are the most cost effective ways in which to build walls to two storeys? and shade them?
Is thermal mass (using block work or slabs) appropriate and how can we guide development of these kinds of construction. What complexities and costs are involved in mixed modes of construction.
Is there a future in Broome for reverse brick veneer? What effects has worksafe had on building costs, is there an alternative solution to this?



Future innovations in cooling methods include the HETAC System or overnight cooling.
High Efficiency Thermal Air Conditioning (HETAC) utilises thermal storage capabilities of Phase Change Materials (PCMs) which are environmentally friendly, biodegradable and non toxic materials.
PCMs provide stored energy for cooling during peak heat load period
HETAC cools/recharges the PCM during most efficient period utilising off peak power and low ambient temperature. Overnight Cooling using mechanical or natural ventilation products such as the Monodraught Windcatcher and Condorvent System.

The most common cladding type in Broome is zincalume or colorbond custom-orb cladding.
Brick is not used presently as there are no local brick-makers and a shortage of supply of brick-layers. Reverse brick veneer construction hasn't been trialled effectively in Broome as yet. Core-filled besser blocks are an alternative method of wall construction and can be rendered or left as face. A 3x2 block-work house costs around $350,000 (2009) and rates 6.5 stars.

Breezeways are a logical feature for promoting natural cooling by capturing breezes. A common sentiment of the builders we met with was to ensure the orientation of lots and houses enabled cross-ventilation. It was also noted that the S, S/W breezes were the most cooling and provided benefit to living areas, wet areas and outdoor living.
Picture above shows a Brolga home with breezeway linking bedrooms, and an external laundry space.

The only available alternative cladding to custom-orb is rendered blue-board but due to the complexity and cost of this method it is used mainly for feature walls. This house in old Broome represents a significant departure from any previous Broome styles or techniques.
Parapet walls, minimal wall shading due to height and a lack of interaction with the street - the old Broome verge keeps the house well set back from the street edge.

Several multi residential housing projects have been built in recent years. This project is a modern take on Broome housing - there may be some benefit to passive cooling with multiple residential designs, with the lower floors being shielded from heat build up. Effective screening, shading and privacy devices have been employed here to minimise heat gain on the external street facing walls.

The choice of finishes can significantly impact the affordability of a building. From our conversations the range of square metre rates varied from $1800-4000/m2 (2009) depending on wall height, finishes and complexity. These rates are inclusive of everything except landscaping this option is preferred by clients as it is quicker and easier. Phase change materials were suggested as an alternative wall lining for cooling.

In Broome external living areas are typically finished with Batu decking, an area for possible cost reductions is to use concrete deck as an alternative. Eaves are often lined in ply or villaboard and painted, using colorbond eaves can reduce painting areas and bring down costs. Carpet is the cheapest floor covering, $40/m2 and tiles are also more affordable at $110/m2. (2009) Polished concrete has potential as an affordable alternative floor finish and could be pushed but it is hard to get a good finish.

Typically the landscaping contract will be completed separately to the building contract. Owners often plant out their gardens with lawn and exotic tropical species. The reduction of lawns is preferable in terms of water saving but drainage must be carefully managed, the retention and planting of native vegetation should be promoted as it aids in the filtration of storm water. Planting aids in cooling breezes before they enter a house, and provide shade to roof and wall areas that would be impossible through fixed shading devices such as awnings and eaves.

What is the market acceptance of housing that is specifically tailored for the Broome climate?
Are there enough buyers out there interested in modern housing that accepts the concepts of outdoor living, breeze capture and passive cooling. This house, although full of clever climate ideas, has little interaction with the street, and minimal opportunity for enjoying the front garden.

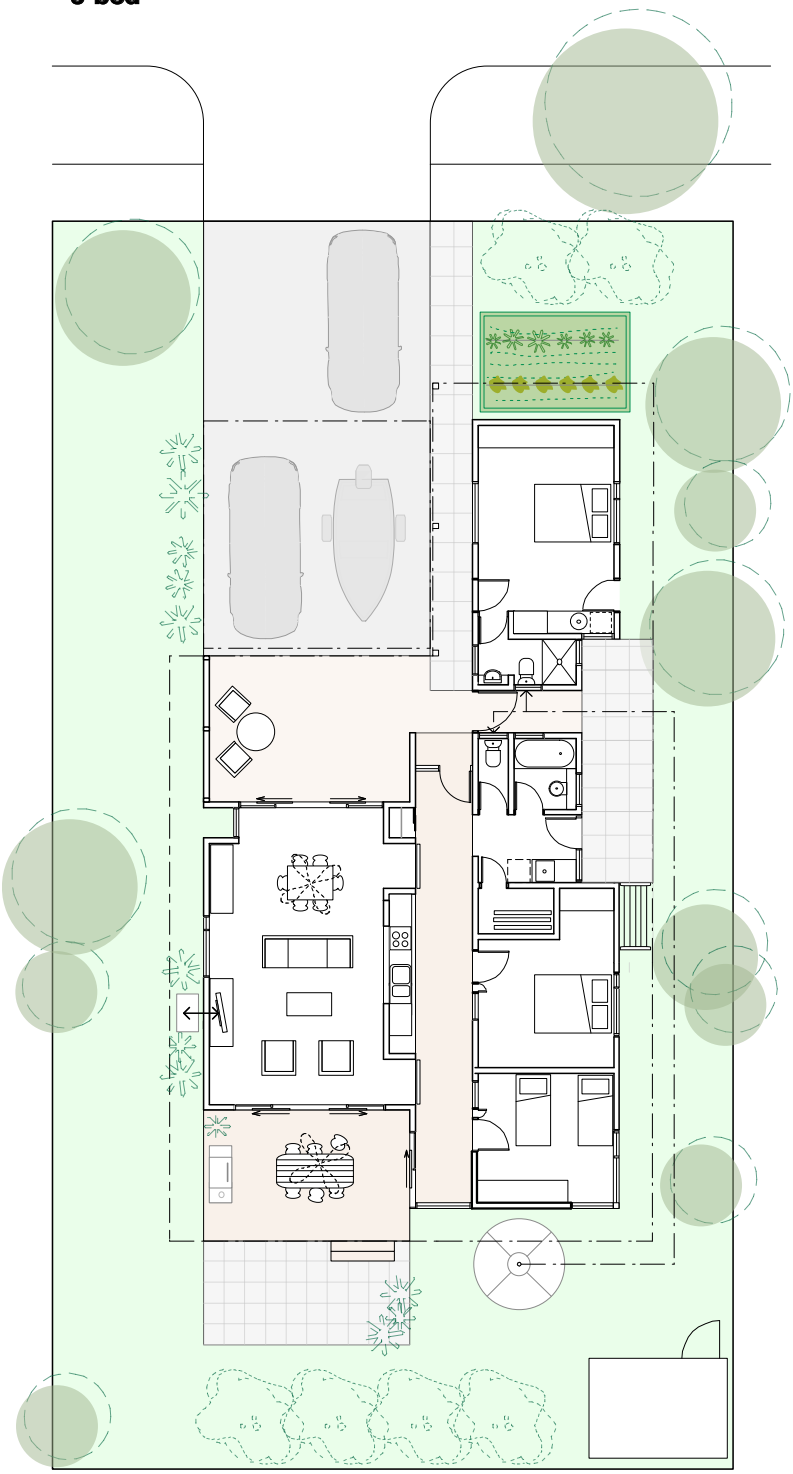
HOUSING TYPOLOGIES

KEY OBJECTIVE

To provide solutions to dwelling typologies for Broome with sustainable passive design performances at affordable prices for the housing market that can respond to the demands of the housing mix now and in the future

HOUSE TYPE 1

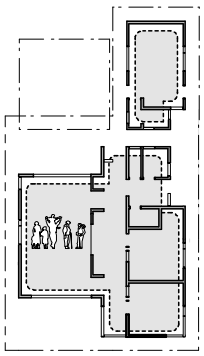
Young parents, two children and live-in Grandparents in self contained unit
3 bed



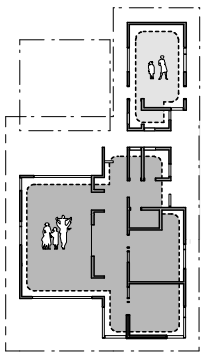
HOUSE AREA :
Gross internal: 142 sqm
Covered outdoor living: 37 sqm

0 1 2 5

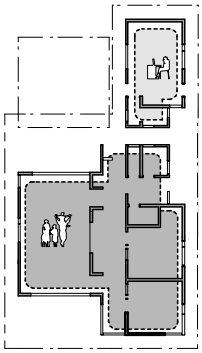
Scale 1:200



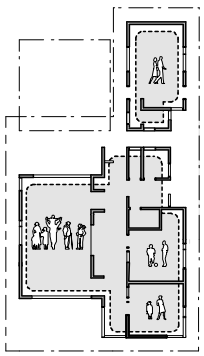
ADAPTABILITY 1
Family Home:
Three bedroom house with extensive outdoor living. Large master bedroom at front includes ensuite, ktichenette and adjacent outdoor living area.



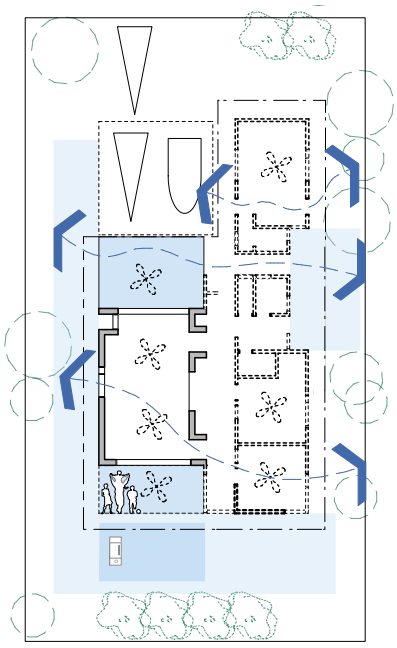
ADAPTABILITY 2
Shared house/Cultural:
Self contained room at the front of the house with a seperate entry and outdoor space. House responds to shared households and cultural rules by allowing for independence of occupant groups



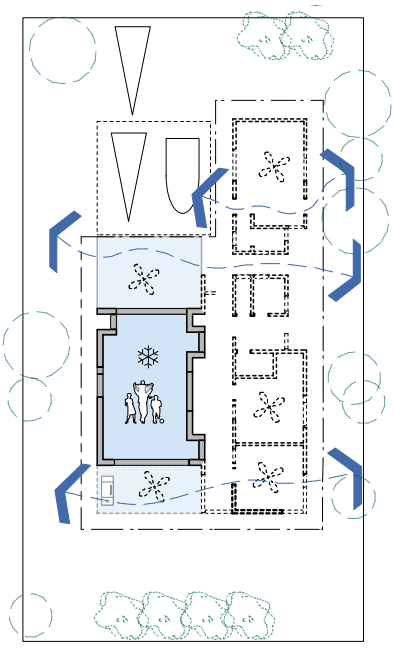
ADAPTABILITY 3
Live/Work:
Fully contained home office at the front of the house with a seperate entry, allowing for complete seperation of home and work environments.



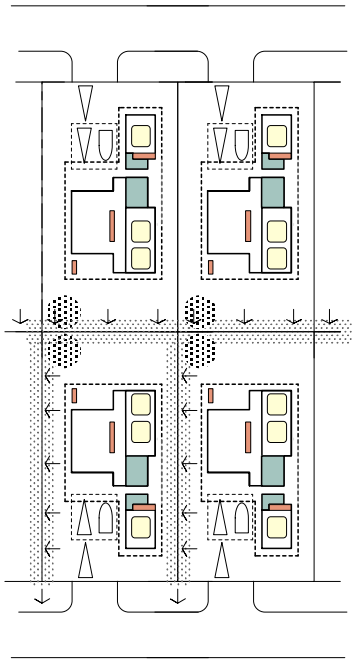
ADAPTABILITY 4
Extended Family:
Mattresses can be taken from the store room and used in the living space (and outdoor decks) when extended family come to stay



OPERABILITY-
DRY SEASON
Living spills outdoors to the north and south. Central breeze-way and sleeping wing open up for maximum ventilation.
Outdoor cooking.



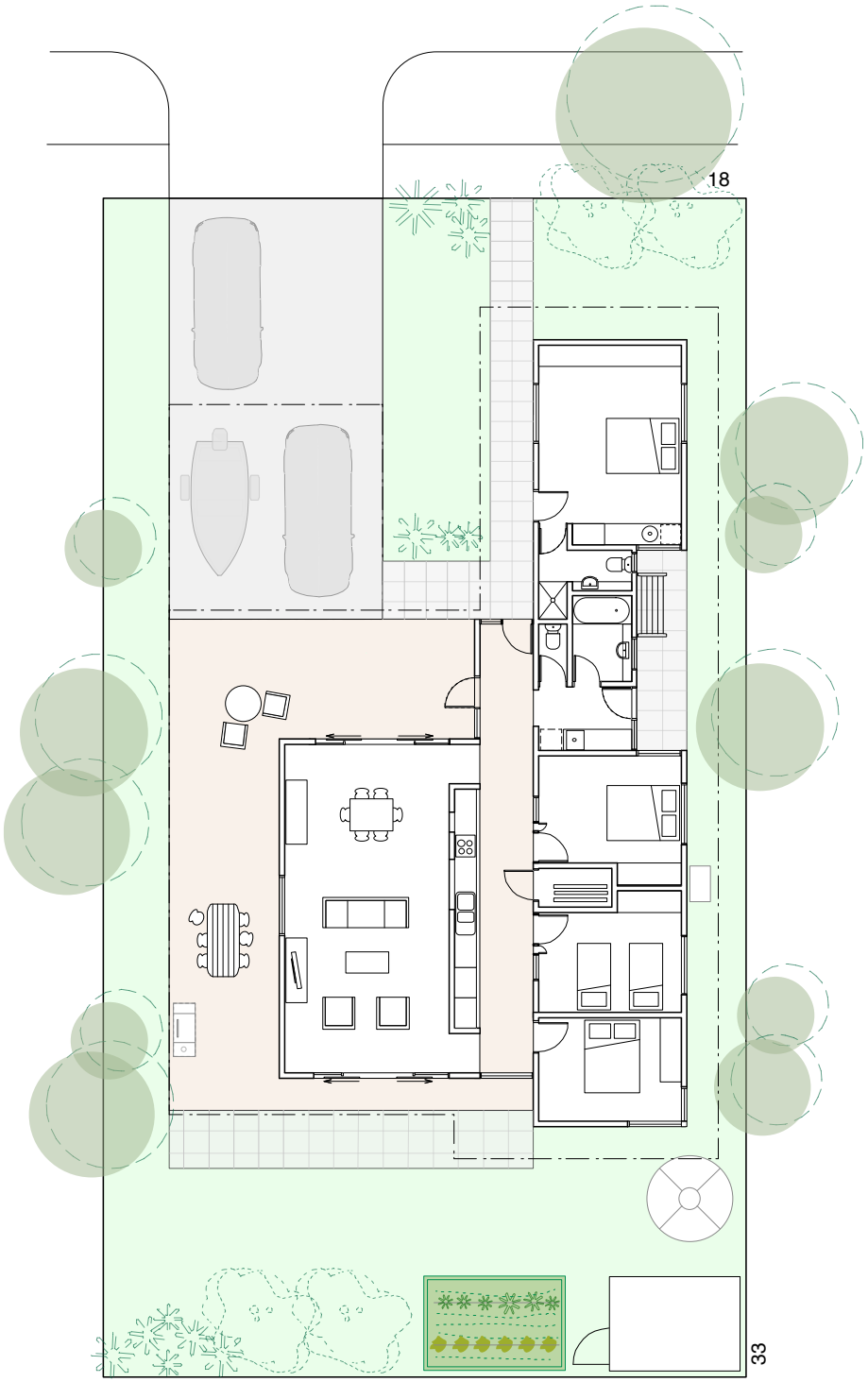
OPERABILITY-
WET SEASON
Living retreats to the air-conditioned core.
Ventilation still provides some relief.
Covered outdoor cooking.



LOT DRAINAGE
Drainage of subdivision follows land gradient wherever possible
Each lot required to have 3% of lot area allocated as a rain garden
Drainage of lot falls to side or rear before discharging to road system
Drainage aligns with breezepaths where possible

HOUSE TYPE 2

Share house: Couple with 3 children and working couple in self contained unit
4 bed

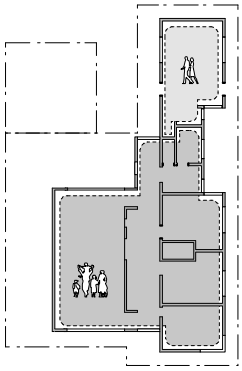


HOUSE AREA :
Gross internal: 166 sqm
Covered outdoor living: 60 sqm

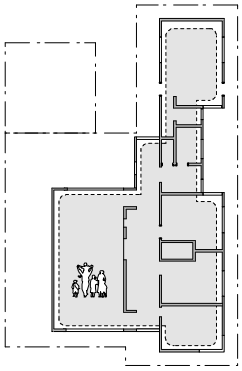
LOT AREA: 594 sqm

0 1 2 5

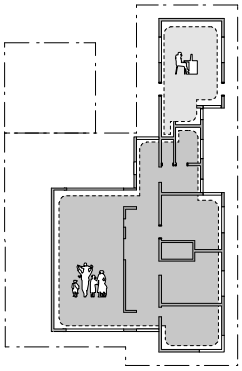
Scale 1:200



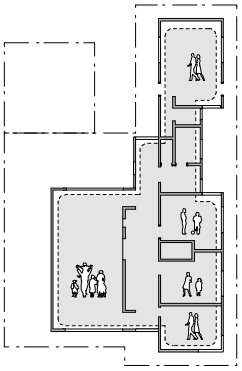
ADAPTABILITY 1
Shared house/Cultural:
Self contained room at the front of the house with a seperate entry and outdoor space. House responds to shared households and cultural rules by allowing for independence of occupant groups



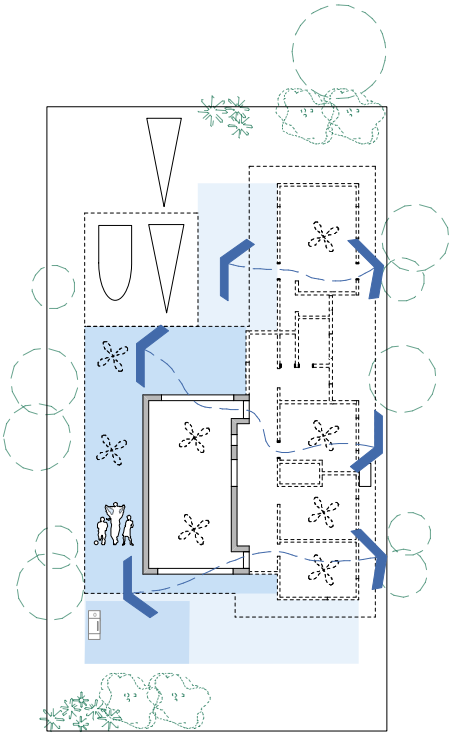
ADAPTABILITY 2
Family Home:
Four bedroom house with extensive outdoor living. Large master bedroom at front includes ensuite, ktichenette and adjacent outdoor living area.



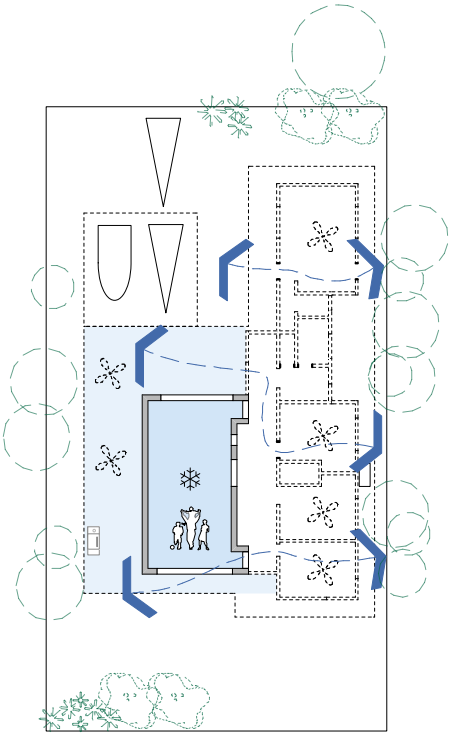
ADAPTABILITY 3
Live/Work:
Fully contained home office at the front of the house with a seperate entry, allowing for complete seperation of home and work environments.



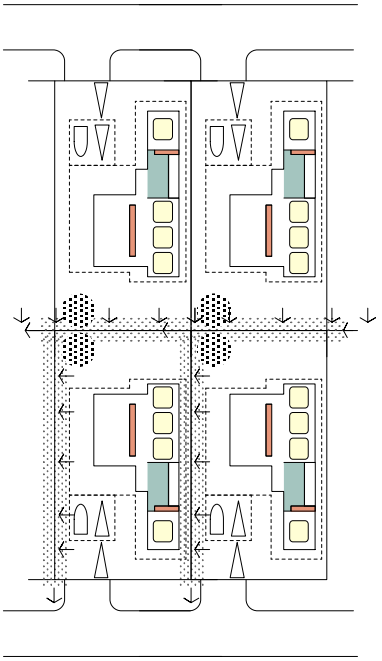
ADAPTABILITY 4
Extended Family:
Mattresses can be taken from the store room and used in the living space (and outdoor decks) when extended family come to stay



OPERABILITY-
DRY SEASON
Living spills outdoors to the south and east. Central breeze-way and sleeping wing open up for maximum ventilation. Outdoor cooking.



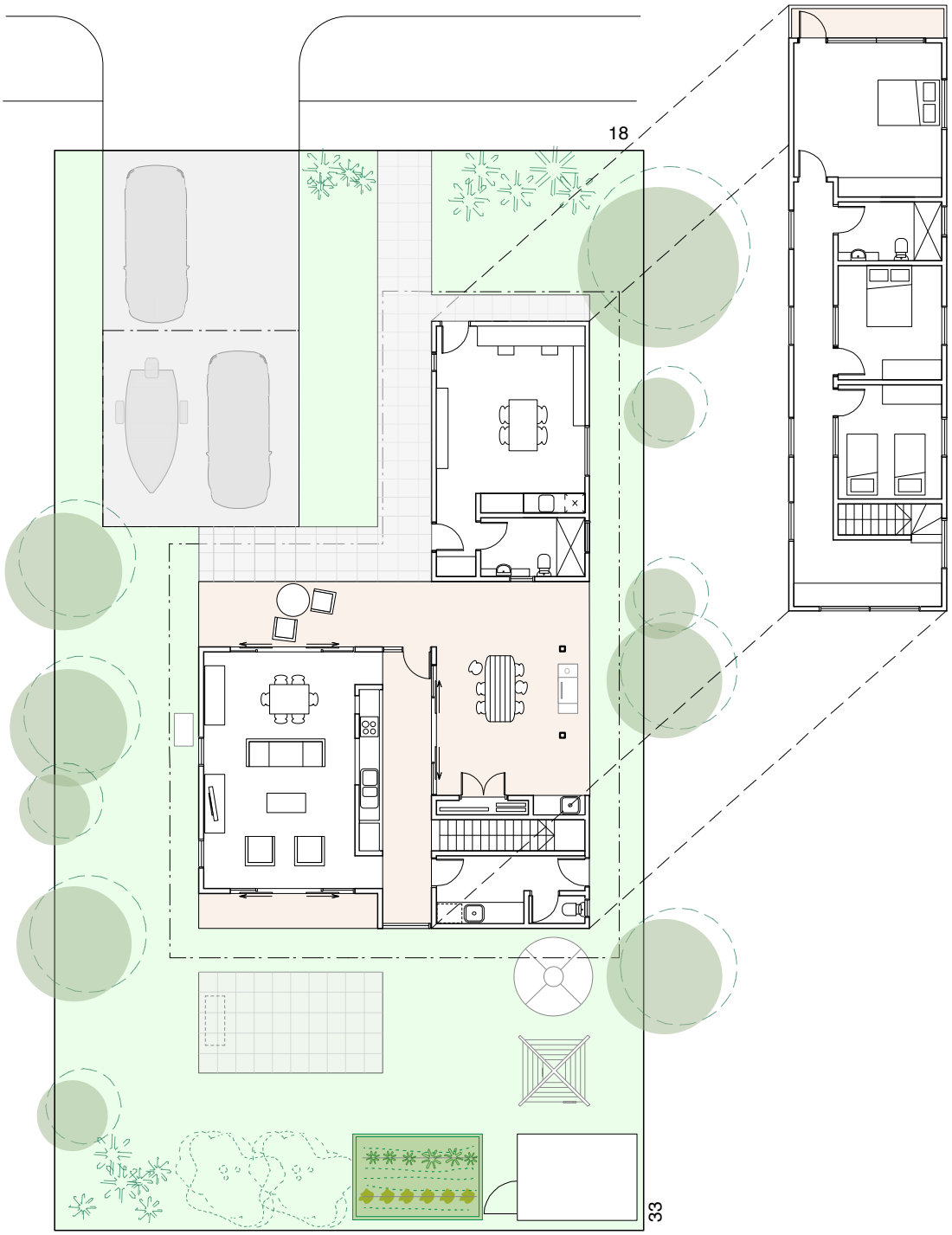
OPERABILITY-
WET SEASON
Living retreats to the air-conditioned core. Ventilation still provides some relief. Covered outdoor cooking.



LOT DRAINAGE
Drainage of subdivision follows land gradient wherever possible
Each lot required to have 3% of lot area allocated as a rain garden
Drainage of lot falls to side or rear before discharging to road system
Drainage aligns with breezepaths where possible

HOUSE TYPE 3

Couple with extended family and self contained home office
4 bed

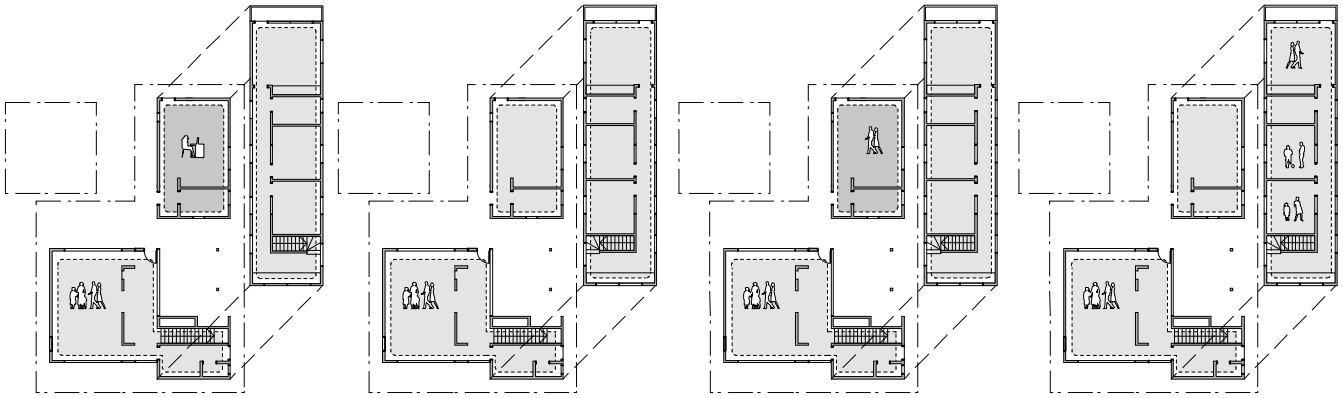


HOUSE AREA :
Gross internal: 220 sqm
Covered outdoor living: 41 sqm

LOT AREA: 594 sqm

0 1 2 5

Scale 1:200

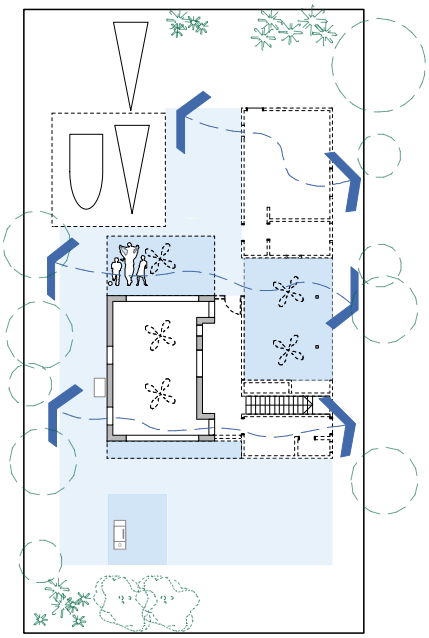


ADAPTABILITY 1
Live/Work:
Fully contained home office at the front of the house with a seperate entry, allowing for complete seperation of home and work environments.

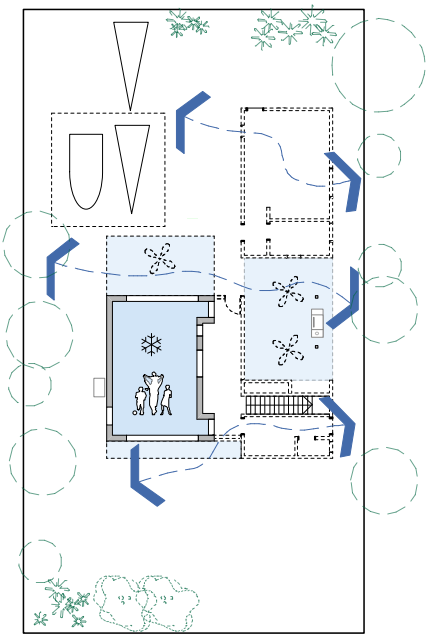
ADAPTABILITY 2
Family Home:
Four bedroom house with extensive outdoor living. Large master bedroom at front includes ensuite, ktichenette and adjacent outdoor living area.

ADAPTABILITY 3
Shared house/Cultural:
Self contained room at the front of the house with a seperate entry and outdoor space. House responds to shared households and cultural rules by allowing for independence of occupant groups

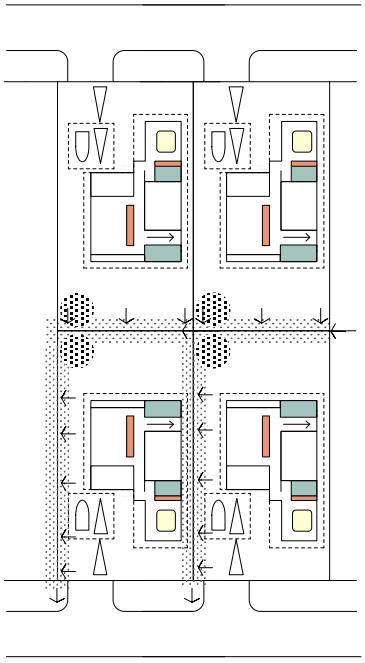
ADAPTABILITY 4
Extended Family:
Mattresses can be taken from the store room and used in the living space (and outdoor decks) when extended family come to stay



OPERABILITY-
DRY SEASON
Living spills outdoors to the north and south. Central breeze-way and sleeping wing open up for maximum ventilation.
Outdoor cooking.



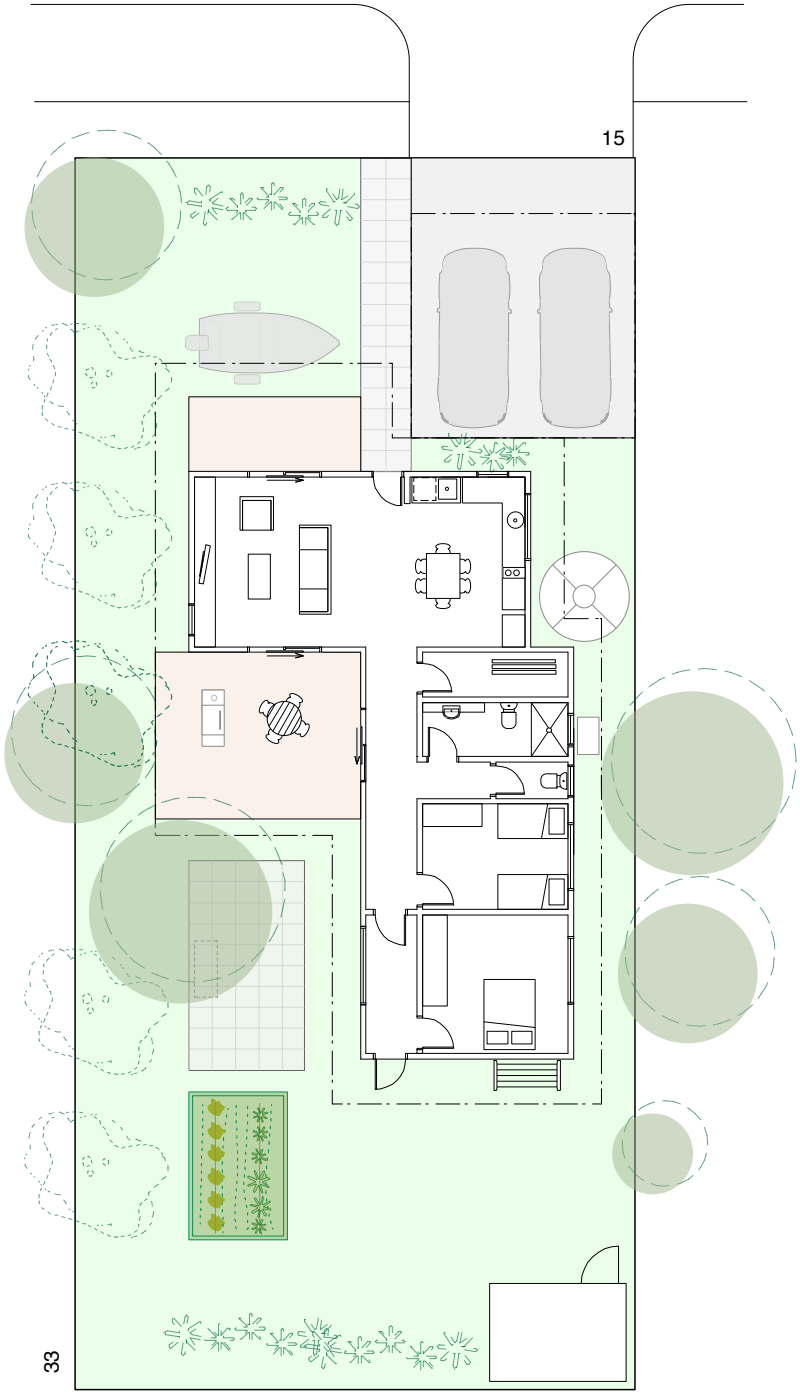
OPERABILITY-
WET SEASON
Living retreats to the air-conditioned core.
Ventilation still provides some relief.
Covered outdoor cooking.



LOT DRAINAGE
Drainage of subdivision follows land gradient wherever possible
Each lot required to have 3% of lot area allocated as a rain garden
Drainage of lot falls to side or rear before discharging to road system
Drainage aligns with breezepaths where possible

HOUSE TYPE 4

Working couple and extended family
2 bed

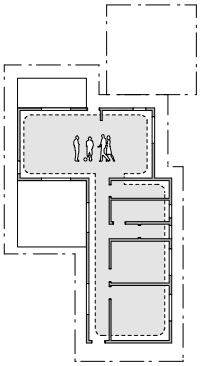


HOUSE AREA :
Gross internal: 106 sqm
Covered outdoor living: 29 sqm

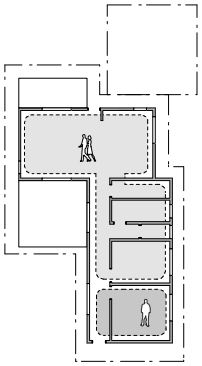
LOT AREA: 495 sqm

0 1 2 5

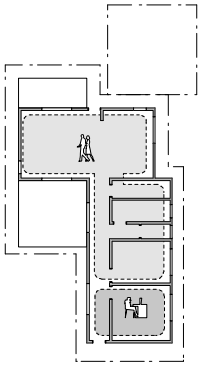
Scale 1:200



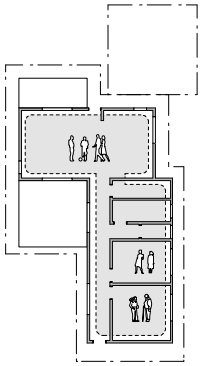
ADAPTABILITY 1
Family Home:
Two bedroom house with extensive outdoor living.



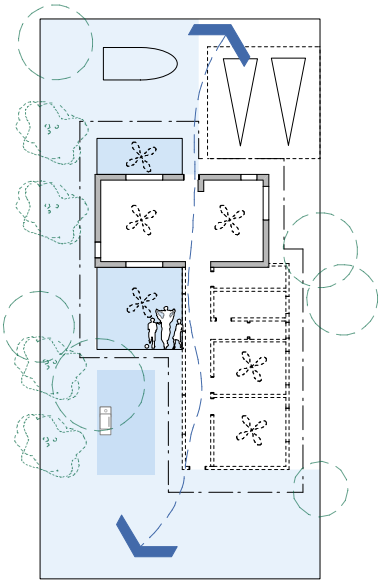
ADAPTABILITY 2
Shared house/Cultural:
Semi-private room at the rear of the house with a seperate entry and outdoor space. House responds to shared households and cultural rules by allowing for independence of occupant groups



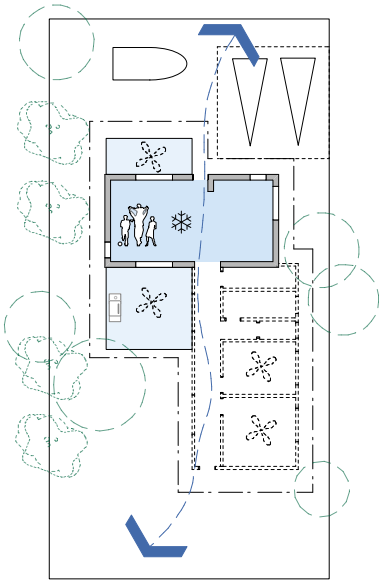
ADAPTABILITY 3
Live/Work:
Semi-private home office at the rear of the house with a seperate entry, allowing for complete seperation of home and work environments.



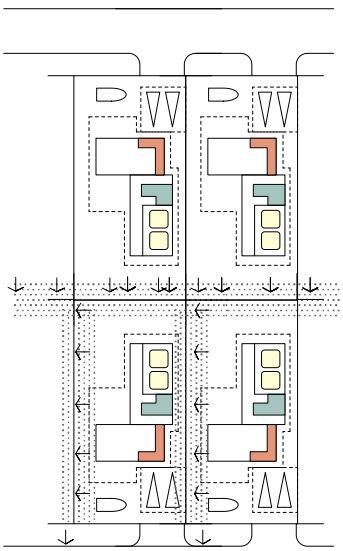
ADAPTABILITY 4
Extended Family:
Mattresses can be taken from the store room and used in the living space (and outdoor decks) when extended family come to stay



OPERABILITY-
DRY SEASON
Living spills outdoors to the north and east. Central breeze-way and sleeping wing open up for maximum ventilation. Outdoor cooking.



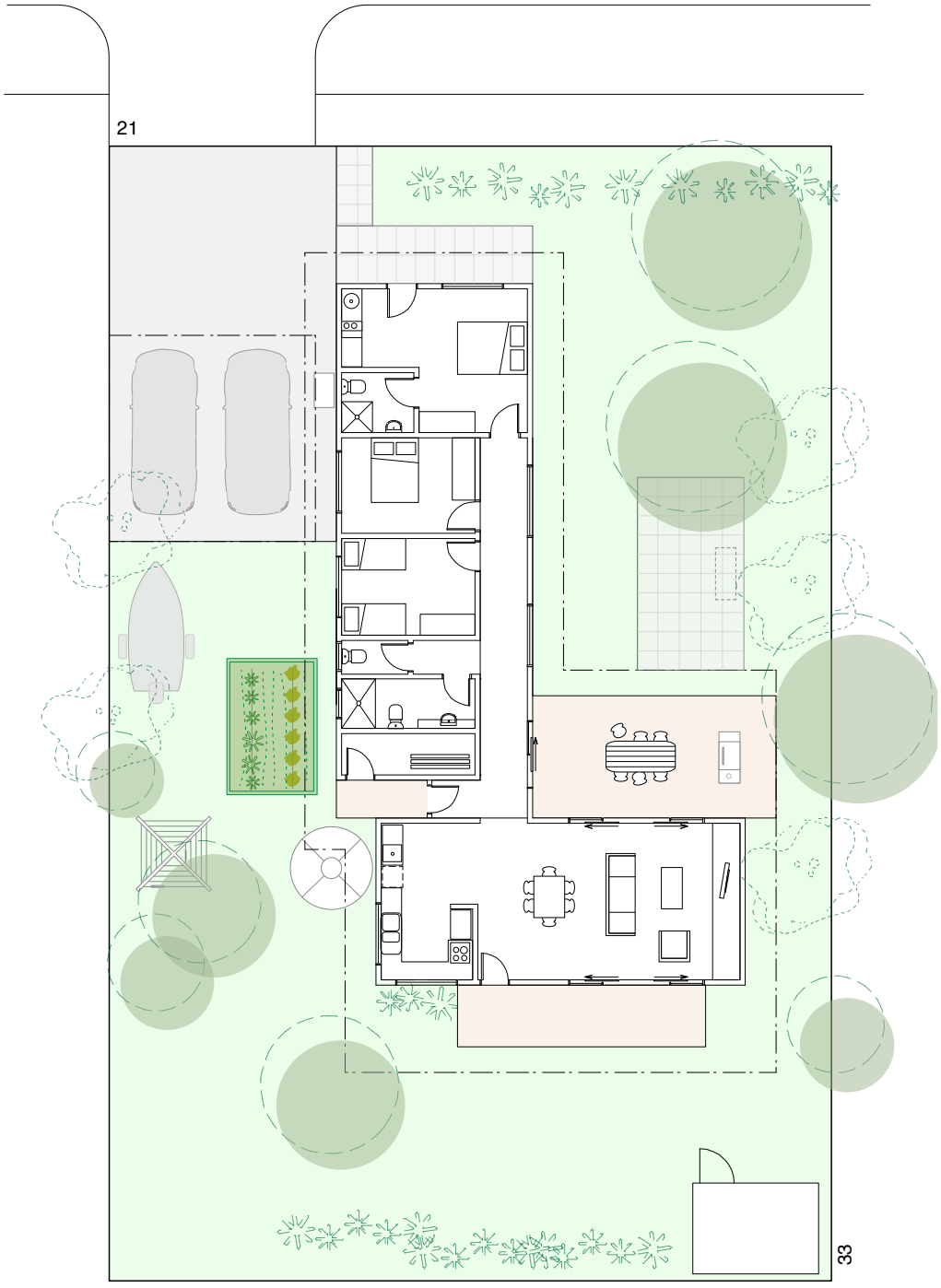
OPERABILITY-
WET SEASON
Living retreats to the air-conditioned core. Ventilation still provides some relief. Covered outdoor cooking.



LOT DRAINAGE
Drainage of subdivision follows land gradient wherever possible
Each lot required to have 3% of lot area allocated as a rain garden
Drainage of lot falls to side or rear before discharging to road system
Drainage aligns with breezepaths where possible

HOUSE TYPE 5

Single parent with two children and single worker in self contained unit
3 bed

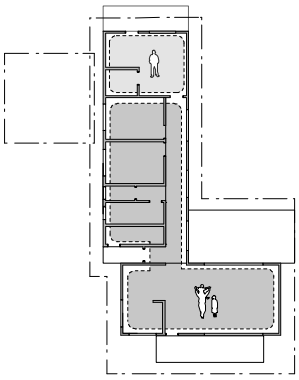


HOUSE AREA :
Gross internal: 138 sqm
Covered outdoor living: 38 sqm

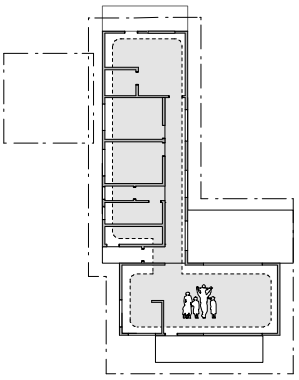
LOT AREA: 630 sqm

0 1 2 5

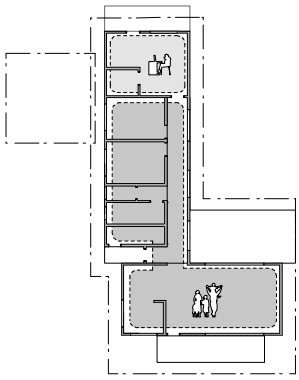
Scale 1:200



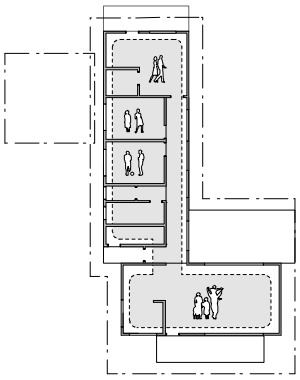
ADAPTABILITY 1
Shared house/Cultural:
Self contained room at the rear of the house with a seperate entry and outdoor space. House responds to shared households and cultural rules by allowing for independence of occupant groups



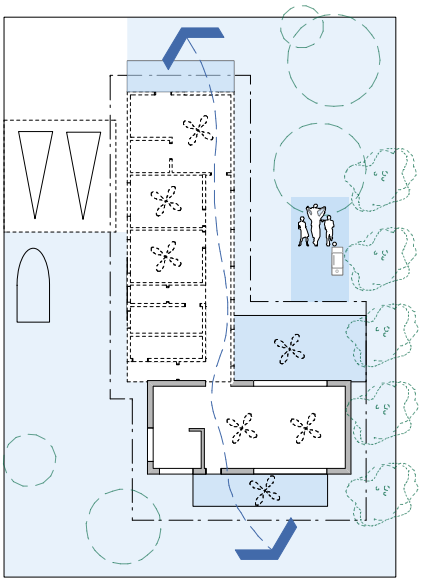
ADAPTABILITY 2
Family Home:
Three bedroom house with extensive outdoor living. Large master bedroom at rear includes ensuite, ktichenette and adjacent outdoor living area.



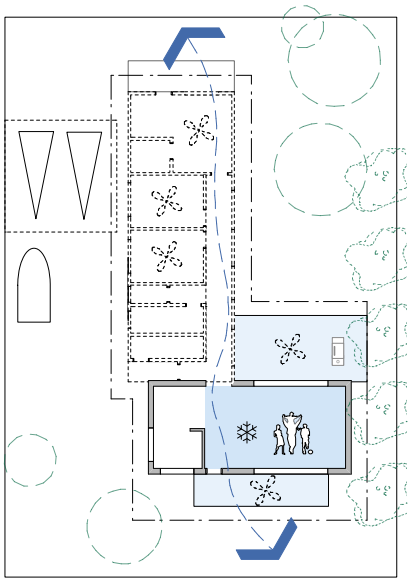
ADAPTABILITY 3
Live/Work:
Fully contained home office at the rear of the house with a seperate entry, allowing for complete seperation of home and work environments.



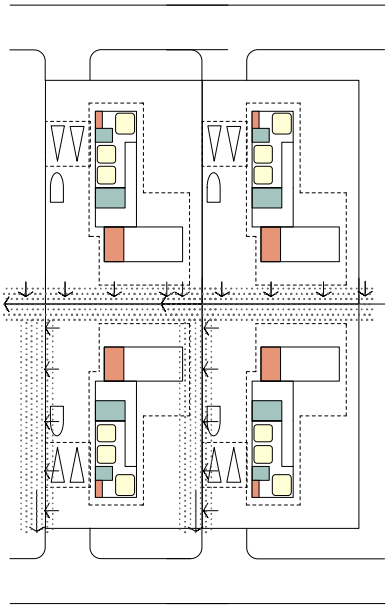
ADAPTABILITY 4
Extended Family:
Mattresses can be taken from the store room and used in the living space (and outdoor decks) when extended family come to stay



OPERABILITY-
DRY SEASON
Living spills outdoors to the north and east. Central breeze-way and sleeping wing open up for maximum ventilation. Outdoor cooking.



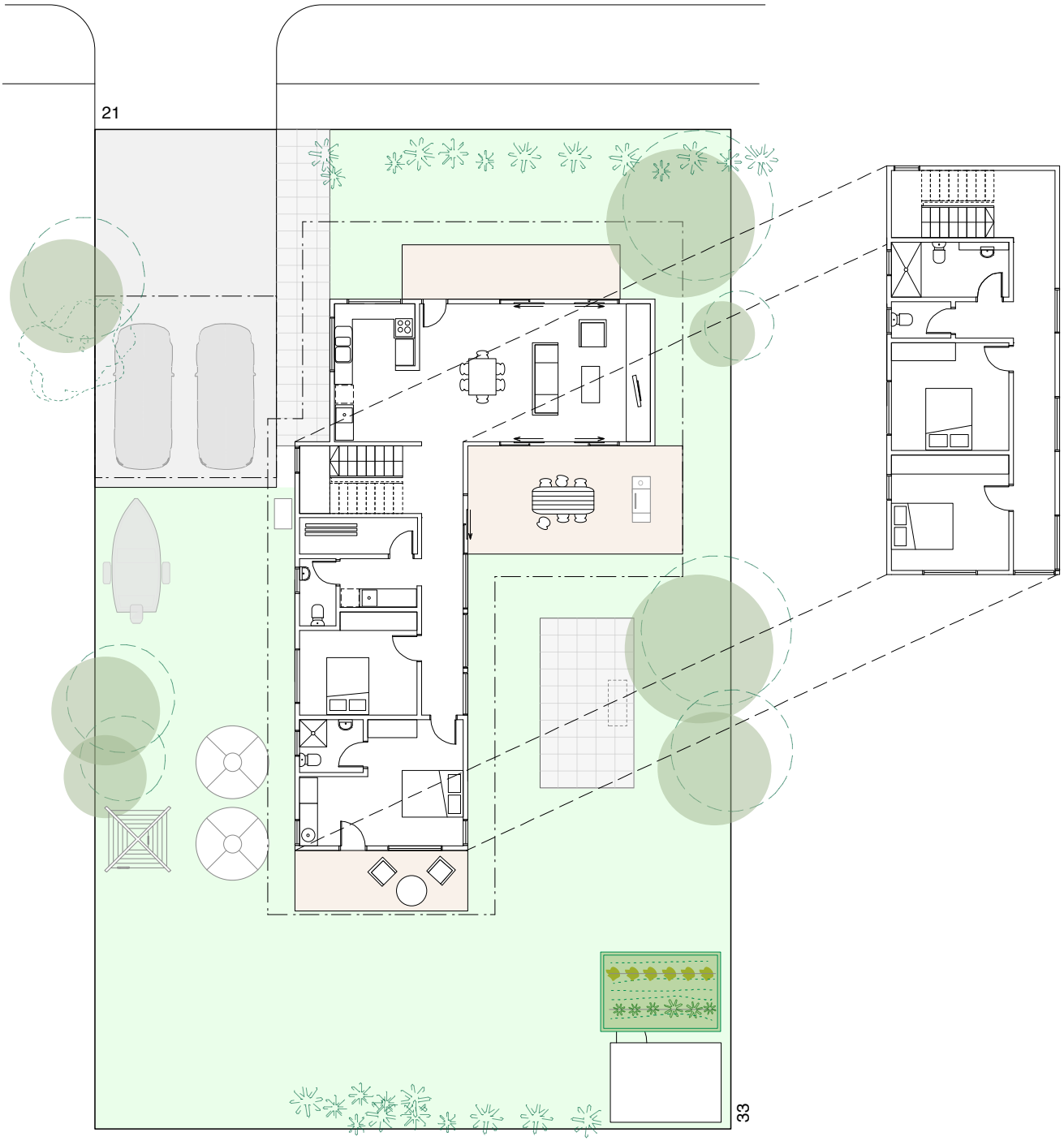
OPERABILITY-
WET SEASON
Living retreats to the air-conditioned core. Ventilation still provides some relief. Covered outdoor cooking.



LOT DRAINAGE
Drainage of subdivision follows land gradient wherever possible
Each lot required to have 3% of lot area allocated as a rain garden
Drainage of lot falls to side or rear before discharging to road system
Drainage aligns with breezepaths where possible

HOUSE TYPE 6

Couple with four children and working couple in self contained unit
4 bed

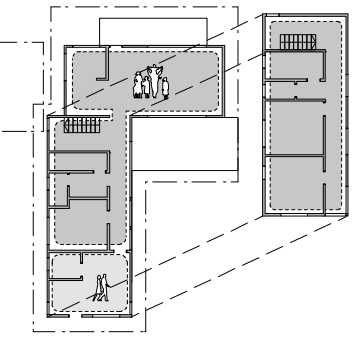


HOUSE AREA :
Gross internal: 205 sqm
Covered outdoor living: 49 sqm

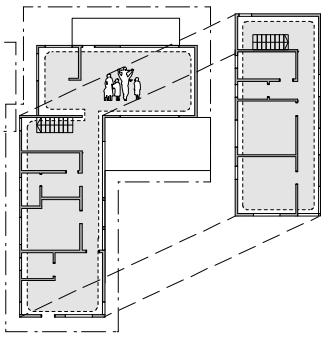
LOT AREA: 693 sqm

0 1 2 5

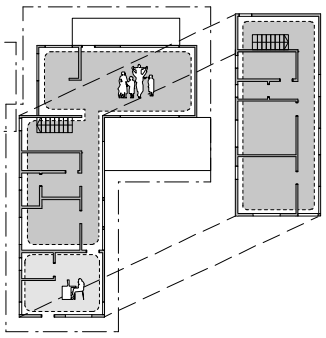
Scale 1:200



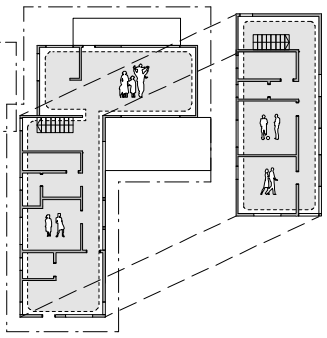
ADAPTABILITY 1
Shared house/Cultural:
Self contained room at the rear of the house with a seperate entry and outdoor space. House responds to shared households and cultural rules by allowing for independence of occupant groups



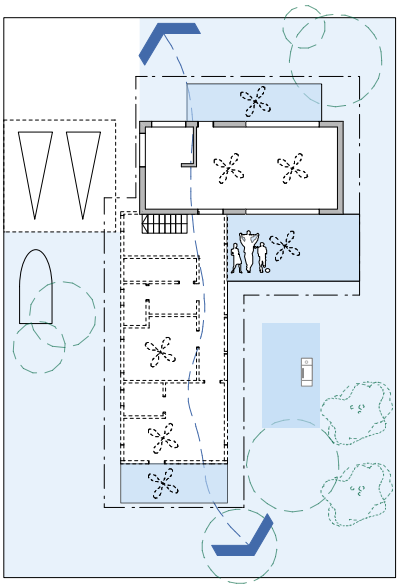
ADAPTABILITY 2
Family Home:
Four bedroom house with extensive outdoor living. Large master bedroom at rear includes ensuite, ktichenette and adjacent outdoor living area.



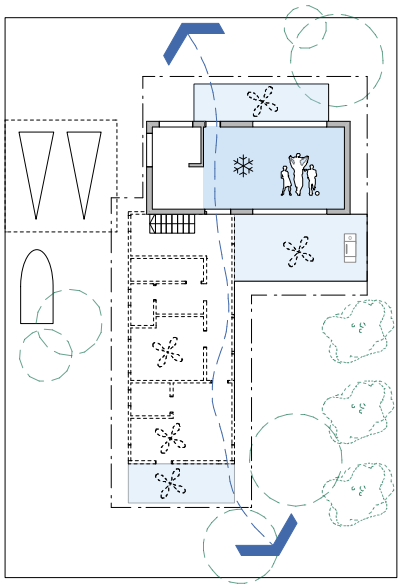
ADAPTABILITY 3
Live/Work:
Fully contained home office at the rear of the house with a seperate entry, allowing for complete seperation of home and work environments.



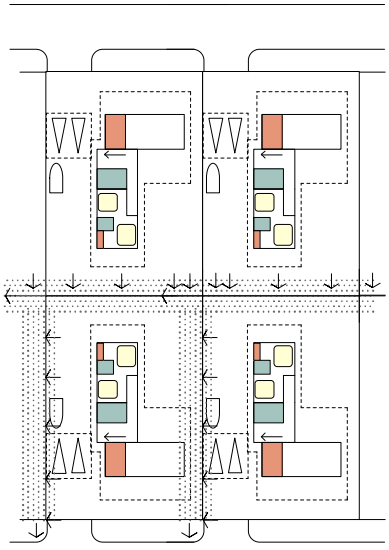
ADAPTABILITY 4
Extended Family:
Mattresses can be taken from the store room and used in the living space (and outdoor decks) when extended family come to stay



OPERABILITY-
DRY SEASON
Living spills outdoors to the north and east. Central breeze-way and sleeping wing open up for maximum ventilation. Outdoor cooking.

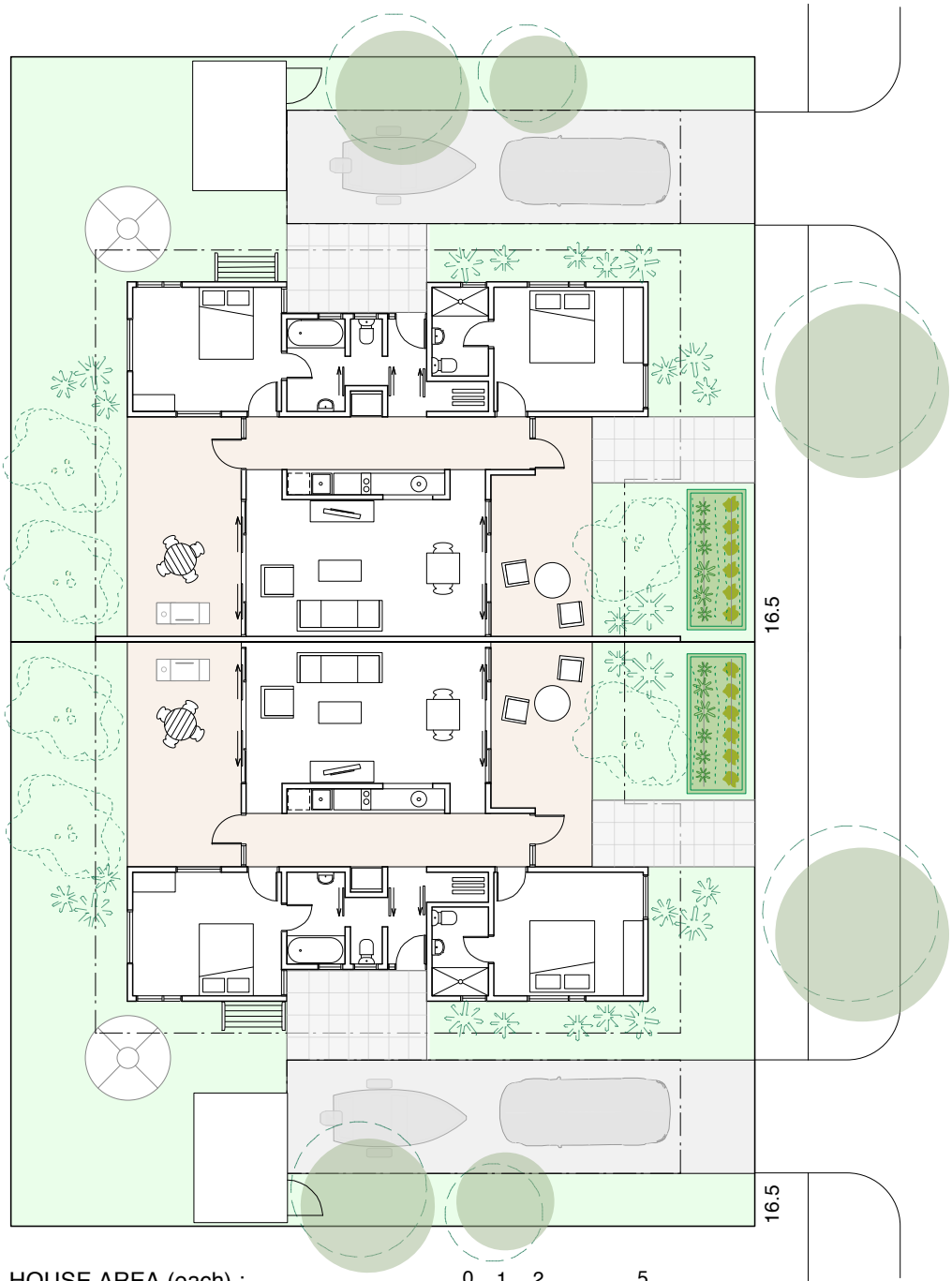


OPERABILITY-
WET SEASON
Living retreats to the air-conditioned core. Ventilation still provides some relief. Covered outdoor cooking.



LOT DRAINAGE
Drainage of subdivision follows land gradient wherever possible
Each lot required to have 3% of lot area allocated as a rain garden
Drainage of lot falls to side or rear before discharging to road system
Drainage aligns with breezepaths where possible

HOUSE TYPE 7 - Duplex
Two single workers (x 2)
2 bed (x 2)

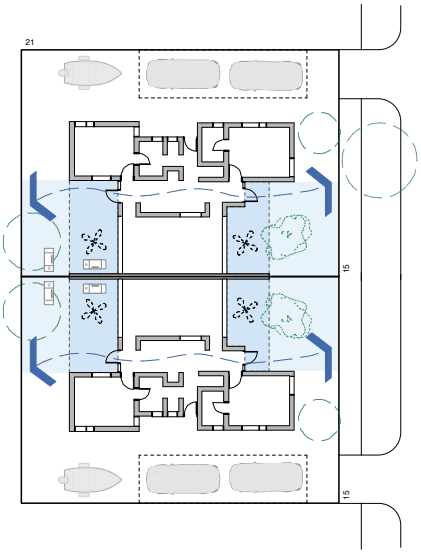


HOUSE AREA (each) :
Gross internal: 100 sqm
Covered outdoor living: 35 sqm

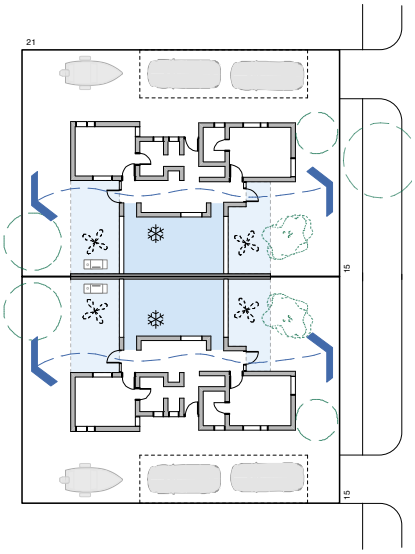
LOT AREA: 2 x 315 sqm

0 1 2 5

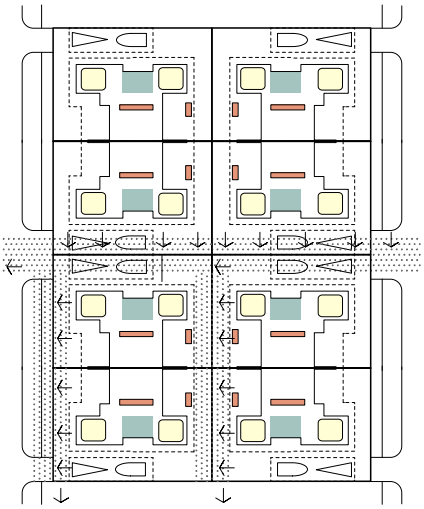
Scale 1:200



OPERABILITY- DRY SEASON
Living spills outdoors to the north and south. Central breeze-way and sleeping wing open up for maximum ventilation

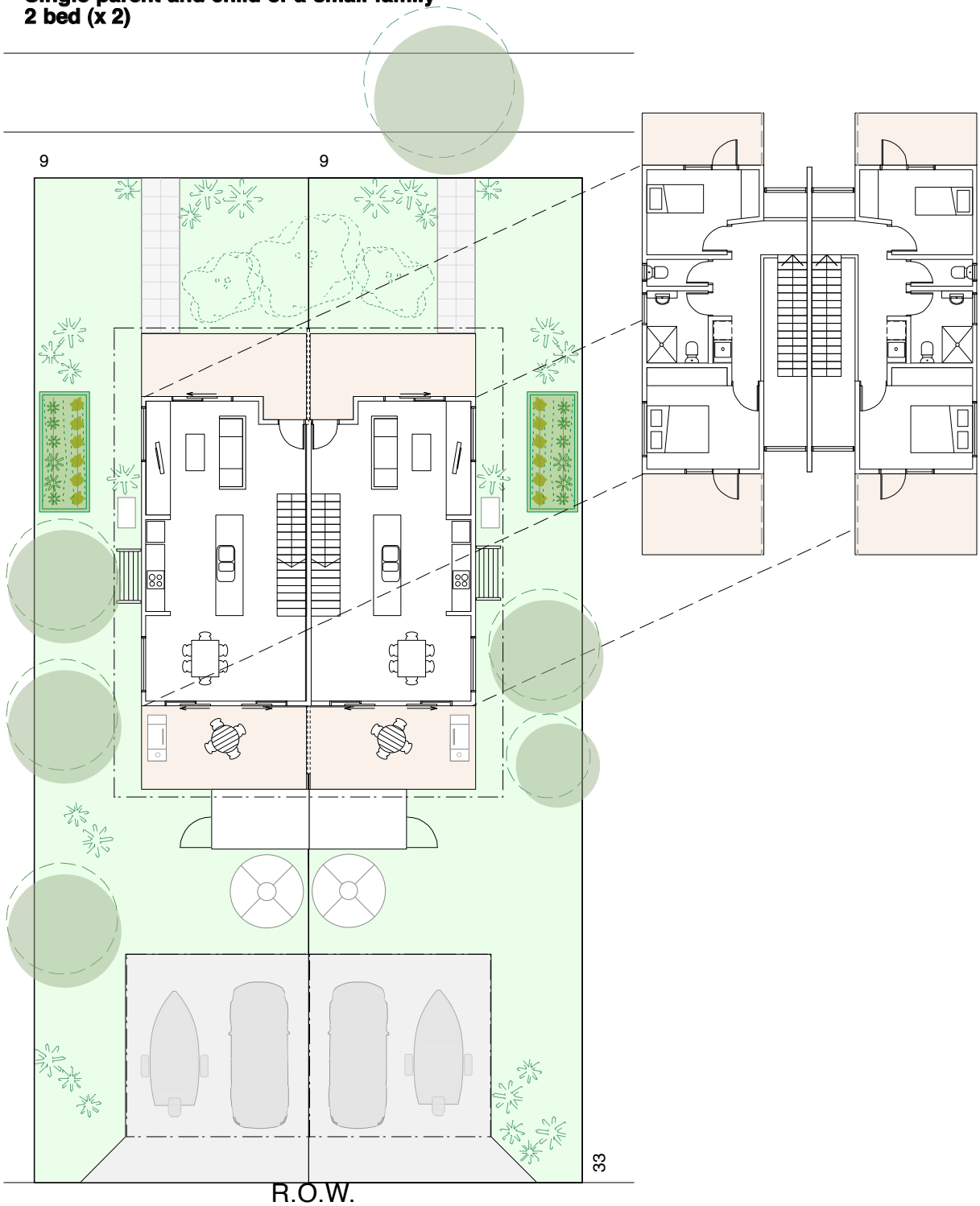


OPERABILITY- WET SEASON
Living retreats to the air-conditioned core. Ventilation still provides some relief



LOT DRAINAGE
Drainage of subdivision follows land gradient wherever possible
Each lot required to have 3% of lot area allocated as a rain garden
Drainage of lot falls to side or rear before discharging to road system
Drainage aligns with breezepaths where possible

HOUSE TYPE 8 - Duplex
Single parent and child or a small family
2 bed (x 2)

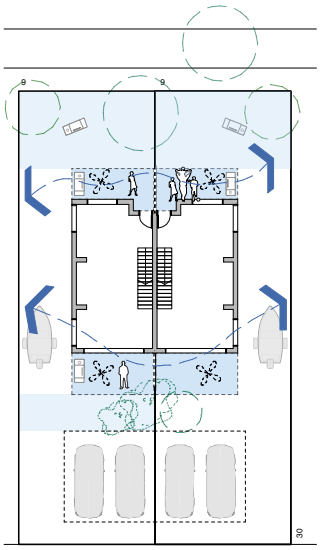


HOUSE AREA (each) :
Gross internal: 106 sqm
Covered outdoor living: 43 sqm

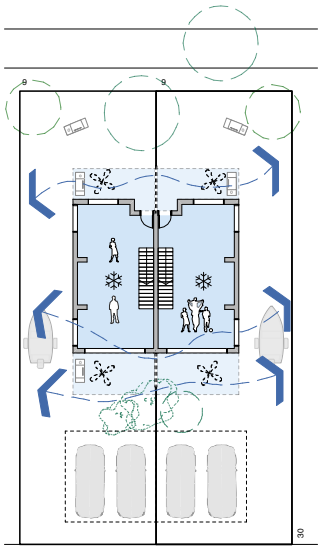
LOT AREA: 2 x 270 sqm

0 1 2 5

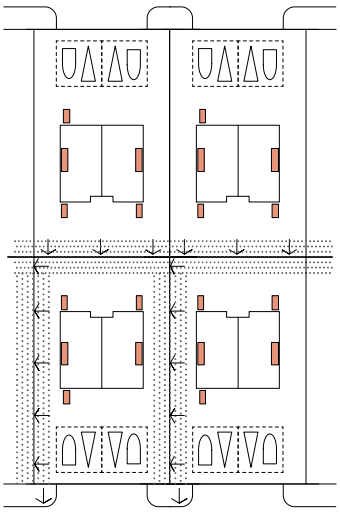
Scale 1:200



OPERABILITY- DRY SEASON
Living spills outdoors to the north and south.
Central breeze-way and sleeping wing open up for maximum ventilation



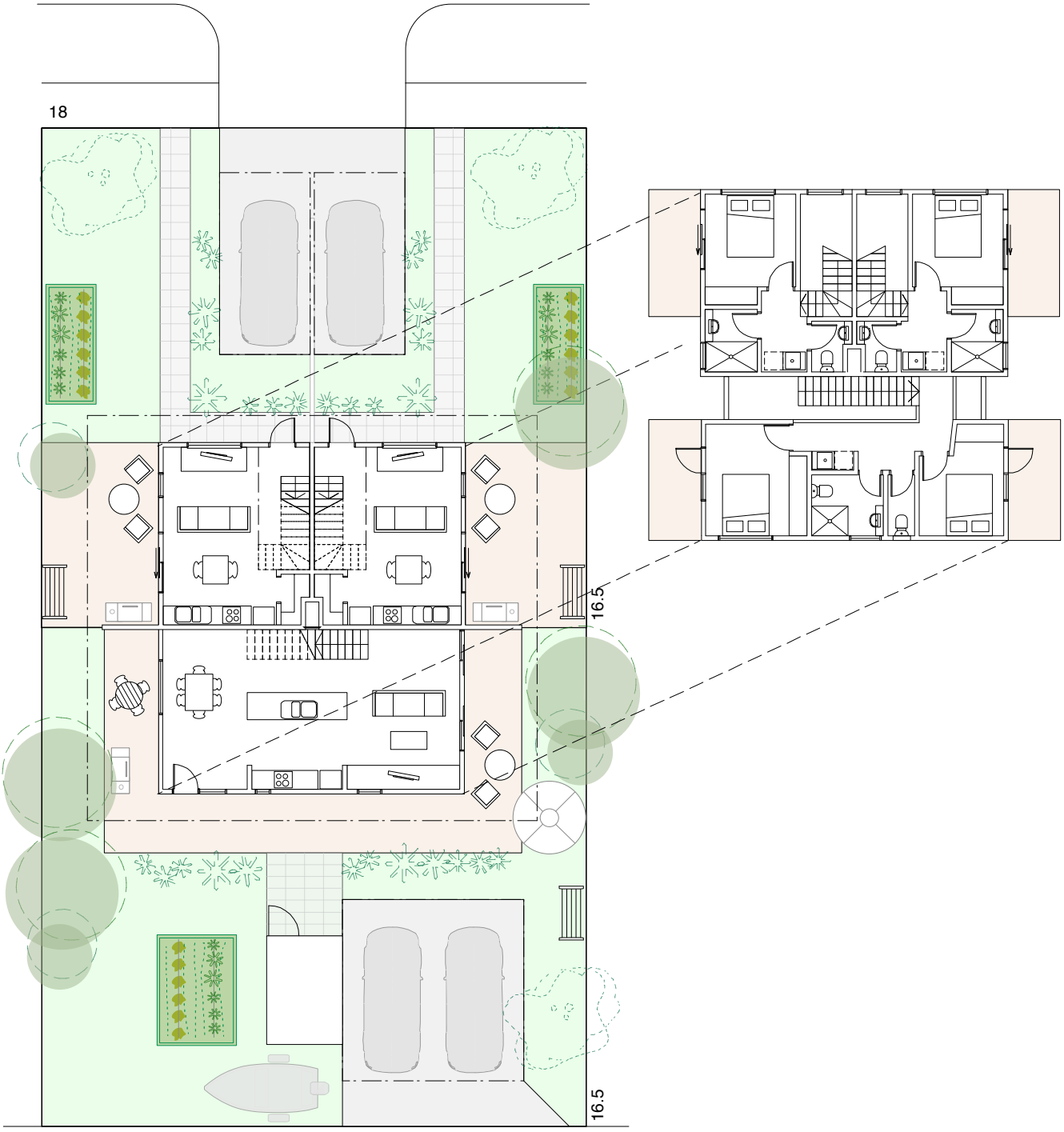
OPERABILITY- WET SEASON
Living retreats to the air-conditioned core.
Ventilation still provides some relief



LOT DRAINAGE
Drainage of subdivision follows land gradient wherever possible
Each lot required to have 3% of lot area allocated as a rain garden
Drainage of lot falls to side or rear before discharging to road system
Drainage aligns with breezepaths where possible

HOUSE TYPE 9 - Triplex

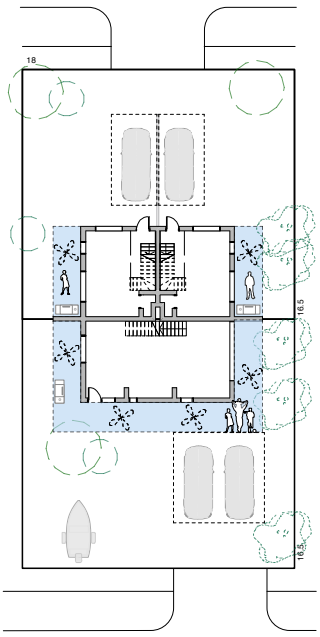
Small family, a couple and a single worker
1 x 2 bed and 2 x 1 bed



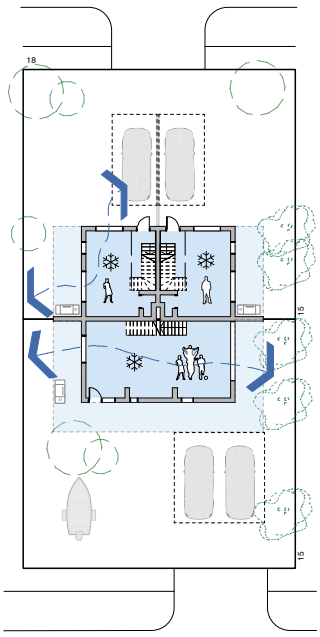
HOUSE AREA (each) :
Internal: 57 sqm, Covered Outdoor: 23sqm
Internal: 57 sqm, Covered Outdoor: 23sqm
Internal: 100 sqm, Covered Outdoor: 47sqm
LOT AREA: 2 x 270 sqm

0 1 2 5

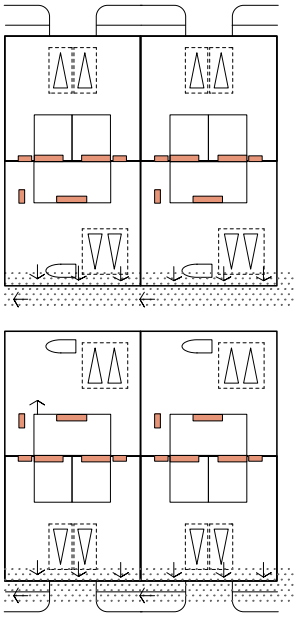
Scale 1:200



OPERABILITY- DRY SEASON
Living spills outdoors to the north and south.
Central breeze-way and sleeping wing open up for maximum ventilation

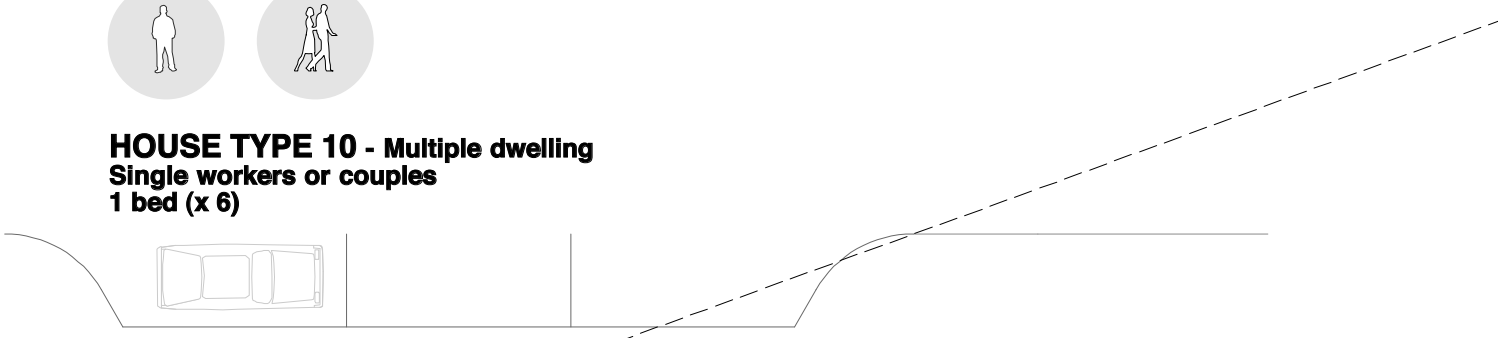


OPERABILITY- WET SEASON
Living retreats to the air-conditioned core.
Ventilation still provides some relief

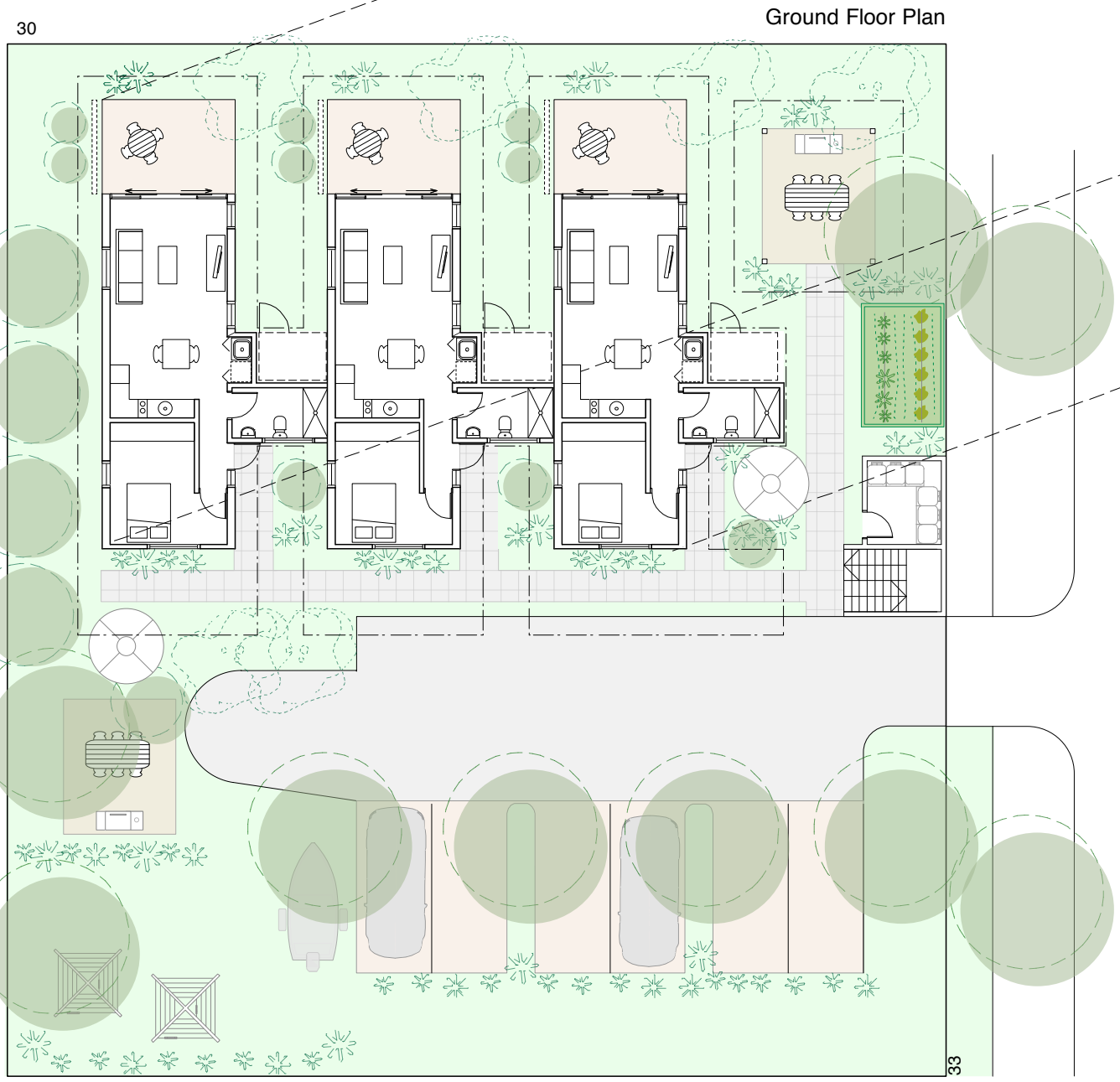


LOT DRAINAGE
Drainage of subdivision follows land gradient wherever possible
Each lot required to have 3% of lot area allocated as a rain garden
Drainage of lot falls to side or rear before discharging to road system
Drainage aligns with breezepaths where possible

HOUSE TYPE 10 - Multiple dwelling
Single workers or couples
1 bed (x 6)



Ground Floor Plan

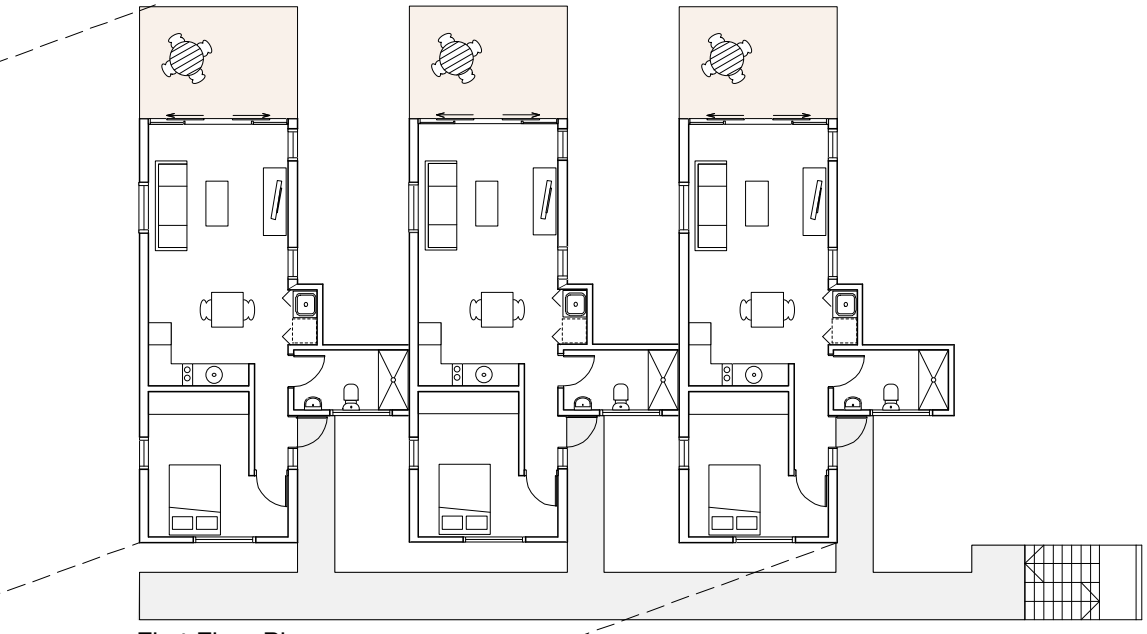


APARTMENT AREA (each) :
Gross internal: 54 sqm
Covered outdoor living: 13 sqm

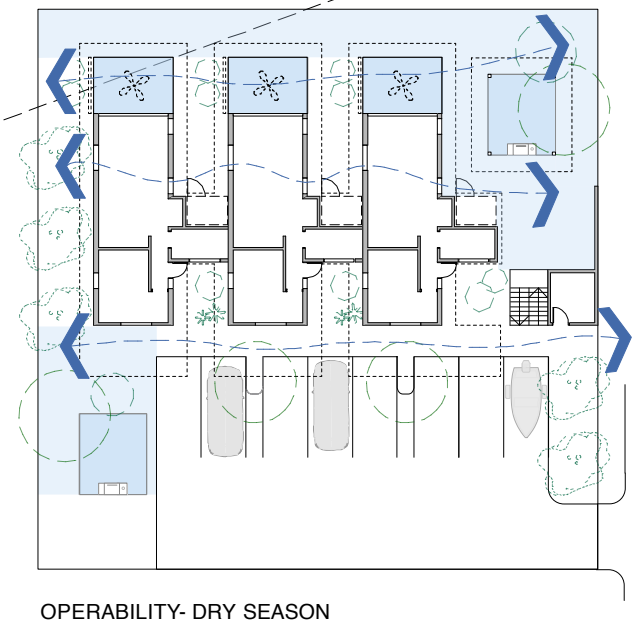
LOT AREA: 900 sqm

0 1 2 5

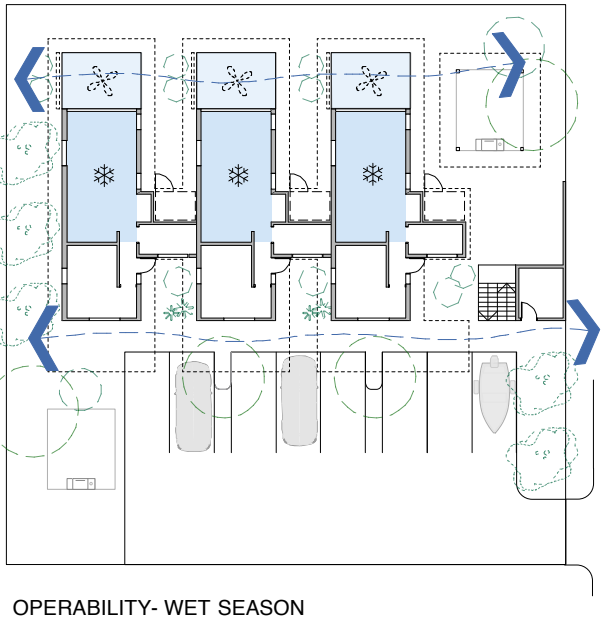
Scale 1:200



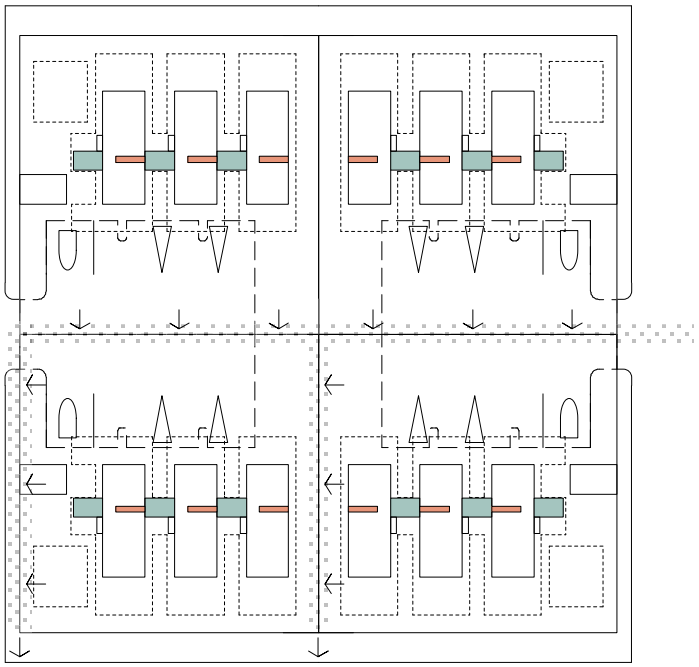
First Floor Plan



OPERABILITY- DRY SEASON
Living spills outdoors to the north and south. Central breeze-way and sleeping wing open up for maximum ventilation



OPERABILITY- WET SEASON
Living retreats to the air-conditioned core. Ventilation still provides some relief



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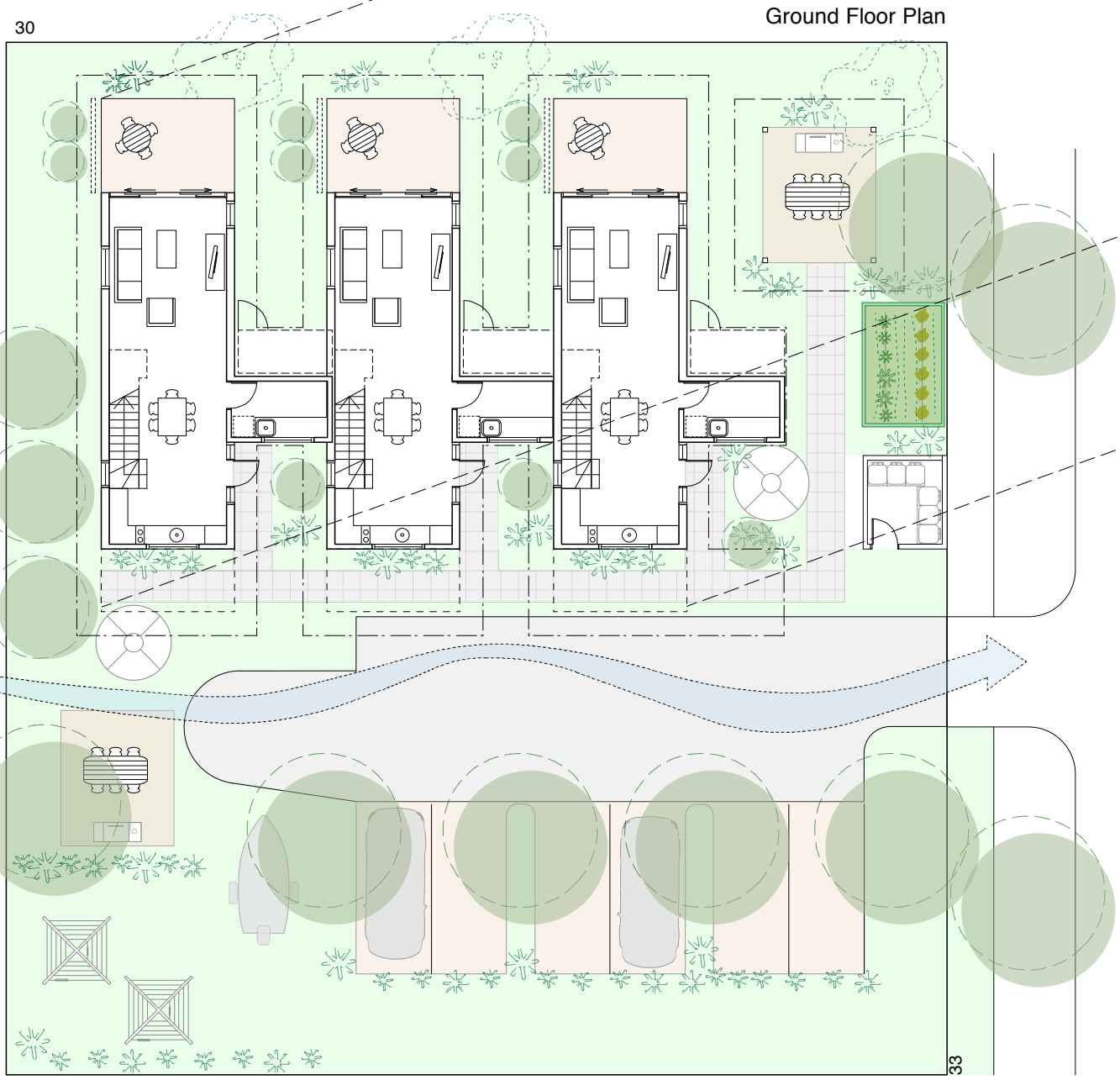
Drainage aligns with breezepaths where possible

HOUSE TYPE 11 - Grouped dwelling
Single parent with children or two single workers
2 bed (x 3)

Ground Floor Plan

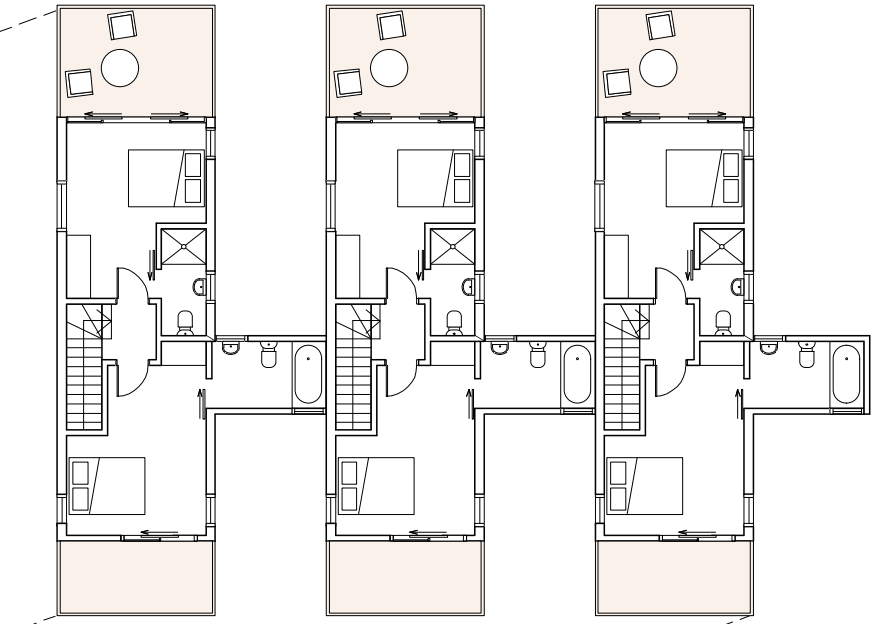


APARTMENT AREA (each) :
Gross internal: 109 sqm
Covered outdoor living: 34 sqm

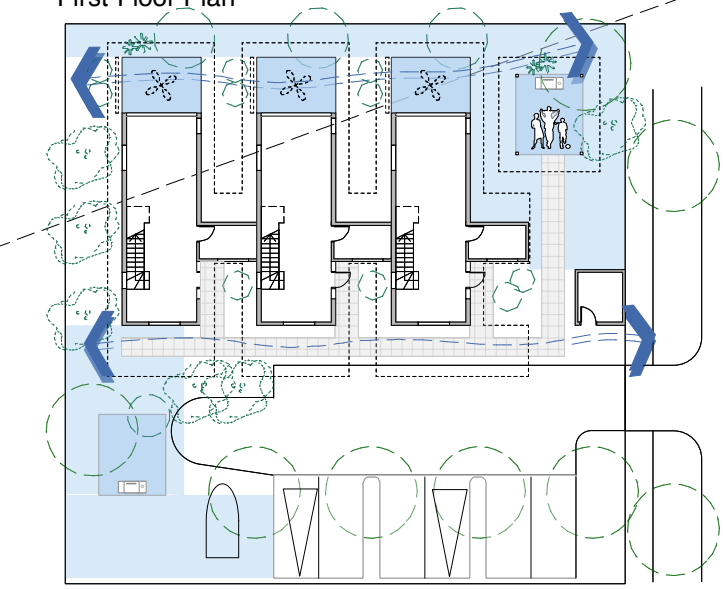
LOT AREA: 900 sqm

0 1 2 5

Scale 1:200



First Floor Plan



OPERABILITY- DRY SEASON
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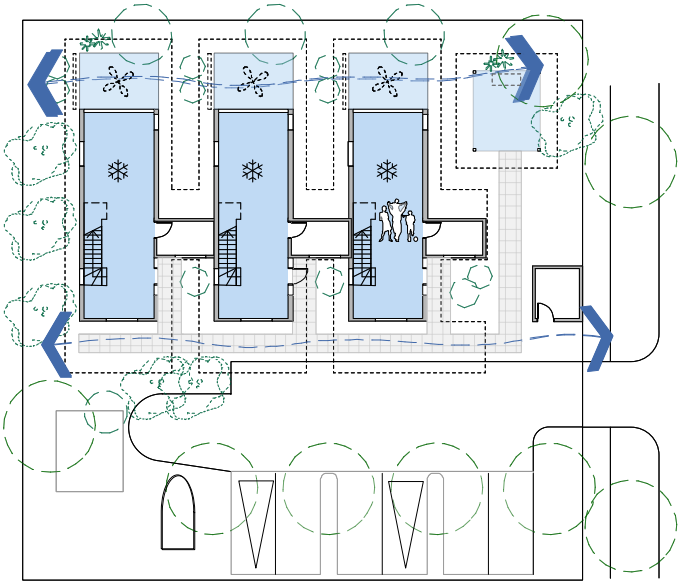
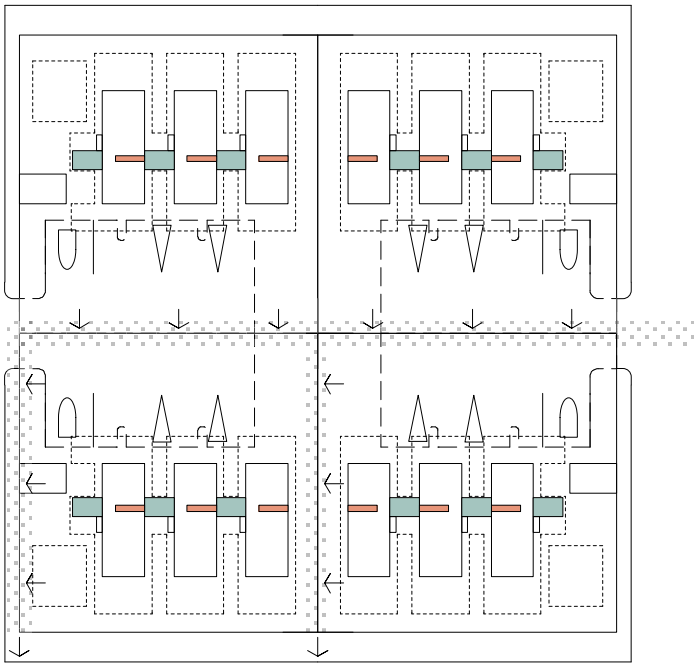


OPERABILITY- WET SEASON
Living retreats to the air-conditioned core. Ventilation still provides some relief



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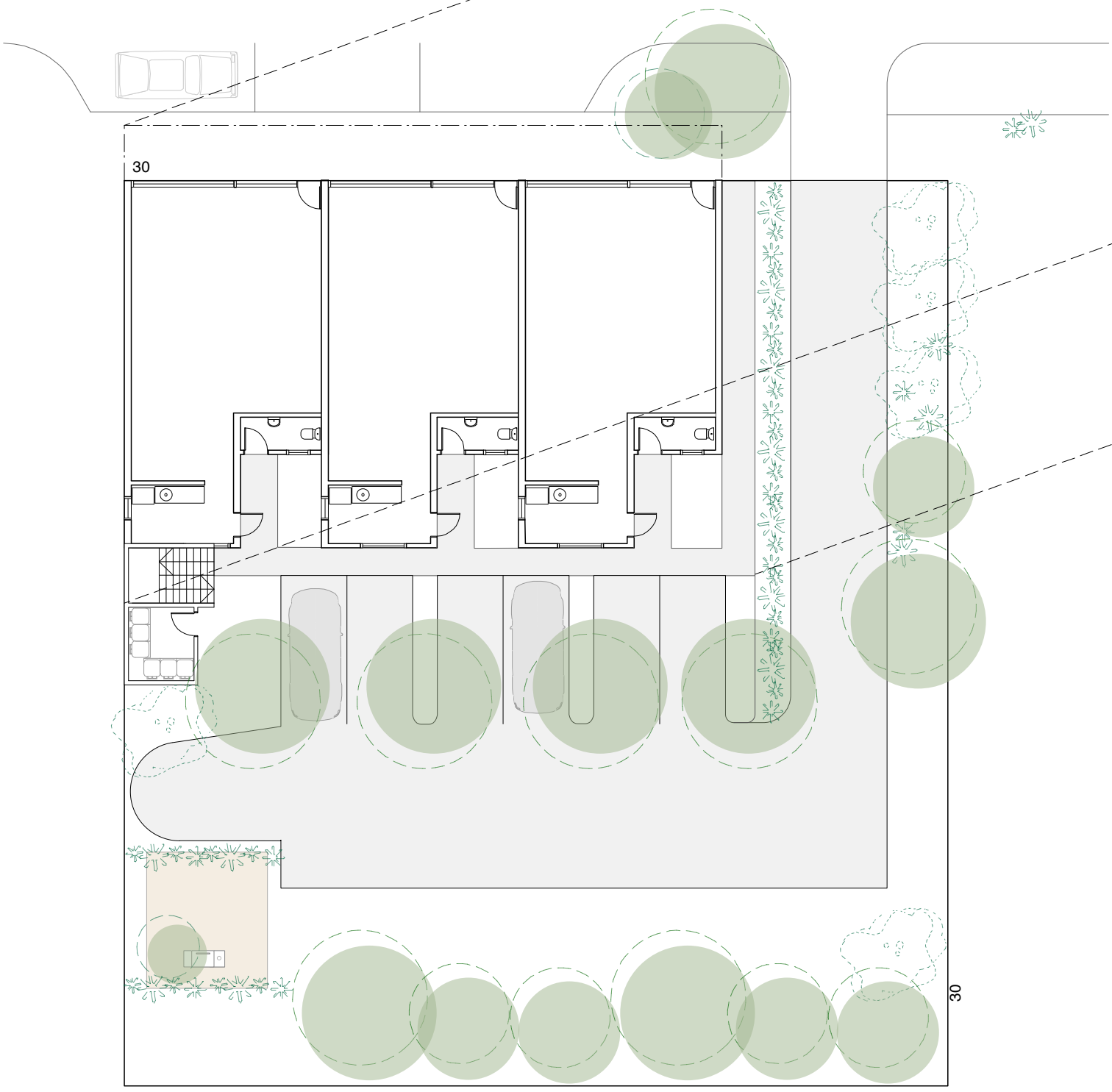
HOUSE TYPE 12 - Mixed Use / Grouped dwelling
Office Tenancy with young couple living above
1 bed (x 3) + 3 x Commercial Tenancy

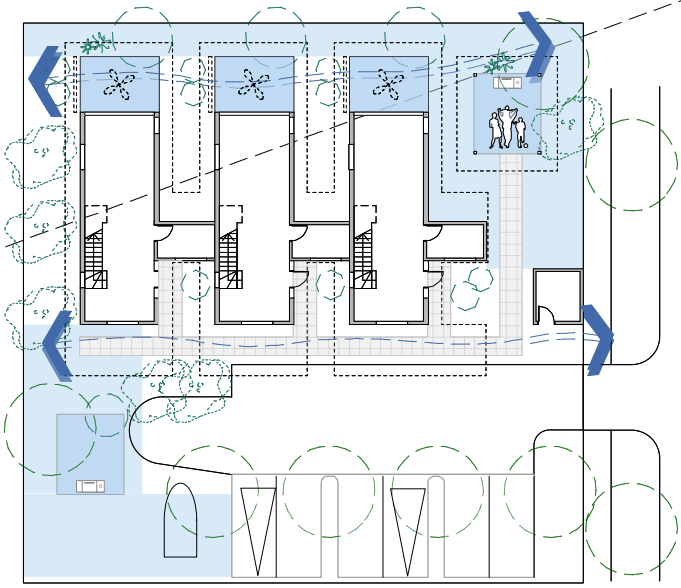


Ground Floor Plan

APARTMENT AREA (each) :
Gross internal: 109 sqm
Covered outdoor living: 34 sqm
LOT AREA: 900 sqm

0 1 2 5

First Floor Plan



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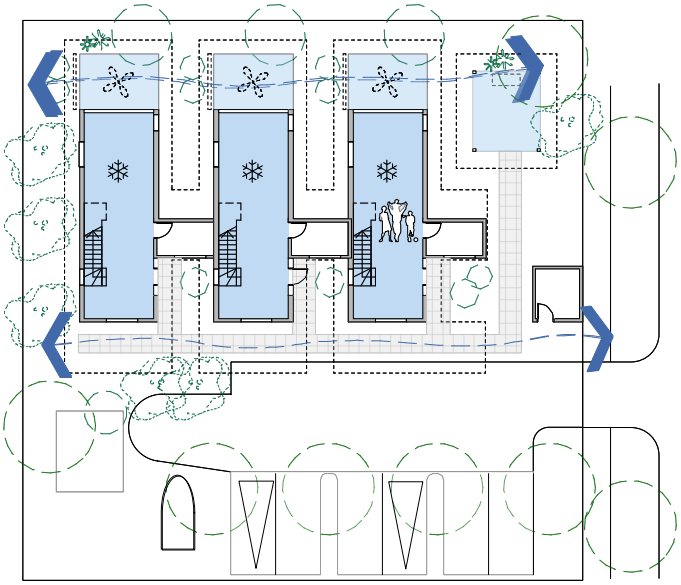

OPERABILITY- WET SEASON
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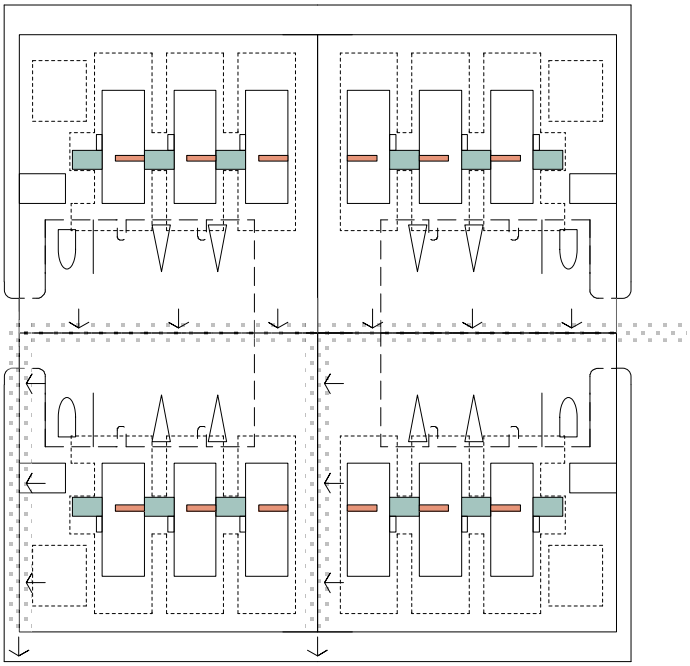

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APPENDICES

APPENDIX A: CONVERSATIONS WITH BUILDERS
APPENDIX B: AERIAL PHOTOGRAPHS

APPENDIX A: BUILDERS

PROJECT: BROOME NORTH

AIM: To deliver climate responsive and affordable housing specifically in the proposed Broome North Development.

BUILDERS/DEVELOPERS:

BUILDER/DEVELOPER	DATE	ATTENDEES	INITIAL
WILLIAM'S HOMES	30.06.09	Kieran Wong Frangiska Skiadas Graeme Williams Paul Davies	KW FS GW PD
ECO-CONSTRUCTIONS	30.06.09	Kieran Wong Frangiska Skiadas Karl Plunkett	KW FS KP
BROLGA	06.07.09	Dene Purdon Kieran Wong Frangiska Skiadas	DP KW FS
SUMMIT	10.07.09	David Simpson Richard Simpson Angus Murray Kieran Wong Frangiska Skiadas	DS RS AM KW FS
KJ'S CONSTRUCTION	13.07.09	Bob Sweet Kieran Wong Frangiska Skiadas Paul Ferrante Margriet van Tuyll	BS KW FS PF MT
H&M TRACEY	13.07.09	Harold Tracey Steven Thompson Frangiska Skiadas Paul Ferrante Margriet van Tuyll	HT ST FS PF MT

1.0 WILLIAM'S HOMES

1.1 Market Type

- Target Low-mid range, single storey single residential
- House prices range from $250,000-500,000
- Minimum house price is $250,000 = 110m2 living, 40m2 verandah, 200m2 roof, 3bed, 1car
- Construct 35-45 houses per year, 50 houses during peak
- Most Requested features are 180-190m2, 3-4 bed, en-suite & bath, double carport 6mx6m, colorbond custom-orb roof & wall, outdoor living with ceiling lining & fan, no local brick-maker, besser block sometimes used as feature or rendered blue-board, standard timber truss roof frame and steel frame walls

1.2 Affordability

- 2 storey construction is considerably more expensive
- More external walls = more $
- Sliding doors/windows are more affordable than louvers
- Cyclonic area, remote location and small market causes high costs
- Making land more readily available will reduce panic buying

1.3 Climate

- Better Insulation to external walls R1.5, is the maximum batt in a 75mm stud wall
- Solar HW units
- Split system A/C
- Breeze-paths: At Januburu the N/W breeze was indicated on the plans, this is a hotter wind compared to S-S/W winds that are cool sea-breezes
- Recommend 750-900 eaves although 900 eaves produce issues for setbacks
- William's trialed the U shape plan about 20 years ago and found they were hotter, larger wall areas means more heat, breeze-paths weren't effective
- William's found outdoor kitchens to be un-useful due to inflexibility, they block breeze paths and the environment is harsh causing corrosion, generally people will prefer to use their BBQs to cook outside
- Block, lot orientation that is effective for Breeze paths

1.4 Lot Type

- Recommend R20 min, R12.5 is difficult.
- Use of retaining walls can sometimes lead to an excessive amount of fall on the site, they suggested a 400mm fall over a 30m length was enough, an example is at Mangalla Drive where the pindan is being washed away to expose the boundary fence footings
- Avoid small blocks on corners, this can cause access issues
- Retaining walls in corner blocks can cause access issues, suggested landscaping incentives instead
- Suggested 550m2 lots for a 3x2house and 700m2 lots for a 4x2house
- Lots at Januburu were too narrow for their standard house plans
- An ideal lot size would be 18x30 or 20x3
- They are happy with the standard set-backs, 6m at the front. A 0m setback for carports is difficult as it creates a short and steep driveway

1.5 Examples of Work

- Currently house and land packages are being sold at the Roebuck Estate for $537,000 with a 3x2 house, block value of $255,000, 132m2 block, their cheapest package available now
- Release of lots at Roebuck estate was adequate, about 50 lots were on sale while another 50 were being prepared then the 1st home buyers grant ended and there was a rush to purchase remaining lots then the availability of lots never caught up

2.0 ECO-CONSTRUCTIONS

2.1 Market Type

- Building rates are approx. $2200/m2
- 6yrs ago blocks at Roebuck estate sold for $45,000

2.2 Affordability

- Repetition reduces cost
- Suggested to keep the land value down and have a fixed profit margin
- Currently a 2 bed unit on a block sells for $510,000 minimum
- Ideal scenario would be an $100,000 block with a $250,000 2 bedroom unit
- Believes the auction of a block at Sunset Rise during Broome Cup 3 years ago caused market values to rise

2.3 Climate

2.4 Lot Type

- Suggested having Strata Lots: less head works cost, someone to manage verges, grey water irrigation
- Suggested more R35, R50

2.5 Examples of Work

- Recently worked on a subdivision in Derby with 500-700m2 lots
- GROW series: 100m2, 10x10 2 bed module, $250,000, available with 1.2 or 1.6m overhang
- Recently constructed Sheba Lane a 3-storey 2-bed unit development.
- 2-bed unit = 92m2

3.0 BROLGA

3.1 Market Type

- People with an interest in individually designed houses
- $400-600,000, they usually start with a budget and work backwards
- $1,800-2,000/m2 starting price
- 3x2-4x2 bedroom houses
- Mostly build steel frame, colorbond cladding with timber trusses
- 15-20/year

3.2 Affordability

- Besser block construction is more complicated, needs to be rendered and is expensive.
- Built on concrete slab: 600 build up, 500 above ground - big footing is mandatory
- Carpet is the cheapest floor covering, $40/m2 Tiles are also more affordable $110/m2. Polished concrete - would like to push this finish but it is hard to get a good finish.
- Work-safe has affected the cost of 2nd storey but they have their own scaffolding
- Januburu development is usually more stringent on guidelines
- Govt. blocks, Homes-west has held the value down.
- Land Cost - needs to go down, should be 1/3 of cost of whole property. Will continue to customise houses using their in-house drafting, $1,500/m2 3x2. House stripped back, could go down by reducing the size of the house to 3x1 or reducing the living area, take out deck - concrete instead. Carpet instead of tiles. Kitchen designs can be economised, bench lengths. Using colorbond eaves can reduce painting area.

3.3 Climate

- Minimum ceiling plate height 2.7m. Lack of flexibility for raked ceilings
- Roebuck Estate 26° minimum pitch roof
- No 98mm frames available for more insulation
- NSF – national steel frames
- Air cell – insulbreak, Baseboard over it, creates a slight bulge
- Aluminium windows/doors, no double glazing
- More breezes make a more affordable house. Dene only has A/C in his bedrooms. Outdoor Living Areas- integrated indoor/outdoor, avoid corridors

3.4 Lot Type

- An ideal lot size is 20x30.
- R12.5 at Sunset Rise was hard to work with as it has 6.5m rear setback, not enough room. So the blocks had to be re-zoned to R20.
- Smaller Blocks are ok but you will have to provide options, standard house designs will be difficult.
- Eg. Fox Court 390m2 block, 10m frontages.
- Eg. Harmon/De Marchi 400m2 block, 2 storeys.

3.5 Examples of Work

- Recently designed a $298,000 set price house in Roebuck Estate for a house and land package. Choose your block and builder, 3x2 house or 4x2 for an extra $24,000
- Cost of house less than block
- Built the Kapang by IPH

4.0 SUMMIT

4.1 Market Type

- 28-45 yr olds - owner occupier
  20-30 yr olds – renters
- 3x2 Single Storey & 4x2 Single Storey, Carport for 2 cars
- Colorbond cladding, steel frame, timber truss roof.
- Some alternative materials are being introduced as features. eg. Rendered blueboard
- Mostly 1 storey construction. At Roebuck Estate out of 700 houses only 20 are 2 storey homes
- Villa model more acceptable and affordable
- Potentially there is demand for 3x1 houses but resale drives for bigger houses 3x2, 4x2. People don't want to under capitalise

4.2 Affordability

- Needs to be a step down to townhouse/villa type models on 110m2, 3x2 with 1 carbay that is acceptable to the market
- Modular will be a big answer to affordably to meet certain segments of the market.
- Design-Construct opportunities
- Currently involved in developing a model with James Hardie "House in a shed" modular construction, developing 2 storey & 1 storey types in 4.2 modules joint together
- In Broome they would potentially use a combination of prefab. buildings in Perth with local construction. Would have to determine the right balance in terms of sustainability, embedded energy, local labour & training. But proportion will inevitably come down to cost
- Difficulty with competition for tourism industry, although this is well policed in Broome. Will need to be clearly identified in codes NOT to allow short stay
- Opportunity to create a new town centre or a couple of new village centres. New multi-use, multi-residential or villa type could be located around town centres. There should also be normal residential components. People should have that option
- 95% of residencies are owned by traditional family models. 70% owner occupied. Out of 200 rentals 25% are shared houses. Houses are mainly owned by families and companies. All the houses in the Roebuck estate were sold to couples and families
- Block Size: land price is never going to come down, so make smaller block sizes around 450-500m2
- Open land to private developers
- Don't restrict the supply; recently the supply has been so far below demand.
- Don't want transportable housing - don't want slums
- Broome has a natural advantage because the labour force likes living there; construction costs are 100,000 less than Karratha
- More flexibility from the council for the provision of workers camps
- Reduce Land Price

4.3 Climate

- People want 1 decent sized verandah space 3m deep, for living. Must capture Easterly and Westerly breezes, sun orientation is not important.

4.4 Lot Type

- Entry-level product must go below 450m2. Provide various options in terms of scale

4.5 Further Comments

- The architecture of Broome is very unique. Don't implement change for change's sake.
- The quality of Broome's construction is higher than Perth. The quality must be kept at the same level.
- Summit's involvement should have a 10-year life ahead - no. of houses will be substantial
- Summit is interested in commercial opportunities, caryards, big box retail, shopping centres, and subdivision. Would prefer to take up a cross section of the development. Gubinge Rd has an opportunity for Big Box.
- Interface with tourism area. Enough area needs to remain solely for tourism, Dual use.
- Consider access to the beach, Pedestrian access & Car park, Managed/ formal access

5.0 KJ'S CONSTRUCTION

5.1 Market Type

- Clients usually want 4x2 and are usually purchasing their 2-3rd house
- Rate per square metre $1800-4000/m2 depending on wall height, finishes and complexity, Inclusive of everything except landscaping, preferred by clients as it is quicker and easier
- Target higher end multi-story, large houses, some 4x2, smallest house 160m2, biggest house 330m2 (living m2)
- Construction methods: 75mm steel frame, timber trusses. A bit of core filled block-work.
- Constructs about 15 houses per year

5.2 Affordability

- To create affordability things need to become smaller, smaller lots and smaller houses.
- Up to 10 houses on the go at one time
- If a truss company was to come up it would increase supply and reduce cost
- Don't use steel trusses because some tradies wont touch them and the cost is too high.

5.3 Climate

- Insulbreak for thermal break
- NSF 90mm frame to beef up thermal insulation
- Believes that it is better with less insulation in the walls as they cool down quicker at night time
- Uses True North as energy assessor from mandurah
- Januburu believes it was strange that there is no clause regarding the colour of roof sheeting, he would recommend using zincalume
- There are always exceptions for cross-breezes
- They always include 2 windows when cross breezes aren't possible
- A/C Dacun inverter split system - only available combination of multi-zones and single-zone
- Water Collection - Has only ever tried this on 1 House
- Nervous about gutters blowing off, 1-5000 litre tank not going to last, too much dust, not a market demand for water collection, a lot of money for not much return
- Suggested using a diverter in the laundry, to water garden
- Grey-water systems are expensive and complicated the water released in subsoil drainage, you require a decent garden frontage for grey-water recycling and toilets, require pumps and float valves
- Purple Pipe to the lot, allows you to control the water from a central location
- Water is not an Issue in Broome, we should be targeting power, Diesel and Gas creates carbon emissions
- Landcorp should be offering real incentives for solar power

5.4 Lot Type

- Liked stage 3 of the Januburu Development, grouped dwellings, duplex blocks, affordable, good size
- Would be difficult to convince buyers of retaining the native vegetation.
- Currently doing a couple of houses in Januburu with 18-19m lot frontage
- Believes 17m frontages are too squeezy for breeze-paths, end up with long corridors & hallways
- A larger Block allow for Rainwater Tanks & Breezeways
- Recommended the inclusion of a caravan park in the development

5.5 Examples of Work

- A couple of set plans for investment houses $370,000
- Has everything, 4 bed, 2 bath, 2 car carport, outdoor living, rates 8 stars thermal rating, compact
- Roebuck Estate 3x2 $288,000
- About to construct a display home using Block-work, has more strength, 200x200 concrete blocks, besser blocks, 3x2 block-work house costs around $350,000. Rates 6.5 stars
- Eco-house: Grey water system, under 500 litre storage capacity, Solar Power & Rainwater Collection

6.0 H&M TRACEY

6.1 Market Type

- Single Residential Houses range from $300,000-$1,500,000
- 20-40 single residential per year
- 250 houses over the last 7 years
- No set house plans, each design is unique to the block, individual, work with local architects
- Usually if a buyer wants 3 bedrooms they will go to a house
- Short-term accommodation is very popular. 3 month contracts from govt. Employees, furnished units

6.2 Affordability

- Steel frame and gyprock - most construction
- Use alternative materials such as tilt-up panel, have used the local tilt up guys before but usually do it themselves
- Good medium for building but doesn't meet acoustic rating, must be lined with gyprock
- Core filled block-work, enough block layers for current demand
- All 2 storey except Dampier terrace which is 3 storey, 3 storey becomes a different class of building and has fire rating issues, scaffolding increases construction costs, less economical than Perth, this can be minimized by design and ease of building

6.3 Climate

- 2/3 bed unit, outdoors area is vital and breeze paths become harder to utilise
- Currently in Broome there is a mindset that they must have a 3x2 or a 4x2 house
- Design Guidelines, Pretty Pool - Port Hedland, do nothing for the North West, builders are not mindful of why they are there, simply tick the boxes to get approval, not outdoor friendly, no requirement for shaded outdoor area, no street appeal

6.4 Lot Type

- Wider lots are more important than deeper, especially when implementing 900mm eaves, would suggest 17-18min
- Single Bed developments are best when connected to commercial, becomes more attractive
- Town Planning has to provide mixed-use sites. If a site is zoned residential you cannot put commercial on it but if a site is zoned commercial you can potentially argue to put residential on it.
- The shire has recently rezoned from Haas to Frederick St from residential to mixed use
- Believes they would be positive to incorporating mixed-use in the Broome North scheme

6.5 Examples of Work

- NAPIER TCE, 2023m2 Block, 8 units
  6 x 2 bed 2 bath units 110-130m2
  2 x 1 bed units above
  Car park will be excavated
  Ground floor commercial tenancies
  2 bays per residence
  4 ground floor tenancies
  Central courtyard through all levels
  Shire has given them the verge, which provides 13-14 car bays

- COGHLAN STREET, 1000m2 Block, 6 units
  6 x 1 bed 70m2
  2 storey
  Mixed use, commercial out front
  Potential to house staff
  Shire has given them the verge

- HAAS ST, 2700m2 Block, 16 units
  16 x 2 bed, 2 bath
  Mixed use site, 1 garage and car provided in package
  Short stay apartments
  Uses block work and suspended slab, simpler for fire-rating
  $6 million project, higher end of range
  Alfresco areas in each

7.0 CONCLUSIONS

7.1 Market Type

- Great demand for 3x2 or 4x2 houses, either just a mindset or people don't want to undercapitalise on their property.
- Majority single storey construction
- Minimum construction cost for single residential is $250,000
- Minimum building rates $1,800-2,000/m2
- Generally all single residential house plans are individualised
- Typical construction method is concrete slab, steel frame, timber truss roof, custom orb cladding, gyprock internal lining
- Alternative materials available include core filled Besser blocks, tilt-up panels, rendered blue-board

7.2 Affordability

- Recurring suggestion to offer smaller lots to creates smaller land price
- Make land more readily available, don't limit supply
- Provide 1-2 bedroom units
- Reduce size of house, 3x1 or less living area
- 2-3 storey construction increases cost of building due to work-safe requirements and fire-rating requirements, but this can be minimised by design
- Tile and carpet finishes are most affordable
- Polished concrete floor finish is underutilised
- More external walls make a more expensive house
- More breezes make a house more affordable, less energy costs
- Investigate modular construction opportunities

7.3 Climate

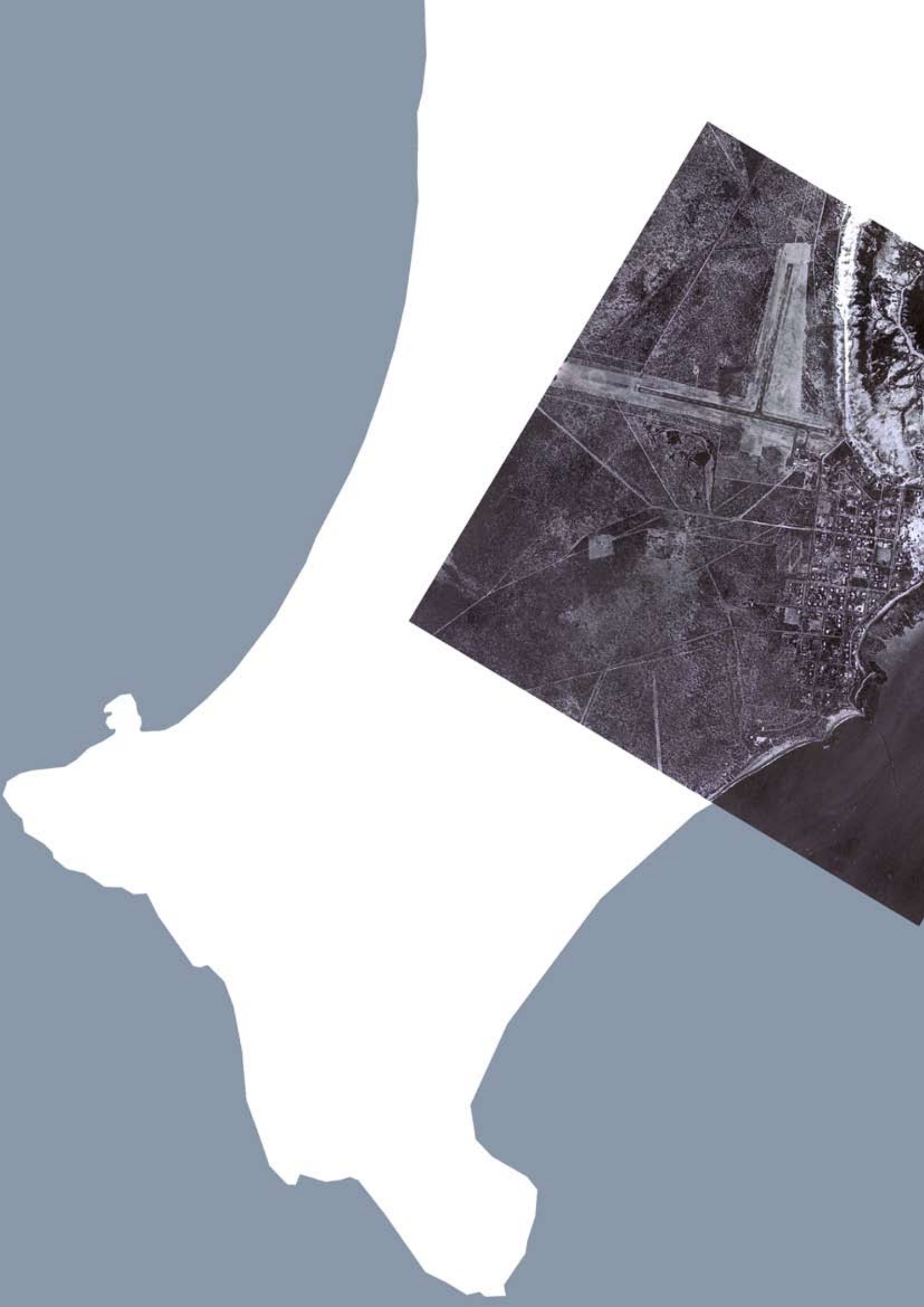
- Orientation of lots and houses must promote breeze-paths
- S, S/W being the most cooling breezes
- 2-3 bed units are harder to cross-ventilate
- Promote solar power and solar HW system
- Not as much of a market for rainwater collection
- Suggested mandatory requirement for outdoor shaded area
- Suggested mandatory roof sheet colours, lighter

7.4 Lot Type

- Preferred minimum frontage of 18m
- Larger lots accommodate breeze paths and rainwater tanks
- Provide townhouse/villa type models
- Provide mixed-use sites, single bed developments are more attractive when connected to commercial
- Opportunity to create new town centre/s
- Allocate areas for a caravan park and tourism
- Suggested having Strata Lots: less head works cost, someone to manage verges, grey water irrigation

APPENDIX B: AERIALS


BEACON HI



ARCHITECTURE
& URBAN DESIGN

83 SOUTH ST, BEACONSFIELD
WA 6162
T: 08 9433 6000
F: 08 9433 3700
E: studio@coda-studio.com
W: www.coda-studio.com