STRUCTURE PLAN

LOTS 501, 1302 AND 1500 BATHGATE ROAD AND LOT 3860 TAMBREY DRIVE, NICKOL (TAMBREY NEIGHBOURHOOD CENTRE)

SEPTEMBER 2016

TOWN PLANNING
URBAN DESIGN AND HERITAGE

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ENDORSEMENT PAGE

This structure plan is prepared under the provisions of the
Shire of Roebourne Town Planning Scheme No. 8.

IT IS CERTIFIED THAT THIS STRUCTURE PLAN WAS APPROVED BY RESOLUTION OF THE WESTERN AUSTRALIAN PLANNING COMMISSION ON:

Signed for and on behalf of the Western Australian Planning Commission:

_____

an officer of the Commission duly authorised by the Commission pursuant to section 16 of the *Planning and Development Act 2005* for the purpose, in the presence of:

_____ Witness

_____ Date

_____ Date of Expiry

TABLE OF AMENDMENTS

Amendment No.	Summary of the Amendment	Amendment type	Date approved by WAPC

TABLE OF DENSITY PLANS

Density Plan No.	Area of density plan application	Date endorsed by WAPC

EXECUTIVE SUMMARY

This Structure Plan has been prepared to facilitate the approval and development of a Neighbourhood Shopping Centre and associated residential development at Tambrey on the corner of Dampier Road and Bathgate Road.

The Structure Plan is applicable to Lots 501, 1302 and 1500 Bathgate Road and Lot 3860 Tambrey Drive, Nickol, hereon referred to as 'the site'.

The site is owned by the WA Land Authority (LandCorp) and is to be developed by the Tambrey Joint Venture in conjunction with LandCorp. The Structure Plan has been prepared with input from a team of experts, including:

- LandCorp;
- FJM Property and Raydale Holdings (The Tambrey Joint Venture);
- GMPM – Project Managers;
- Taylor Robinson – Commercial Architecture and Urban Design;
- Christou – Residential / Mixed Use Architecture;
- TPG Town Planning, Urban Design and Heritage – Town Planning;
- Wood & Grieve – Engineering;
- Coterra – Environmental;
- Emerge Associates – Landscape Architecture;
- McMullen Nolan – Surveying;
- Uloth & Associates – Traffic Engineers; and
- MacroPlan Dimasi – Retail / Economic Consultants.

The Structure Plan comprises two parts, being:

Part 1: Implementation; and

Part 2: Explanatory section and technical appendices.

PURPOSE

This Structure Plan provides a framework to guide and facilitate the future subdivision and development of land and has been prepared to address the requirement for a structure plan pursuant to 'Development Area' (DA7) of the Shire of Roebourne Town Planning Scheme No. 8 (herein referred to as 'the Scheme'), which is a prerequisite to subdivision and development.

LAND USE

This Structure Plan seeks to allow uses consistent with the 'Town Centre' zone over the land pursuant to TPS8, to achieve a range of retail, commercial and residential outcomes for the site. In the short term, it is intended to establish a full line supermarket and associated specialty retail, restaurant and tavern amenities near the intersection of Bathgate Road and Dampier Highway.

EXECUTIVE SUMMARY TABLE

Item	Data	Structure Plan Ref (section no.)
Total area covered by the structure plan	9.6055 hectares	Page 13; Subject Site
Area of each land use proposed		
Single Residential	1.4687 ha / 40 dwellings	Page 38; Population and Residential Densities
Grouped Dwellings	0.3710 ha / 45 dwellings	Page 38; Population and Residential Densities
Multiple Dwellings	0.7925 ha / 80 dwellings	Page 38; Population and Residential Densities
Estimated number of dwellings	165 dwellings	Page 38; Population and Residential Densities
Estimated residential site density	17.2 dwellings per site/hectare	-
Estimated population	410 (2.5 persons/dwelling)	Page 38; Population and Residential Densities
Commercial	5.1128 ha	Page 38; Population and Residential Densities
Serviced apartments	0.4835 ha	Page 38; Population and Residential Densities
Estimated retail floor space	8,500 m^2 net lettable area	Page 57; Movement Network
Estimated area and percentage of public open space given to		
• Regional open space	0 ha	-
• District open space	0 ha	-
• Neighbourhood parks	Refer to Clause 4.6 of this Structure Plan	Clause 4.6; Page 4
• Local parks	Refer to Clause 4.6 of this Structure Plan	Clause 4.6; Page 4
Estimated percentage of natural area	Not applicable	-

PART 1 – IMPLEMENTATION

1. STRUCTURE PLAN AREA

This Structure Plan shall apply to Lots 501, 1302 and 1500 Bathgate Road and Lot 3860 Tambrey Drive, Nickol, being the land contained within the inner edge of the line denoting the Structure Plan boundary on the Structure Plan Map (Plan 1).

2. OPERATION

(a) In accordance with Clause 22 of Schedule 2 of the *Planning and Development (Local Planning Scheme) Regulations 2015*, this Structure Plan shall come into operation on the day on which it is endorsed by the Western Australian Planning Commission (WAPC).

(b) In accordance with Clause 28 (1) of Schedule 2 of the *Planning and Development (Local Planning Scheme) Regulations 2015*, this Structure plan has effect for a period of 10 years commencing on the day on which the WAPC endorses the Plan in accordance with 2 (a) above.

2.1 INTERPRETATIONS

(a) Unless otherwise specified in this part, the words and expressions used in this Structure Plan shall have the respective meaning given to them in the Shire of Roebourne Town Planning Scheme No. 8 (the Scheme) including any amendments gazetted thereto.

(b) In addition to the above, the decision making authority shall have due regard to the following land use definition/s for applications within the Structure Plan area. These additional land uses may be permitted at the discretion of the decision making authority and are to be processed as a 'Use Not Listed' under the Scheme.

'Boat Storage Facility' means land or buildings used primarily for parking private boats, caravans or motor homes or the like, and where such vehicles may be stored with or without payment or reward.

(c) The decision making authority shall have due regard in applying the following terms not defined under the Scheme:

'Net Lettable Area' is defined as the area of all floors contained within the finished surfaces of permanent walls which are readily accessible to the public, but exclude the following areas;

- *all toilets, cleaners' cupboards, lift shafts, service areas and motor rooms;*
- *lobbies between lifts facing other lifts servicing the same floor; and*
- *areas set aside as public space or thoroughfares and not for the exclusive use of the occupiers of the floor of the building.*

For the avoidance of doubt all other storage and service areas, not accessible to the general public/customers are excluded regardless of whether they are for exclusive or shared use.

3. STAGING

Development envisaged by this Structure Plan shall be staged. Staging of road connections and accessways is permitted where supported by a suitable Transport Statement.

4. SUBDIVISION AND DEVELOPMENT REQUIREMENTS

(a) The Structure Plan Map (Plan 1) outlines land use, zones, reserves and the residential density codes applicable within the Structure Plan area. The decision making authority is to have due regard to the land use permissibility, zoning, subdivision and development requirements as contained within this Structure Plan.

4.1 LAND USE PERMISSIBILITY

(a) Land use permissibility within the Structure Plan area shall be in accordance with the corresponding zone or reserve under the Scheme.

(b) In determining any application relating to a 'Motor Vehicle Wash' within the Structure Plan area, the decision making authority shall have due regard to the location of such a use, and in making its determination, shall consider a location adjacent to the existing service station as depicted on Plan 1 as a favourable location.

(c) The maximum combined net lettable area of all retail ('shop') floorspace within the Structure Plan area shall not exceed 8,500m^2 unless otherwise specified in the Scheme.

(d) The decision making authority in having due regard to this Structure Plan shall require the following uses to be located at least 50 metres away from Tambrey Drive:

a. Motor Vehicle and/or Marine Repair;

b. Outdoor Display;

c. Reception Centre;

d. Restaurant;

e Restricted Premises;

f. Take-Away Food Outlet;

g. Emergency Services;

h Funeral Parlour;

i. Veterinary Centre;

j. Entertainment Venue; and

k. Tavern.

(e) In determining any application for a non-residential use, the decision making authority shall have regard to the proximity of the proposed use to planned or established residential development and shall ensure that the proposed use will not have any undue impact on the amenity of the nearby residential development with respect to the generation of noise, light, traffic movement or other factors.

4.2 RESIDENTIAL

4.2.1 Dwelling Target

(a) Objective

To provide for a minimum of 140 dwellings within the Structure Plan area.

4.2.2 Residential Density

(a) The density of residential development in the Town Centre zone is prescribed by Clause 6.6.4 of TPS8, which prescribes an R40 density code.

4.2.3 Specific R-Code Variations

(a) The decision making authority shall have due regard to the development provisions of this Structure Plan in applying its discretion in relation to the applicable deemed-to-comply provisions of the R-Codes.

(b) Variations to the deemed-to-comply requirements of the R-Codes shall be specified on the individual Local Development Plans (LDP). Such variations shall include provisions relating to:

- Plot ratio;
- Height (4 storeys unless otherwise indicated on the LDP);
- Street setbacks;
- Lot boundary setbacks;
- Stormwater (no onsite retention required);
- Visual privacy (where simultaneous approval and construction precludes overlooking of active habitable spaces and outdoor living areas); and
- Solar access (no overshadowing requirements).

4.3 BUILT FORM REQUIREMENTS

(a) The maximum height of development shall not exceed 4 storeys in height unless varied by an approved Local Development Plan.

(b) Nil setbacks and the use of awnings are encouraged where development fronts the main street as denoted on Plan 1.

(c) The maximum site cover for non-residential development is 100% and there is no maximum plot ratio requirement for any non-residential development.

4.4 PARKING REQUIREMENTS

(a) Parking shall be determined in accordance with Clause 6.12 'Vehicle Parking and Access' of the Scheme with the exception of the following:

- Reciprocal parking for non-residential development and for residential visitor parking is supported whereby a minimum of 50% of the required parking as specified by the Scheme is still available to the off peak use. The peak day time uses are residential visitors, 'shops', 'offices' and 'medical/ consulting rooms' or the like and the peak 'night time' uses are 'restaurants', 'taverns', 'take away food outlets' or the like.
- Each dwelling less than 75m^2 shall be provided with a minimum of 1 bay and each dwelling between 75m^2 – 110m^2 shall be provided with a minimum average of 1.5 bays and each larger dwelling a minimum of 2 bays unless specifically varied by a Local Development Plan.
- Each development application which relies on reciprocal parking, including a change to the approved use of a building shall be accompanied by an updated schedule as appended to the Explanatory Report of this Structure Plan which outlines the use, and the existing and proposed parking allocation to ensure compliance with this Structure Plan.

- Parking within the commercial zoned lots marked 'A' and 'B' on the Structure Plan may be calculated on a communal/shared basis with the exception that parking bays in Area A cannot be used to satisfy the parking requirements in Area B and vice versa. All other parking shall be determined on an individual lot basis as per the provisions of this Structure Plan unless otherwise shown on a Local Development Plan approved by the City.
- The on street parking shall be apportioned to the commercial lots which directly abut those bays and included within the parking allocations;
- No parking is required for a 'Boat Storage Facility'; and
- Parking for a Take Away Food Outlet within the Structure Plan area shall be calculated based on a 'Restaurant' for the seated dining component and a 'Take Away Food Outlet' for the serving area accessible to the public.

4.5 ACCESS

(a) Direct vehicle access to Bathgate Road or Dampier Drive is precluded unless shown as a 'Key Access Point' or a road connection as shown on the Structure Plan, or otherwise approved by the City as part of a Local Development Plan.

(b) Temporary access arrangements for Stage 1 subdivision and development will be at the discretion of the relevant authority and will not be required to align with the 'key access points' shown on the Structure Plan map (Plan 1), provided that the functionality of the temporary access locations are supported by traffic modeling

(c) The ultimate road network and configuration is to generally accord with the Structure Plan map (Plan 1)

(d) Any residential development within the Structure Plan shall be located on a lot that has constructed access to a gazetted road. Where it is not practical to provide a lot with constructed access to a gazetted road, the relevant authority may consider the provision of a reciprocal rights of access easement to provide public access to a lot within the Structure Plan area.

4.6 OPEN SPACE

(a) In determining any Public Open Space (POS) or cash in lieu contribution for subdivision within the Structure Plan, the following shall apply:

i. A regional variation pursuant to R34 of Element 4 of Liveable Neighbourhoods, being a 5% reduction to the amount of POS required, shall be applied and POS shall only be calculated based on the residential portion of the Structure Plan area (excluding commercial and mixed use development sites);

ii. Any landscaping of the adjoining Recreation, Construction and Drainage Reserves undertaken and maintained for two years by the developer shall be taken into account in determining any cash in lieu of POS requirement;

iii. Provision of public open space shall be satisfied by either providing public open space to the satisfaction of the City or WAPC, or landscaping the adjoining Drainage Reserve to the west of the site, or by a cash in lieu contribution based on 5% of the area of any Local Development Plan (LDP) for residential development. Each LDP shall include such provision and each Development Application for such development shall be burdened with a relevant condition to ensure payment prior to commencement of the development.

4.7 LOCAL DEVELOPMENT PLANS

(a) A Local Development Plan (LDP) is required to be prepared for any residential component of the Structure Plan area and not for solely non-residential development. Variations to the provisions of the R-Codes shall be permitted where outlined on the LDP.

(b) This does not preclude a LDP being prepared to vary a height or access restriction elsewhere in the Structure Plan area.

(c) A Local Development Plan shall be prepared (by the developer, an owner of the land or the City) and adopted by Council prior to any substantial residential development commencing and used as the basis for the determination of all development applications for residential development.

(d) A Local Development Plan will enhance, elaborate and expand the details and provisions contained in this Part as well as supplement the provisions of the Scheme and the R-Codes.

4.8 DRAINAGE

(a) The intent of the Drainage area is to provide a landscaped setting and pedestrian access ways whilst facilitating stormwater conveyance in major storm events.

(b) Development standards to be satisfied for the Drainage area include:

i. The design of open space areas shall ensure appropriate provision for stormwater drainage management; and

ii. The landscaping of open space areas shall be suitable for an arid climate having regard to minimising maintenance and water use whilst providing areas of highly aesthetic and functional amenity.

4.9 ACOUSTIC REPORT

(a) An Acoustic Report is required to be prepared by a suitably qualified Acoustic Consultant as part of a development application demonstrating how the proposed development complies with relevant noise legislation for the following circumstances:

- Any noise sensitive development proposed within 100 metres of the centreline of Dampier Road;
- Any noise sensitive development proposed within mixed use development or located near (within approximately 50m) of a site(s) in which there is the potential for after-hours activity to occur (e.g. restaurant, tavern, service station); or

- Any non-residential development in which there is the potential to generate noise that may impact on noise sensitive development (e.g. tavern, entertainment venue, restaurant with alfresco dining, retail areas with loading docks etc). Where the City considers that there is sufficient distance between the use and any noise sensitive premises this requirement may be addressed by a noise management plan required by a condition of development approval.

4.10 OTHER REQUIREMENTS

(a) Additional reports and information shall be required as follows:

i. Each Local Development Plan or Development Application where no Local Development Plan has been approved shall be accompanied by an Urban Water Management Plan and Landscaping Concept Plan.

ii. The approved Urban Water Management Plan and Landscaping Plans shall, by condition of Development Approval, be implemented to the satisfaction of the City prior to occupation of the development unless otherwise specifically agreed by the City.

iii. Each application for non-residential development shall be accompanied by a car parking schedule demonstrating compliance with the policy requirements of the Scheme of this Local Development Plan unless an otherwise agreed variation is granted by the City.

(b) Landscape Plans shall be required as a Condition of Subdivision and/or development approval. A stage 1 Landscape Plan shall be provided as a condition of Subdivision Approval for the first application for subdivision within the Structure Plan area. This Stage 1 Landscape Plan shall detail landscaping requirements for road reserves, drainage reserves and public open space to be ceded as part of the Stage 1 Subdivision in order to ensure that the public realm amenity is established as part of initial developments.

PLAN 1

TAMBREY NEIGHBOURHOOD CENTRE STRUCTURE PLAN

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LEGEND

- Structure Plan Area
- Existing Cadastre

Zones

- Town Centre

Other

- Drainage
- Neighbourhood Connector Type B 18m Reserve
- Neighbourhood Connector Type B 16m Reserve
- Access Street Type B 15m Reserve
- Access Way Type C 13m Reserve
- Right of Way - 6m Reserve
- Existing
- Roundabout
- Intersection Treatment
- Residential Local Development Plans
- Motor Vehicle Wash Permitted (P)
- A B Parking Areas
- Key Access Points
- Key Pedestrian Routes / Drainage
- Landscape Nodes
- Focal Point / Entry
- Acoustic Report required for Noise Sensitive Development (100m from Dampier Rd Centre Line)
- Local Development Plan Boundary

STRUCTURE PLAN
TAMBREY NEIGHBOURHOOD CENTRE

Date: 24 Mar 2016 Designer: ER

Scale: 1:2000 @ A3 Drawn: TW

Drawing No. 713-222 ST1A Tambrey 2016-03-24.ai

TOWN PLANNING AND URBAN DESIGN

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PART 2 - EXPLANATORY REPORT

INTRODUCTION

Karratha has a vision to become a regional city with a diversified economic base and healthy local community afforded full range of jobs and services, convenience shopping and amenities typically found in major regional centres. With a population of approximately 20,000 people, a regional city should no longer just be afforded a service station as its only neighbourhood centre providing convenience shopping outside the city centre. This Structure Plan is aimed at helping Karratha become a true regional city by providing a neighbourhood shopping centre that has the opportunity to provide the local community with amenities that could include café's, restaurants, bistros, local shops and a supermarket where residents can easily and quickly drop in for their daily shopping needs, or enjoy a meal and a drink with friends. Community infrastructure such as that proposed will enhance the lifestyle of the local community and encourage residents to stay longer and become part of Karratha's long term community.

The vision is to be implemented by this Structure Plan that has been prepared on behalf of FJM Property & Raydale Holdings and LandCorp to facilitate the development of the Tambrey Neighbourhood Centre (TNC) which currently comprises vacant land on the corner of Dampier Road and Bathgate Road, Nickol. The site is currently vacant and unused, and is surrounded by residential neighbourhoods, some of which have only recently been developed or are planned for the future, and others that are already established.

The TNC will be a vibrant mixed use centre, providing convenience goods, services and facilities to its growing residential hinterland. In addition to its commercial functions, the Structure Plan will also facilitate the development of additional medium to high density housing, providing a more intense form of accommodation to that typically provided in the surrounding area, and also providing activity and passive surveillance within the Centre.

The subject site is currently zoned 'Urban Development' part of which was rezoned from 'Parks Recreation and Drainage' by Amendment No 24 in November 2011. This Structure Plan has been prepared in accordance with the requirements of the Shire of Roebourne Town Planning Scheme No. 8 for the 'Urban Development' zone and the *Planning and Development (Local Planning Scheme) Regulations 2015* as discussed in detail in this report.

This report addresses relevant planning requirements, as well as traffic, environmental and engineering matters with input from a team of experts including:

- LandCorp;
- FJM Property & Raydale Holdings (The Tambrey Joint Venture) – Developers;
- GMPM – Project Managers;
- Taylor Robinson – Commercial Architecture & Urban Design;
- Christou – Residential/Mixed Use Architecture;
- TPG Town Planning, Urban Design and Heritage – Town Planning;
- Wood & Grieve – Engineering;
- Coterra – Environmental;
- Emerge Associates – Landscape Architecture;
- MNG McMullen Nolan – Surveying;
- Uloth & Associates - Traffic Engineers; and
- MacroPlanDimasi - Retail/Economic Consultants.

CONSULTANT TEAM

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COTERRA
ENVIRONMENT

WOOD & GRIEVE ENGINEERS

MacroPlanDimasi

MNG.

SUBJECT SITE

SITE LOCATION AND TENURE DETAILS

The subject site is situated within the suburb of Nickol, approximately four kilometres to the west of the Karratha town centre. The land currently comprises four land parcels as detailed below totalling 9.605ha, with frontages to Tambrey Drive to the north of approximately 130m, Bathgate Road to the east of approximately 296m, Dampier Road to the south of approximately 285m and a drainage reserve to the west of approximately 486m.

Refer to Figure 1 – Location Plan

Refer to Figure 2 – Site Plan

The site is owned by the WA Land Authority (LandCorp) and is to be developed by the Tambrey Joint Venture in conjunction with LandCorp.

The subject site itself is currently undeveloped, and is generally surrounded by residential development, with the exception of the Caltex service station located on the corner of Bathgate Road and Tambrey Drive.

The site's Certificate of Title particulars are as follows:

Certificate of Title Volume / Folio	Lot No.	Plan / Deposited Plan No.	Street Address	Legal Area
2883 / 298	501	DP 407053	Lot 501 Bathgate Road, Nickol	0.1895 ha
2883 / 299	1302	DP 407053	Lot 1302 Bathgate Road, Nickol	3.6977 ha
2785 / 815	3860	DP 215374	Lot 3860 Tambrey Drive, Nickol	0.9671 ha
2883 / 300	1500	DP 407053	3 Bathgate Road, Nickol	4.7492 ha

Refer to Appendix A – Certificates of Title
Refer to Appendix B – Feature Survey

LOCAL CONTEXT

Surrounding the subject site, the local area has generally been developed for single residential dwellings at relatively low densities.

Refer to Figure 3 – Aerial Photograph

The residential area to the immediate west was built in the mid 2000's, and a residential area to the south-west (Bayton West) is currently being built out. Madigan residential estate, is planned on the eastern side of Madigan Road, which will eventually add some additional 1000 dwellings to the area with the first 140 lots currently on sale. These developments will result in additional demand for services, goods and amenities in this area, with the small local centre in Madigan being limited to only 500m^2 NLA to ensure that it did not detract from the viability of the proposed Tambrey Neighbourhood Centre.

Immediately to the north-east of the site at the corner of Tambrey Drive and Bathgate Road is a Caltex service station, which currently also acts as the convenience shopping centre for the western suburbs.

Approximately 400m to the west of the site is the Tambrey Tavern and Function Centre, Tambrey Oval and a children's playground area, and situated further beyond is the Tambrey Primary School.

Figure 1 – Location Plan.

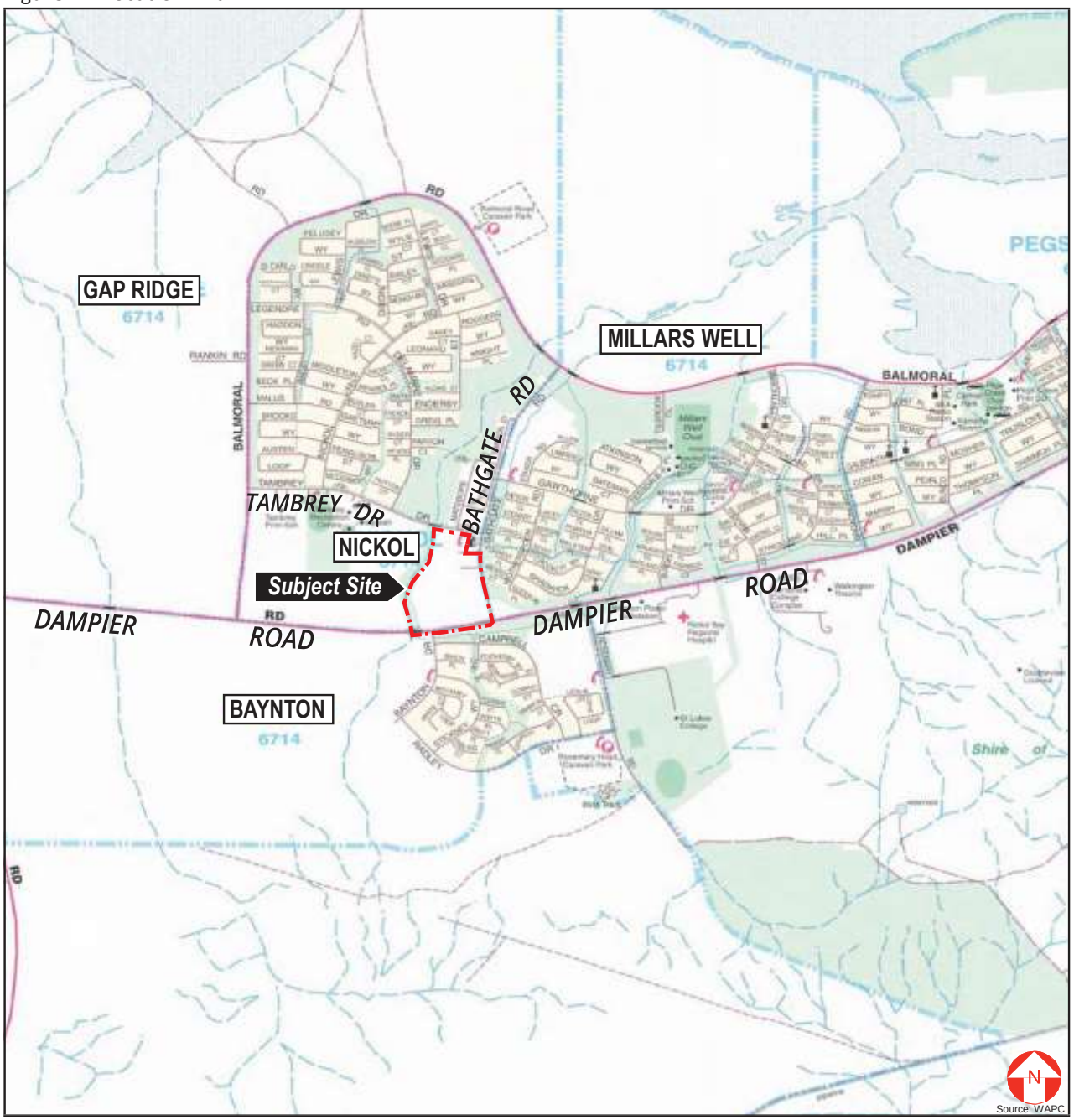

Figure 2 – Site Plan

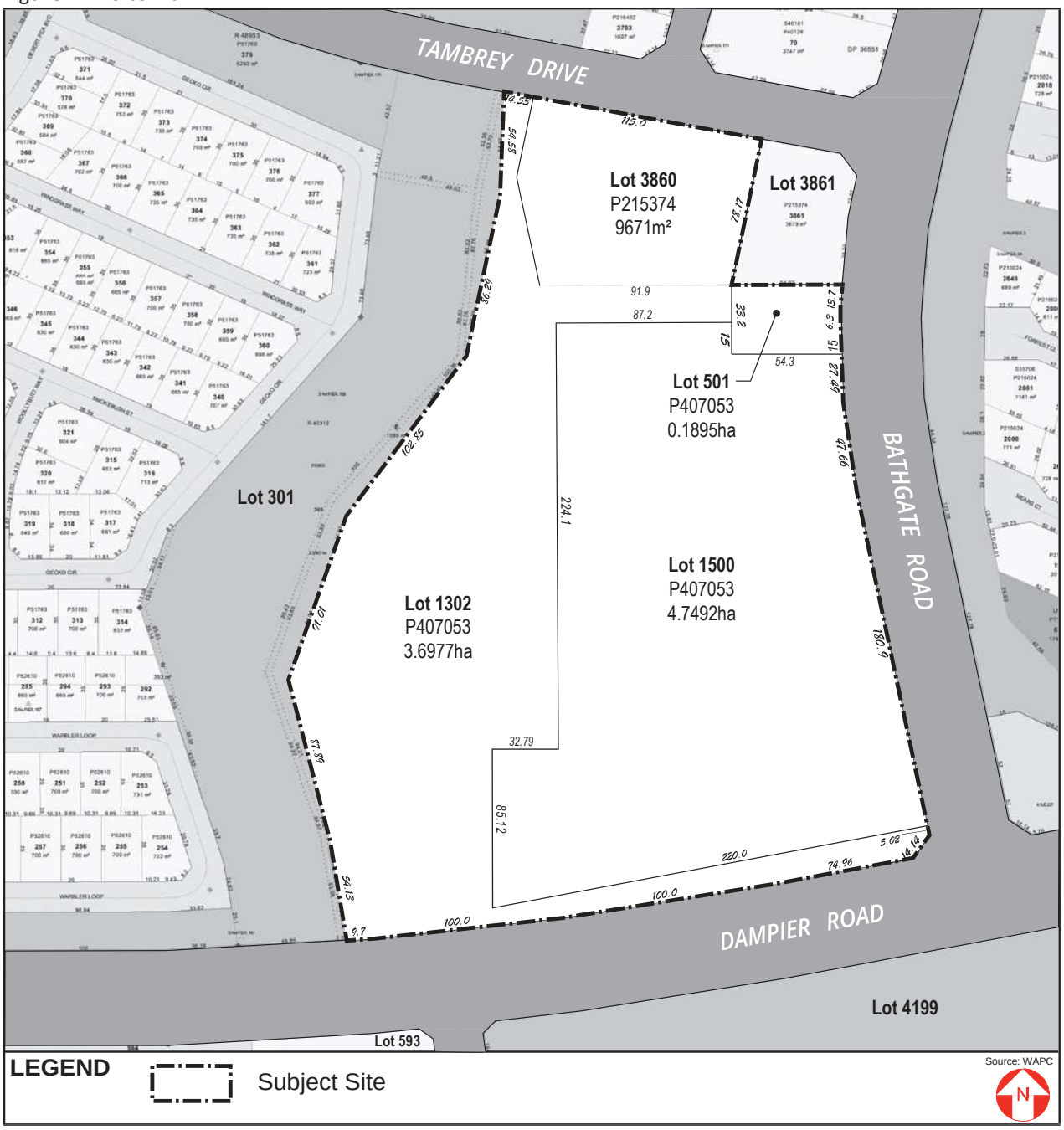

Figure 3 – Aerial Photograph

The Pam Buchanan Community Centre, is located approximately 1km south west of the subject site was opened in January 2012. It is a 'one stop shop' for family and child-related services. The facility contains a child care centre, office and clinic space for specialist health providers, two infant health clinics and various other facilities, and also temporarily contains the Karratha Community Library.

Refer to Figure 4 – Context Plan

HERITAGE AND CULTURAL SIGNIFICANCE

The subject site was excluded from the original Burrup-Maitland Industrial Land Agreement and therefore was not cleared of Native Title claims during that process. There are two Corporations entitled to native title claims on the Tambrey Neighbourhood Shopping Centre Site - Murajuga Aboriginal Corporation (MAC) and Ngarluma Aboriginal Corporation (NAC). Final settlement of all NAC entitlements was finalised in November 2012. A draft Deed has been prepared for the MAC entitlement, and MAC has recently executed the document which is nearing final completion and will be resolved before any development is undertaken on the land.

The Department of Indigenous Affairs Aboriginal Heritage Database does not identify the presence on any Aboriginal heritage sites within the project site or immediate surrounds. Two areas of significance are identified to the south of the site, being "LCK/16 - grinding set, mythological, grinding patches/groves" and "Baynton West scatter 2 artefacts/scatter" which will not be impacted on by the development.

The Australian Heritage Database does not identify any areas of European heritage significance on the site with the nearest heritage site listed on the Western Australian Heritage database being the nearby Tambrey Neighbourhood Centre.

ENVIRONMENTAL CHARACTERISTICS

Coterra have prepared an Environmental Report for the site, which details site characteristics and makes recommendations for the implementation of the Structure Plan.

Refer to Appendix C – Environmental Report

Topography

Topography over the majority of the site has a gentle decline from 15m AHD on the southern boundary to 12m AHD in the north. The centre line of the drainage reserve on the western boundary lies at 11.5m AHD adjacent to the southern site boundary and 10m AHD adjacent to the northern site boundary.

The environmental geology mapping series shows most of the site to be underlain by alluvium (clay, silt and sand) deposits amongst large expanses of clay.

Department of Environment Regulation (DER) mapping indicated the site predominantly has a 'moderate to low' risk of Acid Sulfate Soils (ASS) within 3m of the natural surface. The south eastern corner of the site is mapped as having 'no known risk of ASS'. The closest high risk area is located over 2km from the site.

Figure 4 – Context Plan

HYDROLOGY

Groundwater

The site is underlain by the Pilbara Fractured Rock Aquifer which comprises of water pockets in fractured and weathered granitoid rock of low permeability (DoW 2012). This aquifer is not considered to be a major regional groundwater resource with bore yields varying depending on intersection of fractures.

Regional groundwater mapping suggests that the watertable is generally within 5 to 10 metres of the surface (DoW 2012).

Surface Water and Drainage

There are no existing surface water drainage features within the site boundary.

Karratha experiences unreliable and variable rainfall and is seasonally prone to cyclones. Cyclonic events have the ability to cause widespread flooding and flood related damages. In order to address this issue, the drainage network in Karratha was developed primarily for the rapid removal of stormwater away from key infrastructure within developed areas, to prevent and minimise flooding.

Runoff generated on site flows in a north westerly direction into a drainage reserve which runs along the western boundary of the site. The drainage reserve conveys runoff from the site and upstream catchments towards Pegs Creek and eventually into Nickol Bay, as further discussed in the Local Water Management Strategy prepared for the site.

Refer to Appendix D - Local Water Management Strategy

FLORA AND VEGETATION

Database Search Results

A search of the DER's Threatened Ecological Community (TEC) database by GHD (2011) indicated that there are no TEC's within, or in close proximity to this area.

A search of the DER's Rare Flora Databases, Western Australian Herbarium and Western Australian Museum NatureMap records by GHD (2011) found no Declared Rare Flora (DRF) have been recorded within 10km of the Karratha Land Release project study area.

A search of the NatureMap database for a 5km radius around the Tambrey site indicated that Acacia glaucocaesia (Priority 3) was the only Priority Flora species known to occur in the area. This plant is described as a dense, glabrous shrub or tree, 1.8-6m high with yellow flowers appearing from July to September. The species occur on red lam, sandy loam, and clay in floodplain areas (DEC, 2012).

During GHD's vegetation and flora assessment for the Karratha Land Release project, which includes numerous areas in the vicinity of this site, no DRF or Priority flora species were encountered (GHD, 2011).

Onsite Vegetation and Flora

An assessment of the vegetation onsite was undertaken by Coterra Environment in May 2012, which found the following:

- The majority of the site appears to have been previously disturbed especially the northern half which is dominated by closed introduced grassland.
- The southern half is variously disturbed, both directly and indirectly.
- The flora species (in particular grass species) present and the clay substrate, which has now been largely disturbed, indicates prior to disturbance this would have been an area of Roebourne Plains Priority Ecological Community (DEC, 2006).
- The predominantly introduced grassland on the lot is particularly dense on the northern half where the soil has been largely disturbed. Towards the southern end of the site Acacia species shrubland occurs over the grassland, which becomes more mixed.
- Clusters of the Priority 3 flora species, Themeda sp Hamersley Station (M E Trudgen 11431) are located in grassland within the southern end of the site. Priority 3 flora species are defined by the EPA as Taxa which are known from several populations and are not believed to be under immediate threat (that is, not currently endangered), due to the number of known populations (generally greater than or equal to five), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as rare flora but are in need of further survey (EPA, 2008).
- Eight weed species were recorded onsite. Two of these, **Cenchrus ciliaris* and **Cenchrus setiger* dominate the grassland over the majority of the site.

A description of the onsite vegetation units is provided in the table below.

Vegetation Description	Condition	Comment
Cenchrus ciliaris*/Cenchrus setiger* closed tussock grassland on previously disturbed earths with some gravel.	Completely Degraded	70-100% grass cover. Completely degraded. Northern and western portion of site.
Acacia bivenosa shrubland over mixed tussock grassland of **Cenchrus ciliaris, Eragrostis xerophila, Aristida latifolia, Astrebla pectinata, Sorghum plumosum* on mosaic of cracking clays and gravelly silts, semi disturbed.	Fair	15% Acacia shrub cover over mixed grasses. 40-60% native flora composition but signs of disturbance. Southern portion of site.

Notes: * denotes introduced flora species Vegetation condition rating adapted from Keighery (1994) and Kaesehagen (1995)

FAUNA AND HABITAT

As previously discussed, the condition of the vegetation at the site is disturbed and degraded, with little ecological value remaining. Based on this, and the relatively small size of the site, this area is not anticipated to provide significant fauna habitat opportunities.

A search of the NatureMap database for a 5km radius around the Tambrey site indicated that the following conservation significant fauna have been recorded in this area:

- Northern Quoll (*Dasyurus hallucatus*)
- Lined soil-crevice skink (*Notoscincus butleri*)
- Eastern Curlew (*Numenius madagascariensis*)

Habitat requirements for each of these species are summarised in the following table.

Species	Habitat
Northern Quoll	The species' preferred habitat consists of rocky escarpment, open forest and open woodland (SEWPaC, 2005)
Lined soil-crevice skink	Found mainly in stony spinifex areas (Cogger,2000; Cyberlizard, 2012)
Eastern Curlew	The Eastern Curlew is most commonly associated with sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with large intertidal mudflats or sandflats, often with beds of seagrass. Occasionally, the species occurs on ocean beaches (often near estuaries), and coral reefs, rock platforms, or rocky islets. (SEWPaC, 2012; Dann 1994).

The site does not contain landforms or vegetation which provide habitat opportunities required for the species above.

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PLANNING FRAMEWORK

CITY OF KARRATHA LOCAL PLANNING STRATEGY

The City of Karratha is currently in the process of preparing a Local Planning Strategy to form the guiding document for the preparation of a new town planning Scheme. Whilst at the time of writing this report the Strategy had yet to be released, a number of technical documents are available and an Outcomes Report has been released. The Outcomes Report outlines a number of key messages relative to this Structure Plan which will be considered in the preparation of the Strategy including:

- Karratha is to remain as the major population and service centre for the region;
- It is recognised that employment and the provision of amenities are key factors required to drive growth;
- Small business and economic diversification is very important to the community, but the cost of business and residential accommodation is high and there is a lack of affordable short stay accommodation.
- There is a need for housing diversity to accommodate young singles/couples and retired/aging population; and
- There is support for common boat storage.

Implementation of this Structure Plan will assist the City in achieving some of these objectives, particularly by providing more amenities and services, and enhancing the City as a retail destination, but also providing greater employment opportunities, commercial diversification and opportunities for housing diversity.

KARRATHA CITY OF THE NORTH PLAN

The Karratha City of the North Plan (KCNP), adopted by the City of Karratha (then the Shire of Roebourne) on 18 May 2010, comprises a series of documents being the *Karratha City Growth Plan, the Karratha City Centre Master Plan and the Implementation Blueprint*. Together, these documents identify a range of spatial and non-spatial requirements to guide the future growth of Karratha into a regional city of 50,000 residents.

The KCNP will provide a basis for guiding decision makers in assessing rezoning, subdivision and development applications as well as the provision of infrastructure and community facilities over time.

KARRATHA CITY GROWTH PLAN

The Karratha City Growth Plan (CGP) is a city–wide strategy to guide the future development of Karratha into a city of 50,000 residents. Specifically the CGP will guide the future spatial and non-spatial development requirements for the growth of Karratha, identifying the need for land supply, housing diversity, open spaces, commercial nodes, entertainment and retail areas, as well as the provision of community and servicing infrastructure.

The CGP identifies Karratha as a series of neighbourhood precincts. Each precinct isdescribed in terms of its desired urban character, land use and urban structure as well as identifying key assumptions and planning considerations requiring further resolution.

Under the CGP, the site is situated within the 'Nickol/ Baynton' precinct which is to be an 'Enhanced Existing Residential' area with the 'Potential for Increased Density'.

Refer To Figure 5 – City Growth Plan

The general design intent of the Precinct is for the development of a site responsive, walkable and connected residential neighbourhood that provides good pedestrian and vehicular connectivity within and to and from existing residential areas. The Tambrey Neighbourhood Centre itself is identified to be developed as a *"district centre comprising mixed use development (ground floor commercial/retail with upper floor medium density residential)"*.

Generally the Karratha CGP envisages residential development to provide a range of densities to achieve an average of R40 with "higher densities around areas of activity such as the Tambrey Centre".

The proposed Structure Plan and the development it facilitates will implement this vision.

KARRATHA PRIMARY TRADE AREA RETAIL & COMMERCIAL STRATEGY (2009)

The Karratha Primary Trade Area Retail & Commercial Strategy prepared by the Department for Planning and Infrastructure in 2009 analysed existing retail and commercial floorspace provision for the principle towns within the City of Karratha and identified future floorspace demand by the year 2020.

With regard to the site, the Strategy provides for the development of a neighbourhood centre in Nickol (Tambrey), recognising that the City Centre is some 4km from residents to the west of the site. The Strategy recognises the residential growth of the western end of town and advocates a retail neighbourhood centre with a 4,500m^2 supermarket and an overall 8,100m^2 centre size.

The proposed Structure Plan will assist with achieving the objectives envisaged under the document.

KARRATHA REGIONAL HOTSPOTS LAND SUPPLY UPDATE

The Karratha Regional HotSpots Land Supply Update updated by the WAPC in December 2010 provides an overview of land supply within Karratha based on the status of major projects and current and anticipated lot creation activity. The latest update reflects the Karratha City Growth Plan (discussed above) which is proposed to be reflected in the Scheme via Amendment 21 and a review of the Scheme.

Refer To Figure 6 – Hot Spots Update

The subject site is identified on Map 6 as being area KA24 and KA24A and intended to be developed as mixed use to include a neighbourhood centre with a range of residential dwelling types and other uses.

The document is relevant to the planning of the site as it guides infrastructure agencies in the planning of future servicing requirements.

Figure 5 – City Growth Plan

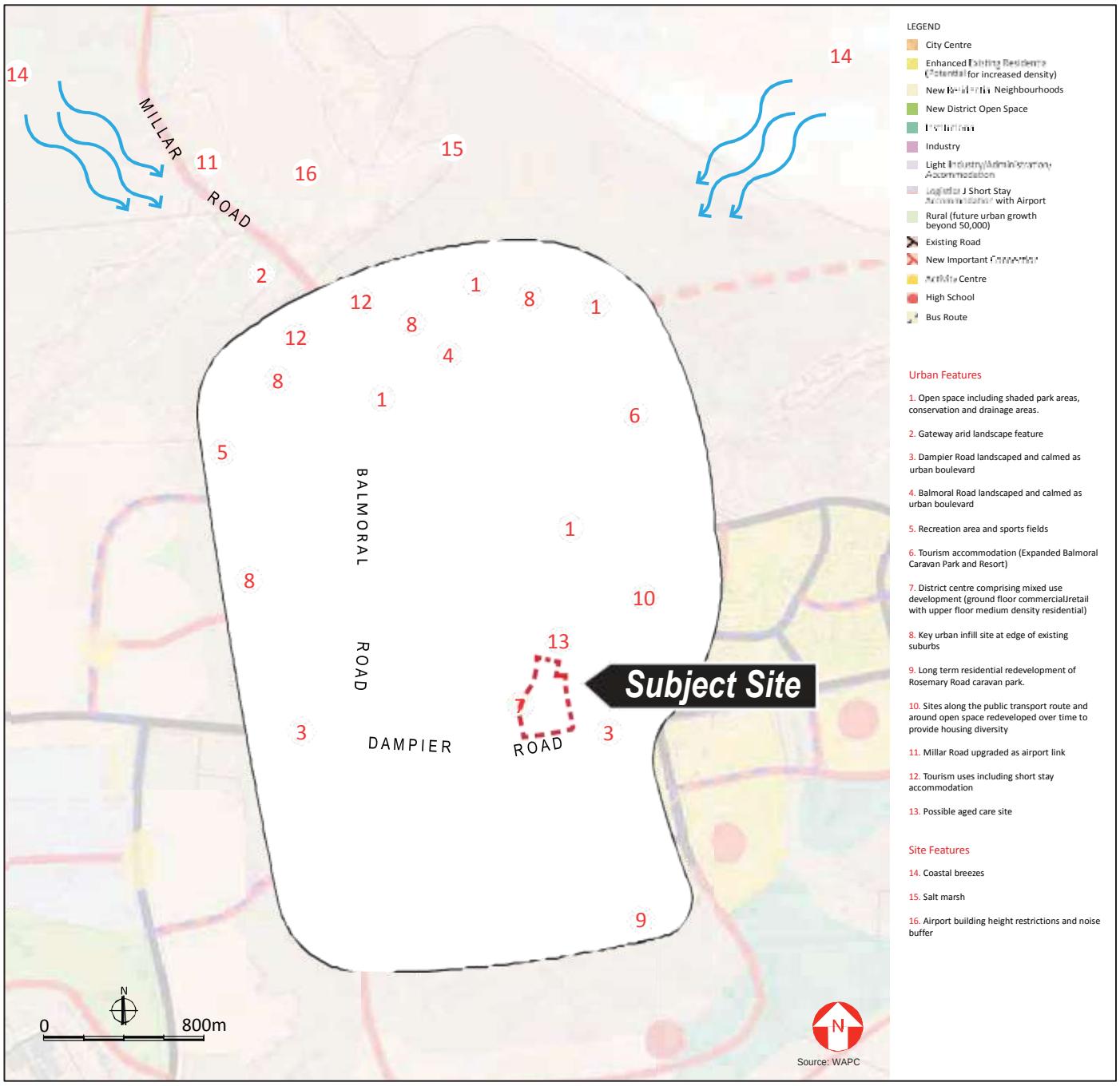
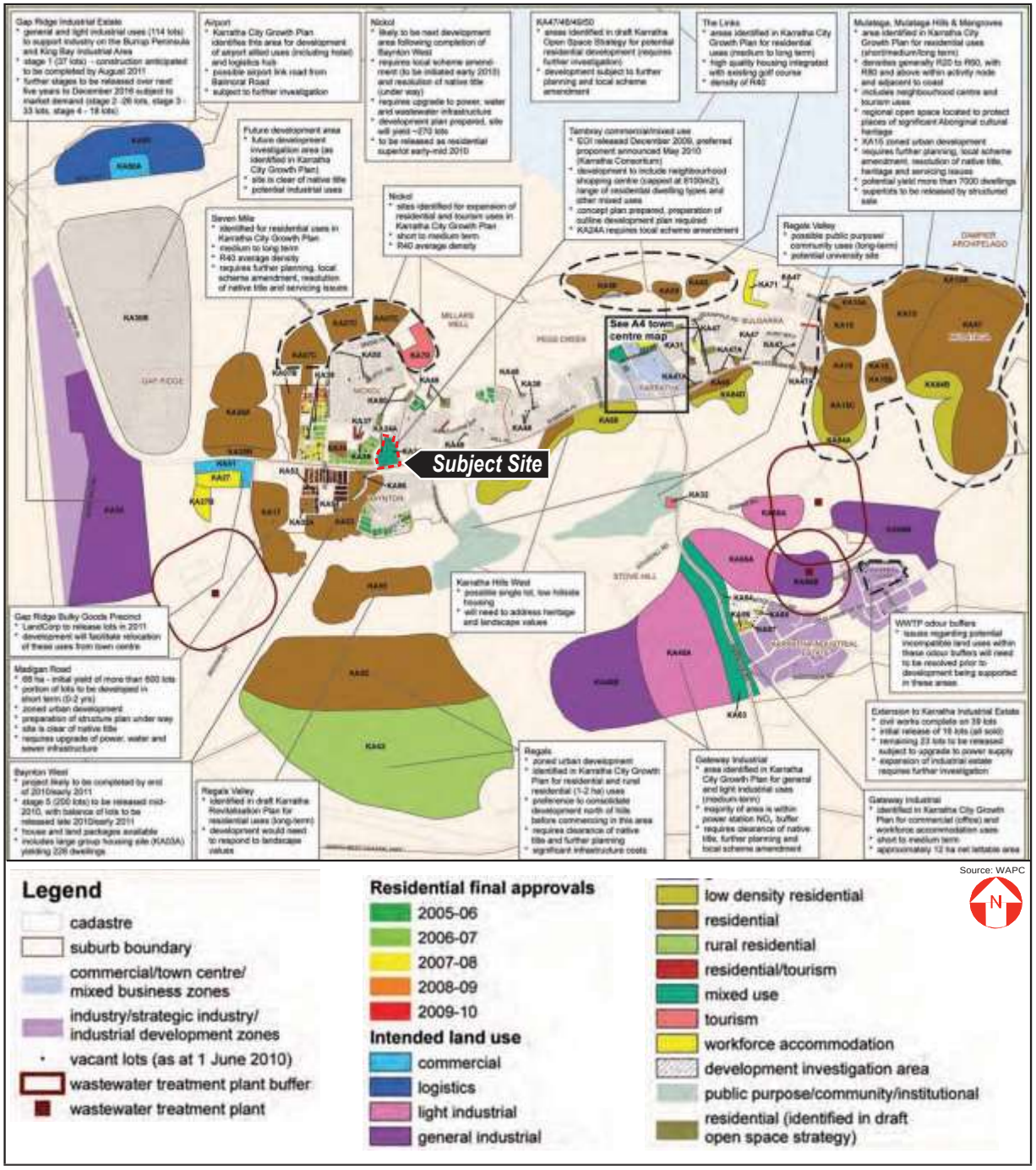


Figure 6 – Hot Spots Update



KARRATHA 2020

The Karratha 2020 Vision and Community Plan (2009), prepared by the City of Karratha in partnership with the State Government and industry, assesses Karratha's infrastructure and service needs in response to anticipated future population growth.

Key themes highlighted by the document include the need to provide affordable, non-mining related office, commercial and retail space to facilitate economic diversity as well the provision of a range of family services and amenities.

The document also highlights the need to provide affordable housing to address the escalating costs of housing and also the need to provide a diverse variety of housing types that appeal to a greater variety of family types and increase the town's liveability.

The proposed Structure Plan will assist with achieving the objectives envisaged under the document by not only providing additional amenities and services, but also providing non-mining related employment and a variety of housing types.

SHIRE OF ROEBOURNE TOWN PLANNING SCHEME NO. 8

The Shire of Roebourne Town Planning Scheme No. 8 (TPS 8) was gazetted on 22 August 2000 and provides the statutory basis for the planning for all land within the City of Karratha, including Karratha.

Under the Scheme, the subject site is zoned 'Urban Development' and comprises 'Development Area 7' (DA7). The eastern portion of the site was rezoned to 'Urban Development' as part of Amendment 24 to TPS 8 in December 2011, and included in DA7. This rezoning was originally to be undertaken as part of a larger amendment, being Amendment 21 to the Shire's Scheme, which sought to rezone and set aside developable land as identified in the City Growth Plan. However, due to the long time frames associated with the assessment and approval of Amendment 21, the separate Amendment 24 was undertaken, to enable the Neighbourhood Centre to be developed sooner.

Refer To Figure 7 – TPS8 Zoning

With regard to DA7, Appendix 7 of the Scheme states the following:

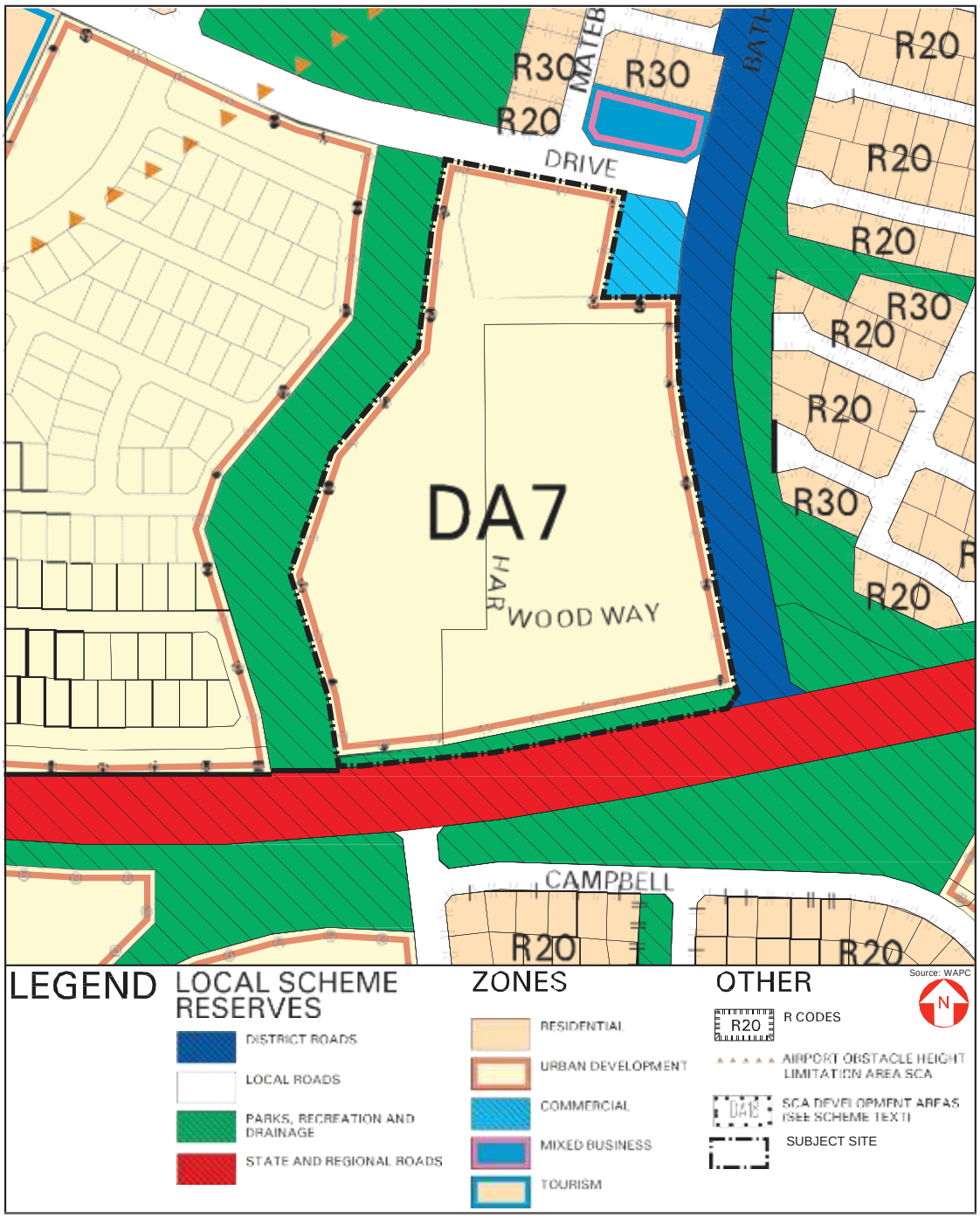
1. *An approved Development Plan together with all approved amendments shall apply to the land in order to guide subdivision and development.*

2. *To provide for commercial, holiday accommodation, medium density residential, aged persons and/or mixed use (commercial/ residential) development.*

3. *The amount of retail floor space shall be determined based on an Economic Impact Assessment which shall also consider economic impacts on the Karratha City Centre. Provision of retail floor space is to be commensurate with a Neighbourhood Centre, delivered in stages and capped at an ultimate maximum floor space of 8,500m² NLA.*

4. *The Shire may require the preparation of Detailed Area Plans to ensure development adequately addresses the public realm (including drainage reserves), climatic conditions, a Karratha vernacular and reflects 'main street' design principles.*

Figure 7 – TPS8 Zoning



5. *Land uses classified on the Development Plan apply in accordance with clause 7.2.11.4.*

This Structure Plan is specifically aimed at satisfying these provisions.

Proposed Amendment No. 27 to TPS8

Amendment No. 27 seeks to amend Clause 7.5 of TPS8 to provide Council with greater flexibility to consider applications for planning approval relating to land located within the Storm Surge Special Control Area which in the opinion of the Council incorporate risk management and mitigating measures which present risks to human life and health, property, utility and service infrastructure and social, cultural and environmental values are suitably avoided remedied or mitigated.

The intent of the Amendment is to provide Council with the ability to consider mitigating factors when determining all applications within land that is known to be prone to 100 year ARI storm rainfall events or may be susceptible to a 1:500 year storm surge event.

Coterra has confirmed that the site is outside the 1:100 year and 1:500 year ARI storm events and therefore storm events are no impediment to the City and WAPC approving this Structure Plan under the Scheme.

Refer To Appendix D – Local Water Management Strategy

STATE PLANNING POLICY 5.4: ROAD AND RAIL TRANSPORT NOISE AND FREIGHT CONSIDERATIONS IN LAND USE PLANNING (2009)

This Policy is primarily concerned with how the planning system can be used to minimise the adverse impact of transport noise on noise-sensitive development without placing unreasonable restrictions on development or adding unduly to the cost of road and rail infrastructure.

The Policy is applicable in the case where noise-sensitive development is proposed in proximity to major roads and/or railways. In this regard, the Policy identifies Dampier Road as a 'State Freight Road' for which transport noise may affect sensitive land uses.

The Policy sets out the outdoor noise criteria that apply for new noise-sensitive development. The noise levels are measured at a distance of one metre from the most exposed, habitable façade of the proposed building, at each floor level, and within at least one outdoor living area on each residential lot. The outdoor noise criteria requirements are as follows:

Time of day	Noise Target	Noise Limit
Day (6 am–10 pm)	LAeq(Day) = 5dB(A)	LAeq(Day) = 60dB(A)
Night (10 pm–6 m)	LAeq(Night) = 0dB(A)	LAeq(Night) = 55dB(A)

Generally where the noise target is likely to be exceeded for outdoor areas, a detailed noise assessment and/or the implementation of mitigation measures may be required by the developer to achieving the target levels. For residential buildings, acceptable indoor noise levels are LAeq(Day) of

40dB(A) in living and work areas and LAeq(Night) of 35dB(A) in bedrooms. To help mitigate any potential negative impacts of noise, this Structure Plan requires that, as part of any application for development for a noise sensitive land use (such as residential) within 100m of the centreline of Dampier Road, an Acoustic Report be prepared to demonstrate that the proposed development complies with the relative legislation.

100 metres is considered more than adequate given the Acoustic Report for the Madigan Road Structure Plan only required an acoustic amelioration for dwellings within 81.5 metres of Dampier Road. The Structure Plan also requires any sensitive development within 50m of a noise generating land use to also provide an acoustic report. 50m is considered more than adequate given the Structure Plan also requires the noise generating land use to also prepare and complete an appropriate report.

PROPOSED STRUCTURE PLAN

This Structure Plan aims to facilitate the development of the site into a mixed use Neighbourhood Centre, comprising both commercial and residential development around a central retail main street. To achieve this vision, the site was analysed and the development brief refined to ensure that a vibrant neighbourhood centre core would be established with residential development on those adjoining areas with higher amenity. The following design parameters were established to formulate the design and then the Structure Plan was prepared to facilitate the development of the design whilst still allowing flexibility for the design to evolve and adapt to an often changing market.

At the time of writing this report the demand for residential development is low, so the key aim is to facilitate the development of a shopping centre and non-residential services and amenities in the short term. The Structure Plan nevertheless puts in place a framework where appropriate residential development can be readily accommodated in the longer term through the preparation and approval of a series of Local Development Plans as envisaged under the objectives of DA7 under the Scheme.

URBAN DESIGN CONSIDERATIONS

The design team examined various options for the arrangement of the uses and land configuration for the Tambrey Neighbourhood Centre. The Structure Plan design is based around the Consortium's successful EOI submission. This design has been further developed in association with LandCorp with input from City of Karratha.

The now presented final draft plan arrangement has given consideration to addressing the following important parameters:

- The primary premise for much of the design arrangement is to offer a neighbourhood centre that is convenient to access and to use, whilst appreciating the various tenants for 'making a main street based retail centre work'. The anchor is a 'major' supermarket which can allow activation of convenience retail shops/services in the first instance, and later, the associated additional retail, commercial and other services. The size of the major supermarket requires that the design allows for locating the 'large footprint' with consideration of how the centre will be staged, how it can 'activate' the external tenancies and how it remains convenient to park and easy to service. There are many nuances of this design challenge and several remain with the leasing team for further consideration at a later date, but the design team has nonetheless, liaised with commercial leasing agencies for their opinion on such matters and the proposed design reflects this opinion.
- The main street needs to be kept to a 'manageable length' and requires both 'vehicular traffic' and 'pedestrian friendliness' to offer it a chance to function optimally. The total length of the main street proper on completion is circa 150 metres, which is comparable to Bay View Terrace in Claremont, or Mends Street in South Perth. In the first stages it may be less than 100 metres, but the design allows for 'anchoring the ends' with social and service functions (like the tavern and medical) and creation of a focal point at the heart by way of a partly covered entry that also intersects with the primary east west linkages. Parking is intentionally (and proportionately) distributed in three locations, being west, south east and north east.

- The main street connects the main Dampier Road through the site towards Tambrey Drive, with an intention to encourage a modest amount of traffic up the middle of the centre. The pavement treatments and hardscape will be designed to accommodate plateaued (shopping trolley and pram friendly) crossing points, (whilst also considering stormwater management), and shade structures is to span over parts of the road adjacent to it. The (main) street trees are generally located within the central median refuge to enable shade at the dwell points (as pedestrians cross) and slow down traffic. Their location also allows the building forms, awnings and retail signage to be evident and uncompromised by tree canopies.
- The commercial part of the main street is 'signalled' on approach from the south by a smaller roundabout (than the one on Dampier Road). This slows down traffic and allows an efficient 'split' of the traffic headed to the pad sites or to the residential fringe. The main street (including the roundabout) are designed to allow for future bus usage. Bus dwell points are designed in at the plaza area.
- The Dampier Road frontage has a character appropriate for that edge, insomuch as it comprises a larger landmark development to the west and a series of 'pad sites' to the east, the latter being probable fast food and entertainment uses. The south western corner will (subject to market) have the potential to accommodate a food and beverage Tavern type development and the eastern side is envisaged for fast food outlets.
- The eastern and western fringes of the site have potential as residential, where each has aspect, an address and a relationship to other 'opposite' residential. The possible product is also one that could be 'rear loaded' from a rear right of way and narrow lot design, with a view to encouraging density in some locations with garages at the rear. The residential fringe obviously also performs the important function of screening parking and the services areas of the primary centre. The design team recognises that the treatment to the rear of the lots needs some 'design control' so as to ensure that the carparks (onto which these garages/carports face) are still quality environments and it is intended that LDPs will be prepared with the City to address this interface. These issues may also be resolved by appropriately designed non-residential development that addresses the street.
- The northern sector of the development recognises the existence of the service station and offers a possible link via a proposed carwash with a minimum lot size of 1400m^2 on the corner of Bathgate Road. The north western quadrant of the proposed development is residential, and/or short stay accommodation to provide an appropriate and manageable interface with the service station and existing short stay to the north.
- The entire development is designed to have permeability both for vehicles/cycles and pedestrians. There is a strong north south axis (via the main street) but also several east west connections, the most evident of which is the extension of the proposed pedestrian connection westwards across the drainage reserve to Gecko Circle via a pedestrian link.

- The final architectural design detail has yet to evolve, but it is anticipated that shade awnings, activated shop frontages, human scale and 'north western' vernacular/materiality will all be considered as being important. The uses, scale, form, language and height of buildings have been considered in relation to the roles of each site/location as a 'marker' or as a 'vista' or both.

Refer to Figure 8 - Preliminary Master Plan

Refer to Figure 9 - Notional Building Use Plan

DESIGN INTENT

The Structure Plan is derived from these parameters for the site to provide a main street style Neighbourhood Centre which provides retail goods and other services and amenities for the surrounding residential catchment, whilst also providing places for people to live. The TNC will be a lively mixed use centre with retail, restaurants and entertainment venues; a place with sheltered walkways, convenience shopping and accessible parking, with active streets during the day and evening. Landscaped outdoor entertainment venues, community facilities and evening shopping opportunities will capture the benefits of the climate to maintain this activity into the evening. A variety of different shopping experiences will be provided within the Neighbourhood Centre, from the shaded 'Main Street', which will comprise a range of different goods and services, to the air-conditioned shopping centre, within which the supermarket will dominate.

Refer to Figure 10 – Structure Plan

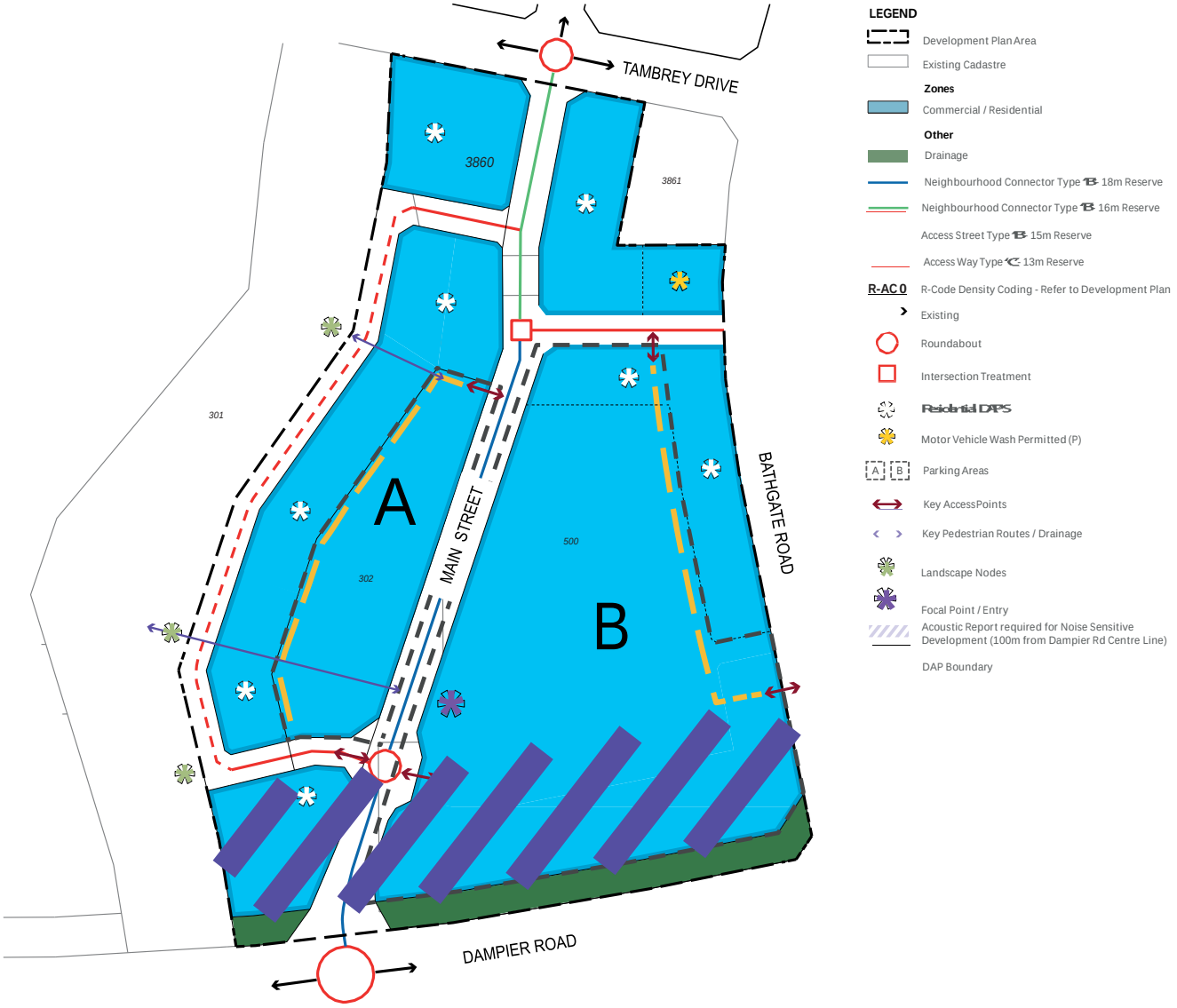
The design of the Structure Plan allows for retail uses to be developed along the north-south, central spine or 'Main Street', with parking largely sleeved behind buildings. Smaller scale fine grain retail uses will be concentrated along the central spine, with larger scale uses (such as a supermarket) located further back to draw people past the specialty stores within the large centre proposed. It is also envisaged a minor major or key anchor tenant will be provided on the western side of the street to draw people out of the centre and activate the main street.

Residential uses are also permitted in the 'Town Centre' zone, particularly in the form of apartments with 'town house' type development envisaged on

Figure 8 – Preliminary Master Plan

Figure 9 – Notional Building Use Plan

Figure 10 – Development Plan



the peripheries overlooking the Drainage Reserve, Bathgate Road and Tambrey Drive. Some areas located away from the central main street are envisaged to be developed for housing with potential for apartments above garages. These are located to provide surveillance over the adjoining landscaped drainage reserve and in the northern part of the site to interface with residential uses to the north of Tambrey Drive. There is the potential for residential live/work terraces with offices or other compatible non-residential uses to the street to face Bathgate Road located towards the edge of the Structure Plan area.

The Structure Plan also aims to optimise the residential development potential of the site whilst providing a variety of housing forms to cater for a range of household types. Whilst the predominant land use is for single residential dwellings (suitable for families with children who wish to benefit from the site's proximity to the Tambrey Primary School and Early Learning Centre), grouped and multiple dwelling housing sites will provide an opportunity for development of either villas, townhouses or apartments which can capitalise on the site's proximity to well developed open space and nearby key transport linkages. At the southern entry to the Centre it is envisaged there will be a gateway, mixed use or commercial building with active uses to the ground floor fronting the Main Street.

A key consideration is also accommodation for the service workers and retail attendants which are essential to the operation of the facility. These essential employees who are not already living in the local community are intended to be accommodated in a diversity of housing typologies within the Structure Plan area.

The single residential lots have been maintained on the periphery of the site where abutting existing single residential dwellings to provide a consistent interface and streetscape. The larger mixed use/ residential dwelling site in the north west corner is located such that a higher density of development can benefit from proximity to the facilities associated with the commercial area, whilst also providing an opportunity for a mixed use interface with the main street. It is envisaged that the road abutting this site will be a traffic calmed road with designated entry treatments to clearly signalise that it is a low speed environment.

On the southern edge of the site, the Design Concept envisages the development of a number of fast food /restaurant outlets which require convenient access and good exposure to traffic along Dampier Road.

In terms of road layout, the Structure Plan is designed around the central Main Street, which runs north-south though the site, intersecting with Tambrey Drive in the north and Dampier Road in the south. A loop road which links on to the Main Street in two locations has also been proposed abutting the existing open space and school site to the west of the site to ensure that dwellings address and overlook the amenities to provide passive surveillance and greater security, but are not subject to commercial traffic volumes. Another road is proposed off the eastern side of the Main Street, linking the development to Bathgate Road to ensure a highly connective centre.

POPULATION AND RESIDENTIAL DENSITIES

The Structure Plan provides for a diversity of residential living options (and a point of difference from the surrounding predominantly single residential lots), being proposed to be developed with a flexible R-Coding where density and plot ratio can be determined by a subsequent Local Development Plan (LDP) to promote a denser urban form. The distribution of residential density has also been based on the provision of higher densities around the areas of amenity such as the landscaped drainage channel, but ultimately its to encourage a more sustainable form of development where residents can easily walk to amenities and services and the threshold population is increased to enhance the viability of the centre.

A range of residential densities will assist with meeting future market demand for residential housing. Densities are envisaged to be higher than those in the surrounding residential areas, highly appropriate due to their Neighbourhood Centre location, and to provide a greater level of dwelling diversity than is currently typical in Karratha.

The tables below summarise the estimated development yields and population generated by the future subdivision under the Structure Plan if the site were to be developed in accordance with the draft Preliminary Master Plan shown in Figure 8.

Development Areas Summary

Land Use	Lan d Area	Percentage of Future Subdivision Area
Single Residential (Approx. 200m^2)	14687	15.2%
Potential Grouped Housing (Approx. 150m^2)	3710	3.8%
Commercial	51128	53.3%
Multiple Dwellings	7925	8.3%
Serviced Apartments	4835	5.1%
Drainage	3743	3.8%
Roads and access ways	10022	10.5%
Total	96050	100%

Estimated Dwelling Yield and Population

Residential Type	Estimated No. of Dwellings	Estimated Population (2.5 PPD)
Single Residential	40	100
Grouped Dwellings	45	110
Multiple Dwellings	80	200
Total	165	410

*Note: These are based on current concept planning and subject to change.

Whilst the current Development Concept does not show residential uses above commercial uses, the Structure Plan still provides the flexibility for these to be added in subsequent stages should the demand arise. There is also an area in the northern section of the Structure Plan just south of the east west link to Bathgate Road which may be used for either Commercial or Residential uses depending on what the demand for secondary commercial outside the Main Street is like. Should this change be desired then there is a provision in the Plan for a LDP to be prepared as a pre-requisite to any built form for residential which will provide the City with the level of comfort that it will have control over the resulting built form.

Based on the above and if the site were developed as per the Preliminarily Concept Plan, it isestimated that there will be approximately 165 dwellings provided in the precinct. Whilst based on the 2011 population in Pegs Creek, the typical number of persons per dwelling is 2.71, a reduced rate of 2.5 persons per dwelling is considered more likely given the higher density of development proposed is likely to result in smaller dwellings and household size. Based on this the anticipated population ofthe development is only around 400 persons which does not give any undue rise in the need for community services or amenities beyond that proposed in the development. In fact it is considered that the proposed development considerably adds to the amenity provided to all residents in the western suburbs of Karratha, and community facilities such as a child care and/or medical centre may be included in the final development.

LOT LAYOUT AND DEVELOPMENT TYPOLOGIES

The Structure Plan encourages the development of a diverse range of lot types, including larger robust lots for commercial purposes, down to facilitating smaller freehold residential terrace lots.

Commercial lots are generally to be fairly large, to provide flexibility for development design and allow room for parking and servicing. The largest commercial lot will contain the supermarket and speciality stores, which have a significant land take and the largest parking area, as well as requiring a good level of exposure. This main lot will also provide vehicular access directly onto Bathgate Road. The Main Street Design Concept (Figures 8 and 9) demonstrates the indicative layout of uses within the core of the 'Town/Centre' zone.

Residential lots as shown along the western, northern and eastern edges of the Structure Plan will provide an interface with the single residential dwellings beyond. Lots are oriented to look out onto the drainage channel to the west of the site, to provide a high level of passive surveillance and assist in creating a safe and attractive environment. A degree of overlooking will also be required to the rear to provide passive surveillance over rear commercial parking areas in the evenings. Residential street blocks are provided with a minimum depth of 30m, to facilitate a flexible range of lot typologies.

It will be determined at the time of a Development Application and ultimate subdivision of the site for it to be demonstrated that the minimum and average lot sizes areachieved.

DWELLING TYPOLOGIES

The Structure Plan enables a diverse range of housing options to be provided through a range of potential single, grouped and/or multiple dwelling sites. Whilst indicative typologies have been prepared to illustrate how the lots could potentially be developed under the Structure Plan, these do not form part of the approval being sought and are subject to review and change. It is envisaged that the dwellings will be constructed on a stage by stage basis, depending on the market. Whilst it is not envisaged that housing will be developed above the major retail uses, the Structure Plan does allow for residential dwellings above the commercial/retail uses in thefuture.

The Concept Plan envisages a series of single residential lots in the north western and western edges of the Structure Plan where they interface with the drainage swale and existing residential uses.

It is likely that these will comprise a mix of green title and strata titled grouped dwellings containing typically three or four bedroom homes. In addition, the ability to have additional multiple dwellings above mixed use development. Grouped townhouse style development is envisaged to be located at the periphery of the zone abutting Bathgate Road and has the flexibility to incorporate live/work offices interfacing with Bathgate Road.

Within the Structure Plan the following dwelling typologies are provided for:

- The site in north west corner abutting Tambrey Drive – This lot is envisaged to be developed as grouped or multiple dwellings, with several dwellings either in the one strata titled lot, or the site is also of a shape which lends itself to be developed for a series of north/south orientated terrace lots that could be serviced by a rear laneway accessing onto to Tambrey Drive. A LDP is required which will ensure that the lots have an appropriate interface with Tambrey Drive and also address and provide surveillance over the main street and the drainage open space to the west.
- The site in the central northern portion west of the main street – This lot is envisaged to allow for commercial type uses to interface with the main street, and a residential above and to the west. This lot has been tested to accommodate a series of terrace dwellings serviced by a rear laneway, but also lends itself to being developed as a mixed use development with commercial uses on the ground floor to the east and a series of residential apartments above accessed either from the shopping centre car park to the south and/or from the new road which interfaces with the drainage open space.
- The western portion adjacent to the drainage open space has been tested to provide for a series of dual fronted single dwelling lots that can be approximately 8m wide and 30m deep intended to support a larger housing form commensurate with the higher value open aspect provided to the west. The LDP prepared for these lots will have a focus on ensuring that vehicle access is provided from the rear and a good level of passive surveillance is provided in the evenings over both the drainage reserve to the west and the commercial lots to the east with the ability to incorporate additional development above the garages. Some dwellings will have a 'Fonzy Flat' for a teenager or lower income service worker above the garage which can be fully closed off from the rest of the house, with a separate detached entry from the rear and a kitchenette, thus providing another form of housing type.
- Southern multiple dwelling site – This is a triangular shaped lot earmarked as a taller landmark entry building of either three or four storeys. This building could include office and/or apartment accommodation with undercroft parking and commercial tenancies of the ground floor, fronting onto the Main Street. If developed for apartments, then they are likely to be located over three storeys and provide a denser urban form where acoustic amelioration can be incorporated into the design and with predominately one or two bedrooms in each apartment.
- Eastern commercial/residential lots – A precinct has been earmarked on the eastern edge to potentially provide for a flexible living

and working options where a 'home office' type use can be provided on the ground floor to interface with Bathgate Road or a series of compatible non-residential uses. This site has been tested to provide lots approximately 8m wide and 30m deep which are access from the rear where the garages will provide a separation between the dwellings and the retail core.

- Northern service/commercial housing – It is envisaged that this lot will be developed to contain serviced apartments and provide an interface between the commercial sites to the south, existing short term accommodation on the opposite side of Tambrey Drive and the service station and car wash to the east. These are envisaged to be developed with smaller modular apartments, with either a single bedroom or in a 'studio' configuration with a rear parking area providing a buffer to the service station and ensuring that the parking does not adversely impact on the streetscape.

LANDSCAPE DESIGN AND INTENT

The design intent of the landscape response of the public realm is to create a civic area that is to become the focal point of the immediate area and form a vibrant urban public realm. This will be complemented by an attractive tree lined Main Street with appropriate shade canopies from building awnings to ensure pedestrian activity is encouraged by being a pleasant and viable option in the often harsh Pilbara weather conditions.

The Pilbara region boasts a large range of unique landscapes including coastal plains and mountain ranges with cliffs and gorges. The landscape design of the Tambrey Neighbourhood Centre as a whole, but in particular the focal civic plaza, including detailed elements within the plaza will draw inspiration in the form of a design language that pays homage to the unique local landscapes of the Karratha area.

Refer to Appendix E– Landscape Strategy

Public Realm

A crucial aspect of the landscape in the Town Centre is the design of external public places to ensure that they are filled with activity. The provision of interactive public spaces must have a seemless synergy with surrounding urban activities, ie cafes, bars, shops & alfresco dining, which will liven the centre and enrich the experience of the users of these spaces.

To best enhance the public realm the following strategies should be considered:

Identity

The identity of the public realm refers to those elements that contribute to a positive sense of place and identity that is unique and authentic to Tambrey and Karratha. Identity can assist with way finding and personal safety whilst fostering community pride. Strategies include:

- Reinforce and enhance TNC and Karratha's positive attributes, build on its areas of strength and respect the distinctive identity;
- Promote local distinctiveness through use of materials that reflect the relative importance of the location;
- Ensure the identity reflects it's principal role as a Town Centre and community hub; and

- Celebrate the natural and cultural heritage of the area through public realm elements and public art.

Consistent and Connected Network

The network refers to the key community and commercial destinations and the connections in between. Defining and reinforcing the connections between each destination and links to the broader community through consistent use of material and contentious routes promotes safety, assists in effective way finding and promotes walking. Strategies include:

- Create a continuous and linked public realm that is clearly defined and consistent;
- Ensure all public realm development is consistent and coordinated in regards to material selection and function;
- Link activity nodes and destinations within the Town Centre;
- Connect to the surrounding pedestrian network;
- Respond to the main routes of vehicle movement throughout the area;
- Establish a hierarchy of streets and spaces;
- Promote place based intuitive way finding, supported by a simple signage system;
- Use a selective palette of materials to provide a unifying theme and a distinctive sense of identity; and
- Ensure accessibility for prams, wheelchairs users and people with disabilities or mobility problems as an integral element of the public realm design.

Activity

Activity can be defined as the events and functions that occur in a public realm that generate and encourage positive social interaction; and the land uses and functions that adjoin public spaces that supports and encourage pedestrian use. Strategies include:

- Provide space and amenities in order to maintain and enhance activity throughout the day and into the evening;
- Allow uses adjacent to the public realm to spill out and use the public zones, i.e. café seating to extend into the street;
- Design spaces to have multiple functions and be flexible, i.e. outdoor markets;
- Encourage people to stay longer including more resting areas along streets and in gathering spaces;
- Promote walking as the main mode of transport within the Neighbourhood Centre through the provision of footpaths, slower traffic and adequate shelter;
- Provide activities for a range of cultures and age groups including children, young adults and the elderly.

Interest

The public realm should provide enjoyment to the community. This can be achieved through activity, social interaction and the visual environment. A public realm that interests the community will encourage more use and foster community pride. Strategies include:

- Enable streets and public spaces to be lively places where people can engage with others in the community;
- Furniture arrangement provides options for different seating groups, i.e. loose furniture; and
- Establish consistency and ensure the overall quality, appearance and amenity of the public realm within the Neighbourhood Centre is at its optimum.

Comfort

Comfort responds to the physical arrangement of the public realm to ensure that users are comfortable within the space. Strategies include:

- Provide protection from the weather along major pedestrian routes and at key stops through canopies and awnings;
- Provide shade in summer and allow sunlight in winter through appropriate tree plantings;
- Use trees to provide a structure and scale to the public realm;
- Provide places for people to rest;
- Position elements within the public realm so that it does not obstruct pedestrian desire lines or pose a hazard to the visually impaired; and
- Reduce the number of elements within the public realm to prevent clutter.

Safety and Protection

The design of the public realm is to address the issues of community safety and deter opportunities for crime and anti-social behaviour. Based on the principles of Crime Prevention Through Environmental Design (CPTED) the strategies include:

- Creating well defined routes, spaces and entrances that provide convenient movement;
- Ensure passive surveillance of public spaces to raise the likelihood that an offender can be either deterred, viewed and identified;
- Provide a range of lighting to ensure spaces are well lit at night time;
- Promote a sense of community ownership, respect, responsibility and pride;
- Incorporate well designed security features into the public spaces;
- Ensure ongoing maintenance of the public realm to indicate the intolerance for vandalism; and
- Provide management of the public realm to ensure there are regular activities in the public realm.

Environment

The urban infrastructure within the TNC needs to respond to the natural systems and environment in order to mitigate emerging environmental issues and to develop healthier places. Strategies include:

- Design drought tolerant, water efficient landscapes to reduce irrigation needs;
- Use locally native plant species where appropriate in order to maintain and encourage biodiversity and ecology;
- Incorporate water sensitive urban design features in the public realm, including possibly rain gardens where stormwater is directed to flow into garden beds, but definitely porous pavements to locally capture and treat stormwater runoff;
- Plant trees to maximise shading of pavements in order to reduce the heat island effect;
- Limit the use of turf to areas of maximum visual and functional benefit to the community;
- Use materials and resources efficiently, i.e. local materials; and
- Promote energy efficiency where possible.

Management and Maintenance

Ongoing management and maintenance of the public realm plays a significant role in its success. Best practice in management and maintenance can assist safety and foster community pride. Strategies include:

- Implement an event programme for gathering spaces to ensure the local community uses them regularly, i.e. outdoor markets;
- Select materials and elements that are hardwearing and resistant to vandalism;
- Use best practice construction methods to optimise lifecycle and performance of public realm elements, i.e. Street furniture, fixing methods, paving substrates.

Water Sensitive Urban Design

An integrated approach to water management which inputs appropriate water sensitive urban design (WSUD) techniques is required within urban spaces. The Town Centre as a whole will take a precinct wide approach to sustainable use of all water forms.

Precipitation in the North West in general is both scarce but also heavy in volume during the cyclonic storm periods. Systems should be in place to help ensure that the water is able to be disposed of without causing undue flooding or damage during cyclonic events.

Applying WSUD practices becomes challenging when dealing with the harsh nature of the North West. Dramatic change of weather conditions from major flooding events to comprehensive periods of drought, as well as the impervious nature of local Pindan soils all present unique challenges to a WSUD approach.

Within streetscapes WSUD can be applied through rain gardens infiltration techniques and swale networks to medians and verges. The adoption of Xeriscaping principles can also minimise the need for irrigation.

Within urban spaces – swales and bioretention methods can be used in a more formalised and urban matter to ensure water does not linger and create a mosquito issues within public areas. Swales can be seamlessly used within the urban areas and can become a celebrated design element within the public realm.

As water is a major issue in the North West ensuring suitable WSUD practices are adopted is critical, especially for a successful landscape response.

By adopting WSUD practices within the Town Centre successful landscape spaces are created that provided essential aspects of the public realm such as provision of shade, softening of harsh urban environments, greenery and cooling while integrating a modern water wise approach.

Civic Plaza & Main Street Landscape Design

Civic Plaza

Karratha Gorge Landscapes

The gorges of the Pilbara region display some of Earth's oldest rock formations as well as creating unique and instantly recognisable scenery. The landscape design response should draw inspiration from these landscapes through the following possible responses:

- Opportunities for vector sensitive interactive water feature designs that reflect the river systems and tidal flats of the Pilbara landscape, whilst also forming attractive stormwater drainage lines through pedestrian focussed areas; and
- Incorporating the gorge geology including ridges, furrows or linear marks into design elements such as walls, stairs, paving patterns & water features.

This can be achieved through irregular shaped stairs, angled wall shapes or through a direct interpretation of the geology in the form dry staked / stratified stone garden walls.

River Systems

The river systems of the North West are integrative and diverse network of tributaries. When viewed from an aerial perspective they create interesting and complex meandering patterns across the landscape. The plaza concept landscape design aims to encapsulate some of the patterns these systems create in a design language legible on the ground plane through the following possible responses;

Tributaries (through differing paving patterns) could be used as way-finding by guiding people to the main heart of the plaza where life, gathering & vibrancy are to dominate.

Tributaries can direct stormwater runoff through pedestrian focussed areas in an attractive landscape response that could include informal mini rapids as a source of interest.

The possible creation a small urban microcosm ecosystem that displays flora and fauna common to Pilbara area, through the provision of an indicative water feature and rockwork and associated shrub and tree plantings that mimic a Pilbara landscape.

Main Street

Streetscapes within activity centres and urban areas play a major role in creating a pedestrian focused urban environment as well as creating hierarchy and strong entry focal points.

Successful streetscapes look to work seamlessly with surrounding high quality urban spaces with high quality materials, encouraging activation, integrate vehicle provision, trees for hierarchy, aesthetics and shade & creating human scale streetscapes.

The mainstreet of the TNC will be designed to provide an urban amenity encouraging the community to use the space for activity and interaction. With a focus on promoting community ownership and pride in the urban environment, the Main Street is to be clearly legible with an active streetscape, connectivity, enhanced pedestrian experience and provide the community with a sense of safety and security to encourage use throughout the day and evening.

The streetscape will create an extension to the vibrant heart to the new centre through the provision of the same materials palette for hard and soft landscaping, including street furniture.

Car parking

Car parking is proposed to be located along the length of the Main Street for convenience access to retail trade located along the street. Parallel parking spaces are located at the same level as the adjacent footpath enabling for ease of access while also allowing pedestrians to be able to cross the road easily.

Larger designated carpark areas are to be provided to periphery of the retail core. These parking areas will have shade provided by trees at the rate of approximately 1 tree per 10 carbays.

The reduction of heat within a carpark is important especially due to the climatic conditions of the North West. The use of pedestrian pavements around the carpark that are reflective coupled with landscaped car parking areas are aimed at decreasing the effects of the bituminous hardstand in the carparking. Once matured large canopy shade trees will ensure heat transfer is somewhat reduced and a more comfortable pedestrian environment created.

Drainage Swales

Precipitation in the North West in general is both scarce but also heavy in volume during the cyclonic storm periods. Flooding events combined with the impervious nature of local Pindan soils creates large movements of water run-off which needs to be strategically redistributed and redirected through the site.

Linear drainage swales along the verge area to Dampier Road are to redirect water run-off from the site to the main existing drain to the west of the site. These drainage swales are to be landscaped in an attractive response utilising local endemic species that can tolerate a level of inundation. It is proposed that these areas will not be irrigated and plant species selected to ensure that they survive and flourish on the natural rainfall patterns of Karratha. The landscaping will be supplemented with the placement of rocks and gravels which will provide a unification technique across the swales to prevent erosion in flooding events. Swales and bioretention methods can be used in a more formalised and urban matter to ensure water does not linger and create a mosquito issue within public areas.

The existing drainage swale to the west of the site is to have a landscaped edge to the development boundary using unirrigated native endemic shrub and tree species. The existing dual use path that runs primarily north south along the drainage swale is to be retained and integrated into the footpath network for the development. Nodal locations are proposed at the major footpath intersections to add to the pedestrian experience and signalise possible changes in direction. The major east west pedestrian network will terminate on a proposed pedestrian bridge crossing over the existing drainage channel to ensure good pedestrian connectivity to the existing Tambrey neighbourhood to the west.

Planting Palette and Strategy

Plant species are proposed to be predominantly endemic in composition and / or known to be waterwise and tolerant to the harsh Pilbara conditions. Feature amenity areas, such as the Main Street and Civic Plaza will have feature shade trees that maybe exotic, but all understorey garden beds will consist of predominantly native species. All trees in pedestrian areas will be selected to provide shade and colour and where possible be an extension of a coordinated planting through the greater Karratha area.

It is proposed that the following indicative planting palette will be used in the amenity areas of the development and streetscape.

Trees (Exotic)	
Caesalpina ferrea	Leopard Tree
Cupaniopsis anacardiodes	Tuckeroo
Delonix regia	Poinciana
Ficus hillii	Hill's Ficus
Mimusops elengi	Bullet Wood Tree
Peltophorum pterocarpum	Yellow Poinciana
Pongamia pinnata	Indian Beach
Pterocarpus indicus	Rosewood
Tabebuia rosea	Pink Trumpet Tree
Tipuana tipu	Pride of Bolivia
Trees (Native)	
Acacia coriaccea	Wirewood
Corymbia flavescens	Cabbage Ghost Gum
Corymbia opaca	Bloodwood
Eucalyptus leucophloia	Snappy Gum
Eucalyptus victrix	Coolibah
Melaleuca argentea	Silver Cadjeput
Terminalia canescens	Joolal
Shrubs	
Acacia hilliana	Hill's Tabletop Wattle
Allamandra nerifolia	Bush Alamanda
Alternanthera dentata	Purple Knight Alternanthera
Bougainvillea glabra	Paper Flower

Trees(Exotic)cont.	
Conostylis candicans	Grey Cottonhead
Dianella caerulea	Dianella Cassia Blue
Eremophila glabra 'Kalbarri Carpet'	Emu Bush
Evolvulus pilosus	Blue Eyes
Senna glutinosa	White Cassia
Strelitzia reginae	Bird of Paradise
Triodia pungens	Soft Spinifex
Westringia fruticosa	Native Rosemary
Zamia furfuracea	Cardboard Palm

Final species selection will be determined in accordance with the City of Karratha's approval and availability at nurseries at the submission stage of detailed landscape construction drawings.

Street Furniture, Signage & Lighting

Street furniture will be selected to ensure it is robust and durable in the harsh environment and that can tolerate a level of vandalism to ensure maintenance minimisation. The street furniture will be selected to complement the architectural style of the built form response and include bench seats, bollards, tree grates, rubbish bins etc. Bicycle racks will be provided at prominent locations around the site, including within the civic plaza to promote a reduction in the dependence of vehicle use.

Where signage is proposed it will be to ensure way-finding opportunities are maximised for clear and legible navigation through the development. Signage will be simple and fabricated from materials that complement the landscape materials, finishes and overall street furniture strategy.

Landscape lighting will be designed in accordance with the architectural lighting to minimise overprovision and ensure consistency in materials. Landscape lighting will focus on the lighting of the civic plaza and any feature elements contained within it such as trees, public art or water features. Where possible overspill lighting from the Main Street street lights and carpark areas will be utilised to light landscape and pedestrian areas.

Irrigation

The landscape masterplan for the TNC has been designed with the reduction of water consumption as a key driving strategy. At this stage, landscaped areas that are to be irrigated will have their water source drawn from mains water supply. Investigations and considerations of recycled water technology will be

considered in the progression of the development to detailed design based on viability and budget constraints with the view to alleviate or reduce the requirements to utilise potable water supplies.

No lawn areas are proposed on the predominant commercial mixed use sites and all garden bed areas will be mulched with gravels or mulches to aid water retention and reduce moisture evaporation. Soil conditioners will also be used in garden beds to add water retention. Not all garden beds are proposed to be irrigated, with areas in drainage swales and other lesser priority areas proposed to be unirrigated areas utilising native and drought tolerant species.

Where irrigation systems are to be installed, a focus on Waterwise accredited systems utilising sub-surface droplet emitters will be used in accordance with the City's current specifications.

Maintenance

The landscape design will incorporate recreation and environmental requirements, whilst focusing on maintenance minimisation principles and techniques. The robustness of the landscape design and the material and elements placed within it will be critical to its lasting success. All elements whilst selected for their aesthetics will also be selected to provide a robust, low maintenance solution. Where possible, the use of local suppliers will be encouraged to enable ease of replacement or repair in the event of damage or theft. All landscape hardscape items will be constructed to ensure they conform to the appropriate cyclone ratings to ensure their longevity.

PUBLIC OPEN SPACE

Liveable Neighbourhoods and WAPC Policy usually requires that for residential development, 10% of the subdivisional area be given up free of cost for POS. Element 4 - R34 of Liveable Neighbourhoods however, allows for this to be reduced to 5% in regional areas, where agreed with the local government and subject to a number of conditions regarding the quality of POS provided. Liveable Neighbourhoods also allows for cash in lieu of POS to be paid by the developer where there is already adequate public parkland in the area.

The Shire's Open Space Strategy (2008) notes that the existing suburb of Nickol is provided with approximately 19.6% open space, significantly more than the traditional 10% standard, or the 5% regional variation which can be supported under Liveable Neighbourhoods. The Strategy also identifies a number of 'candidate' sites for future development. Whilst the Strategy identifies Lot 302 within a 'Parks, Recreation and Drainage' zone, this is inconsistent with the Lot's 'Urban Development' zoning under TPS8, as per Amendment 24. Indeed, the specific purpose of Amendment 24 was to facilitate the redevelopment of this open space, as it was considered surplus to requirements.

Given the proximity of abundant and well developed open space in the area, no additional POS is being contemplated as part of this Structure Plan. The Structure Plan, does however, propose to provide a contribution to POS by providing upgrades to the drainage reserve to the west of the site.

The actual requirement for the POS is difficult to determine as the extent of residential development

is yet undefined. It is therefore proposed that open space will be calculated and required to be provided as a condition of any Local Development Plan (LDP),given a LDP is required for all residential development. An appropriately worded provision in the Statutory Section of this Structure Plan is proposed to require a 5% POS contribution at the time of a Detailed Area Plan, which may be satisfied by landscaping of the drainage reserve.

The following table summaries the open space contribution for the site.

Public Open Space Schedule	Area (sqm)
Site Area	96,050
Deductions	
Commercial main streets and access ways	10,022
Likely Town Centre Area (commercial) and Drainage included	67,631
Net Residential Subdivisional Area	18,397
Public Open Space @5% (as per Element 4, R34)	920
Deficit	920m²

The proposed upgrading of landscaping nodes is considered appropriate for the following reasons:

- There are little logical opportunities for the provision of POS in the Structure Plan area;
- The developer will also be responsible for all costs in upgrading three 'Landscaping Nodes' at the termination of the streets and PAW's on the western side of the Structure Plan. It is proposed that if any cash-in-lieu of POS is required to be paid will be used to enhance the City's drainage reserve at these key focal points;
- It will provide an alternative passive recreation opportunity than existing open space, which can be enjoyed not only by future residents of the Structure Plan area but also existing surrounding residents; and
- The areas to be upgraded are well located, being at the termination of east west roads and pedestrian access ways, where they are most visible, and would well exceed the equivalent of 5% of the gross residential subdivisional area.

MOVEMENT NETWORK

A Transport Assessment Report prepared by Uloth and Associates provides specific detail regarding traffic and transport matters relating to the proposed Structure Plan and is attached to this report. The following summarises the key findings of their report.

Refer to Appendix F – Transport Assessment Report

Existing Situation

Dampier Road (which is reserved 'State and Regional Road' under TPS8) is a four lane divided arterial road, with a dual-lane roundabout at Bathgate Road and an unsignalised junction at Baynton Drive (with an intersection spacing of 250 metres). Dampier Road has a 70 kilometre per hour speed limit in the vicinity of the proposed development.

In order to identify the existing traffic flows in the vicinity of the proposed development Uloth and Associates initially obtained available traffic count data from Main Roads WA, being weekly traffic counts on Dampier Road, Bathgate Road and Baynton Drive, from 2008 and 2009.

The Dampier Road data shows Thursday as the busiest day of the week. Additional traffic counts were carried out by Uloth and Associates at the Dampier Road junctions with both Bathgate Road and Baynton Drive on Thursday 10 May 2012, in order to identify up to date traffic data. Dampier Road currently carries 14,400 vehicles per day adjacent to the proposed development, falling to approximately 12,500 vehicles per day west of Baynton Drive.

Bathgate Road (which is reserved 'District Road' under TPS8) is a two lane road with wide gravel shoulders, and a speed limit of 60 kilometres per hour. Bathgate Road carries 6,500 vehicles per day north of Dampier Road, while Baynton Drive carries 5,500 vehicles per day south of Dampier Road.

Tambrey Drive and Baynton Drive (both reserved 'Local Roads' under TPS8) are kerbed 2-lane roads with footpaths. Both Tambrey Drive and Baynton Drive have 50 kilometres per hour limits as they are local residential streets with no alternative speed signage. Tambrey Drive carries 4,400 vehicles per day west of Bathgate Road and 4,900 vehicles per day west of the petrol station access.

It is important to note that the existing petrol station at the corner of Bathgate Road and Tambrey Drive comprises two access driveways off each road. It is also important to note the significant drainage reserve along the western boundary of the development site, together with a paved dual-use path that runs from Baynton Drive through an underpass beneath Dampier Road and then north to Tambrey Drive.

Proposed Road Hierarchy and Road Reserves

The proposed north-south Main Street is to be a Neighbourhood Connector A under Liveable Neighbourhoods, with a road reserve width of approximately 18m for the 'Main Street' section, narrowing to 16m to the north, facilitating a possible bus route and providing opportunities for on-street parking and footpaths along the retail frontages. This reserve is intended to comprise 3.0m wide paved and landscaped verges, 2.5m wide embayed car parking, a 3.5m wide carriageway suitable to accommodate buses. This is generally consistent with Figure 17 of Liveable Neighbourhoods with no cycle lanes given the predominant east/west cycle desire line and the main street speed environment desired, and no median given the indented car bays, narrower crossing and estimated traffic of less than 3000vpd. 2.5m wide parking bays are proposed rather than 2.1m given the more frequent use of larger vehicles in Karratha.

Proposed Road Cross Sections

The east-west road linking to Bathgate Road is proposed as an Access Street B, comprising a 15m road carriageway which includes 2.1m parking lanes, 6 metre carriageway and 2.4 metre verges.

The two residential streets to the west of the Main Street are proposed to be Access Street B's also, with a pavement width of 7.2 metres, allowing for frequent on-street parking, with an overall road reserve of approximately 15 metres. A 13m wide Access Street C runs along the western side of the development, between the residential lots and the drainage reserve beyond which is reduced in width as it abuts the Recreation Conservation and Drainage reserve where footpaths can be located in the reserve and services are only required on one side allowing the verge to be reduced to 2.5m.

Intersection Spacing and Access

The intersection spacing requirements adjacent to the proposed development are discussed below, together with the resulting access arrangements for the proposed Structure Plan.

Main Street Connection to Dampier Road

In *'Guide to Road Design - Part 4A: Unsignalised and Signalised Intersections'*, Austroads specifies Safe Intersection Sight Distance (SISD) as the minimum standard that should be provided on a major road at any intersection in order to provide sufficient distance for the driver of a vehicle on the major road to observe a vehicle from the minor road moving into a collision situation, and to stop before reaching the collision point.

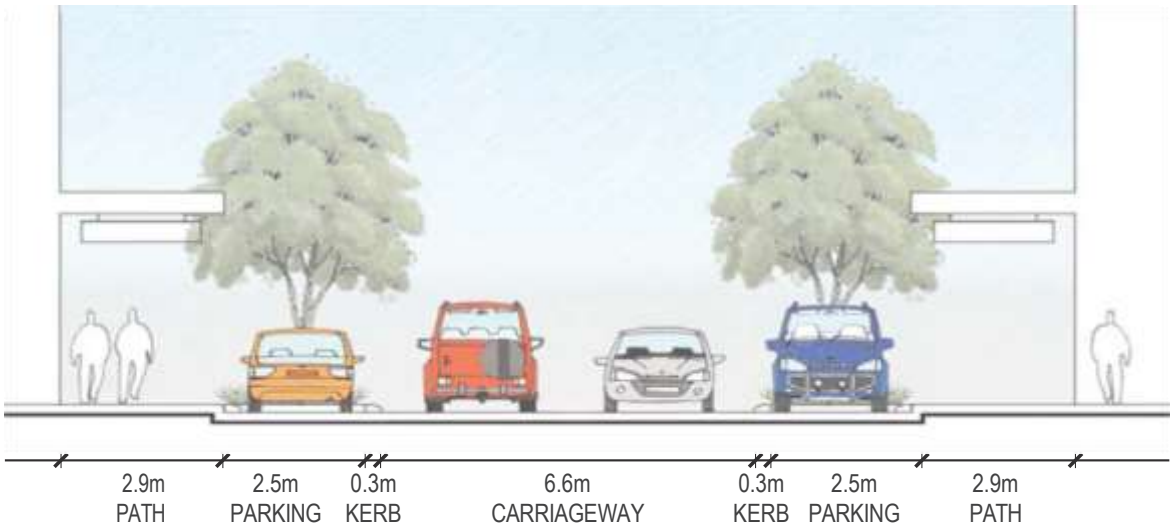
On the basis of this definition, it is recommended that the SISD is a suitable measure to adopt for the minimum acceptable separation between intersections.

The SISD for a speed of 70 kilometres per hour is 151 metres, while the SISD for a speed of 60 kilometres per hour is 123 metres (using a reaction of 2.5 seconds in Table 3.2 of the Austroads Guide), reducing further to 97 metres at 50 kilometres per hour.

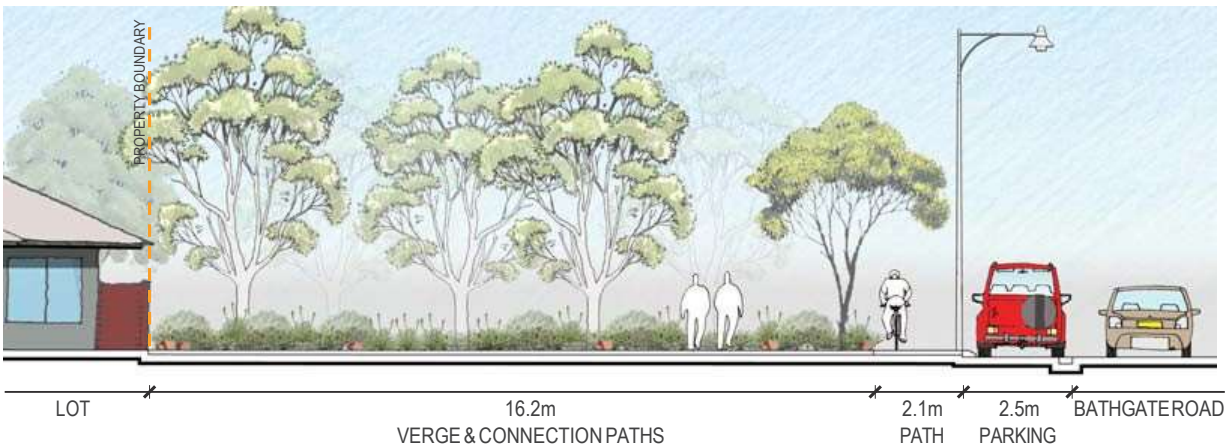
The existing intersection spacing along Dampier Road is 250 metres, from the eastbound give way line at the Bathgate Road roundabout to the centre line of Baynton Drive. If a new road was constructed between these 2 intersections, the resulting intersection spacing would be a maximum of just 125 metres, which is insufficient for the existing 70 kilometre per hour speed limit, and is therefore unacceptable.

However, it is important to note that the development of the Town Centre will attract significant traffic movements from the residential area south of Dampier Road, accessed via Baynton Drive, which will create significant weaving issues within Dampier Road under the current intersection arrangements,

18m Road Reserve (Main Street)



Bathgate Road



with high traffic volumes carrying out the right-left stagger between Baynton Drive and Bathgate Road.

Taking into account the agreed vision for the Town Centre to be focussed around a central 'Main Street' (and the resulting requirement for a highly connected precinct with direct access off Dampier Road) Uloth and Associates support the connection of the Main Street to Dampier Road opposite Baynton Drive, with the construction of a new roundabout to control the resulting 4-way intersection.

In addition to avoiding the construction of an additional conflict point along Dampier Road, this new roundabout will allow north-south traffic between Baynton Drive and the new Centre to safely cross Dampier Road, without having to use the regional road at all for this local shopping trip.

The construction of a roundabout at Baynton Drive also improves the existing weaving manoeuvre for southbound traffic from Bathgate Road to Baynton Drive, by removing the existing left turn lane in Dampier Road and hence increasing the available weaving length for this manoeuvre.

This proposal has been referred to Main Roads WA which has provided a verbal acceptance but is currently awaiting comments or formal referral from the City before advising of its acceptance to the proposal. It is anticipated that the Structure Plan will be referred to MRWA for final comments prior to approval.

Access off Bathgate Road

The proposed access roads off Bathgate Road provide intersection spacings of approximately 110 metres from both Tambrey Drive and the existing Dampier Road roundabout, which is suitable for a speed of approximately 55 kilometres per hour.

Access off Tambrey Drive

The recommended minimum intersection spacing along Tambrey Drive is 97 metres, for a travel speed of 50 kilometres perhour.

With the existing junction at Matebore Street located 120 metres west of Bathgate Road, the only logical location for an intersection with the proposed Main Street is to create a 4-way intersection at Matebore Street, with the construction of a small roundabout which will facilitate the orderly movement of traffic through the intersection.

Future Traffic Flows

The Traffic and Transport report prepared by Uloth and Associates suggests that the Centre, once fully developed, will generate a total of 13,870 vehicle trips per day with 1,388 vehicle trips during the PM peak hour.

Taking into account the existing distribution of residential areas in the vicinity of the proposed Centre, and the planned additional residential growth throughout the assumed catchment area, it is expected that the future traffic flows generated by the proposed development will travel to/from the Centre via the following approach routes:

- Dampier Road, west: 30 percent
- Baynton Drive, south: 20 percent
- Tambrey Drive, west: 20 percent
- Bathgate Road, north: 17 percent
- Dampier Road, east: 12 percent
- Matebore Street, north: 1 percent

Uloth and Associates carried out a traffic assignment process for each of the proposed land uses within the Town Centre, to determine the distribution of future daily development traffic flows and internal daily traffic flows.

The analysis identified the Main Street is anticipated to carry 7,200 vehicle trips per day at the southern end, with 2,100 vehicle trips through the retail core and 3,300 vehicle trips at the northern end, which suggests that approximately 53% of the overall Town Centre traffic will access via the proposed Dampier Road - Baynton Drive - Main Street roundabout.

Total future traffic flows were then determined, by taking into account the anticipated growth of surrounding residential areas, together with the long term forecast of 31,000 vehicles per day on Dampier Road west of Bathgate Road, as published in the KCN City Growth Plan report.

Accordingly the existing traffic flows (excluding the proposed development) will increase as follows:

- Tambrey Drive, west: 10%
- Bathgate Road, north: 25%
- Baynton Drive, south: 30%

Dampier Road is assumed to increase to a long term total of 31,000 vehicles per day, including the proposed development.

Uloth advise that Bathgate Road is expected to increase to between 8,000 and 9,000 vehicles per day in the long term, while Tambrey Drive is expected to carry 5,300 vehicles per day west of Bathgate Road and 8,000 vehicles per day west of the proposed Centre.

Intersection Operational Analyses

Initial analysis showed that if the proposed Town Centre is developed with access only off Bathgate Road and Tambrey Drive (that is without the proposed Main Street connection to Dampier Road), then the right turn movements into Dampier Road from both Bathgate Road and Baynton Drive will fall to low (and ultimately unacceptable) Levels of Service as traffic flows on Dampier Road continue to increase.

These intersection operational characteristics together with the weaving issues that would result, as discussed above, suggest that an acceptable situation can only be achieved if a new roundabout is constructed at Dampier Road - Baynton Drive, with a northern leg connection to the proposed Town Centre.

Detailed intersection operational characteristics for the resulting recommended plan are shown in Tables A.2 to A.9 in Chapter A.4 in the Technical Appendix.

If the Main Street is connected to Dampier Road, as proposed, then the Dampier Road roundabouts at Bathgate Road and Baynton Drive will both operate at overall Levels of Service A and B during the future Thursday PM peak hour, indicating good operating conditions with short traffic delays.

The Bathgate Road - Tambrey Drive junction will operate at an acceptable Level of Service C during the long term future PM peak hour, while remaining access roads into the Centre will also operate at acceptable operating conditions.

Public Transport and Pedestrians

The KCN City Growth Plan report identifies a proposed bus route running in an east-west loop both north and south of Dampier Road. However, with the proposed development of the TNC and Mixed Use Site being a major destination at the western end of the Karratha Town Site, it is considered that a future bus route could be modified to provide a figure 8 loop at the western end in order to provide bus stops within the Main Street of the proposed Neighbourhood Centre.

Possible future bus routes could therefore operate through the proposed Town Centre, with possible bus stops located in the middle of the Main Street as shown in Figure 11.

Refer to Figure 11 – Possible Future Bus Routes

Pedestrian routes will be provided along each of the public roads within the proposed Town Centre, with additional routes also provided on an east-west orientation linking to the existing pedestrian routes adjacent to the Centre. A possible future path network following the construction of the proposed Centre is shown in Figure 12.

Refer To Figure 12 – Possible Future Path Network and Bus Stops

Bicycles

No dedicated bicycle only cycleways are provided throughout the Structure Plan area. No major east west road links are proposed through the site which, given Karratha's shape, is the direction in which the vast majority of commuters travel and there is therefore anticipated to be a very limited need for the bicycle pathways through the Structure Plan area given commuter cyclists to the Town Centre are likely to use Dampier Road.

Cyclists traveling to the Neighbourhood Shopping area will be able to share the road with cars, taking advantage of the low speed environment along the main street provided by embayed parking, frequent pedestrian crossings and central pedestrian refuge.

COMMERCIAL / RETAIL / COMMUNITY LAND USES

The Structure Plan will facilitate the provision of a mix of commercial, retail and community activities. Key features of the proposed development are described as follows:

- The provision of a mix of uses, including retail, commercial and residential facilities (permanent and short-stay accommodation), as well as possible other community uses;
- A core retail precinct comprising an ultimate retail floorspace allocation of approximately 8,500m² centrally provided within the development, accessible via a new 'main-street' through the site;
- Commercial development that may comprise approximately 3,000m², with the main component likely to be located to the south-west of the site, fronting Dampier Road;
- The provision of a number of dining options, including take away food outlets, cafés and restaurants to the southern part of the development, fronting Dampier Road; and
- The provision of other community facilities

to complement the retail and other uses, including a possible medical centre.

Use permissibility is to be in accordance with the Town Centre Zone.

Whilst all the uses are defined by the Scheme, there is one additional use inserted into the permissible uses in Part 1 which specifically allow for a 'Boat Storage Facility'. Given the high level of boat ownership and the higher densities proposed which limit opportunities for boat storage within the lot, provision is made for a lot(s) to be dedicated solely for boat storage which may be offered for use with or without charge and simply operated by either the centre management or another business within the neighbourhood centre.

Needs Assessment

MacroPlanDimasi have undertaken an Economic Impact Analysis for the provision of commercial and retail land uses under the Structure Plan. The report considers the potential economic and related effects of the proposed addition of retail floorspace at Tambrey on the surrounding centres, addressing the economic impacts and benefits of the proposal from a net community benefit perspective.

Refer to Appendix G – Retail Needs Assessment

The report identified the following key findings and conclusions:

- The TNC is proposed to be developed in the western part of Karratha to serve the western part of town with a particular focus on providing convenience shopping and amenity. The TNC is planned to be a mixed-use development including retail, commercial, residential and community uses;
- TNC is proposed to be developed in the western part of Karratha to serve the substantial existing population as well as the significant population growth occurring in the area. The TNC is planned to be a mixed-use development including retail, commercial, residential and community uses.
- For the retail component of the TNC, the draft masterplan proposes to include a full-line supermarket of 3,800 sq.m, two mini-major tenants totalling some 1,500 sq.m, and a supporting provision of retail specialty space. The total retail floorspace of the centre is expected to be around 8,500 sq.m upon completion.
- The primary trade area, which the TNC will serve, contains a present population of 11,710, forecast to grow to 15,360 by 2026.
- The sales potential of the retail component of the TNC is estimated at $69 million in 2017/18.
- The total retail expenditure market generated by primary trade area residents is estimated at $218 million, while the retail expenditure of the total Karratha City population will be $461 million at that time. FIFO workers will add further to the overall demand for retail facilities within the town.
- The estimated market shares which the TNC will achieve are 25.8% of the primary sector expenditure, and 13.5% of the total retail expenditure by the City of Karratha population.
- The analysis shows that whilst retailers within Karratha are expected to be impacted by the

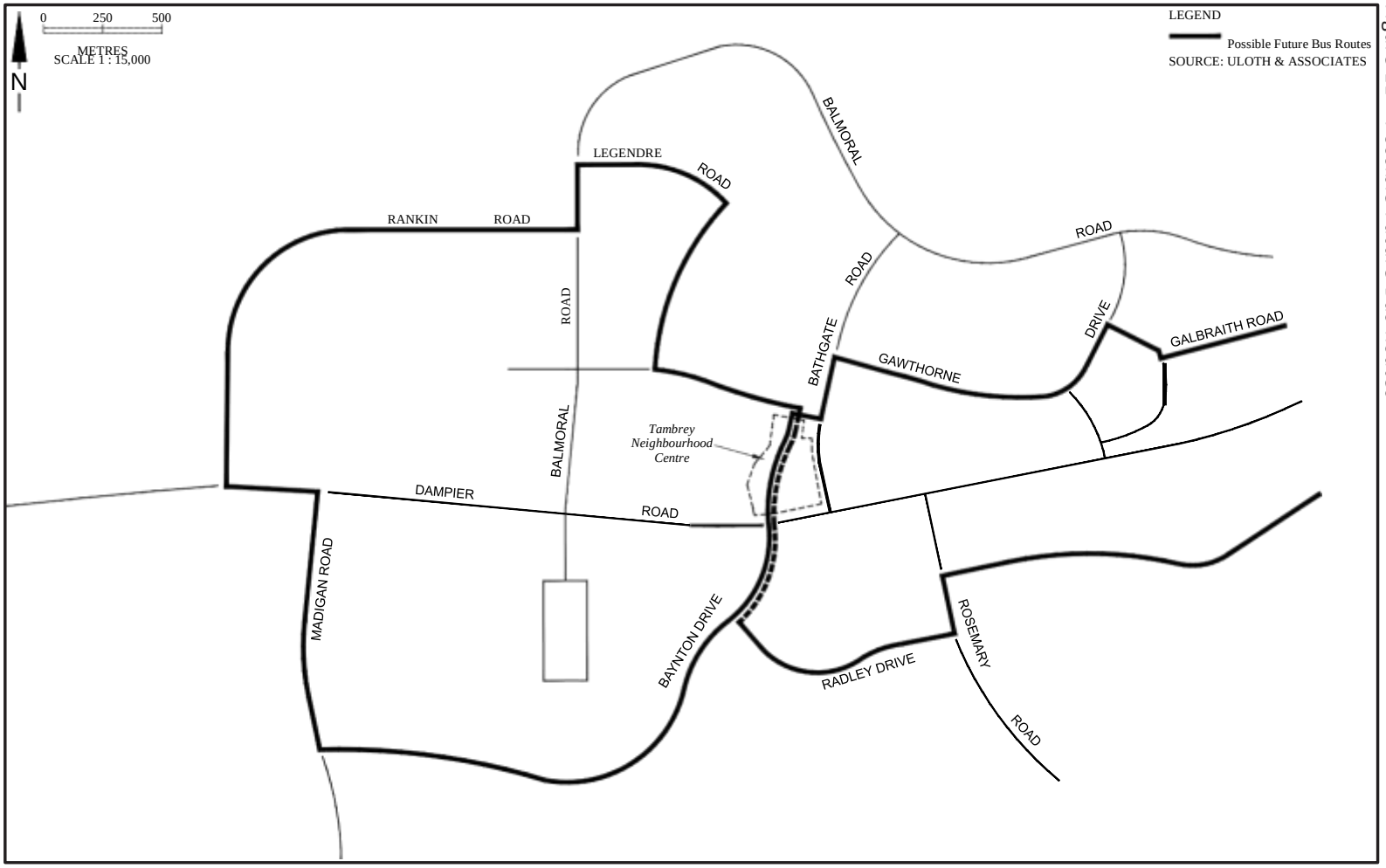


Figure 11 – Possible Future Bus Routes

Figure 12 – Possible Future Path Network and Bus Stops

TNC, those retailers are estimated to achieve sales of $417 million in 2020/21, which is a $33 million increase on their estimated sales at 2014/15.

- Existing Karratha City Centre retailers are expected to be impacted to a small degree by the TNC, however they are still expected to experience net growth in their sales potential over the next 6 years (three years post development of the TNC).
- The analysis shows that in 2017/18, existing retailers in Karratha would be expected to experience an aggregate impact of around $48 million or 11.4%. These average trading impacts, when weighed against the positive economic and social impacts that will be generated by the development of the TNC, and the overall growth in the Karratha market, are considered reasonable and will not threaten the viability of existing retailers within Karratha. Overall, the analysis presented in this report shows that the TNC would not in any way compromise the future role or strength of the Karratha City Centre.
- The other proposed uses at Tambrey, including residential, commercial and ancillary, will help to reinforce the convenience role of the centre and help to achieve the objectives of the Karratha City of the North Plan. Those uses will not detract from the primacy of the City Centre.
- The new Structure centre will be conveniently located in the growing and underserviced western Karratha area. It will therefore greatly improve amenity for local area residents, with shopping and service facilities being provided in an accessible location within the local area. The quality of life of western Karratha residents will be improved as a result.
- The provision of facilities such as the TNC is an important step towards enabling the growth of Karratha that is envisaged under both the Shire of Roebourne Town Planning Scheme and the Karratha City North Plan.

ENVIRONMENTAL IMPACTS AND MANAGEMENT

As discussed earlier in this report, the TNC site does not contain sensitive environmental features, aside from the presence of a Priority 3 flora species within the southern end of the site.

Vegetation Clearing

Vegetation is proposed to be cleared across the entire site to facilitate development. As discussed in Section 2.3, the majority of the vegetation present onsite has been previously disturbed and is dominated by introduced grasses.

The vegetation with the highest conservation significance present onsite is the patches of the Priority 3 flora species, *Themeda sp* Hamersley Station (M E Trudgen 11431) which are located within the southern end of the site.

Prior to clearing works being undertaken FJM Property propose to liaise with the City of Karratha and the DER to determine if either group has a desire to use any plants which could be salvaged from the site for local conservation projects. If a suitable project is identified, FJM will arrange for these plants to be salvaged.

Drainage

The low permeability soils and high intensity rainfall events in Karratha can lead to widespread flooding. To address this issue, the current drainage network in the town has been primarily developed for the rapid removal of stormwater from key infrastructure in developed areas (GHD, 2010).

A Local Water Management Strategy (LWMS) has been prepared to accompany the Tambrey Structure Plan, as discussed above. The key design and management items which relate to onsite drainage as discussed in the LWMS are summarised as follows:

- The stormwater system design for the site is based on a conveyance model, where flows are directed overland to the adjacent drainage reserve.
- Individual urban lot runoff will follow unobstructed overland flow paths to road drainage reserves.
- The road networks will be used as the main conveyance pathway to the drainage reserve in high rainfall events. As such, road levels have been designed to direct flows as required.

Further detailed drainage information can be found within the LWMS.

Acid Sulfate Soils

As discussed previously, the watertable at the Tambrey site is anticipated to occur between 5 to 10m below the ground surface. Based on this depth and the depth of works proposed during construction, no lowering of the watertable during construction of post-development is proposed.

As such, development of the Tambrey site does not trigger any of the DER's criteria for the investigation of ASS. No further onsite investigations are proposed with regards to this matter.

Construction Impacts

The short-term impacts of construction, including noise and dust, will be managed according to industry best practice and in accordance with all applicable government regulations.

All static and mobile machinery employed during construction will be fitted with appropriate noise attenuation equipment and will comply with occupational noise regulations. Construction activities will be managed so as to comply with the *Environmental Protection (Noise) Regulations 1997*.

Dust arising from construction works and bare ground will be controlled so as to comply with the requirements within the EPA's *Guidance Statement No. 18: Prevention of Air Quality Impacts from Land Development Sites (2000)*. In particular:

- All cleared areas will be stabilised by watering, mulching or equivalent means.
- No vegetation or other debris will be burned on the development site.

- Where necessary, watering will be employed to minimise dust generation while earthworks are in progress.

The developer will ensure that provisions are made and responsibility accepted for dust control in all contracts issued for site works.

EARTHWORKS

The subject site typically has a surface fall of approximately 1:200 towards the North West. Coffey Geotechnics have completed a geotechnical investigation of the site. The generalised subsurface profile can be described as clayey gravel, with clayey sand overlaying clayey gravel, which in turn overlays rock at depth.

As soils in this location have a significant clay content, with associated shrink swell characteristics, it is expected that "Class M" Lot Classifications in accordance with AS2870 would be achieved.

Imported fill material will be required to shape lots to ensure stormwater flood routing to adjacent roadways. The road network has been configured to follow ground contours as closely as practical to minimise earthworks required to the site, whilst maintaining an overland flow path function. Minimum lot levels will be provided in accordance with the requirements of the Local Water Management Strategy and ultimately the Urban Water Management Plan for the site.

STORMWATER DRAINAGE

The high intensity rainfall associated with being in a cyclonic region requires the provision of a high capacity drainage scheme to cater for extremely large storm events.

Cyclonic and major storm events will be disposed by open gutter flow along road kerb lines, directed to the existing open drain to the west of the site by drop structures in accordance with the City of Karratha's requirements.

The road network configuration has been designed to provide an overland flow path for the site. Drain reserves are proposed to provide flood routes as required, directing flows to the existing open drain along the western boundary of the site.

Refer to Coterra Environment's Local Water Management Strategy for detailed drainage information.

SEWER RETICULATION

The subject site is currently serviced by an existing DN225 gravity sewer along the western boundary of the site and a DN150 sewer along the northern boundary of the site. A DN250 sewer pressure main is also located adjacent to the site in Bathgate Road.

The Water Corporation's overall sewer planning indicates that sewer disposal for the site will be achieved through direct connection to existing DN225 sewer services adjacent to the site, as discussed above. Ultimately the existing DN225 main discharges to Karratha Wastewater Treatment Plant (WWTP) No 1. The Water Corporation have recently

completed an upgrade to Karratha WWTP No 1 and associated infrastructure, which provides capacity for this project.

WATER RETICULATION

The subject site is currently bounded by existing DN300AC water distribution mains located in Bathgate Road and Tambrey Drive.

The Water Corporation's overall planning indicates that potable water supply to the site will be provided via connection to existing DN300 water distribution mains located in Bathgate Road and Tambrey Drive. The Water Corporation have recently completed upgrades to Water Supply Tank No. 1, which augments water supply capacity of Water Supply Tank No. 3. This work provided overall scheme capacity for the project.

Detailed design of the project will be required to satisfy the Water Corporation's water efficiency measures.

UNDERGROUND POWER SUPPLY

Existing overhead power lines front the site within Bathgate Road and Tambrey Drive. These power lines do not have capacity to service the site and are ultimately redundant under the proposed Pilbara Underground Power Project.

Underground power supply to the development will be provided via a new 22kV high voltage feeder cable connection to the Pegs Creek zone substation located approximately 700m to the east of the site along Dampier Road or through interconnection with new High Voltage feeders that are being installed by Pilbara Underground Power Project (PUPP). The scope of work required for the site connection will depend on construction progress of the Pilbara Underground Power Project at the time of subdivision construction.

Internally the site would be serviced by a high voltage and low voltage underground power network connecting to transformers and switchgear located about the site.

TELECOMMUNICATIONS

The subject site is adjacent to existing Telstra optic fibre infrastructure within Dampier Road and copper network within Tambrey Drive.

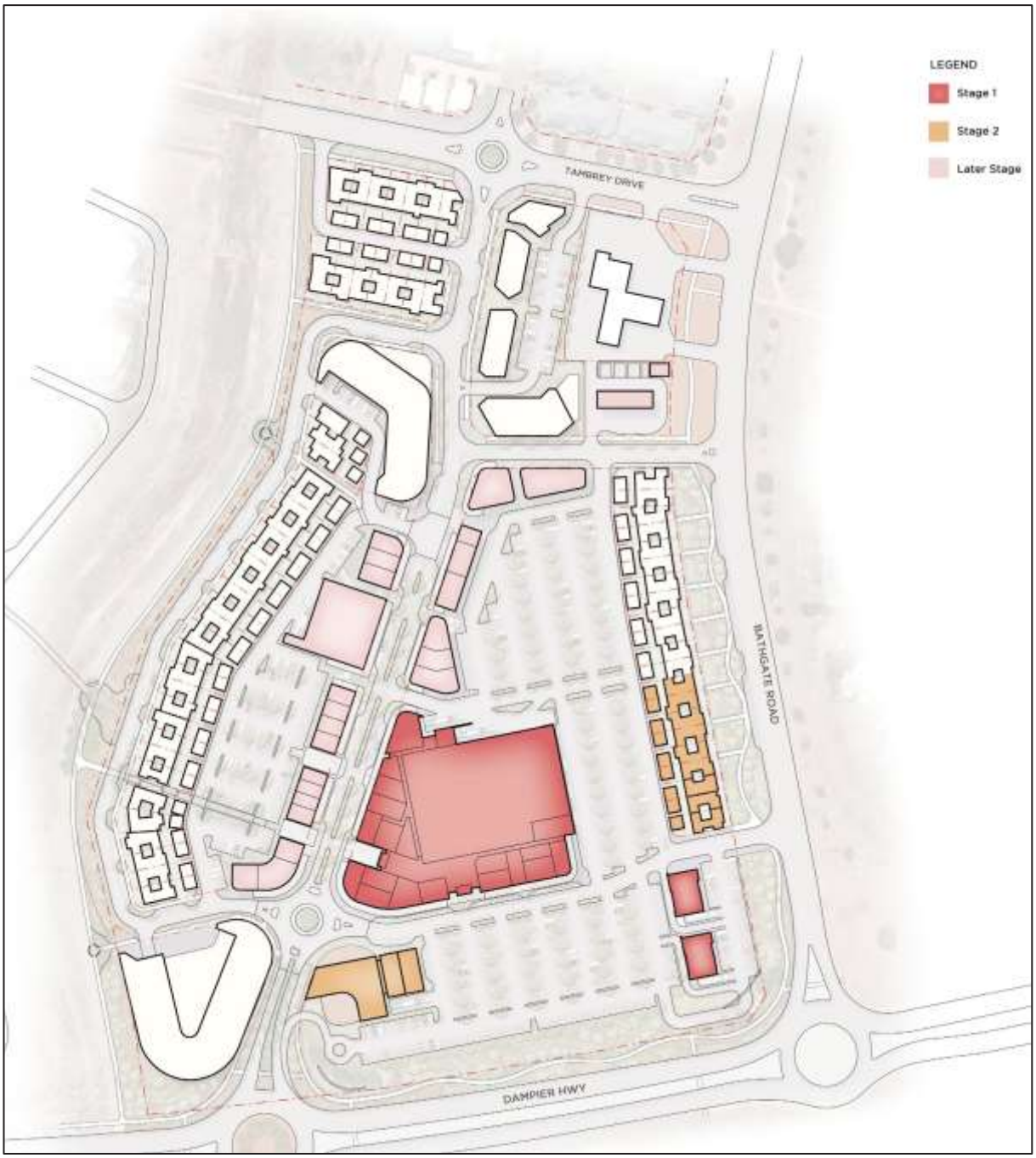
Depending on arrangements for commercial development at the time of subdivision either a Telstra or National Broadband Network telecommunications network would be installed within the development.

STAGING AND TIMING

Given the size and constantly changing market demand it is envisaged that the development will be staged over a number of residential and commercial stages. A notional commercial staging plan is provided at Figure 13 which indicates that the first stage will be the supermarket 'anchor tenant' which once established will act as the catalyst for the centre to grow and evolve to its full capacity.

Refer to Figure 13 - Notional Retail/Commercial Staging Plan

Figure 13 - Notional Retail/Commercial Staging Plan



PLANNING MERIT

The proposed Structure Plan represents the logical, orderly and proper development of the land that is consistent with both the current strategic vision prescribed by the Karratha City of the North Blueprint and also the statutory objectives highlighted by the Scheme and Amendment 24 to the Scheme.

Firstly at the strategic level, the proposed Structure Plan will facilitate achieving the objectives of the recently endorsed KTCN Blueprint City Growth Plan which highlights the site as being developed for a neighbourhood shopping centre to service the western end of town and residential purposes with opportunities for increased density. The site is also a logical extension of the existing neighbourhood and provides housing diversity and density within the established urban fabric to reduce pressure to develop on the fringe and in the Regals south of Karratha Hills. The design is also responsive to the site providing a neighbourhood centre that is within a walkable catchment with a high level of pedestrian and vehicle connectivity, including to the adjoining educational facilities and open space.

The intent for the site to be developed for a neighbourhood centre is also reflected in both the WAPC *Pilbara Framework: Regional Profile (2009)* and the *Karratha Regional Hotspots Land Supply Update 2010* which both highlight that the site is to be developed for a Neighbourhood Shopping Centre with a range of residential dwelling types and other mixed uses.

The City of Karratha's *Karratha 2020 Vision and Community Plan (2009)* also notes the high cost of housing and the situation of employee accommodation being provided by certain employment sectors. The result being that there is an established need for additional housing in Karratha to address the high cost of housing. The proposed Structure Plan will assist with achieving the objectives envisaged under the document by not only providing additional amenities and services, but also providing non-mining related employment and a variety of housing types.

Secondly from a statutory viewpoint, the Structure Plan is also consistent with its intended purpose prescribed by Amendment 24 to the City of Karratha Scheme and also assists in achieving the objectives of the Scheme as per clause 5.8 of TPS 8 in that it represents the continued growth of Karratha and Tambrey and will:

(vii) Develop Local commercial centres so as to provide convenience goods and services, private recreation, and community uses to the local community;

(viii) Enhance the high level of residential amenity within Karratha in both existing suburbs and the residential expansion areas; and

(ix) Encourage residential development that will accommodate a greater range of lifestyles and needs to reflect the broadening population base.

CONSISTENCY WITH SURROUNDS

The proposed Structure Plan is consistent with the built form and development patterns surrounding the subject site. West of Balmoral Road, immediately south and east of the site is land zoned for "Urban Development", in addition to land south of Dampier Road. This "Urban Development" zoned land is being developed for single residential dwellings, consistent with the area north of Tambrey Drive which is generally zoned "Residential R20" and which represents an established residential area comprising single dwellings with pockets of grouped dwellings at the R30 density coding.

The Open Space Strategy identifies that of the existing dwellings in the suburb of Nickol, approximately 87.4% of these are detached houses, with the remaining 12.6% being attached houses. The proposed Structure Plan will allow for additional dwelling stock, including single houses and grouped dwellings, to be developed in Nickol, consistent with the existing development.

PERFORMANCE OF STRUCTURE PLAN

The proposed Structure Plan is also consistent with the various elements of sustainability. These key elements can be identified as environmental, social (heritage) and economic sustainability. The performance of the Structure Plan in relation to these elements is detailed below.

Environmental

Optimising the development potential of the site with a range of dwelling types, including higher density development, within an established neighbourhood with existing services and amenities is inherently more sustainable in that it reduces the demand to develop more sensitive land on the urban fringe and reduces vehicle travel times and vehicle dependence by allowing residents to walk to amenities and essential services. Extensive provision has been made for pedestrian and cyclist connectivity, however it is envisaged to be a slow speed cyclist environment where cyclists walk their bikes rather than it being a commuter thoroughfare which should be more focussed near Dampier Road.

The site is also largely denuded and has little environmental benefits. There are no known Declared Rare and Priority Flora or Threatened Fauna on the site.

In terms of the environmental performance of the design, the road and lot layout has been proposed to provide all lots with a north south and east west orientation where the dwellings can be designed to provide shading of side walls, or extensive eaves to protect east and west facing openings which is the primary concern in the arid climate. The east-west lots will have the ability to capture the cooling dry season breezes and reduce the reliance on mechanical cooling. The Structure Plan also makes provision for a future bus route to run through the middle of the estate to connect it with the City Centre and the possibly the main employment areas on the Burrup and the Karratha Industrial Estate.

Economics

The proposed Tambrey Neighbourhood Centre will facilitate the development of a vibrant mixed use centre which provides a range of employment opportunities whilst also, through the provision of higher density housing opportunities, increasing the viability of these businesses and other services. The mixed use nature of the Structure Plan allows a range of employment opportunities in the food and beverage industry, retail and services industry, community services sector, medical staff and office workers in a variety of different fields. This not only provides employment for professionals, but also essential employment opportunity for teenagers and spouses of those working in other areas. It is estimated that up to 370 persons could eventually be employed in the Centre.

Refer to MacroplanDimasi Retail Needs Assessment & Economic Analysis Report in Appendix G.

The MacroPlanDimasi Report appended to this Structure Plan estimates the sales potential of the retail component of the TNC at $69 million in 2017/18. Despite this, the study concludes that as there is still an undersupply of floorspace to serve the City of Karratha that even once Tambrey is fully operational, the retailers in Karratha are still expected to achieve $33 million in additional sales in 2014/15 and extra $417 million in 2020/21. The report concludes *"Existing Karratha City Centre retailers areexpected to be impacted to a small degree by the TNC, however they are still expected to experience net growth in their sales potential over the next 6 years (three years post development of the Centre)."*

The economic and flow on effects of the development are numerous, but importantly the improved shopping choice, convenience and amenity for the surrounding residents will be vastly improved. This improved quality of life will make the Town more attractive to encourage the transient parts of the population to stay longer, be part of the long term community and social fabric of the Town.

Social

The development of the TNC will provide numerous social benefits to Karratha, helping it transition from a Regional Town to a City of the North. The additional amenities, services, convenience shopping and the restaurants and bistros that will be provided will substantially increase the quality of life for the local community and help attract other key professionals to stay in the area and be part of the community. Simply diversifying the economic base to provide employment for all sectors of the community without relying on work from the mining sector helps to create a 'normalised' community where all members of the family can be involved and be gainfully employed in the community.

The development also has numerous benefits at the micro level. Simply providing numerous meeting places for the community to interact over a coffee and socialise has numerous benefits to the social fabric of a town. Other design elements have also been incorporated into the development which aim to ensure the creation of a quality neighbourhood environment. These include:

- the creation of a clear sense of identity that the local residents can be proud of through the use of consistent palette of furniture and paving in the public domain, a clear landscape

design intent, and quality landmark buildings which help orientate pedestrians and take pride in their surroundings;

- orientation of lots facing onto POS and provide surveillance over the public domain and create a sense of ownership over the Centre and facilitate community interaction;
- providing a landscaped setting and a walkable neighbourhood as first choice of local access will also encourage greater social interaction; and
- providing a variety of lot sizes and configurations will facilitate in providing a social demographic mix within the subject area.

Planning

As outlined above the proposed Structure Plan is consistent with the strategic planning framework and vision for the site to be developed for a Neighbourhood Centre that provides for a good mix of retail, commercial, residential uses and amenities which will all enhance the quality of life of local residents.

The Structure Plan is based on a sound design intent which involves:

- Providing a Main Street focus to the development which provides an active and vibrant streetscape, safe and attractive public domain and encourages pedestrian activity
- Providing an appropriate design and streetscape with development addressing the public domain and providing appropriate interface with the existing short stay uses to the north of the site and recognising the amenity considerations caused by the operation of the adjoining Caltex Service Station;
- Provide a logical and efficient movement network that promotes walkability, facilitates access to the centre from the adjoining neighbourhood and provides for appropriate vehicle connections to Dampier Road and Tambrey Drive by roundabouts, which will also assist in providing safe movement from Baynton West onto Dampier Road;
- Provides for large lots and a robust planning framework with a variety of permitted uses which has the ability to adapt to changing market demands and needs;

- Providing for residential development which has the ability to optimise the number of lots located within close proximity to a Neighbourhood Shopping Centre;
- Including provisions which will address any amenity impacts to allow for noise sensitive premises to be located near amenities such as restaurants and bistros;
- Optimising the number of east west facing lots which allow for the front and rear of the lots to be provided with shading and to capture any cooler winter breezes; and
- Provides an infill development which assists in consolidating the Town north of the Karratha Hills and makes the most efficient use of community facilities and service infrastructure.

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CONCLUSION

This Structure Plan has been prepared in order to facilitate the orderly future subdivision, land use and development of Lots 500 and 302 Bathgate Road, and Lot 3860 Tambrey Drive, Nickol for a Neighbourhood Centre.

The Structure Plan and this supporting report demonstrates how the proposed development is in accordance with State and Local Government vision for the site, in particular the Karratha City of the North Blueprint, City Growth Plan and the Shire of Roebourne Town Planning Scheme No. 8 and will assist Karratha in becoming a true Regional City of the North.

The Tambrey Neighbourhood Centre will be a vibrant mixed use centre, providing goods, services and facilities to its growing residential hinterland. In addition to its commercial functions, the Structure Plan will also facilitate the development of additional housing in the form of townhouses and apartments, providing a different form and diverse range of housing types suitable for a wide demographic, and also providing activity and passive surveillance within the Centre.

Based on the consistency of the Structure Plan with the agreed vision for the site and that the design represents the optimal development outcome for the site, it is requested that the City and WAPC approve the Structure Plan at its earliest convenience to enable subdivision and development to occur.

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APPENDIX A

CERTIFICATE OF TITLE

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REGISTER NUMBER	
302/DP53853	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
1	28/2/2012

WESTERN AUSTRALIA

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

VOLUME 2785 FOLIO 817

The person described in the first schedule is the registered proprietor of an estate in fee simple in the land described below subject to the reservations, condi tions and depth limit contained in the original grant (if a grant issued) and to the limitations, interests, encumbrances and notifications shown in the second schedule.

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:
LOT 302 ON DEPOSITED PLAN 53853

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

WESTERN AUSTRALIAN LAND AUTHORITY OF LEVEL 6, 40 THE ESPLANADE, PERTH
(TF L864790) REGISTERED 23 FEBRUARY 2012

LIMITATIONS, INTERESTS, ENCUMBRANCES AND NOTIFICATIONS:
(SECOND SCHEDULE)

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
* Any entries preceded by an asterisk may not appear on the current edition of the duplicate certificate of title.
Lot as described in the land description may be a lot or location.

----------END OF CERTIFICATE OF TITLE----------

STATEMENTS:
The statements set out below are not intended to be nor should they be relied on as substitutes for inspection of the land and the relevant documents or for local government, legal, surveying or other professional advice.

SKETCH OF LAND:	DP53853 [SHEET l].
PREVIOUS TITLE:	LR3116-735.
PROPERTY STREET ADDRESS:	LOT 302 BATHGATE RD, NICKOL.
LOCAL GOVERNMENT AREA:	SHIRE OF ROEBOURNE.
RESPONSIBLE AGENCY:	WESTERN AUSTRALIAN LAND AUTHORITY.

REGISTER NUMBER	
500/DP59185	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
1	28/2/2012

WESTERN AUSTRALIA

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

VOLUME 2785 FOLIO 816

The person described in the first schedule is the registered proprietor of an estate in fee simple in the land described below subject to the reservations, conditions and depth limit contained in the original grant (if a grant issued) and to the limitations, interests, encumbrances and notifications shown in the second schedule.

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:
LOT 500 ON DEPOSITED PLAN 59185

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

WESTERN AUSTRALIAN LAND AUTHORITY OF LEVEL 6, 40 THE ESPLANADE, PERTH
(TF L864790) REGISTERED 23 FEBRUARY 2012

LIMITATIONS, INTERESTS, ENCUMBRANCES AND NOTIFICATIONS:
(SECOND SCHEDULE)

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
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SKETCH OF LAND:	DP59185 [SHEET 1].
PREVIOUS TITLE:	LR3019-168, LR3019-166, LR3019-164, LR3019-163.
PROPERTY STREET ADDRESS:	3 BATHGATE RD, NICKOL.
LOCAL GOVERNMENT AREA:	SHIRE OF ROEBOURNE.
RESPONSIBLE AGENCY:	WESTERN AUSTRALIAN LAND AUTHORITY.

REGISTER NUMBER	
3860/DP215374	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
1	28/2/2012

WESTERN AUSTRALIA

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

VOLUME 2785 FOLIO 815

The person described in the first schedule is the registered proprietor of an estate in fee simple in the land described below subject to the reservations, condi tions and depth limit contained in the original grant (if a grant issued) and to the limitations, interests, encumbrances and notifications shown in the second schedule.

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:
LOT 3860 ON DEPOSITED PLAN 215374

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

WESTERN AUSTRALIAN LAND AUTHORITY OF LEVEL 6, 40 THE ESPLANADE, PERTH
(TF L864790) REGISTERED 23 FEBRUARY 2012

LIMITATIONS, INTERESTS, ENCUMBRANCES AND NOTIFICATIONS:
(SECOND SCHEDULE)

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
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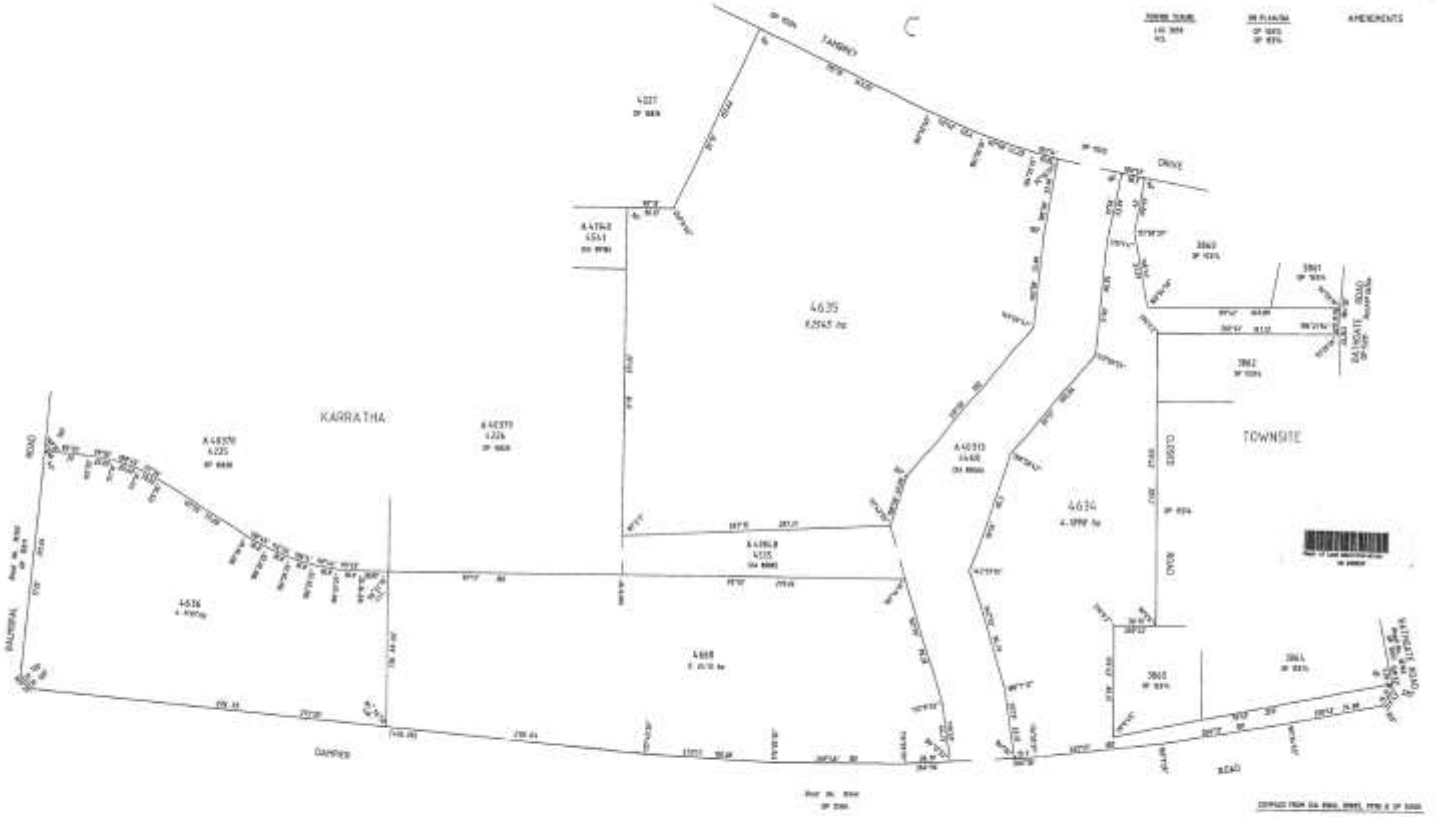
Lot as described in the land description may be a lot or location.

----------END OF CERTIFICATE OF TITLE----------

STATEMENTS:
The statements set out below are not intended to be nor should they be relied on as substitutes for inspection of the land and the relevant documents or for local government, legal, surveying or other professional advice.

SKETCH OF LAND:	DP215374 [SHEET 1].
PREVIOUS TITLE:	LR3019-162.
PROPERTY STREET ADDRESS:	LOT 3860 TAMBREY DR, NICKOL.
LOCAL GOVERNMENT AREA:	SHIRE OF ROEBOURNE.
RESPONSIBLE AGENCY:	WESTERN AUSTRALIAN LAND AUTHORITY.



DISTRICT OF NITT

TOWNSITE KARRATHA

KARRATHA LOTS 4634 - 4636 (INCL.) & LOT 4638

SCALE 1:500

DATE OF INSPECTION

SURVEYOR'S CERTIFICATE

SURVEYOR'S CERTIFICATE - CLOSING BOUNDARY

COMPILED

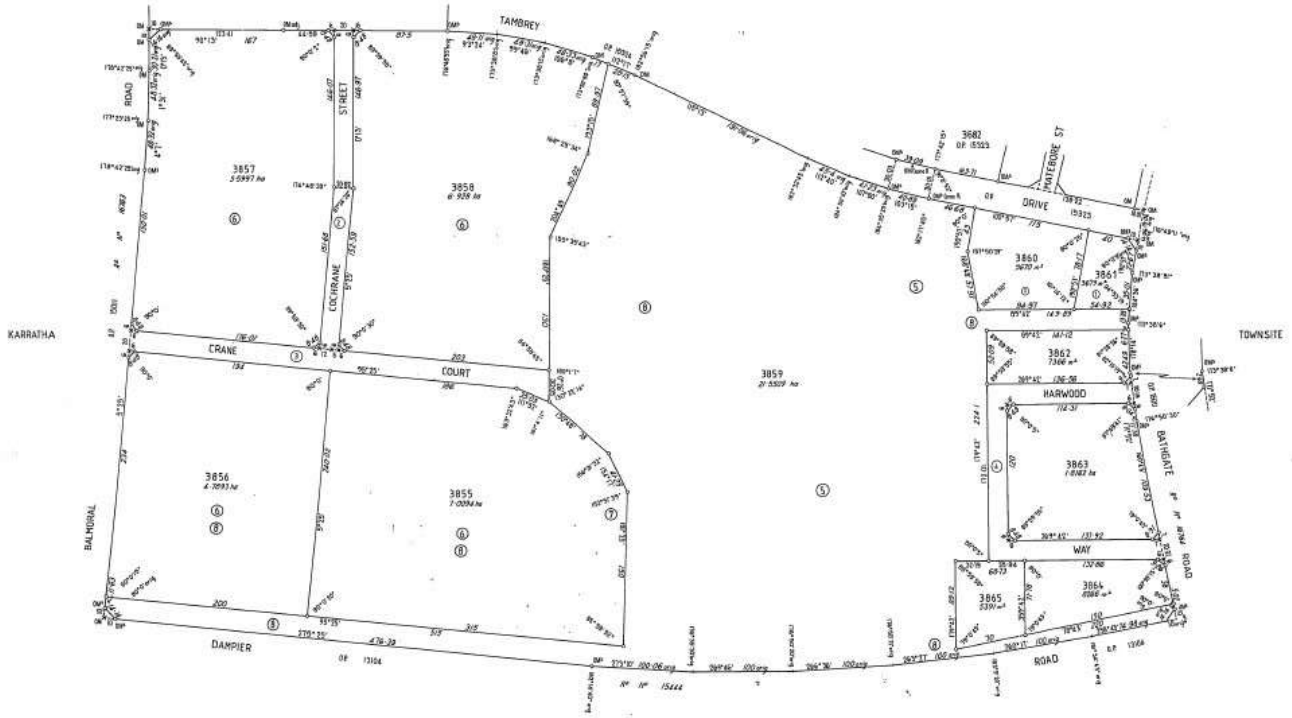
APPROVED BY WESTERN AUSTRALIAN PLANNING COMMISSION

DGLA

LAND ADMINISTRATION ACT

PLAN 20761

LAND ADMINISTRATION ACT PLAN 20761



AMENDMENTS

1. REPEGGED G.S. Diagram 21
2. 3. & 4. Road Closed Gaz 5.10.87 LN 103 AN
5. Karratha lot 4468 Refer Diagram 88966 Area for lot 3859 now 18.0118 ha
6. Superseded by O.P. 14828
7. Refer to Diagram 88885
8. See O.P. 20781

Dept. of Land Administration
NDM 31025

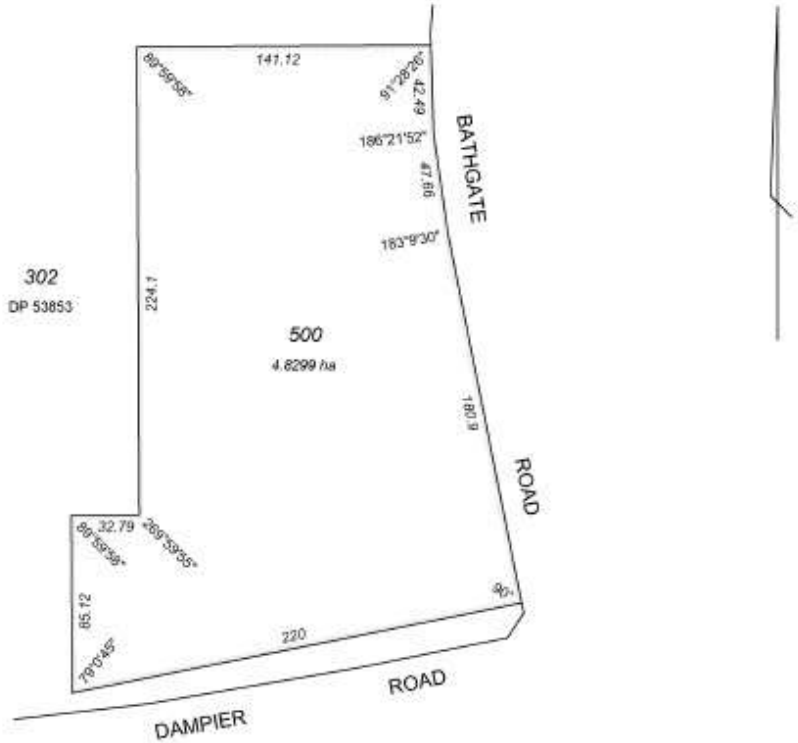
LAND DISTRICT DE WITT	KARRATHA LOTS 3855 - 3865.	FILE No. 2733-981
		SCALE 1:2000 All measurements in metres
SURVEYOR'S CERTIFICATE I hereby certify that this survey was performed by me personally (or under my personal supervision, inspection and field checks), in strict accordance with the Licensed Surveyors (Conference of Surveyors) Regulations, 1961. Licensed Surveyor Date	Accuracy observed or ... or assumed from DOS. DR. O.P. 13365 Date of marking MARCH 1983 Surveyor D.B. SAWM Field Book No. 135 Page 1-10 Colonial Plan KARRATHA 1:2000 Reference ... Diagram Drawn G.FULCHRIST Date 16.9.83	Calc. Bk. No. 7 BRUCHMUELLER, 11 Pg 23-34 Compared with F.B. Account No. Examined Diagram passed ... Inspector of Plans and Surveys Date 22.5.84	SURVEY APPROVED Date 1.9.1986 Surveyor General Recorded on Public Plan F.0077106 29-9-86 Registered in Key Plan/Subdivision No. Chief Surveyor 16.7.1986 Officer DEPT. OF LANDS AND SURVEYS PLAN No. 15374

S.106

VERSION	AMENDMENT	AUTHORISED BY	SIGNATURE	DATE

LOT	FORMER TENURE	ON PLAN/DIAGRAM	TITLE
500	LOT 3862	DP 215374	LR3019/163
	LOT 3863	DP 215374	LR3019/164
	LOT 3864	DP 215374	LR3019/166
	LOT 3865	DP 215374	LR3019/168
	CLOSED ROAD	DP 215374	

COMPILED FROM DP 215374



SCANLAN SURVEYS PTY LTD
LICENSED SURVEYORS
P O BOX 429 MIDLAND 6056
PH: 08 9250 2261 FAX: 08 9274 6286
Email: surveys@scanlansurveys.com.au
0002/0811 GC

INTERESTS AND NOTIFICATIONS

SUBJECT	PURPOSE	STATUTORY REFERENCE	ORIGIN	LAND BURDENED	BENEFIT TO	COMMENTS

TYPE CROWN

PURPOSE SUBDIVISION

PLAN OF

LOT 500

HELD BY LANDGATE IN DIGITAL FORM ONLY.

SSA NO

DISTRICT DE WITT FILE 50850/2007

TOWNSITE KARRATHA

LOCAL AUTHORITY SHIRE OF ROEBOURNE

LOCALITY NICKOL

FORMER TENURE	ON INDEX	FIELD BOOK
SEE TABLE	BH85(2)28.26	COMPILED

SCALE: 1:2000 @ A3

ALL DISTANCES ARE IN METRES

0m 20m 40m 80m 120m

SURVEYOR'S CERTIFICATE – Reg 54

I hereby certify that this plan is accurate and is a correct representation of the –
(a) survey; and/or
(b) calculations from survey records;
(+ delete if inapplicable)
undertaken for the purposes of this plan and that it complies with the relevant written law(s) in relation to which it is lodged.

Licensed Surveyor Date

SURVEYOR'S CERTIFICATE – Compiled

W M SCANLAN

I hereby certify that this compiled plan
(a) is a correct and accurate representation of the survey(s) of the subject land ; and
(b) is in accordance with the relevant law in relation to which it is lodged.

Licensed Surveyor Date

LODGED

DATE 11-Jan-08

FEE PAID N/A

ASSESS No. N/A

TYPE OF VALIDATION

FULL AUDIT

LEGAL COMPONENT B. Francis

DOCKET 856-2006/05

CERTIFIED CORRECT

FSE

FSE

SURVEY FIRM SCANLAN SURVEYS

APPROVED BY WESTERN AUSTRALIAN PLANNING COMMISSION

FILE EXEMPT FROM WAPC APPROVAL

Delegated Under S.16 P & D Act 2005 Date

IN ORDER FOR DEALINGS

SUBJECT TO

FOR INSPECTOR OF PLANS & SURVEYS AUTHORIZED LAND OFFICER DATE

APPROVED

INSPECTOR OF PLANS & SURVEYS AUTHORIZED LAND OFFICER DATE

Landgate
Western Australian Land Information Authority

DEPOSITED PLAN

59185

SHEET 1 OF 1

VERSION 1

APPENDIX B

FEATURE SURVEY

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Point	Easting	Northing	Elevation
8237	37183.494	154948.599	14.875
9000	36906.788	155337.896	11.694
9001	37033.814	155323.903	12.222
9002	37033.576	155232.039	12.923
9003	37109.724	155305.070	12.329
9004	37099.840	155213.723	12.401
9005	37114.106	155096.845	13.397
9006	37097.218	154911.598	16.211
9007	36925.988	154869.358	16.622
9008	36821.052	154903.316	14.354
9009	36801.470	155026.725	13.874
9010	36827.115	155103.177	13.758
9011	36898.309	155217.154	13.302

LEGEND

- Survey Control
- Spot Height
- Signpost (Single / Multiple Poles)
- Power Pole
- Light Post
- Electric Cable Box
- TransformerSteel
- Wire Anchor
- Power Dome
- Telstra Pit
- Telstra Cable Marker
- Telstra Manhole
- Bollard
- Rubbish Bin
- Mail Box
- Invert Level
- Stop Valve
- Ground Hydrant
- Water Meter
- Sewer Manholes
- Tree
- Pram Ramp
- Cadastral Boundary
- Top / Bottom of Kerb
- Edge of Bitumen
- Edge of Concrete
- Road Centreline
- Footpath
- Line of Levels
- Top of Bank
- Bottom of Bank
- Headwall
- Stone Pitching
- Koppa Log Fence
- Fence
- Water Pipe
- Overhead Electric Cable
- U/G Electric Cable
- U/G Sewer Pipe
- U/G Telstra Cable
- Survey Control

Underground services positions supplied by
Dial Before You Dig and are approximate only.

Rev.	Description	Drawn	Date	Checked
B	Additional Road Detail Added	AW	13/12/2012	MBW
A	Initial Issue	GBH	24/04/2012	CJL

FILES

File - Drawing
96916B-96916de-001b

Surveyor:- SGT
Survey Date:- 21/04/2102
Precal/Cad:- Landgate

LOTS 300, 301, 500 & 3860
TAMBREY - KARRATHA
Detail Survey

CLIENT:
GENERATION PROJECTS

The contents of this plan are current and correct as of the date stated within the revision panel. All consultants and persons wishing to utilise this data should satisfy themselves of this plans currency by contacting the McMullen Nolan Group.

SCALE 1:1000 @ A1

0 20 40 60 80 100

ALL DISTANCES ARE IN METRES

For a true to scale reproduction of this plan, plot it to A1 with the Paging Scaling set to None.

The boundaries shown on this plan were not re-established as part of this survey, therefore this plan does not guarantee their accuracy. Existing easements, encumbrances or interests are not depicted and a title search is recommended to obtain this information. Re-establishment of the cadastral boundaries is recommended for any proposed works on or near existing boundaries.

McMULLENNOLAN GROUP
Surveying Excellence

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Offices in: Port Hedland, Margaret River, Broome, Kununurra.

Project Mngr. Matthew Webb | Datum KAR 94/AHD

96916 - DE - 001 - B
Job Number | Type | Plan Number | Revision

APPENDIX C

ENVIRONMENTAL REPORT

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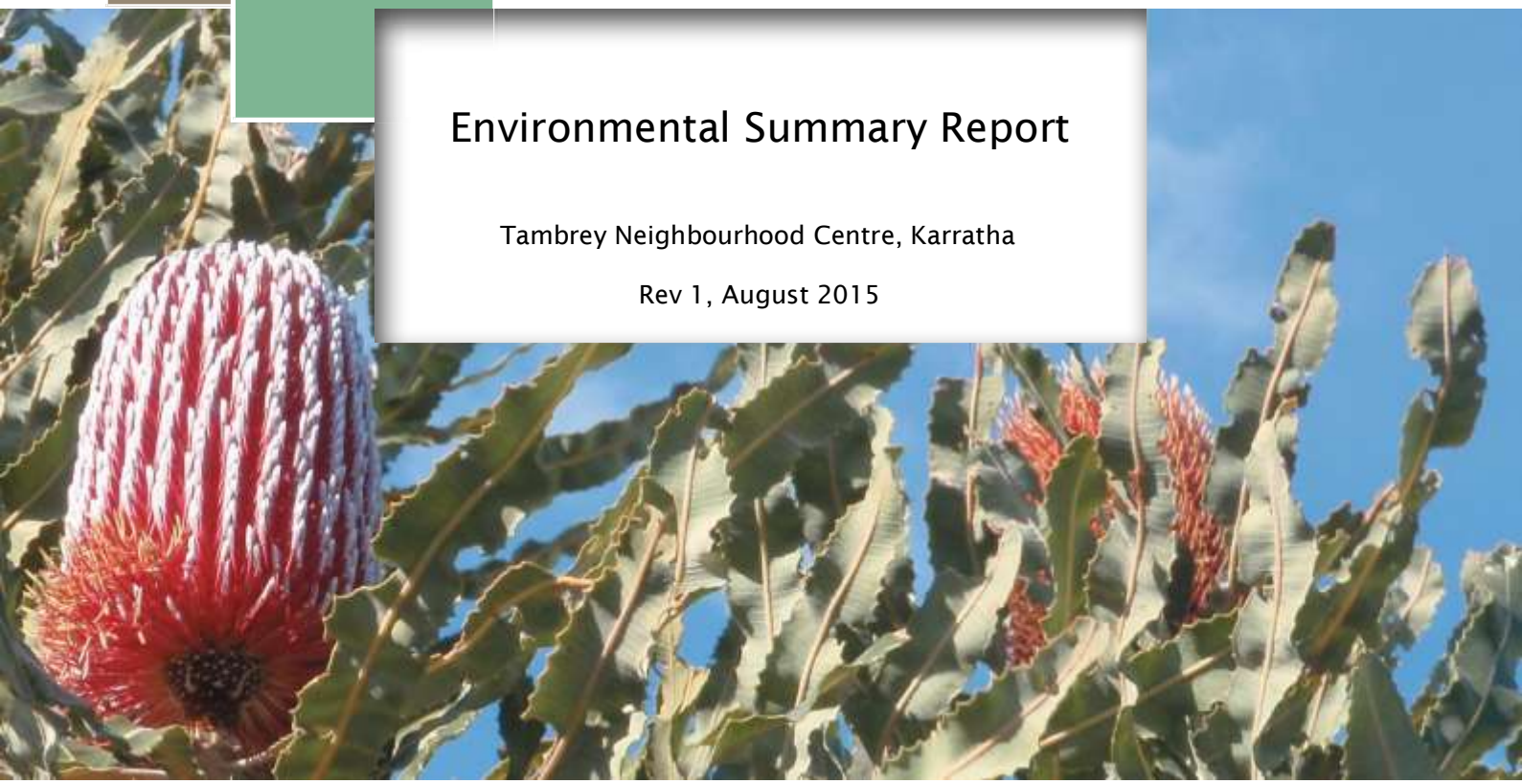
COTERRA ENVIRONMENT



Environmental Summary Report

Tambrey Neighbourhood Centre, Karratha

Rev 1, August 2015

CALIBRE I COMMITMENT I COLLABORATION

COTERRA
ENVIRONMENT

Environmental Summary Report

Tambrey Neighbourhood Centre, Karratha

August 2015

This report was prepared by:

Coterra Pty Ltd trading as COTERRA ENVIRONMENT
ABN: 92 143 411 456

Our Ref: FJMTAM01
Author(s): K. Bennetts
Report Version: Rev 1
Date: August 2015

This report was prepared for:

The Tambrey Joint Venture
34 St Quentin Ave
Claremont WA 6010

Notice

EXECUTIVE SUMMARY

The Tambrey Neighbourhood Centre site is located approximately 4km west of the Karratha Town Centre. The site extends over an area of approximately 10ha. The site has limited native vegetation remaining, with introduced grasses dominating the flora species present onsite. As such the condition is predominantly classed as completely degraded. It is surrounded by residential development, with a drainage reserve located along the western boundary.

Development of the site is generally proposed to comprise commercial, residential and short-stay accommodation land uses. The development will be undertaken by The Tambrey Joint Venture.

The site was included in the Shire of Roebourne Town Planning Scheme (TPS) No. 8, Amendment No. 24 to facilitate rezoning from Parks, Recreation and Drainage Reserve to Urban Development. Following review of the amendment the Environmental Protection Authority (EPA) determined that the scheme amendment did not require assessment, and that the environmental impacts can be managed by the local authority within existing planning controls.

Topography over the majority of the site has a gentle decline from 15mAHD on the southern boundary to 12mAHD in the north. Environmental geology mapping indicates that the majority of the site comprises alluvium and clay deposits.

The site is mapped as having a 'moderate to low' risk of Acid Sulfate Soils within 3m of the natural land surface. Review of the Department of Environment Regulation (DER) requirements for Acid Sulfate Soil (ASS) investigations identify that the site does not trigger the criteria for further ASS assessment.

Regional groundwater mapping suggests that the watertable is generally within 5 to 10 metres of the surface (DoW 2012). There are no existing surface water drainage features within the site boundary. Currently runoff generated on site flows in a south westerly direction into an existing drainage reserve which runs along the western boundary of the site.

It is noted that the low permeability soils and high intensity rainfall events in Karratha can lead to widespread flooding. To address this issue, the current drainage network in the town has been primarily developed for the rapid removal of stormwater from key infrastructure in developed areas (GHD, 2010).

The key design and management items proposed for the onsite drainage system include:

- The stormwater system design to be based on a conveyance model, where flows are directed overland to the adjacent drainage reserve.
- Individual urban lot runoff will follow unobstructed overland flow paths to road drainage reserves.
- The road networks will be used as the main conveyance pathway to the drainage reserve in high rainfall events.

An assessment of the vegetation onsite found that the majority of the site has been previously disturbed, with remaining vegetation dominated by introduced grasses. A number of clusters of a Priority 3 flora species (*Themeda sp* Hamersley Station (M E Trudgen 11431) were identified in the southern end of the site.

Consultation has been undertaken with the Shire of Roebourne and Department of Environment and Conservation (DEC) (now known as Department of Parks and Wildlife) to identify if either group has any conservation projects which may benefit from utilising the *Themeda sp*. No projects at that time were available. If this situation changes plant salvaging will be further investigated.

Given the degraded nature of the site there are limited ecological values remaining. A review of the conservation significant species which have been recorded in the area, found that these species have habitat requirements which are not present onsite.

The Department of Indigenous Affairs Aboriginal Heritage Database does not identify the presence of any Aboriginal heritage sites within the project site or immediate surrounds.

A petrol station is located to the immediate north-east of the site. It has been identified that development must remain 6-10m away from the LPG tanks associated with the petrol station. This setback has been achieved under the project design.

Construction activities will be undertaken in accordance with the *Environmental Protection (Noise) Regulations 1997* and DEC (2011) (now known as DER) *A guideline for managing the impacts of dust and associated contaminants from land development sites, contaminated sites remediation and other related activities*..

TABLE OF CONTENTS Page

TABLES (Compiled within the report)

FIGURES (Compiled at the end of the report)

APPENDICES

1.1 INTRODUCTION

1.2 General

The Tambrey Neighbourhood Centre site is located approximately 4km west of the Karratha Town Centre. The site extends over an area of approximately 10ha and is surrounded by residential development. The site location is shown on Figure 1.

The site generally comprises disturbed and degraded vegetation, with uncontrolled access tracks present across the landholding. A surface water drainage reserve is located along the western site boundary. An aerial photograph of the site is provided in Figure 2.

1.3 Proposed Development

Development of the site is proposed to comprise:

- A central shopping precinct consisting of a shopping centre as well as individual shops adjacent to the main street;
- Drive through restaurants;
- Group housing sites;
- Residential lots; and
- Open space areas.

The existing petrol station located to the immediate north-east of the site will remain post-development.

A copy of the proposed Development Plan is provided in Figure 3.

1.4 Scheme Amendment

The site was included in the Shire of Roebourne Town Planning Scheme (TPS) No. 8, Amendment No. 24 to facilitate rezoning from Parks, Recreation and Drainage Reserve to Urban Development.

Following review of the amendment the Environmental Protection Authority (EPA) determined that the scheme amendment did not require assessment, and that the environmental impacts can be managed by the local authority within existing planning controls (date of decision: 15 March 2011). A copy of this advice is provided in Appendix A.

2.1 SITE DESCRIPTION

2.2 Topography, Soils and Geology

Topography over the majority of the site has a gentle decline from 15mAHD on the southern boundary to 12mAHD in the north (Figure 4). The centre line of the drainage reserve on the western boundary lies at 11.5mAHD adjacent to the southern site boundary and 10mAHD adjacent to the northern site boundary.

The environmental geology mapping series shows most of the site to be underlain by alluvium (clay, silt and sand) deposits amongst large expanses of clay. The soils are expected to feature more sand and gravel in the east towards the drainage reserve and more clay towards the south west. A copy of the environmental geology mapping is provided in Figure 5. This distribution is consistent with the Australian Soil Resource Information System (CSIRO 2012) maps which show the site to be underlain by Light or Light Medium clay.

DER mapping indicates the site predominantly has a Class II 'moderate to low' risk of Acid Sulfate Soils (ASS) within 3m of the natural surface. The south eastern corner of the site is mapped as having 'no known risk of ASS' (Figure 6). The closest high risk area is located over 2km from the site (Landgate, 2013).

2.3 Hydrology

2.3.1 Groundwater

The site is underlain by the Pilbara Fractured Rock Aquifer which comprises of water pockets in fractured and weathered granitoid rock of low permeability (DoW 2012). This aquifer is not considered to be a major regional groundwater resource with bore yields varying depending on intersection of fractures.

Regional groundwater mapping suggests that the watertable is generally within 5 to 10 metres of the surface (DoW 2012). The closest WIN groundwater bore to the site is located approximately 1.6km north east (Site ID 20050734). The highest groundwater level on record was taken in the month of June and was 5.03mAHD (7 to 10m below site ground levels).

2.3.2 Surface Water and Drainage

There are no existing surface water drainage features within the site boundary.

Karratha experiences unreliable and variable rainfall and is seasonally prone to cyclones. Cyclonic events have the ability cause widespread flooding and flood related damages. In order to address this issue, the drainage network in Karratha was developed primarily for the rapid removal of stormwater away from key infrastructure within developed areas, to prevent and minimise flooding (GHD, 2010).

Currently runoff generated on site flows in a south westerly direction into an existing drainage reserve which runs along the western boundary of the site. The drainage reserve conveys runoff from the site and upstream catchments towards Pegs Creek and eventually into Nickol Bay.

Drainage management post development is discussed in greater detail within the Tambrey Neighbourhood Centre Local Water Management Strategy (Coterra Environment, 2013).

2.4 Flora and Vegetation

2.4.1 Regional Description

The site is located within the Roebourne subregion of the Pilbara Bioregion Interim Biogeographic Regionalisation of Australia (IBRA) region. Kendrick and Stanley (2001) described the Roebourne subregion as:

> *Quaternary alluvial and older colluvial coastal and sub-coastal plains with a grass savannah of mixed bunch and hummock grasses, and dwarf shrub steppe of Acacia stellaticeps or A. pyrifolia and A. inaequilatera. Uplands are dominated by Triodia hummock grasslands. Ephemeral drainage lines support Eucalyptus victrix or Corymbia hamersleyana woodlands. Samphire, Sporobolus and Mangal occur on marine alluvial flats and river deltas.*

This area is also within the Fortescue Botanical District as defined by Beard (1975). This Botanical District is then further divided into nine subdivisions by Beard with the study area lying within the Abydos Plain. The vegetation communities of the Abydos Plain area are influenced by the parent geological material of the area, which is Quaternary alluvium near the coast and Archaean granite further inland (Beard, 1975).

Quaternary alluvial deposits near the coast are essentially sandy with cracking clays in smaller portions. Mudflats, dunes and marshes characterise the littoral zone. Vegetation near the coast is predominantly shrub steppe. Spinifex associations with scattered shrubs (mostly Acacia species) or small trees (*Hakea lorea, Grevillea wickhamii*) dominate the granite areas and small rises of the plain. Watercourses may support *Eucalyptus camaldulensis* or *Melaleuca leucodendron* but are generally lined by a diverse shrub assemblage.

There are also areas of extensive grass plains on the Abydos Plain where finer grained alluvia have been deposited, particularly those derived from the weathering of basic rocks. These communities consist of open plains of grass (dominated by two or three species) or of mixed grass and Spinifex with scattered individuals of *Acacia inaequilatera* (Beard, 1975).

2.4.2 Database Search Results

A search of the Department of Parks and Wildlife (DPaW) (formally known as Department of Environment and Conservation- DEC) Threatened Ecological Community (TEC) database by GHD (2011) indicated that there are no TEC's within, or in close proximity to this area.

A search of the DPaW's Rare Flora Databases, Western Australian Herbarium and Western Australian Museum NatureMap records by GHD (2011) found that no Declared Rare Flora (DRF) have been recorded within 10 km of the Karratha Land Release project study area.

A search of the NatureMap database for a 5km radius around the Tambrey site indicated that *Acacia glaucocaesia* (Priority 3) was the only Priority Flora species known to occur in the area. This plant is described as a dense, glabrous shrub or tree, 1.8-6 m high with yellow flowers appearing from July to September. The species occur on red loam, sandy loam, and clay in floodplain areas (DEC, 2012).

During GHD's vegetation and flora assessment for the Karratha Land Release project, which includes numerous areas in the vicinity of this site, no DRF or Priority flora species were encountered (GHD, 2011).

2.4.3 Onsite Vegetation and Flora

An assessment of the vegetation onsite was undertaken in May 2012 by Astron Environmental Services. This survey found the following:

- The majority of the site appears to have been previously disturbed especially the northern half which is dominated by closed introduced grassland.

- The southern half is variously disturbed, both directly and indirectly.

- The flora species (in particular grass species) present and the clay substrate, which has now been largely disturbed, indicates prior to disturbance this would have been an area of Roebourne Plains Priority Ecological Community (DEC, 2006).

- The predominantly introduced grassland on the block is particularly dense on the northern half where the soil has been largely disturbed. Towards the southern end of the site *Acacia* species shrubland occurs over the grassland, which becomes more mixed.

- Clusters of the Priority 3 flora species, *Themeda sp* Hamersley Station (M E Trudgen 11431) are located in grassland within the southern end of the site. Priority 3 flora species are defined by the EPA as Taxa which are known from several populations and are not believed to be under immediate threat (that is, not currently endangered), due to the number of known populations (generally > 5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as rare flora but are in need of further survey (EPA, 2008).

- Eight weed species were recorded onsite. Two of these, **Cenchrus ciliaris* and **Cenchrus setiger* dominate the grassland over the majority of the site.

A description of the onsite vegetation units is provided overleaf.

Table 1 Vegetation Units

Vegetation Description	Condition	Comment
**Cenchrus ciliaris/*Cenchrus setiger* closed tussock grassland on previously disturbed earths with some gravel.	Completely Degraded	70-100% grass cover. Completely degraded. Northern and western portion of site.
Acacia bivenosa shrubland over mixed tussock grassland of **Cenchrus ciliaris, Eragrostis xerophila, Aristida latifolia, Astrebla pectinata, Sorghum plumosum* on mosaic of cracking clays and gravelly silts, semi disturbed.	Fair	15% Acacia shrub cover over mixed grasses. 40-60% native flora composition but signs of disturbance. Southern portion of site.

Notes: * denotes introduced flora species
Vegetation condition rating adapted from Keighery (1994) and Kaesehagen (1995)

2.5 Fauna and Habitat

As discussed above, the condition of the vegetation at the site is disturbed and degraded, with little ecological value remaining. Based on this, and the relatively small size of the site, this area is not anticipated to provide significant fauna habitat opportunities.

A search of the NatureMap database for a 5km radius around the Tambrey site indicated that the following conservation significant fauna have been recorded in this area:

- Northern Quoll (*Dasyurus hallucatus*)
- Lined soil-crevice skink (*Notoscincus butleri*)
- Eastern Curlew (*Numenius madagascariensis*)

Habitat requirements for each of these species are summarised as follows:

Table 2 Conservation Significant Fauna Habitat Requirements

Species	Habitat
Northern Quoll	The species' preferred habitat consists of rocky escarpment, open forest and open woodland (SEWPaC, 2005)
Lined soil-crevice skink	Found mainly in stony spinifex areas (Cogger,2000; Cyberlizard, 2012)
Eastern Curlew	The Eastern Curlew is most commonly associated with sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with large intertidal mudflats or sandflats, often with beds of seagrass. Occasionally, the species occurs on ocean beaches (often near estuaries), and coral reefs, rock platforms, or rocky islets. (SEWPaC, 2012; Dann 1994).

The site does not contain landforms or vegetation which provide habitat opportunities required for the species above.

2.6 Aboriginal Heritage

The Department of Indigenous Affairs Aboriginal Heritage Sites Database does not identify the presence of any Aboriginal heritage sites within the project site or immediate surrounds.

2.7 Land Uses

The site consists of unused land which is generally surrounded by residential development. The residential area to the immediate west was built in the mid 2000's.

The site to the immediate north-east of the project area operates as a service station. Enquiries have been made to the Office of the Environmental Protection Authority (K Schell, pers comm., 21/2/13), Department of Mines and Petroleum (L. Lamb pers comm., 22/2/13) and the Department of Environment and Conservation (L. Dorahy pers comm., 1/3/13) regarding any required setbacks associated with these facilities. These Departments have advised the following:

- General setbacks to these facilities are usually determined by the Local Council.

- Specific setbacks to LPG tanks are required by DMP as outlined in Australian Standard DR AS/NZS 1596 - *The storage and handling of LP Gas* (2013).

Review of DR AS/NZS 1596 indicated that the following setbacks are relevant from the LPG tank at the Tambrey service station site.

- 10m to protected places including dwellings, public buildings etc.
- 6m to public places including streets, roads, parking areas etc.

These setbacks are achieved under the proposed Tambrey Neighbourhood Centre design.

3.1 IMPACTS AND MANAGEMENT

3.2 Vegetation Clearing

Vegetation is proposed to be cleared across the entire site to facilitate development. As discussed in Section 2.3, the majority of the vegetation present onsite has been previously disturbed and is dominated by introduced grasses.

The vegetation with the highest conservation significance present onsite is the patches of the Priority 3 flora species, *Themeda sp* Hamersley Station (M E Trudgen 11431) which are located within the southern end of the site.

Liaison has been undertaken with the Shire or Roebourne and the Department of Parks and Wildlife to determine if there are any local conservation projects which may wish to utilise these plants. Neither DPaW or the Shire have a current use for the plants and have not requested they be salvaged. If this situation changes prior to clearing being undertaken salvaging options will be investigated.

3.3 Drainage

The low permeability soils and high intensity rainfall events in Karratha can lead to widespread flooding. To address this issue, the current drainage network in the town has been primarily developed for the rapid removal of stormwater from key infrastructure in developed areas (GHD, 2010).

A Local Water Management Strategy (LWMS) has been prepared to accompany the Tambrey Development Plan. The LWMS addresses the following matters:

- Identification of site drainage characteristics
- Water usage strategy
- Stormwater management

The key design and management items which relate to onsite drainage as discussed in the LWMS are summarised as follows:

- The stormwater system design for the site is based on a conveyance model, where flows are directed overland to the adjacent drainage reserve.
- Individual urban lot runoff will follow unobstructed overland flow paths to road drainage reserves.
- The road networks will be used as the main conveyance pathway to the drainage reserve in high rainfall events. As such, road levels have been designed to direct flows as required.

Further detailed drainage information can be found within the LWMS (Coterra Environment, 2013).

3.4 Acid Sulfate Soils

The DER has advised that sites should be investigated for ASS if any of the following works are proposed (DER, 2015):

- acid sulfate soil disturbing subdivision or development that is subject to conditional approval requiring the investigation and management of acid sulfate soils;
- soil or sediment disturbance of 100m^3 or more in an area depicted on an ASS risk map as Class I 'high to moderate risk of ASS occurring within 3m of natural soil surface' (e.g. construction of roads, foundations, installation of underground infrastructure, drainage works, land forming works, dams and aquaculture ponds or sand or gravel extraction);
- soil or sediment disturbance of 100m^3 or more with excavation from below the natural watertable in an area depicted on an ASS risk map as Class II 'moderate to low risk of ASS occurring within 3m of natural soil surface but high to moderate risk of ASS beyond 3m of natural soil surface';
- lowering of the watertable, whether temporary or permanent (e.g. for groundwater abstraction, dewatering, installation of new drainage, modification to existing drainage), in areas depicted in an ASS risk map as Class I 'high to moderate risk of AASS or PASS occurrence' or Class II 'moderate to low risk of AASS or PASS occurrence within 3m of natural soil surface';
- any dredging operations;
- extractive industry works (e.g. mineral sand mining) in any of the areas listed in Table 1 of DER, (2015:5).; and
- flood mitigation works, including construction of levees and flood gates, in any of the areas listed in Table 1 of DER, (2015:5).

As discussed in Section 2.1, the watertable at the Tambrey site is anticipated to occur between 5 to 10m below the ground surface. Based on this depth and the depth of works proposed during construction, no lowering of the watertable during construction of post-development is proposed.

As such, once the detailed design plans for the site have been finalised the areas to be earth worked can be confirmed. Should soil or sediment disturbance of 100m^3 or more with excavation from below the natural watertable in the area depicted in the Class II 'moderate to low risk of ASS (refer to Figure 6) be required. An ASS assessment may be warranted and will be undertaken prior to ground disturbance.

3.5 Construction Impacts

The short-term impacts of construction, including noise and dust, will be managed according to industry best practice and in accordance with all applicable government regulations.

All static and mobile machinery employed during construction will be fitted with appropriate noise attenuation equipment and will comply with occupational noise regulations. Construction activities will be managed so as to comply with the *Environmental Protection (Noise) Regulations 1997*.

Dust arising from construction works and bare ground will be controlled so as to comply with the requirements within the Department of Environment and Conservation (2011) (now known as DER) A guideline for managing the impacts of dust and associated contaminants from land development sites, contaminated sites remediation and other related activities.. In particular:

- All cleared areas will be stabilised by watering, mulching or equivalent means.
- No vegetation or other debris will be burned on the development site.
- Where necessary, watering will be employed to minimise dust generation while earthworks are in progress.

The developer will ensure that provisions are made and responsibility accepted for dust control in all contracts issued for site works.

4.1 CONCLUSIONS

The Tambrey Neighbourhood Centre site does not contain sensitive environmental features, aside from the presence of a Priority 3 flora species within the southern end of the site.

The key environmental management requirements for development of the site are:

- Management of onsite drainage through a conveyance system design which connects to the existing town drainage network.
- Investigate opportunities for salvaging of the Priority flora for use in local conversation projects.
- Undertake the construction program in a manner which minimises potential noise and dust impacts.

Based on the above, there does not appear to be any significant environmental impediments to development as proposed.

5.0 REFERENCES

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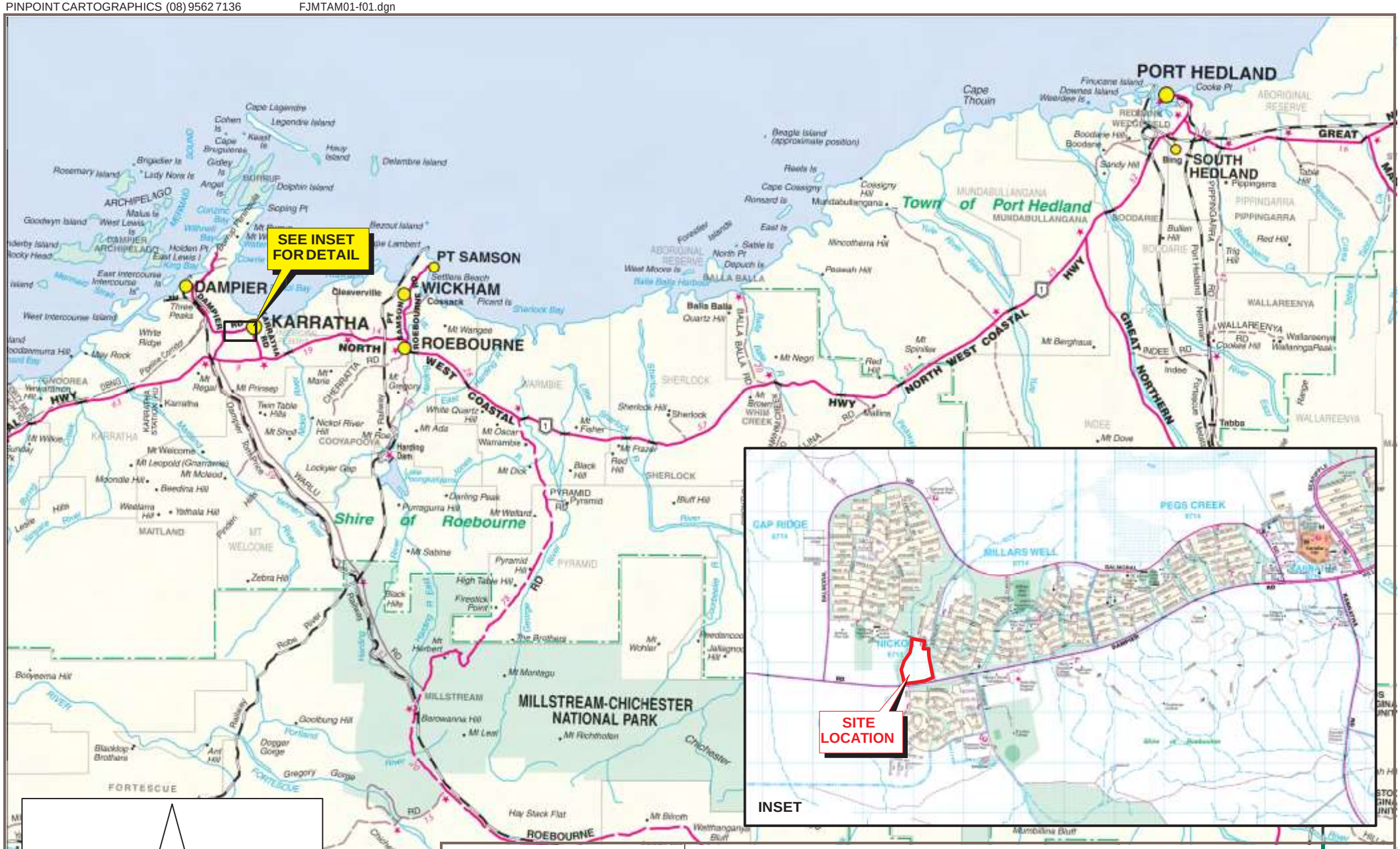
FIGURES



COTERRA ENVIRONMENT

The Tambrey Joint Venture
ENVIRONMENTAL SUMMARY
REPORT TAMBREY, KARRATHA

Drawn: K. Cooper	Date: 6 Aug 2015
Job: FJMTAM01	Revision: A

SITE LOCATION

Figure 1

CADASTRAL SOURCE: Landgate, May 2012.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown November 2011.

FJMTAM01-f02.dgn

PINPOINT CARTOGRAPHICS (08) 9562 7136

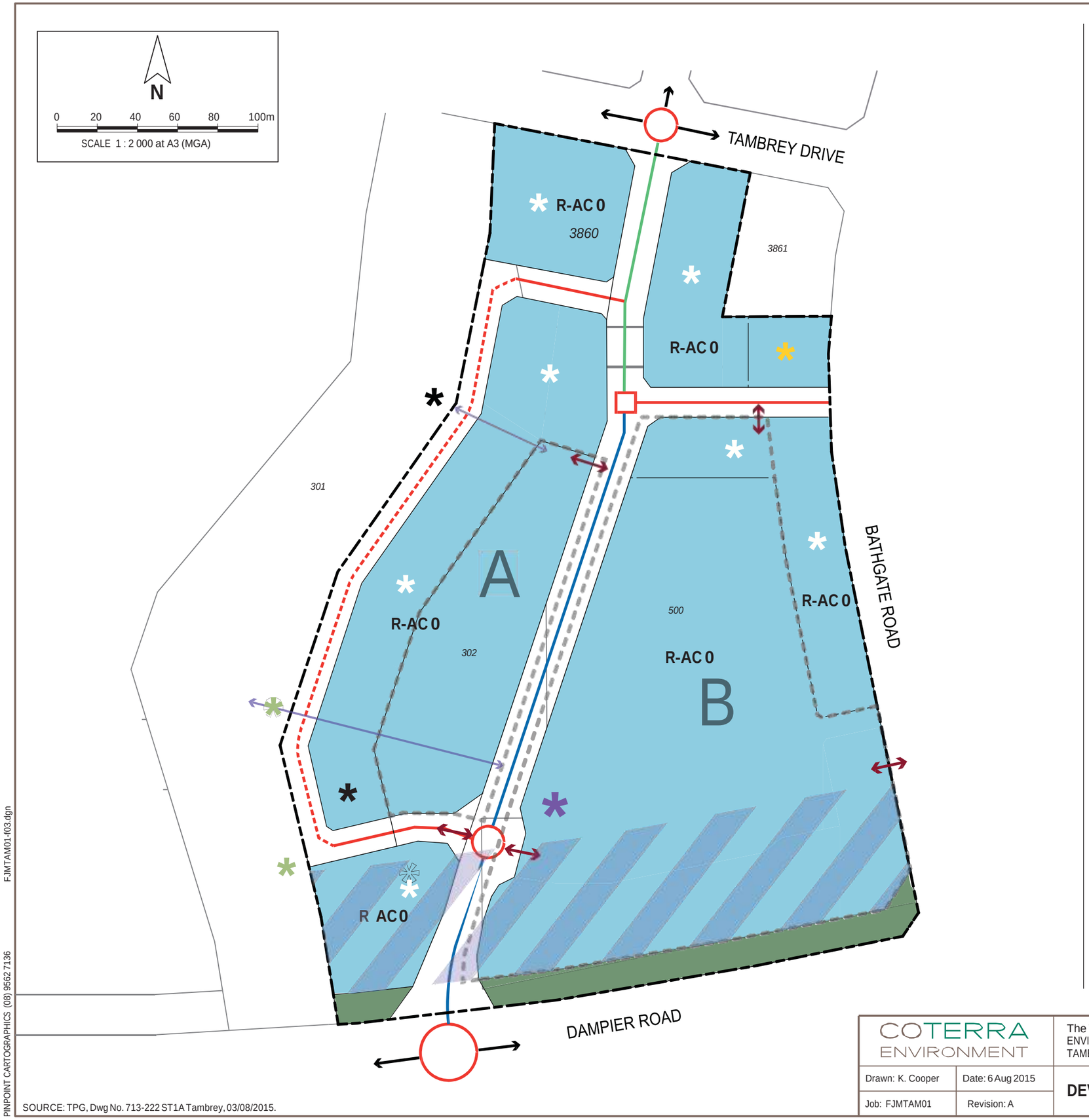
COTERRA ENVIRONMENT

The Tambrey Joint Venture
ENVIRONMENTAL SUMMARY REPORT
TAMBREY, KARRATHA

Drawn: K. Cooper	Date: 6 Aug 2015
Job: FJMTAM01	Revision: A

AERIAL PHOTOGRAPH

Figure 2



LEGEND

- Development Plan Area
- Existing Cadastre

Zones

- Commercial / Residential

Other

- Drainage
- Neighbourhood Connector Type 'B' - 18m Reserve
- Neighbourhood Connector Type 'B' - 16m Reserve
- Access Street Type 'B' - 15m Reserve
- Access Way Type 'C' - 13m Reserve
- R-AC 0 — R-Code Density Coding - Refer to Development Plan
- Existing
- Roundabout
- Intersection Treatment
- Residential DAP'S
- Motor Vehicle Wash Permitted (P)
- A B — Parking Areas
- Key Access Points
- Key Pedestrian Routes / Drainage
- Landscape Nodes
- Focal Point / Entry
- Acoustic Report required for Noise Sensitive Development (100m from Dampier Rd Centre Line)
- DAP Boundary

SOURCE: TPG, Dwg No. 713-222 ST1A Tambrey, 03/08/2015.

COTERRA ENVIRONMENT	The Tambrey Joint Venture ENVIRONMENTAL SUMMARY REPORT TAMBREY, KARRATHA	Figure 3
Drawn: K. Cooper / Date: 6 Aug 2015	DEVELOPMENT PLAN	
Job: FJMTAM01 / Revision: A		

FJMTAM01-f03.dgn

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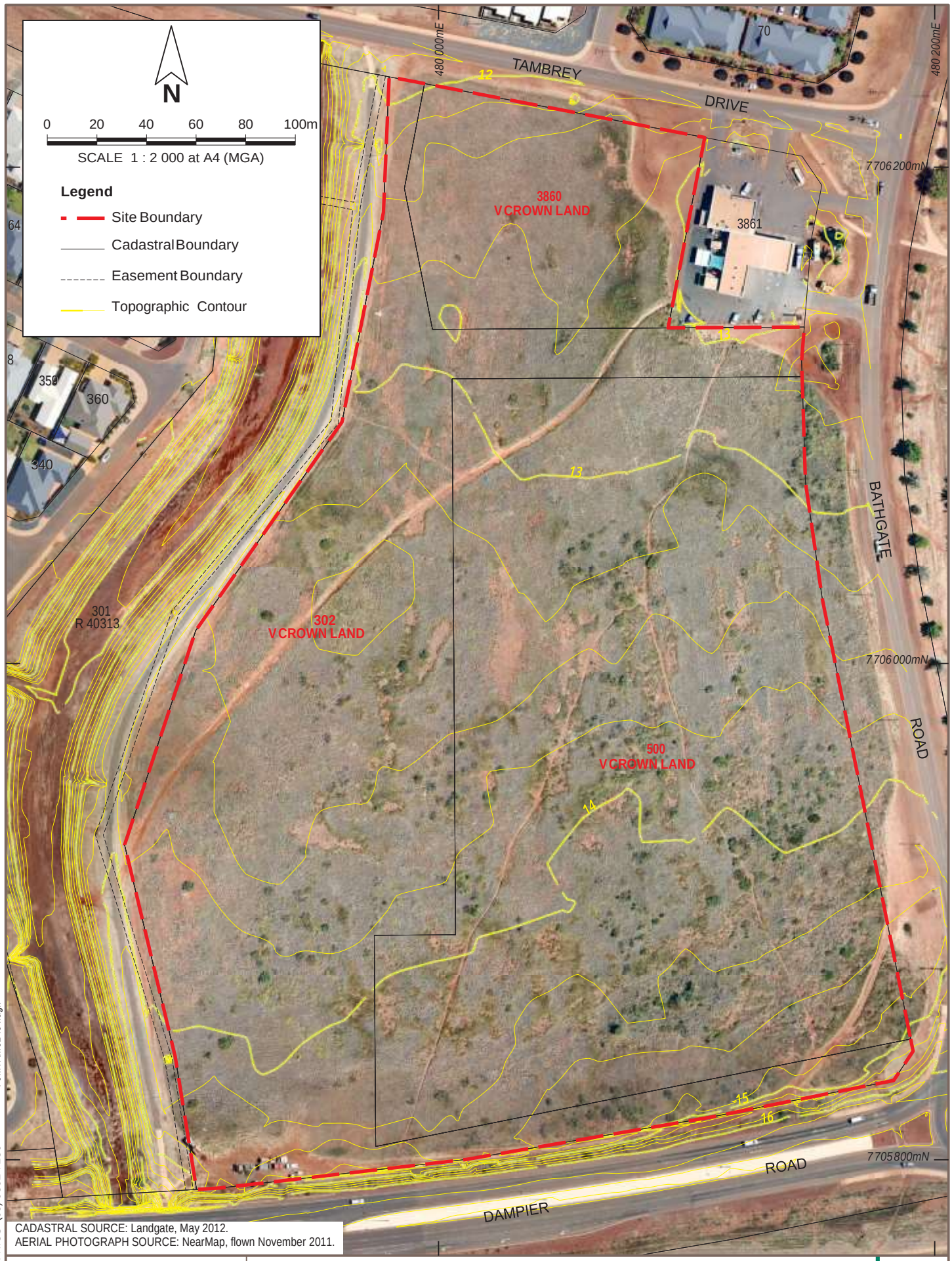

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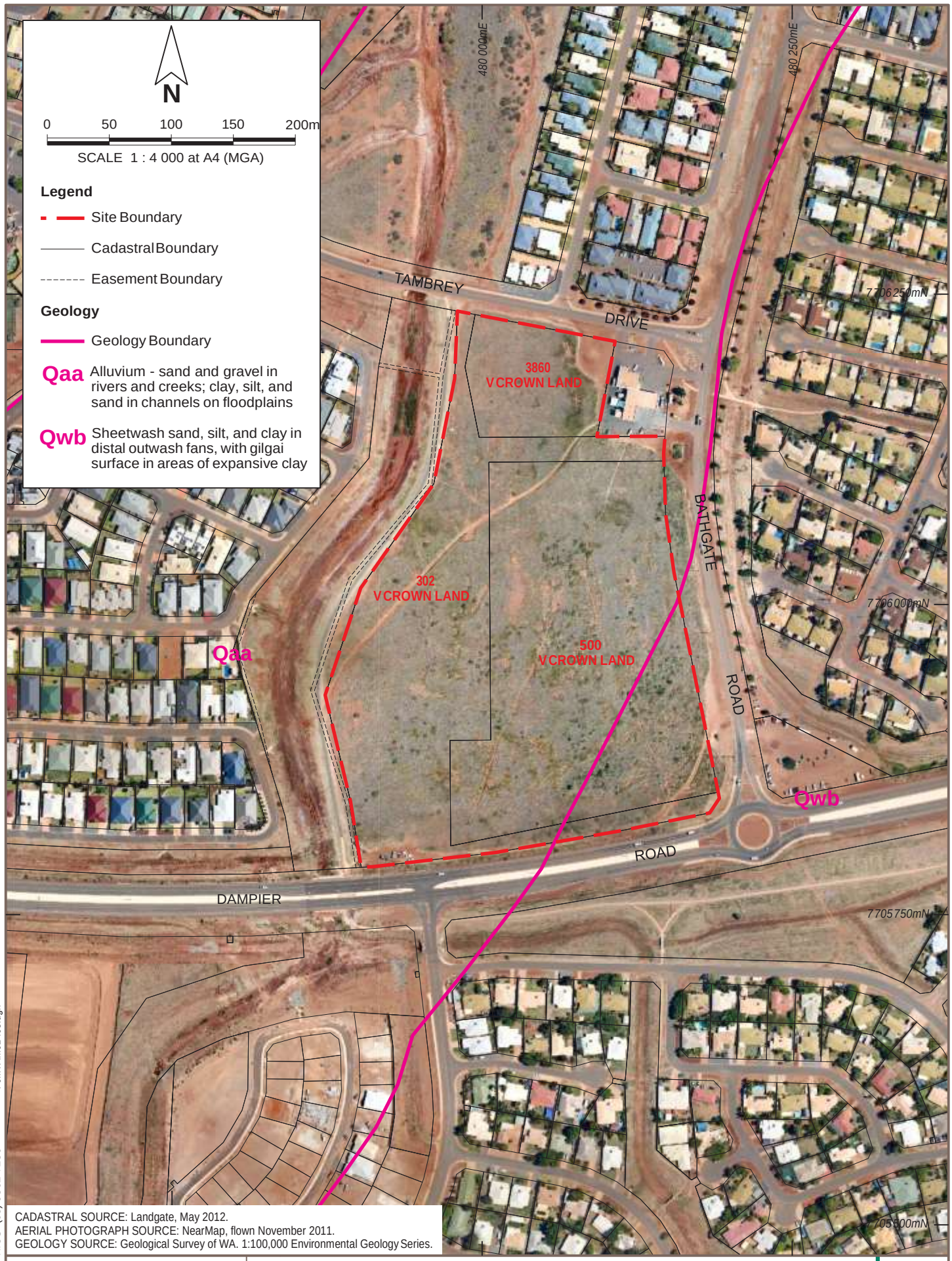
COTERRA ENVIRONMENT

The Tambrey Joint Venture
ENVIRONMENTAL SUMMARY REPORT
TAMBREY, KARRATHA

Drawn: K. Cooper	Date: 6 Aug 2015
Job: FJMTAM01	Revision: A

TOPOGRAPHY

Figure 4



CADASTRAL SOURCE: Landgate, May 2012.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown November 2011.
GEOLOGY SOURCE: Geological Survey of WA. 1:100,000 Environmental Geology Series.

COTERRA ENVIRONMENT

The Tambrey Joint Venture
ENVIRONMENTAL SUMMARY REPORT
TAMBREY, KARRATHA

Drawn: K. Cooper	Date: 6 Aug 2015
Job: FJMTAM01	Revision: A

SOILS AND GEOLOGY

Figure 5

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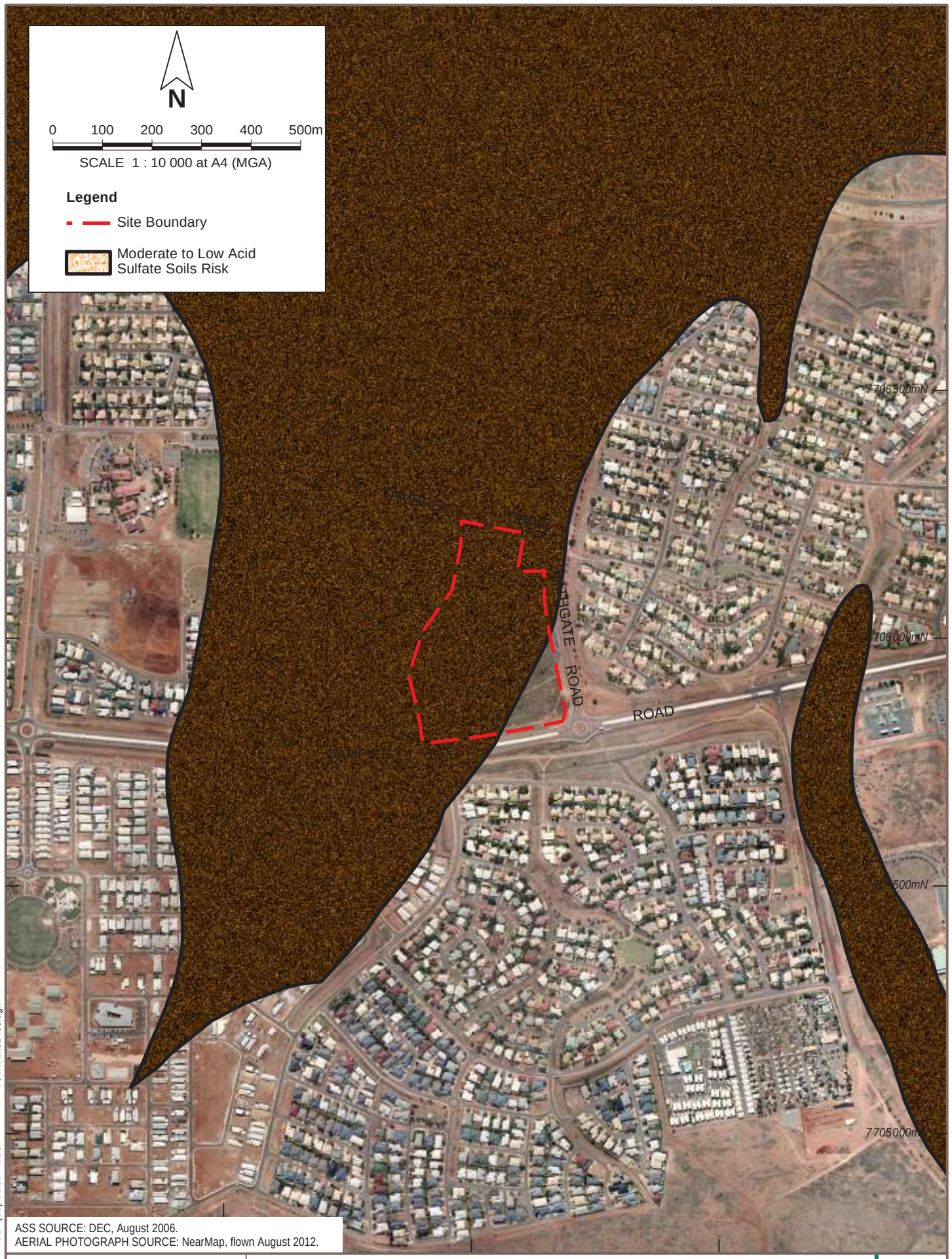
PINPOINT CARTOGRAPHICS (08) 9562 7136



ASS SOURCE: DEC, August 2006.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown August 2012.

COTERRA ENVIRONMENT

The Tambrey Joint Venture
ENVIRONMENTAL SUMMARY REPORT
TAMBREY, KARRATHA

Drawn: K. Cooper	Date: 6 Aug 2015
Job: FJMTAM01	Revision: A

ACID SULFATE SOILS RISK

FJMTAM01-f06.dgn

PINPOINT CARTOGRAPHICS (08) 9562 7136

APPENDIX A – EPA ADVICE ON SCHEME AMENDMENT

Environmental Protection Authority

Weekly record of determinations for

S48A Referrals

1itle: Shire of Roeboume TPS 8 · Amendment 24 Rezoning from Parks, Recreation and Drainage reserw to Urban De\elopment zone (Tambrey Neighbourhood Centre) Lot 302 Tambrey Dri\e Nickol

Ref ID: A372035 Date Recei\ed 25/02/2011 Date More Info

Referrer: Shire of Roeboume

Responsible Authority: Shire of Roeboume

Contact: Attn: Patrick McClure

Telephone: 91868580

LGA: Shire of Roeboume

Environmental Factors: No significant environmental factors associated with this amendment.

Potential Significant Effects: No significant En\ironmental effects expected.

Management: En\ironmental impacts can be managed by local authority within existing planning controls.

Recommendations: Scheme Amendment Not Assessed (no appeals)

Procedure:

Chairman's initial: ...

Date Signed: .....

Officer: Anthony Sheehan

COTERRA
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APPENDIX D

LOCAL WATER MANAGEMENT STRATEGY

This page has been left blank intentionally.

Our Ref: FJMTAM02

11 August 2015

City of Karratha
Lot 1083 Welcome Road
PO Box 219
Karratha WA 6714

TAMBREY NEIGHBOURHOOD CENTRE - LOCAL WATER MANAGEMENT STRATEGY

The Local Water Management Strategy (LWMS) for Tambrey Neighbourhood Centre was prepared and approved by the Department of Water (DoW) in 2013 (please see attached correspondence).

The LWMS was also provided to the Shire of Roebourne (SoR) for comment and a response and amended LWMS was provided to Pascal Keeken (Senior Engineering Technical Officer) where issues were addressed on 14 May 2013.

The changes to the Development Plan do not affect the overall drainage strategy or the approach to the management of water onsite post development, therefore the LWMS has not been amended since then. The approved LWMS has been provided as supporting documentation for the revised Development Plan to ensure there is consistency with the formally approved document.

The only notable changes in the Development Plan which were detailed in the approved LWMS include:

- Water feature – The water feature has been removed from the revised Development Plan. Previous SoR LWMS comments requested the removal of the water feature so this is now in line with the councils' preferences. The water feature did not provide a stormwater drainage or water supply within the development proposals. As such its removal will not affect the over-arching water management strategy at the site. The Urban Water Management Plan (UWMP) prepared at detailed design stage will confirm the removal of the water feature.
- Slight variations to earthworks – There have been slight variations as a result of the Development Plan revision however the overall catchments and flow paths remain largely the same from a conceptual perspective. The minor changes will be addressed when detailed engineering drawings are provided within the Urban Water Management Plan (UWMP) at detailed design stage.

If you have any queries or wish to discuss, please do not hesitate to contact Kristy Chandler or the undersigned.

Yours sincerely

REBECCA EPWORTH
Director

Attachment 1: DoW Approval Letter

Government of Western Australia
Department of Water

looking after all our water needs

Your ref: FJMTAM02
Our ref: WT10160 /TRIM Report13/530NVRD211941
Enquiries: Karen McKeough, 98410128

Kristy Chandler
Coterra Environment
2/460 Roberts Rd
SUBIACO WA 6008

Dear Kristy

Tambrey Neighbourhood Centre Local Water Management Strategy

Thank you for resubmitting the above document. The Department of Water (DoW) advises that the requested changes have been actioned, and therefore the Dow is prepared to approve the document.

If you wish to discuss the above please, contact the Department of Water's Pilbara Office on 6364 6574.

Yours Sincerely,

Hamid Mohsenzadeh
Regional Manager
Department of Water
Pilbara Region

9 July 2013

Pilbara Region
Lot 4608 Cherratta Road KIE
Karratha Western Australia 6714
PO Box 836 Karratha Western Australia 6714
Telephone (08) 9144 0200 Facsimile (08) 9144 2610
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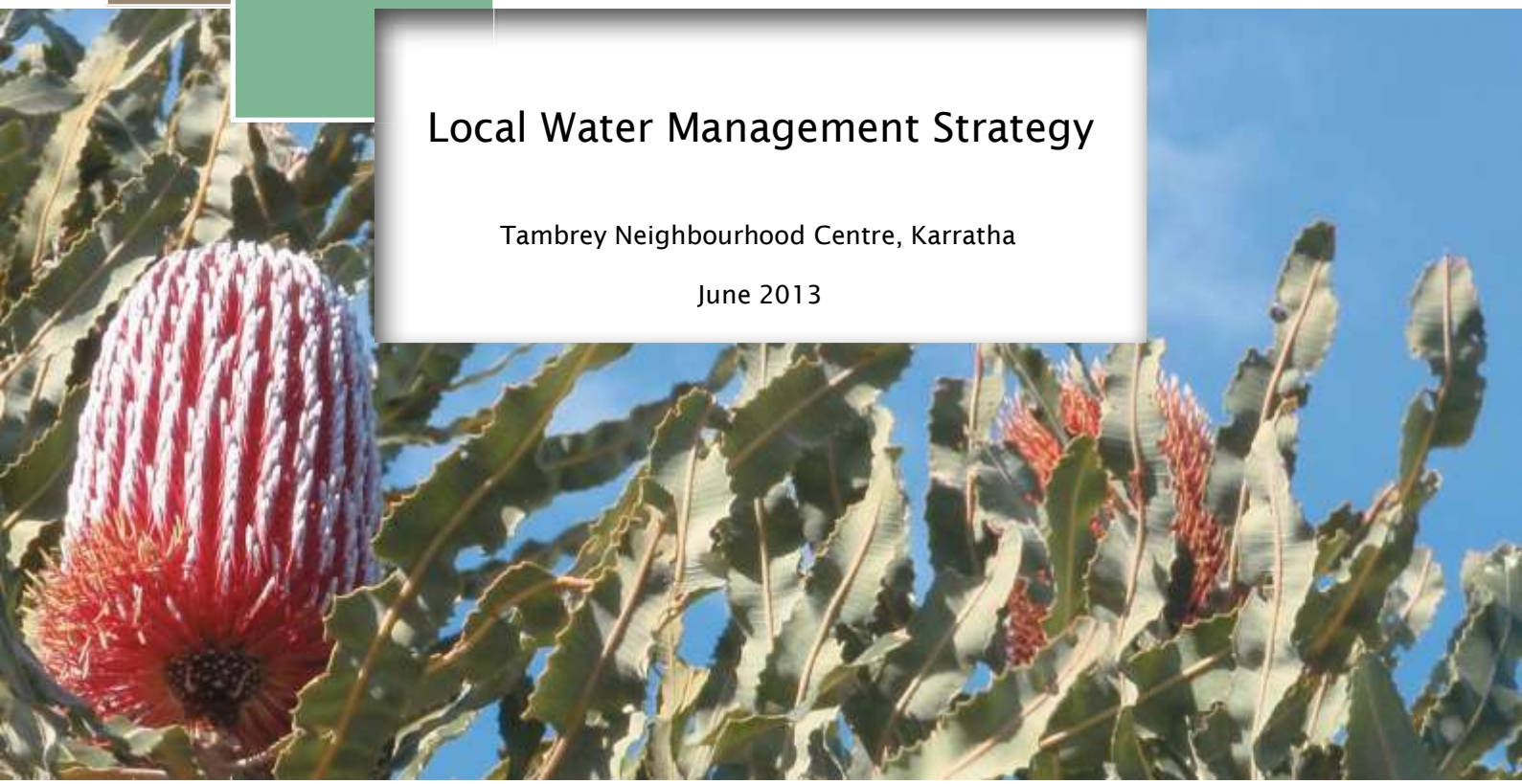

Local Water Management Strategy

Tambrey Neighbourhood Centre, Karratha

June 2013

CALIBRE I COMMITMENT I COLLABORATION

This report was prepared by:

Coterra Pty Ltd trading as COTERRA ENVIRONMENT
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Our Ref: FJMTAM02
Author(s): K. Chandler
Reviewer: R. Epworth
Report Version: Rev2
Date: June, 2013

This report was prepared for:

FJM Property
34 St Quentin Avenue
CLAREMONT WA 6010

EXECUTIVE SUMMARY

This document outlines the Local Water Management Strategy (LWMS) for the site, which has been developed in accordance with the guidelines in the Better Urban Water Management (BUWM) guidelines (WAPC, 2008). The tables below provide an overview of the site and a summary of the design elements and requirements for best management practices and control points.

Site overview	Description
Site location	Tambrey Neighbourhood Centre - Lots 500 and 302 Bathgate Road, and Lot 3860 Tambrey Road, Nickol (see Figure 1)
Size	Approximately 10 ha
Proposed change in land use	The site is currently undeveloped. The proposed development includes three zones: a) Residential, b) Commercial / Residential and c) Drainage.
Planning context	The site is zoned correctly for the intended land use. A Masterplan and Development Plan have been prepared to outline the nature and form of the proposed development (see Figures 2 and 4).
Hydrological constraints	• High intensity rainfall (cyclonic events) • Low soil permeability • Hot dry climate - high water demand • Lack of alternative water sources
Hydrological opportunities	• Wide road reserve for conveyance of stormwater • Regional drainage reserve adjacent to the site with capacity to convey 100 year ARI runoff from the site • High phosphorous retention capability of soils • Large separation distance to groundwater • Site not expected to flood during 500 year ARI storm surge

Key Elements	Design and Compliance to Objectives
Water Conservation Strategy (Section 3)	• Domestic water will be sourced from the regional scheme. • All homes will be fitted with AAA rated water fixtures (toilets, showers, taps). • Wastewater will be disposed of via the regional sewer system. • Irrigation of landscaping will be minimised through a design which combines hand and soft-landscaping, the use of hydroplanting and the selection of low water use native species. • Irrigation water for the landscaped areas is likely to be sourced from the regional scheme.
Stormwater Managemen t (Section 4)	• There are no existing defined drainage lines or drainage infrastructure across the site. Runoff flows as overland flow in a westerly direction towards the regional drainage reserve adjacent to the site. • Low permeable soils and high intensity rainfall limits the use of infiltration techniques. • Post development runoff up to a 100 year ARI event will be

Key Elements	Design and Compliance to Objectives
	conveyed via the road and swale system towards the regional drain. • Roads will have a cross-fall so that they are passable during more frequent rainfall events. • The finished lot levels will be constructed at least 500mm above the 100 year ARI flood level within the main drainage reserve. • The finished lot levels will be higher than the 500 year ARI storm surge flood level. • The finished floor levels of all buildings will be constructed at least 300mm above the 100 year ARI stormwater flood level in the local road drainage network within the development. • The proposed footbridge across the drainage reserve will be designed so that it does not affect flood flows during a 100 year ARI fluvial flood event. • Water quality will be managed via non-structural controls.
Groundwater Management (Section 5)	• No major earthworks are required for surface water drainage as stormwater will be conveyed above ground. • There is unlikely to be any interaction with groundwater for any sub-soil works due to the large separation distance. • The clay soils on the site are considered moderately reactive. 0.8m of non-reactive fill is recommended for stability purposes.
Monitoring (Section 6)	• There are no surface water features on the site and groundwater levels are approximately 7 to 10m below existing ground levels. • Based on available data and DoW advice, monitoring is not required pre or post development at the site.
Implementation (Section 7)	• Roles and responsibilities involved in the implementation of the LWMS are identified.

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TABLES (Compiled within the report)

FIGURES (Compiled at the end of the report)

APPENDICES

1.1 INTRODUCTION

This Local Water Management Strategy (LWMS) has been prepared on behalf of FJM Property and relates to the development at Lots 500 and 302 Bathgate Road and Lot 3860 Tambrey Road, Nickol. The development plan is formally known as Tambrey Neighbourhood Centre.

The proposed development site extends over an area of approximately 10 ha at the western end of the Karratha townsite, within the Shire of Roebourne (SoR). Karratha is situated in the Pilbara region of Western Australia, approximately 1,535 km north of Perth and 850 km south of Broome. The site location is presented in Figure 1.

1.2 Proposed Development

The proposed development includes three zones: a) Residential, b) Commercial / Residential and c) Drainage. The DRAFT Masterplan for the site is presented in Figure 2.

Landscaping will be provided throughout the development and along the site boundaries. Soft landscaping will be included within the central square, carparks, vehicular entrance points and along the drainage reserves. The DRAFT Landscape Concept Plan is presented in Figure 3.

1.3 Planning Context

The site was included in the Shire of Roebourne Town Planning Scheme (TPS) No. 8, Amendment No.24 to facilitate rezoning from 'Parks, Recreation and Drainage' to 'Urban Development'. The Development Plan is now being prepared to facilitate the development of the site. The DRAFT Development Plan is provided in Figure 4.

1.4 Guidance and Previous Studies

This LWMS has been prepared accordance with the Better Urban Water Management (BUWM) guidelines (WAPC, 2008). Although the strategies set out in the BUWM refer to urban development on the Swan Coastal Plain, references are made to Water Sensitive Urban Design (WSUD), which are applicable to the whole of Western Australia.

The strategy has been prepared in accordance with State Planning Policy 2.9: Water Resources (Government of WA, 2007) with specific reference to the following guidance documents and previous studies:

- Interim: Developing a Local Water Management Strategy (Department of Water, 2008)
- Western Australian State Water Plan (Government of Western Australia, 2007)
- Pilbara Regional Water Plan 2010-2030 (Department of Water, 2010)
- Stormwater Management Manual for Western Australia (Department of Water, 2004-2007)

- Local Government Guidelines for Subdivisional Development Edition 2.2 (Institute of Public Works Engineering Australia, 2012)
- Karratha Drainage Management Plan – Karratha Drainage Assessment (GHD, 2010)
- Karratha Coastal Vulnerability Study (JDA *et al.*, 2012)
- Draft WA State Planning Policy 2.6 – State Coastal Planning Policy

1.5 Objectives

The design objectives and criteria for this site have been derived from a review of the relevant Karratha Drainage Design Recommendations (GHD, 2010), and supplemented where necessary with the Design Objectives for WSUD (Department of Water, 2008) (see Table 1).

Table 1 Design Objectives and Criteria

Element	Objective	Design Criteria
Water conservation strategy (potable and wastewater)	Efficient use of potable water.	Minimise external use of potable water.
		Water saving measures to be installed within all residential buildings.
Water quantity management	Post-development annual discharge volume and peak flows for up to the 100 year ARI event to be conveyed to the coastal plain by overland flow.	Manage the catchment runoff (flooding) for up to the 100 year ARI event.
		Protect infrastructure and assets from inundation and flooding.
Water quality management	Maintain surface-water and groundwater quality	Consideration of stormwater treatment in areas of higher risk of contamination discharge (i.e. industrial areas).

2.1 SITE CHARACTERISTICS

2.2 Existing Land Uses

The site consists of unused land which is generally surrounded by residential development and supporting infrastructure. The site vegetation predominantly comprises dry grasses.

The residential area to the immediate west was built in the mid 2000's. The southern boundary of the site is adjacent to Dampier Road which is the primary road through Karratha. There is a sports ground (300m to the west) and the Nickol Bay hospital on Dampier Road (700m to the east).

The site to the immediate north-east of the project area operates as a petrol station, and a drainage reserve runs adjacent to the western boundary of the site. Both of these features have influenced the development proposals for the site. Figure 5 displays surrounding land uses relative to the site.

The influence of the drainage reserve is discussed further in Section 2.5.

2.3 Climate and Rainfall

The site has a hot, dry climate dominated by tropical cyclones which occur predominantly in January to March. Winters are mild with unreliable and variable rainfall. Severe droughts and major floods can occur at close intervals. The average annual rainfall at the site is approximately 287mm, with the vast majority of rainfall falling during high intensity tropical storms. The monthly averages are presented in Table 2 (BOM, 2012).

Table 2 Average Monthly Rainfall Statistics

Month	Average Rainfall (mm)
January	47.7
February	80.5
March	51.3
April	17.9
May	25.1
June	29
July	14.6
August	4.8
September	1.5
October	0.3
November	1.6
December	12.7

Source: Bureau of Meteorology. Karratha Aero Weather Station (Averages from 1972-2012)

2.4 Topography

Regional topographical mapping shows the majority of the site to have a gentle decline from 15mAHD on the south east boundary to 12mAHD in the north west (Figure 6).

The centre line of the drainage reserve on the western boundary lies at 11.5mAHD adjacent to the southern site boundary and 10mAHD adjacent to the northern site boundary.

A detailed elevation survey of the site and adjacent drainage reserve was undertaken by McMullen Nolan Group in April 2012. The topographic levels are provided in Appendix A and are consistent with the regional dataset.

2.5 Geology and Soils

2.5.1 Regional soil description

The Environmental Geological Series shows most of the site to be underlain by alluvium (clay, silt and sand) deposits amongst large expanses of clay (Qaa and Qwb). The soils are expected to feature more sand and gravel in the west towards the drainage reserve and more clay towards the south east. This distribution is consistent with the Australian Soil Resource Information System (CSIRO 2012) maps which show the site to be underlain by Light or Light Medium clay.

Figure 7 shows the geological boundaries across the site.

2.5.2 Site Soil Investigations

A site soil investigation was undertaken by Coffey Geotechnics Pty Ltd in June 2007. Fourteen test pits were excavated by backhoe to depths varying from 1.7m to 2.0m below the existing ground surface. Test pit locations are shown in Figure 7.

All test pits showed a similar soil profile:

- 0.0m below surface - 0.2 to 0.6m top-soil / fill.
- 0.2 to 0.6m below surface – 1.5 to 2.0m clayey gravel / clayey sand of low to medium plasticity, medium to coarse grained, brown.
- 1.5 to 2.0m – clayey gravel of low to medium plasticity, medium to coarse grained, brown, with some weathered Chlorite Schist's containing carbonate veins.

The clay soils on site were considered moderately reactive which can experience moderate ground movement from moisture changes.

The geotechnical report is presented in Appendix B.

2.5.3 Acid Sulfate Soils

DEC mapping indicates the site predominantly has a 'moderate to low' risk of Acid Sulfate Soils (ASS) within 3m of the natural surface (see Figure 7). The south eastern corner of the site is mapped as having 'no known risk of ASS'.

No further investigation will be completed as part of this proposed development as due to the low permeability of the soils, drainage of the site will be undertaken above ground with no major earthworks proposed as part of the application.

2.5.4 Contamination

There is no information to suggest that soils at the site are contaminated from previous land uses.

2.6 Surface Water

There are no existing surface water drainage features within the site boundary. Runoff generated on site flows in a north westerly direction into a drainage reserve which runs along the western boundary. The drainage reserve conveys runoff from the site and upstream catchments towards the coastal front.

A hydrological and hydraulic assessment of the existing drainage reserve was undertaken as part of this LWMS and results are presented in Section 4, including any potential flood risk.

2.7 Groundwater

The site is underlain by the Pilbara Fractured Rock Aquifer which features water pockets in fractured and weathered granitoid rock of low permeability (DoW 2012). This aquifer is not considered to be a major regional groundwater resource with bore yields varying depending on intersection of fractures.

2.7.1 Groundwater Levels

Regional groundwater mapping suggests that the watertable is generally 5 to 10 metres below the existing ground levels at the site (DoW, 2012). The closest WIN groundwater bore to the site is located approximately 1.6km north east (Site ID 20050734). The highest groundwater level on record was taken in the month of June and was 5.03mAHD (7 to 10m below site ground levels).

No groundwater was encountered during geotechnical investigations on site (Coffey Geotechnics, 2007).

Advice received from DoW (*pers.comm*. Peter Kata, September 2012) advised that no further groundwater investigations are required as no groundwater was encountered in geotechnical test pits and there is considered significant separation to groundwater. Therefore no further site specific pre development investigations have been undertaken.

2.7.2 Groundwater Quality

Regional analysis suggests that groundwater in the Pilbara Fractured Rock Aquifer is mainly fresh, ranging up to brackish towards the coast (DoW 2012). The generalised salinity of the fractured rock aquifer at the site is expected to range from 1000-3000 mg/L (brackish).

TDS measurements taken in the WIN bore closest to the site were consistent with regional mapping (2670mg/L measured in June 1971).

Given the nature of the aquifer and salinity of the groundwater, it is unlikely that groundwater will be suitable for irrigation purposes. This is discussed further in Section 3.4.

2.8 Vegetation

The Department of Environment and Conservation (DEC) databases do not show any Threatened Ecological Community (TEC) or Declared Rare Flora (DRF) within, or in close proximity to the site.

The NatureMap database indicates that *Acacia glaucocaesia* (Priority 3) is known to occur within 5km of the site.

An assessment of the vegetation onsite was undertaken in May 2012 by Astron Environmental Services. The survey found that the site was largely disturbed and dominated by introduced grasses. The majority of the site was classed as degraded – although clusters of Priority Flora Species *Themeda asp* Hamersley Station (M E Trudgen 11431) were found in grassland within the southern end of the site.

These species are not water-based and do not rely on shallow / perched groundwater systems.

2.9 Aboriginal Heritage

The Aboriginal Heritage Database does not identify the presence of any Aboriginal heritage sites within the project site or immediate surrounds (Department of Indigenous Affairs, 2012).

A more detailed description of the environmental and heritage features of the site is provided in the Tambrey Neighbourhood Centre Environmental Summary Report (Coterra Environment, 2013).

3.1 WATER USAGE STRATEGY

3.2 Household Water Supply

The site lies within the West Pilbara Water Supply Scheme area which draws from the Harding Dam and Millstream Aquifer. The Water Corporation are currently upgrading two water supply tanks and the Dampier Highway Townsite Water Main to allow for new development within the scheme area. The increased supply will be available mid to late 2014.

The site is surrounded by a good network of existing sewer and water reticulation services for connection.

The Engineering Servicing Report (WGE, 2013) will address the water supply in more detail.

3.3 Wastewater Disposal

Wastewater disposal will be undertaken by the Water Corporation via the regional sewer system. The Karratha Wastewater Treatment Plant 2 is currently being upgraded to allow for new development in the area. Existing sewer connections are present along the northern and western boundaries of the site.

The Engineering Servicing Report (WGE, 2013) will address the wastewater disposal in more detail.

3.4 Household Water Efficiency and Conservation

Household water use efficiency will be required through compliance with the 'Energy Use in Houses Code' and the 'Water Use in Houses Code'. These are known as the 5 Star Plus Codes, introduced by the Department of Housing and Works in 2007 (DoH, 2007 a,b).

The following requirements will be mandatory for each dwelling:

- Gas hot water system with a minimum 5 stars WELS rating (or a solar hot water system, or a high energy efficient electric heat pump).
- Water efficient (i.e. 3 star WELS rated) shower heads.
- Water efficient (i.e. 4 star WELS rated) tap fittings in all kitchen sinks, bathroom basins and vanities.
- Water efficient (i.e. 4 star) dual flush toilets.
- Pool blankets for all new pools to reduce the rate of evaporation.
- Hot water outlets must be located close to the hot water system or a recirculating hot water supply to minimise wastage of energy and water.

3.5 Landscaped Areas

3.4.1 Irrigation Source

External potable water use in the Pilbara Region can be high due to the climate and lack of alternative water sources.

The groundwater underlain the site is brackish (see Section 2.6.2) and as such not considered suitable in its raw form for irrigation. It may be possible to create a 'shandy' system that is a combination of bore water and potable water for irrigation usage. Such a system would require water storage tanks with a probe that automatically detects salinity levels and activates the input of potable water to keep the salinity levels at a tolerance acceptable for irrigation purposes. The feasibility of this option will be considered at detail design stage.

In the absence of a confirmed alternative irrigation supply, regional scheme water could be used to establish the plants and for ongoing maintenance. It is recognised that this is not an ideal use of potable water and a number of features have been included in the proposals to minimise external water use in landscaped areas.

3.4.2 Landscape Design and Vegetation Selection

A Landscape Strategy has been prepared to provide an indication of the landscape design concept, materials and planting palette which will be used in the Tambrey Neighbourhood Centre (Emerge, 2013). This landscape strategy is indicative and subject to availability of materials and council approval at detailed design stage.

The strategy has been designed as a composite of hard and soft landscaping to reduce the amount of plants requiring irrigation. For example, over 80% of the Civic Piazza is hard paved.

The plants within the vegetated areas will be drought tolerant native species which have lower water demand. Indicative species are listed in Table 3.

Table 3 Indicative Species List

	Irrigation Zone		
	Low Water Usage	**Medium Water Usage**	**High Water Usage**
Trees	Eucalyptus victrix Eucalyptus leucophloia	Corymbia flavescens Corymbia opaca Melaleuca argentea	Ficus hillii Delonix regia Caesalphina ferrea Tabebuia rosea Tipuana tipu
Shurbs	Acacia sp. Aristida contorta Eremophila sp Senna sp. Triodia pungens	Acacia hilliana Allamandra nerifolia Conostylis candicans Eremophila 'Kalbarri Carpet' Ptilotus sp. Swainsona formosa Westringia fruticosa	Alternanthera dentata Bougainvillea glabra Dianella 'Cassa Blue' Stretlizia reginae Zamia furfuracea

A hydroplanting approach will be followed which requires the grouping of plants with similar water demand. Figure 3 provides an indication of the Hydroplanting Zones proposed. A description of each zone and indicative plants are described below:

- Low Water Usage: planting with dry tolerant native species. Minimal irrigation will be required for establishment, with no ongoing irrigation requirements.
- Medium Water Usage: planting with drought tolerant native species. Minimal irrigation will be required for establishment and thereafter.
- High Water Usage: planting with ornamental native species. Irrigation will be required for establishment and thereafter.

Initial calculations indicate that 22,900kL of water will be required per annum for irrigation (440kL/week). Table 4 contains a breakdown for each irrigation zone.

Table 4 Indicative Irrigation Requirements

	Irrigation Zone		
	Low Water Usage	Medium Water Usage	High Water Usage
	Planting	Planting	Planting
Area (m^2)	18,200	4,300	2,000
Irrigation rate (mm/week)	15	25	30
Total (kL/week)	273	107.5	60
Total irrigation requirement per week (kL)			440
Total irrigation requirement per year (kL)			22,900

In addition to the above design elements, the following water saving measures will be implemented:

- **Soil Improver:** soil improvement (such as organic matter) is to be carried out prior to planting. This dramatically increases the moisture and nutrient holding capacity of sandy soil and encourages the soil micro fauna.

- **Mulching:** bare soil encourages weeds, wastes water and increases stress upon plants. A waterwise mulch spread to a depth of 75mm deep over all landscaped areas will reduce evaporation from the soil surface. It will also prevent erosion, reduce weeds, reduce temperature fluctuation in the soil, slowly break down over time to feed the soil and improve the overall appearance of the landscape. Gravel mulches are also a good alternative is less high profile areas.

- **Irrigation system:** the most efficient irrigation systems are those that deliver the right amount of water to the right place, at the right time, with minimal wastage. The simplest and most efficient system available is sub-irrigation, integrated dripper or in-line dripper which delivers water directly to the root system with little or no evaporative loss. At least two irrigation networks will be installed to reflect the ongoing ownership and maintenance arrangements. One system will be installed for the road reserve, which will eventually be handed over to the Shire of Roebourne. The remaining systems will be designed to reflect the final subdivision arrangement. The irrigation systems will be

designed to reduce unnecessary water loss and to be in accordance with Council standards. Final irrigation plans will be submitted to the Shire of Roebourne for approval during the detailed design stage.

- **Alternative water sources:** the project will consider alternative irrigation water sources such as recycled water (dependent on availability and financial viability) for landscape purposes. It is proposed that the water feature with the civic piazza area (see Section 3.4.3) will make use of water from a non-potable supply, be it stormwater capture & storage, recycled water and / or possible treated groundwater. The design of the water feature will be subject to approval by the Shire of Rosebourne at the detailed design stage.

3.4.3 Water feature

The proposals include an option for a water feature in the civic piazza area.

If this option is progressed and is unmanaged, water features can promote mosquito breeding. There are a number of methods which can be explored during the detailed design stage to reduce the risk of this occurring. These include:

- **Rapid turnover of water (through recirculation):** the current concept is to have water being collected at one end of the water feature and piped back to the other end where it is reinjected. The turn-over would occur in a matter of minutes, therefore eliminating mosquito breeding potential.

- **Water feature designed to ensure no stagnant water:** the water feature can be designed so that there are no stagnant pools of water when it is not operational. The water feature could be designed so that the depth of the water is less than 100mm when flowing, and when switched off, the water can drain via gravity into an underground storage tank, thus preventing access by mosquitos.

- **Movement / aeration of water:** the inclusion of a rocky base in the water feature can increase turbulence and promote aeration which prevents mosquito breeding.

- **Installation of a UV filter:** a UV filter can be placed in the underground storage tanks to kill all micro-organisms and mosquito larvae as a contingency measure. The ongoing maintenance of a UV filter is a 2 year replacement of the UV globe and the ongoing power costs of running the filter, which associated with the pumps for water would be similar to running an average sized domestic pool pump and filter system. This is the same technology that is being employed in water play parks. Our Landscape Architects (Emerge Associates) have recently installed this technology (on a much larger scale) at the Marquee Water Play Park in Port Hedland.

4.1 STORMWATER MANAGEMENT

The low permeability soils and high intensity rainfall events in Karratha can lead to widespread flooding. To address this issue, the current drainage network in the town has been primarily developed for the rapid removal of stormwater from key infrastructure in developed areas (GHD, 2010).

The Karratha Drainage Management Plan (DMP) (GHD, 2010) suggests that the ideal drainage system uses the road network to convey runoff towards a network of large open drainage reserves. The network of drainage reserves flow in a northerly direction and discharge onto low lying flats which are considered to detain and retard the flow. This allows the settling of suspended solids prior to eventual discharge into Nickol Bay.

The specific design guidance set out in the DMP has been prepared with reference to the Local Government Guidelines for Subdivisional Development (IPWEA 2012) and Stormwater Manual for Western Australia (DoW, 2004-2007).

4.2 Existing Drainage Infrastructure Flood Assessment

There is no existing manmade drainage system on the Tambrey site. Runoff currently flows overland in a north westerly direction, discharging into the drainage reserve adjacent to the western boundary.

The hydrology and hydraulics of the drainage reserve were modelled as part of the Karratha DMP (GHD, 2010). The 100 year ARI peak flow immediately upstream of the site was estimated to be 33.60m^3/s for the existing scenario and 34.35m^3/s when taking into account future urbanisation.

The existing scenario modelling indicated that the drainage reserve had sufficient capacity to convey flow for 1 in 5 and 1 in 10 year ARI events, however began to overtop into the downstream extent of the site during the 100 year ARI event (see Table 5). The same results were shown for the 100 year ARI future scenario.

Table 5 Karratha Drainage Management Plan Modelled Flood Levels

Location along drainage reserve	Flood depth from top of channel in existing scenario (m)		
	5 year ARI	10 year ARI	100 year ARI
Downstream (northern) extent	-1.2	-0.9	0.1
Upstream (southern) extent	-2.9	-2.6	-1.7

The DMP supported the floodplain development strategy described in the Local Government Guidelines for Subdivisional Development (IPWEA, 2012):

- Minimal habitable floor levels are set 0.5m above the 100yr ARI flood level.
- Development within the flood fringe does not raise the 100yr ARI flood level by more than 0.15m.
- The flood fringe boundary is properly defined.

The regional scale hydrological and hydraulic assessments undertaken for the Karratha DMP were reviewed as part of this study. The hydrological assessment was found to be reasonably accurate. The hydraulic modelling however was less reliable as the regional scale model did not contain sufficient information to accurately define the channel cross-sections and culverts at a site scale.

To address this uncertainty, additional hydraulic modelling has been undertaken during the preparation of the LWMS. The new modelling has included more detailed cross-sectional information for the drainage reserve as well as more accurate culvert information for the Dampier Road and Tambrey Drive culverts.

The revised 100 year ARI post-development modelling included hydrological inflows derived in the Karratha DMP (34.35m^3/s) plus inflows from the site (3.26m^3/s).

The results showed that the drainage reserve has sufficient capacity to convey all runoff from the site and upstream catchments in all events up to the 100 year ARI event now and in the future. The revised maximum modelled water levels are displayed in Appendix C.

The modelling results indicated minimum habitable floor levels to be 13.12mAHD in the south of the site and 11.60mAHD in the north (100 year ARI flood level plus 0.5m freeboard). This is well below the proposed lot levels across the site and thus no additional ground raising would be required for flood management purposes.

The revised modelling has shown that the site does not lie within the flood fringe (Figure 8) and will have no impact on the 100 year ARI flood level through loss of floodplain storage.

Some landscape nodes and a raised walkway are proposed within the drainage reserve. The landscape nodes (shown on Figure 3) are small areas of vegetation at discrete locations along the eastern boundary of the drainage reserve. They lie outside of the flood fringe and will have no significant impact on flooding in the area.

The raised walkway will be designed so that it does not have a hydraulic influence on the drainage reserve.

4.1.1 Storm Surge and Flood Protection

Tambrey Neighbourhood Centre lies within the Storm Surge Risk Special Control Area as defined by the Shire of Roebourne Town Planning Scheme Number 8, Amendment 27.

Clause 7.5 seeks to ensure that adequate provision is made for the protection from storm surge inundation of sensitive land uses within the control area. The policy focuses on the risk of flooding during a 100 year ARI storm surge event.

The first requirement of the policy is to confirm whether the site is actually at risk during this event by examining local site characteristics and liaising with relevant agencies to obtain the most up to date information.

If the land is found to be at risk during the 100 year ARI storm surge event then it must be demonstrated that the development will be designed in such a way as to

adequately reduce the risk to human life/health, property, infrastructure and social/cultural/environmental values.

Tambrey Neighbourhood Centre is located approximately 4.7km upstream of Nickol Bay. During a storm surge event there is potential for water to travel upstream along the drainage reserve towards the site.

The Karratha Coastal Vulnerability Study (KCVS) was commissioned by Landcorp in 2012 to identify which areas of the town would most likely be affected by a storm surge event. The Department of Water has provided the results of this study for use in the LWMS (see Appendix D and Figure 8).

The KCVS predicted that a storm surge would cause flooding in the drainage reserve adjacent to the site, with flood levels during a 100 year ARI flood level ranging from 13.9mAHD at the southern end of the drain next to the site to 10.6mAHD in the northern end. The existing ground levels across the site are above well above these levels.

Whilst Clause 7.5 focuses on the 100 year ARI flood event, the Draft State Planning Policy 2.6 (Coastal Planning Policy Guidelines) requires consideration of the 500 year ARI storm surge event over a 100 year time horizon. The KCVS estimated the 500 year ARI flood level in the drainage reserve adjacent to the site to be 14.1mAHD to 11.2mAHD at the southern and northern ends, respectively. These levels still remain well below existing ground levels at the site (Figure 8).

On this basis, the site is not considered to be at risk of flooding from a storm surge and no further mitigation measures have been included in the design.

4.2 Proposed Drainage Strategy

The drainage strategy proposed for the site follows the accepted approach outlined in the Karratha DMP (GHD, 2010).

Runoff from all events will be conveyed via an overland flow system (roads and swales) towards the drainage reserve to the west of the site. The site will be contoured to promote conveyance. Runoff from all events will flow along the same flow paths. Indicative sub-catchments and flow paths are provided in Figure 9. Road cross-sections will have a cross-fall so that they are passable in smaller events. Figures 10 and 11 provide indicative cross-sections of road reserves and swales.

Key features of the drainage strategy are listed in the following sections.

4.2.1 Lot Drainage

- Where possible, roofs shall not contain downpipes and will discharge directly to the lot.
- Where possible, lots should be landscaped to prevent direct runoff to the drainage network and promote on-site infiltration.
- Lots will be contoured so that they generally slope towards the conveyance network (road or swale).
- Individual urban lot runoff will follow unobstructed overland flow paths to road drainage reserves.

- Open drains will be constructed using local clayey soil materials which have a high phosphorous retention ability.

4.2.2 Conveyance System

- An overland conveyance system (roads and swales) will be designed to convey runoff up to a 100 year ARI flood event.
- Roads will have a cross-fall so that they are passable during 1 year and 10 year ARI events.
- The finished floor levels of all buildings will be constructed at least 300mm above the 100 year ARI stormwater flood level within the local road network (note: finished floor levels will be constructed at least 500mm above the 100 year ARI flood level in the regional drainage reserve adjacent to the site).
- Continuous fall of roads (1:200 gradient) to prevent ponding.
- Kerb breaks will exist at appropriate low points throughout the road network to discharge stormwater to the drainage reserve. Rock pitching to be included where required.

4.2.3 Non-Structural Controls

- Waste Management Plan, such as:
  - Prompt removal of litter when discovered.
  - Providing sufficient public facilities for rubbish disposal.

- Community signage will be used (where necessary) to provide stormwater protection messages (e.g. spill contact details, illegal dumping penalties, public education, etc.).

- Information packs will be provided to each new home and business owner:
  - Drainage structural controls in place and their objectives.
  - How to prevent pollution from entering the stormwater conveyance system.
  - The importance of correct fertiliser and pesticide application.
  - How to report illegal waste dumping or report spills.

4.2.4 Water Quality Treatment

The KDMP was prepared in line with the Stormwater Management Manual for WA (2005-2007). The KDMP includes the following design principles relating to surface water quality:

- *Consideration for stormwater treatment should be given in areas at higher risk of contamination discharge (i.e. industrial areas) in the form of bio-filters or detention areas prior to discharge to the open drainage network.*

  Tambrey Neighbourhood Centre is not industrial and the proposed post development land use is not considered to be at high risk of contaminated discharge.

- *Ensure that all runoff contained in the drainage infrastructure network receives treatment prior to discharge to a receiving environment consistent with the Stormwater Management Manual.*

  In this instance the receiving environment is Nickol Bay. All flows generated on the site will be conveyed via the open drainage reserve towards Nickol Bay. Whilst there are no bioretention structures present within the regional drainage network, it is acknowledged in the KDMP that the low lying flats act as a form of detention within the drainage network, allowing the settling of suspended solids, thereby offering a form of water treatment prior to discharge to the receiving environment.

The KDMP recognises that a modified approach to stormwater management is required in Karratha compared to other developments in the south of the State. The plan states that there is evidence that treatment of stormwater in the North West region has not been practical or required for the protection of downstream ecosystems, due mainly to the intensity of major event rainfall, low permeability of soils and the use of overland flow as the principle conveyance method.

Not with-standing this, additional measures for water quality treatment of first flush events should be considered at the detailed design stage. These options could include rain-gardens or discharge to landscaped areas along the western perimeter of the site.

5.1 GROUNDWATER MANAGEMENT

Due to the low permeability of the soils, drainage of the site will be undertaken above ground with no major earthworks proposed as part of the application. Therefore the potential for interaction with groundwater is negligible.

5.2 Fill Management

As mentioned previously, Coffey Geotechnics Pty Ltd undertook a geotechnical investigation in 2007. Due to the onsite clay soils which can experience moderate ground movement from moisture changes, the report recommended that at least 0.8m of controlled sand fill be placed over the clay for stability purposes to upgrade to a Class S.

A soil profile consisting of sand on clay can be prone to groundwater perching within the subsoil profile above the clay horizons. The geotechnical report recommended that lot developments be constructed at least 200mm above road kerb heights for protection. In addition, the finished surface level of the site should be graded away from structures and their foundations (minimum fall of 2% recommended).

6.0 MONITORING

Regional information indicates that maximum groundwater levels are 5 to 10m below ground level and no groundwater was encountered during on site geotechnical investigations (Section 2.6.1).

As previously mentioned, advice received from DoW (*pers.comm*. Peter Kata, September 2012) stated that when no groundwater is encountered in geotechnical test pits and there is considered significant separation to groundwater, no further groundwater investigation is required. Therefore due to the large separation distances to groundwater, no further site specific investigations are proposed post development.

There are no waterways surface water features on the site which would require pre or post development monitoring.

7.1 IMPLEMENTATION

The effective implementation of the LWMS requires ongoing involvement by the relevant stakeholders. The roles and responsibilities associated with the site are summarised in Table 6.

7.2 Roles and Responsibilities

The effectiveness of this LWMS will rely on the systems regular maintenance and grouped knowledge. The following operation and maintenance program is proposed.

Table 6 Roles and Responsibilities for Implementation

Principals	Role	Responsibility	Time-scale
Water Usage	Connection to mains water supply	Proponent	At construction
	Connection to sewer system	Proponent	At construction
	Installation of water efficient fixtures and fittings	Lot owner	At construction
	Waterwise landscaping and other water efficiency measures	Lot owners	At construction
Landscaped Areas	Maintenance of landscaped areas	The Proponent	As required until handover to SoR
	Fertiliser application	The Proponent	As required during revegetation and ongoing maintenance until handover to SoR
	Plant establishment (via planting and irrigation regime)	The Proponent	One to two years after planting
	Irrigation scheduling	The Proponent	As required following planting until handover to SoR
Stormwater Management	Installation of road and swale conveyance system	The proponent	At construction
	Maintenance of stormwater infrastructure	The Proponent	As required until handover to SoR
	Waste Management Plan	The Proponent	As required until handover to SoR
	Community awareness campaigns, signage and education packs	The proponent	At construction

7.3 Further Work

The preparation of Urban Water Management Plan(s) (UWMPs) will be required as a condition of subdivision approval and will include the following design measures in more detail:

- Compliance with this LWMS criteria and objectives to the satisfaction of DoW and SoR.
- Confirmation of water supply and disposal by Water Corporation.
- Specific detailed information on structural and non-structural BMP's to be implemented within each subdivision.
- Further consideration of water treatment of first flush event (12mm rainfall) at UWMP Stage.
- Final subdivision layout including cut and fill levels, minor and major drainage layouts and overland flow paths.
- Management of sub-divisional works, including details of licence applications for dust suppression if required.
- Landscaping Management Plan for vegetated areas finalised, including fertiliser regimes and irrigation scheduling.
- Finalised implementation plan including roles and responsibilities of all parties involved.

8.0 REFERENCES

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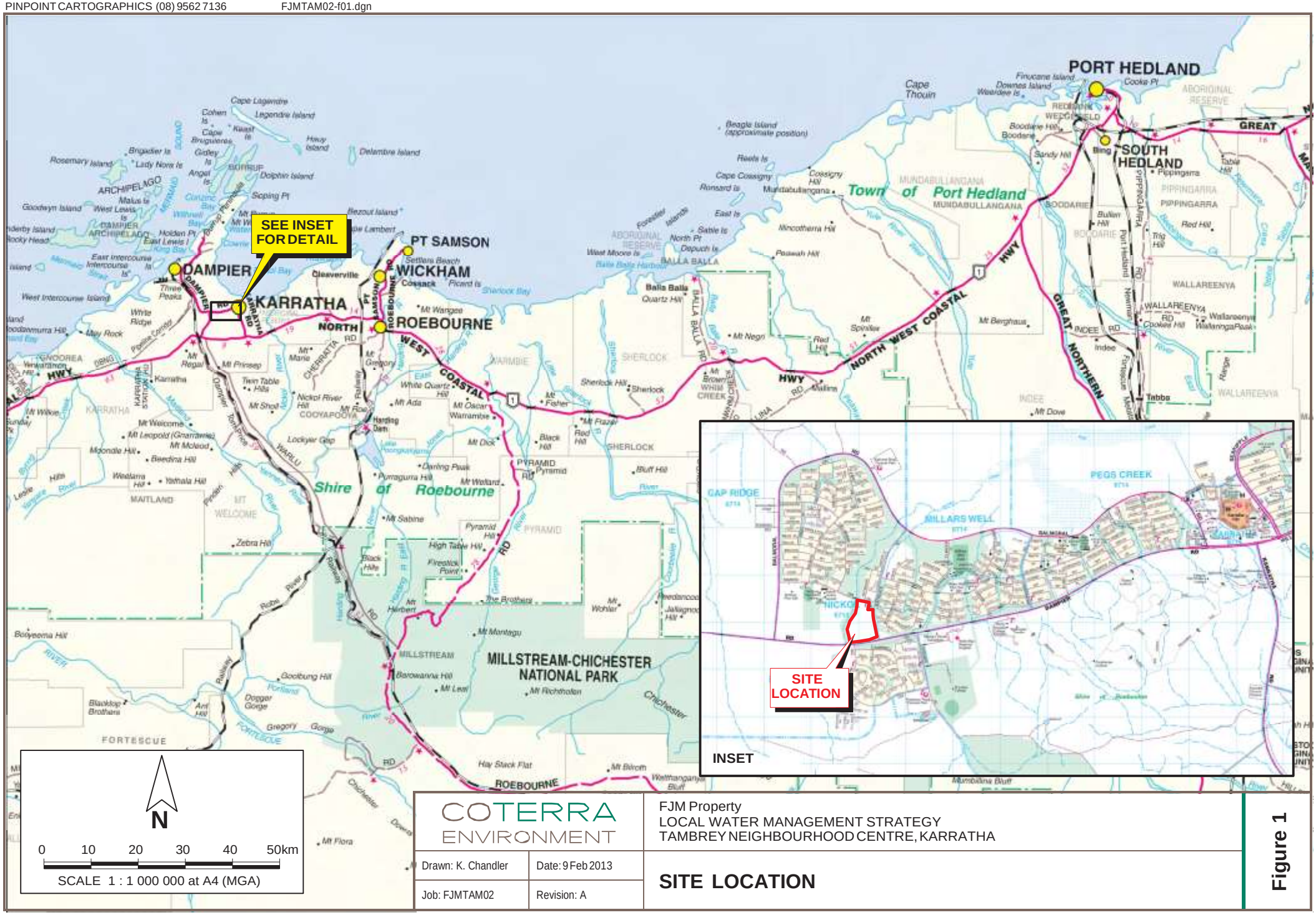
FIGURES



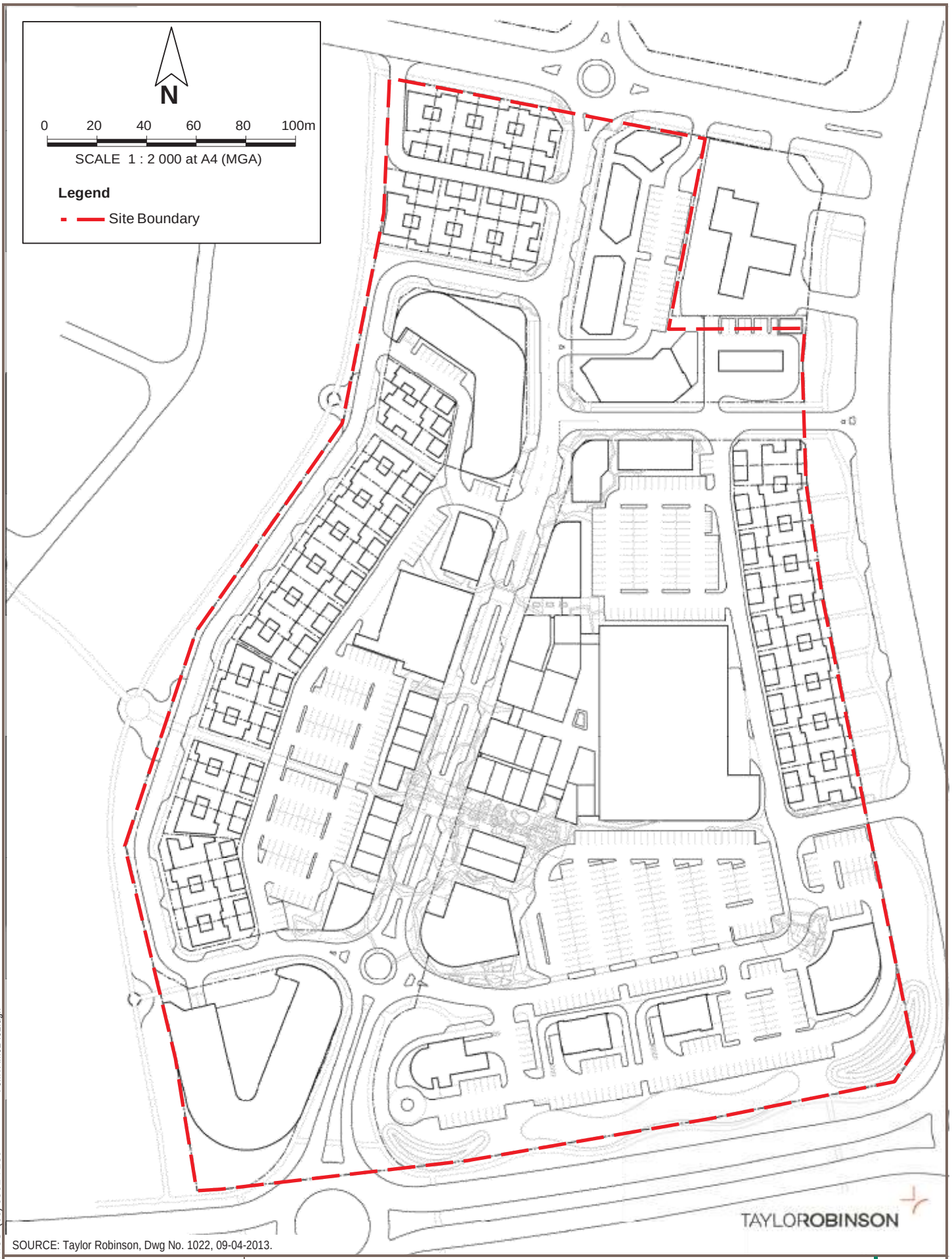
COTERRA ENVIRONMENT

FJM Property
LOCAL WATER MANAGEMENT STRATEGY
TAMBREY NEIGHBOURHOOD CENTRE, KARRATHA

Drawn: K. Chandler	Date: 9 Feb 2013
Job: FJMTAM02	Revision: A

SITE LOCATION

Figure 1



SOURCE: Taylor Robinson, Dwg No. 1022, 09-04-2013.

COTERRA ENVIRONMENT

FJM Property
LOCAL WATER MANAGEMENT STRATEGY
TAMBREY NEIGHBOURHOOD CENTRE, KARRATHA

Drawn: K. Chandler	Date: 26 Jun 2013
Job: FJMTAM02	Revision: A

MASTERPLAN

Figure 2

PINPOINT CARTOGRAPHICS (08) 9562 7136 FJMTAM02-f02.dgn

SOURCE: Emerge Associates, March 2013 Rev 4.

COTERRA ENVIRONMENT

FJM Property
LOCAL WATER MANAGEMENT STRATEGY
TAMBREY NEIGHBOURHOOD CENTRE, KARRATHA

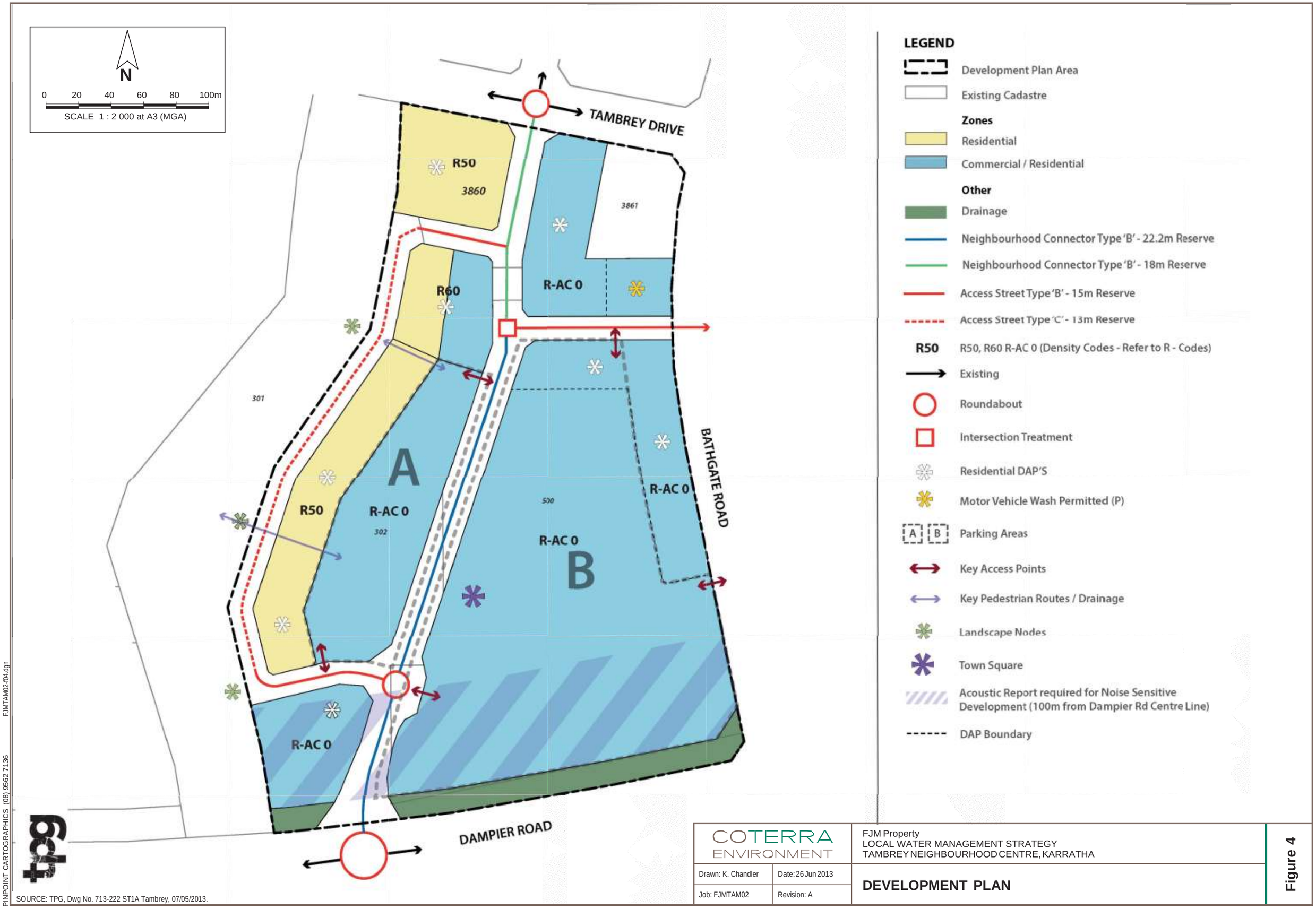
Drawn: K. Chandler	Date: 26 Jun 2013
Job: FJMTAM02	Revision: A

LANDSCAPE PLAN

Figure 3

FJMTAM02-f03.dgn

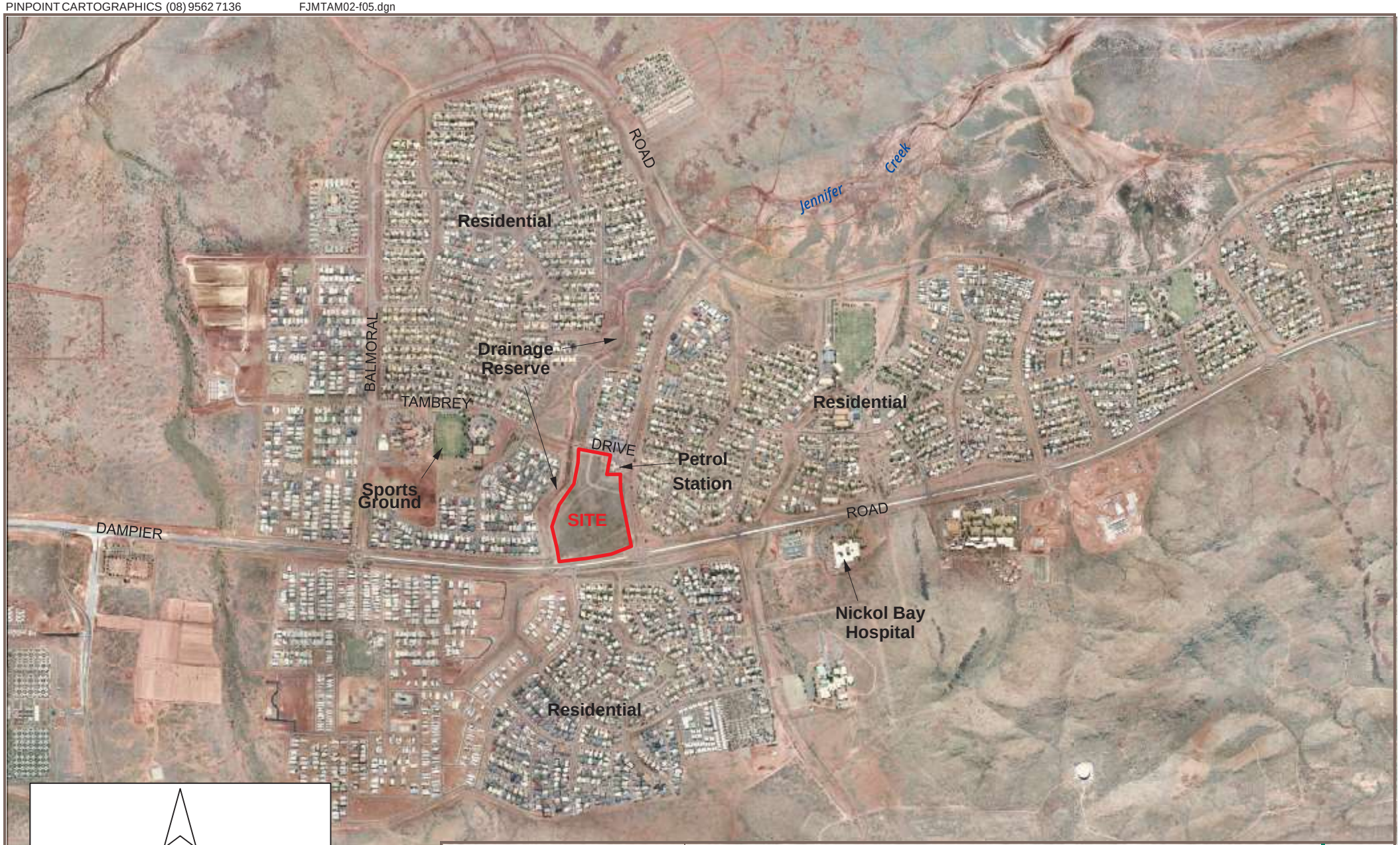
PINPOINT CARTOGRAPHICS (08) 9562 7136



SOURCE: TPG, Dwg No. 713-222 ST1A Tambrey, 07/05/2013.

COTERRA ENVIRONMENT		FJM Property LOCAL WATER MANAGEMENT STRATEGY TAMBREY NEIGHBOURHOOD CENTRE, KARRATHA
Drawn: K. Chandler	Date: 26 Jun 2013	**DEVELOPMENT PLAN**
Job: FJMTAM02	Revision: A	

Figure 4



AERIAL PHOTOGRAPH SOURCE: NearMap, flown August 2012.

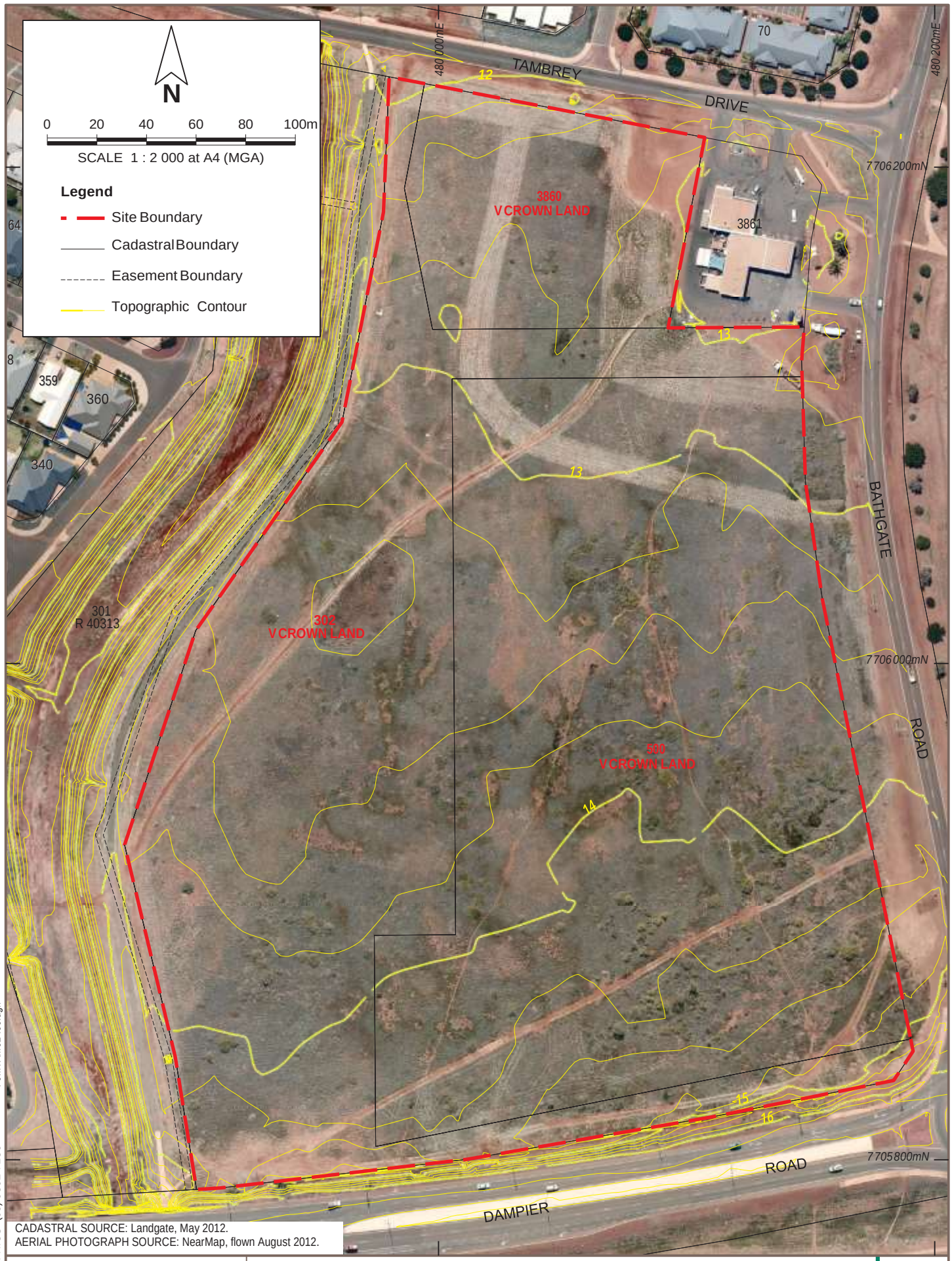
COTERRA ENVIRONMENT

FJM Property
LOCAL WATER MANAGEMENT STRATEGY
TAMBREY NEIGHBOURHOOD CENTRE, KARRATHA

Drawn: K. Chandler	Date: 4 Apr 2013
Job: FJMTAM02	Revision: A

SITE CONTEXT

Figure 5



CADASTRAL SOURCE: Landgate, May 2012.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown August 2012.

COTERRA ENVIRONMENT

FJM Property
LOCAL WATER MANAGEMENT STRATEGY
TAMBREY NEIGHBOURHOOD CENTRE, KARRATHA

Drawn: K. Chandler	Date: 4 Apr 2013
Job: FJMTAM02	Revision: A

TOPOGRAPHY

Figure 6

FJMTAM02-f06.dgn

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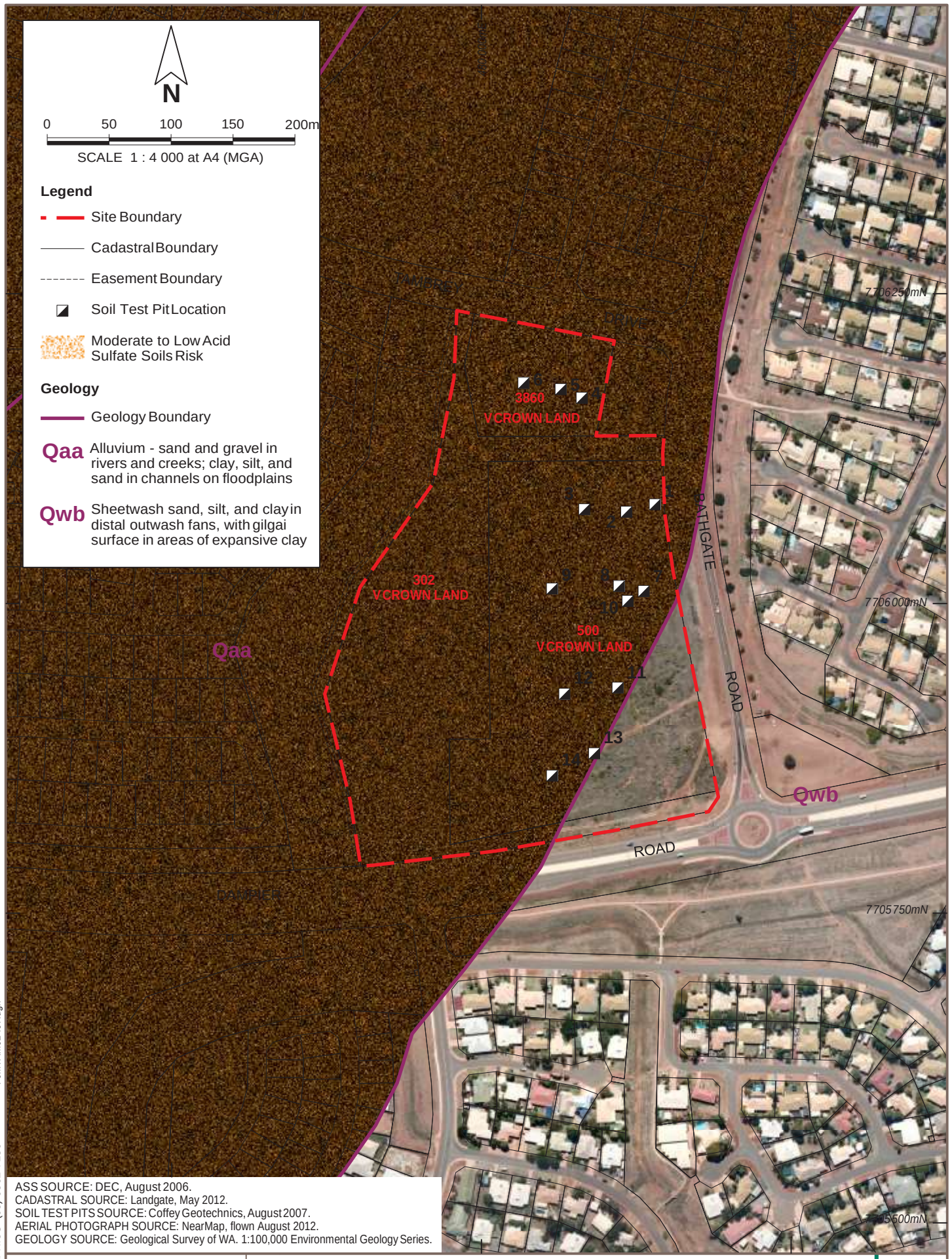


ASS SOURCE: DEC, August 2006.
CADASTRAL SOURCE: Landgate, May 2012.
SOIL TEST PITS SOURCE: Coffey Geotechnics, August 2007.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown August 2012.
GEOLOGY SOURCE: Geological Survey of WA. 1:100,000 Environmental Geology Series.

COTERRA ENVIRONMENT

FJM Property
LOCAL WATER MANAGEMENT STRATEGY
TAMBREY NEIGHBOURHOOD CENTRE, KARRATHA

Drawn: K. Chandler	Date: 31 May 2013
Job: FJMTAM02	Revision: A

GEOLOGICAL BOUNDARIES AND ASS

Figure 7

FJMTAM02-f07.dgn

PINPOINT CARTOGRAPHICS (08) 9562 7136

SOURCE: McMullen Nolan, Dwg No. 96916-DE-001-A, 21/04/2012.

N

0 20 40 60 80 100m

SCALE 1 : 2 000 at A3 (MGA)

Legend

- Site Boundary
- Indicative 100 Year ARI Fluvial Flood Extent (SOURCE: Hyd2o, 2013)
- Indicative 500 Year ARI Storm Surge Flood Extent (SOURCE: DoW, 2013)

LEGEND

- Survey Control
- Spot Height
- Signpost (Single / Multiple Poles)
- Power Pole
- Light Post
- Electric Cable Box
- Transformer
- Steel Wire Anchor
- Power Dome
- Telstra Pit
- Telstra Cable Marker
- Telstra Manhole
- Bollard
- Rubbish Bin
- Mail Box
- Invert Level
- Stop Valve
- Ground Hydrant
- Water Meter
- Sewer Manholes
- Tree
- Pram Ramp
- Cadastral Boundary
- Top / Bottom of Kerb
- Edge of Bitumen
- Edge of Concrete
- Road Centreline
- Footpath
- Line of Levels
- Top of Bank
- Bottom of Bank
- Headwall
- Stone Pitching
- Koppa Log Fence
- Fence
- Water Pipe
- Overhead Electric Cable
- U/G Electric Cable
- U/G Sewer Pipe
- U/G Telstra Cable
- Survey Control

Underground services positions supplied by Dial Before You Dig and are approximate only.

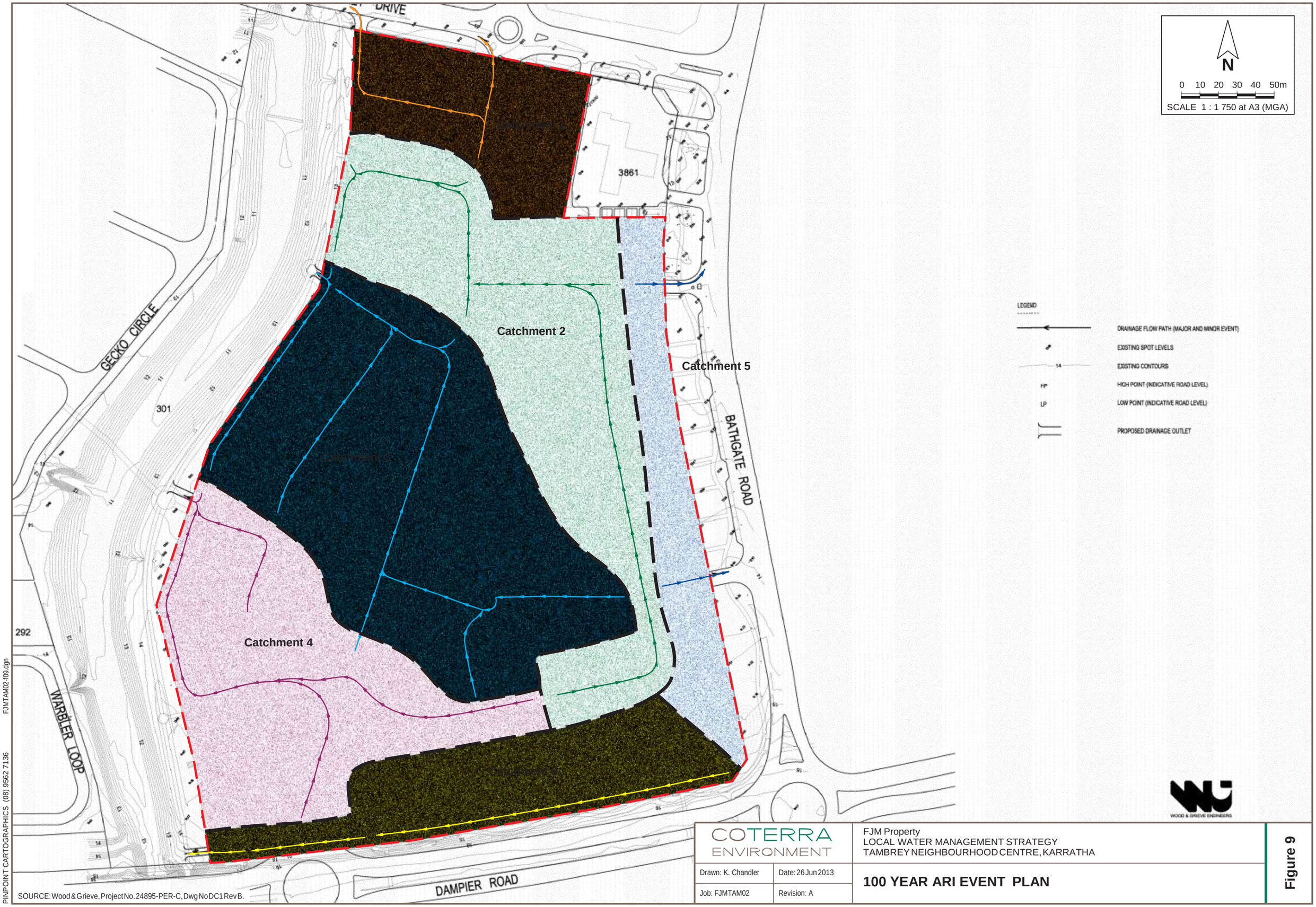
COTERRA ENVIRONMENT

FJM Property
LOCAL WATER MANAGEMENT STRATEGY
TAMBREY NEIGHBOURHOOD CENTRE, KARRATHA

Drawn: K. Chandler	Date: 4 Apr 2013
Job: FJMTAM02	Revision: A

100 YEAR ARI FLOOD FRINGE AND 500 YEAR ARI STORM SURGE EXTENT

PINPOINT CARTOGRAPHICS (08) 9562 7136 FJMTAM02-108.dgn



SOURCE: Wood & Grieve, Project No. 24895-PER-C, Dwg No DC1 Rev B.

COTERRA ENVIRONMENT

Drawn: K. Chandler	Date: 26 Jun 2013
Job: FJMTAM02	Revision: A

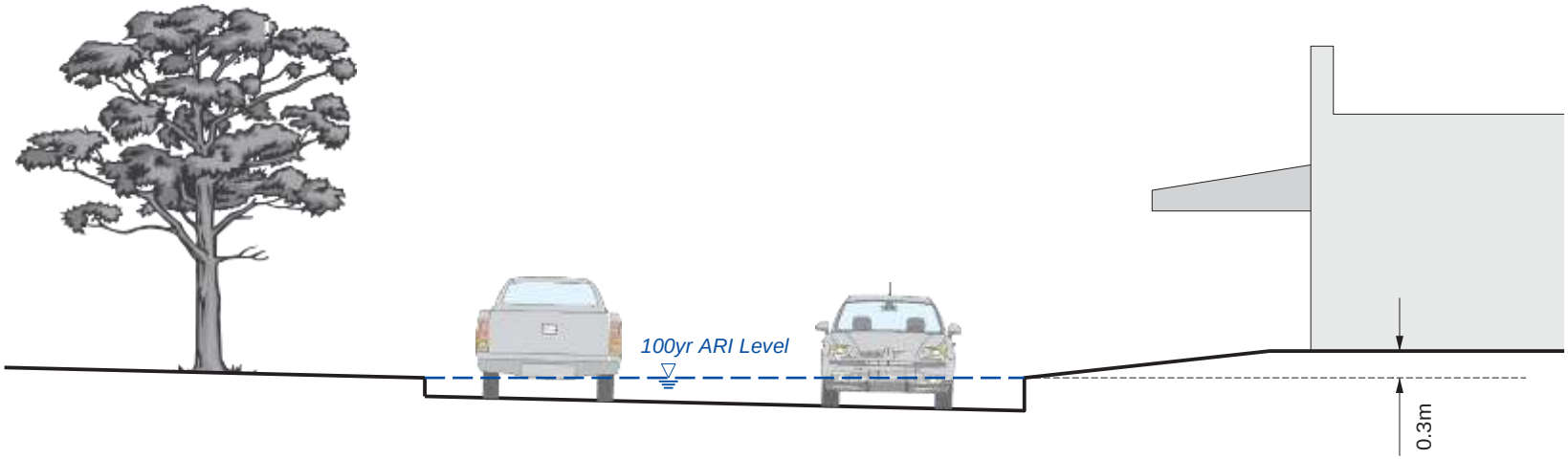
FJM Property
LOCAL WATER MANAGEMENT STRATEGY
TAMBREY NEIGHBOURHOOD CENTRE, KARRATHA

100 YEAR ARI EVENT PLAN

Figure 9

FJMTAM02-f09.dgn

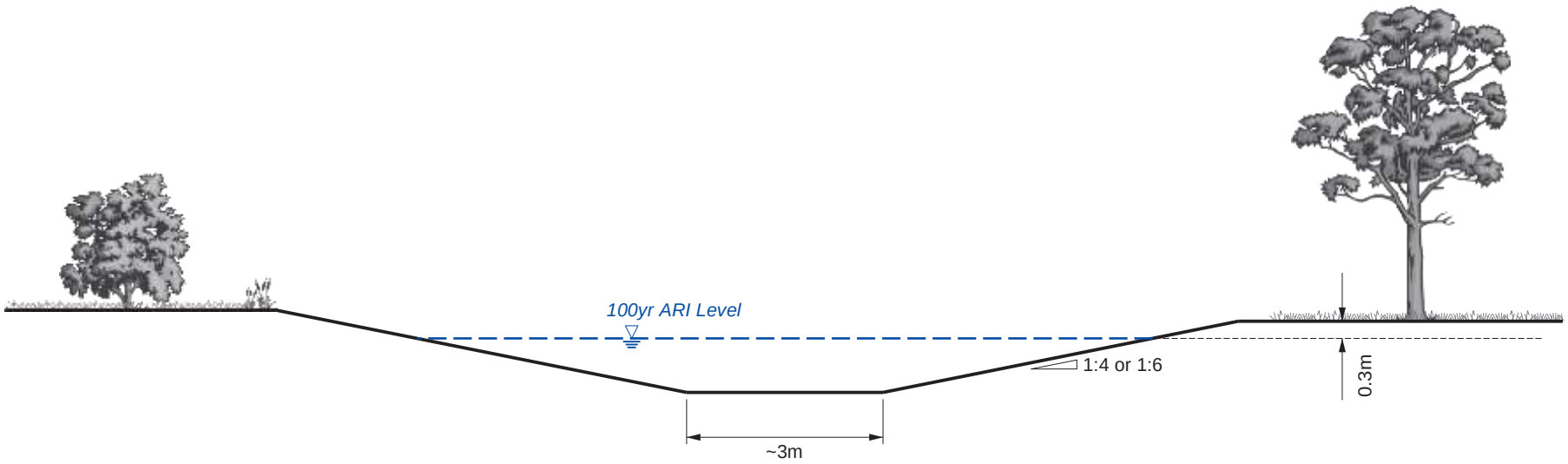
PINPOINT CARTOGRAPHICS (08) 9562 7136



NOT TO SCALE

COTERRA ENVIRONMENT		FJM Property LOCAL WATER MANAGEMENT STRATEGY TAMBREY NEIGHBOURHOOD CENTRE, KARRATHA
Drawn: K. Chandler	Date: 4 Apr 2013	**TYPICAL ROAD CROSS-SECTION**
Job: FJMTAM02	Revision: A	

Figure 10



NOT TO SCALE

COTERRA ENVIRONMENT

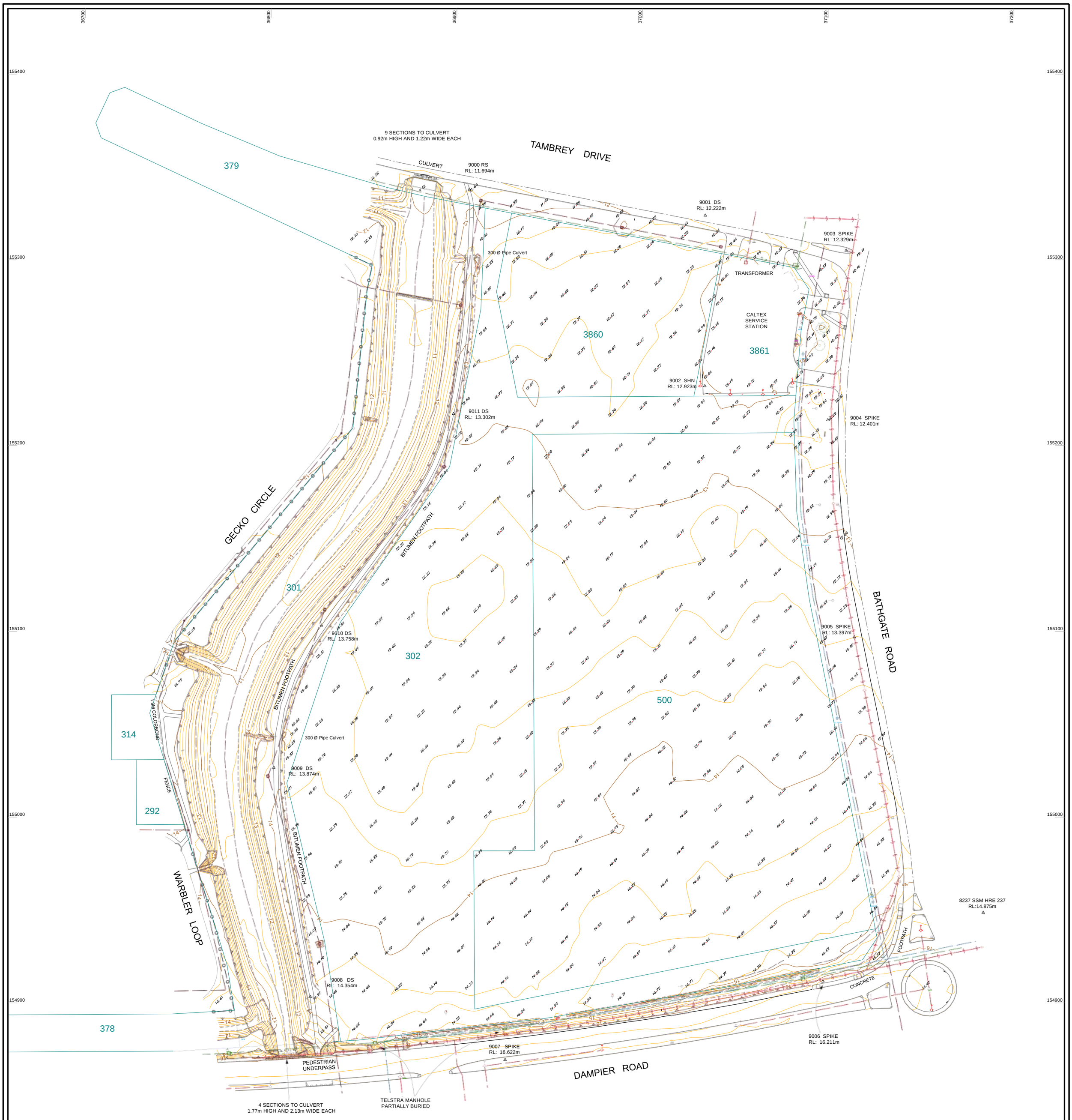
FJM Property
LOCAL WATER MANAGEMENT STRATEGY
TAMBREY NEIGHBOURHOOD CENTRE, KARRATHA

Drawn: K. Chandler	Date: 4 Apr 2013
Job: FJMTAM02	Revision: A

TYPICAL SWALE CROSS-SECTION

Figure 11

APPENDIX A – SITE SURVEY



LEGEND

- Survey Control
- Spot Height
- Signpost (Single / Multiple Poles)
- Power Pole
- Light Post
- Electric Cable Box
- Transformer
- Steel Wire Anchor
- Power Dome
- Telstra Pit
- Telstra Cable Marker
- Telstra Manhole
- Bollard
- Rubbish Bin
- Mail Box
- Invert Level
- Stop Valve
- Ground Hydrant
- Water Meter
- Sewer Manholes
- Tree
- Pram Ramp
- Cadastral Boundary
- Top / Bottom of Kerb
- Edge of Bitumen
- Edge of Concrete
- Road Centreline
- Footpath
- Line of Levels
- Top of Bank
- Bottom of Bank
- Headwall
- Stone Pitching
- Koppa Log Fence
- Fence
- Water Pipe
- Overhead Electric Cable
- U/G Electric Cable
- U/G Sewer Pipe
- U/G Telstra Cable
- Survey Control

Underground services positions supplied by
Dial Before You Dig and are approximate only.

Survey Control Coordinates

Point	Easting	Northing	Elevation
8237	37183.494	154948.599	14.875
9000	36906.788	155337.896	11.694
9001	37033.814	155323.903	12.222
9002	37033.576	155232.039	12.923
9003	37109.724	155305.070	12.329
9004	37099.840	155213.723	12.401
9005	37114.106	155096.845	13.397
9006	37097.218	154911.598	16.211
9007	36925.988	154869.358	16.622
9008	36821.052	154903.316	14.354
9009	36801.470	155026.725	13.874
9010	36827.115	155103.177	13.758
9011	36898.309	155217.154	13.302

Rev	Description	Drawn	Date	Checked
A	Initial Issue	GBH	24/04/2012	CJL

FILES

File - Drawing
96916A - 96916de-001a

Surveyor:- SGT
Survey Date:- 21/04/2012
Precal/Cad:- Landgate

LOTS 300, 301, 500 & 3860
TAMBREY - KARRATHA
Detail Survey

CLIENT:

GENERATION PROJECTS

The contents of this plan are current and correct as of the date stated within the revision panel. All consultants and persons wishing to utilise this data should satisfy themselves of this plans currency by contacting the McMullen Nolan Group.

SCALE 1:1000 @ A1

0 20 40 60 80 100

ALL DISTANCES ARE IN METRES

For a true to scale reproduction of this plan, plot it to A1 with the Paging Scaling set to None.

The boundaries shown on this plan were not re-established as part of this survey, therefore this plan does not guarantee their accuracy. Existing easements, encumbrances or interests are not depicted and a title search is recommended to obtain this information. Re-establishment of the cadastral boundaries is recommended for any proposed works on or near existing boundaries.

Quality Assured Company

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Surveying Excellence

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Offices in: Port Hedland, Margaret River, Broome, Kununurra

Project Mngr: Matthew Webb | Datum: KAR94 / AHD

96916 - DE - 001 - A
Job Type Plan Revision

APPENDIX B – GEOTECHNICAL REPORT

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

ARRATHA TOWNSITE AND INDUSTRIAL ESTATE

Wood & Grieve Engineers
Karratha

GEOTHERD02828AK-AA
6 August 2007

Coffey Geotechnics Pty Ltd ABN 93 056 929 483
24 Hasler Road Herdsman WA 6017 Australia

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

6 August 2007

Wood & Grieve Engineers
Level 3, Hyatt Centre, 3 Plain Street,
EAST PERTH WA 6004

Attention Mr ermayne Fabling

Dear Sir

RE GEOTECHNICAL INVESTIGATION FOR ARRATHA TOWNSITE AND INDUSTRIAL ESTATE

This letter presents our report on a geotechnical investigation carried out at the above sites.

If you have any questions related to the report or we can be of further assistance, please do not hesitate to contact Miss Jemma Dyer or the undersigned.

For and on behalf of Coffey Geotechnics Pty Ltd

Hamish Nelson

Associate Geotechnical Engineer

Distribution:	Original held by	Coffey Geotechnics Pty Ltd
	1 copy	Coffey Geotechnics Pty Ltd Library
	3 copies	Wood & Grieve

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1 INTRODUCTION

This report presents the results of geotechnical investigation carried out by Coffey Geotechnics Pty Ltd (Coffey) for Wood & Grieve Engineers for the two projects located at Karratha Townsite and Karratha Industrial Estate.

This work was commissioned by Mr Jermayne Fabling of Wood and Grieve via a completed "Authorisation to Proceed" form enclosed with the Coffey proposal dated 8 June 2007 (Ref. GEOTHERD02828AK-P-AA)

This report is prepared and is to be read subject to the terms and conditions contained in our proposal dated 27 March 2007 (Ref. GEOTERD02828AK-P-AA). Our advice is based on the information stated and on the assumptions expressed herein. Should that information or the assumptions be incorrect then Coffey Geotechnics Pty Ltd shall accept no liability in respect of the advice whether under law of contract, tort or otherwise.

Coffey has previously performed several investigations for residential sites in Karratha for Wood & Grieve Engineers and Landcorp.

2 PROPOSED DEVELOPMENT

It is understood that the project comprises a Residential/ commercial area at the Tambrey site and an industrial area at Karratha Industrial Estate.

3 O ECTIVES

The objectives of the geotechnical investigation were to ascertain the following:

- Soil, rock and groundwater conditions within the significant foundation support zone and at the number of investigation stations specified;
- Classification of the site in accordance with the general provisions of AS 2870-1996 and requirements to improve the classification;
- Suitable foundation systems and geotechnical parameters for foundation design, including allowable bearing pressure;
- Capacity and estimates of total and differential foundation settlement based on the results of the investigation;
- Pavement design parameters and construction requirements;
- Soil parameters for retaining wall design;
- Foundation improvement options;
- Groundwater aggressivity to buried structural elements;
- Suitability of the site for disposal of stormwater runoff by soakage;
- Construction considerations pertinent to the proposed development, including site preparation, excavation conditions, protection of footing excavations, suitability of materials for structural fill, compaction control and groundwater control and the need for subsoil drainage;

4 INFORMATION SUPPLIED Y OTHERS

Wood & Grieve had provided Coffey Geotechnics with:

- A Written Brief and
- Location sketches of both sites.

5 FIELDWOR

5.1 General

Fieldwork was carried out between 26 June and 27 June 2007 in the full time presence of personnel from Coffey. At the time of fieldwork, testpit locations were measured by hand held GPS relative to Map Grid of Australia (MGA) to an accuracy of +/- 5 by a Coffey representative using a hand help GPS unit. The locations and elevations for each testpit were subsequently surveyed by a licensed surveyor, Whelans, who were engaged by Wood & Grieve Engineers.

Access at the site was clear and trafficability at the time of fieldwork was good.

Weather conditions at the time of fieldwork were fine and warm.

Approximate testpit locations for the Townsite and the Industrial area are shown in Figures 1 and 2 respectively.

5.2 Test Pitting

A total of 34 test pits (TP1 to TP34) were excavated by backhoe to depths varying from 1.7m to 2m below the existing ground surface at the approximate locations shown on Figure 1. Testpit TP1 to TP14 were excavated in the Residential area with the remaining (TP15 to TP34) in the industrial area.

Disturbed samples were taken from 28 locations of representative soil types for laboratory examination and testing.

The records of the test pit logs showing the major strata intersected, the depths at which the samples were taken, and the results of the Laboratory tests, together with Explanation Sheets defining the terms used, are presented in Appendix A

6 DESCRIPTION OF LA ORATORY TESTING

Laboratory testing was carried out in accordance with the general requirements of the latest edition of AS 1289 by the Coffey NATA registered soils laboratory.

The extent of testing carried out to provide the geotechnical parameters required for this study are presented in Table 1.

Table 1 Extent of Laboratory Testing

Type of Test	Number
Particle Size Distribution tests	8
Atterberg Limits tests	8
Moisture Content	8
Percent Fines	8
Soaked CBR tests	4
Laboratory compaction	4

Test results for the above mentioned tests are attached in Appendix B.

7 SITE CONDITIONS

7.1 Surface Conditions

The Tambrey residential and commercial area occupies 0.062km², with the Karratha Industrial site occupying an area of 0.259km². Both sites are situated in generally flat topography and is well vegetated with dry grasses.

Existing site development consists of new residential lots and a petrol station at Karratha Townsite and Industrial Buildings at Karratha Industrial Estate. Existing roads were located on each side of the Karratha Townsite area, and to the north and west of the Karratha Industrial Estate site.

Services including telecom and Western Power were located around the outer area of both sites.

Access to the site was by 4WD and trafficability at the time of fieldwork was good.

Adjacent structures show no signs of cracking and adjacent roads were in good condition.

7.2 Subsurface Conditions

Based on previous investigations in the area and topographical, groundwater and geotechnical information available we expected the subsurface profile to be red brown silty, gravely Clay in the Residential/ Commercial site and clayey material overlying basic and Intermediate Volcanics with minor Metasediments and Cherts and Clastic sediments in the light industrial site.

Based on the field investigation, the Karratha Townsite site has a generalised subsurface profile as presented in Table 2.

Table 2 Generalised Subsurface Profile Townsite

Layer Unit	Typical Depth to Top of Layer m	Typical Layer Thickness m	Description Remarks
1	0.0m	0.2m-0.6m	Topsoil/Fill
2	0.2m	1.5m-2.0m	Clayey Gravel, Clayey Sand - low to medium plasticity, medium to coarse grained, brown.
3	1.5m	unknown	Clayey Gravel - low to medium plasticity, medium to coarse grained, brown, with some weathered Chlorite Schist's containing Carbonate veins.

Based on the field investigation the site has a generalised subsurface profile of Karratha industrial Estate is presented in Table 3.

Table 3 Generalised Subsurface Profile Industrial Area

Layer Unit	Typical Depth to Top of Layer m	Typical Layer Thickness m	Description Remarks
1	0.0m	0.1m0.3m	Topsoil
2	0.1m	1.8m-2.0m	Clayey Gravel -low to medium plasticity, medium to coarse grained, brown.
3	1.8m	unknown	Chlorite Schist, highly weathered, strongly foliated, blue/green

7.3 Groundwater Levels

Groundwater was not encountered in the testpits excavated for this investigation. The lowest elevation reached in the testpits was approximately 11.63mAHD (1.80m below the ground surface) at testpit TP14 for Karratha townsite and 8.49mAHD (2m below the ground surface) at testpit TP32 for Karratha Industrial Estate.

The February 1978 report commissioned by the Department of Industrial Development and the Western Cell Sheet of the 1:10,000 Groundwater and Soil Chemistry Plan were used to obtain information on the groundwater.

The above reports cover an area between the proposed areas for development and the town centre, and indicates that groundwater flows to the north and was recorded at nominally RL6m AHD along Dampier Road, dropping to RL2m AHD nominally 1km to the north, closer to the coast. This equates to a groundwater level that is at least nominally 4m below ground surface level at the location of the residential area.

The previously supplied Karratha townsite investigation, “Karratha area Groundwater contours (Light Industrial Area) Map” indicates that the groundwater is nominally RL4m AHD in the Karratha industrial area, nominally 8m below the current surface level.

It should be noted that groundwater levels are subject to variation due to the influence of rainfall, temperature, tides, local drainage and the seasons. There is potential for development of perched groundwater tables following periods of rainfall.

7.4 Laboratory Results

A summary of laboratory testing on samples taken from the Karratha Townsite are presented in 4.

Table 4 Laboratory Results arratha Townsite

Material	Location	Depth	fine	Sand	gravel	W_L	I_P	MMDD	OMC
CLAYEY GRAVEL (GC)	TP1	1.0-1.5	37	24	39				
	TP 3	1.0-1.5	38			39	22		
	TP 5	0.5-1.0						2.05	12.0
	TP 6	1.5-2.0	38			33	16		
	TP 8	1.0-1.5						2.08	11.0
	TP 14	1.5-1.8	42	22	36	35	20		
SANDY CLAY	TP 4	1.0-1.5	50	27	23				
CLAY (CL,CI)	TP 12	0.5-1.5	71	25	4				

Note: % fine = % passing 0.075mm sieve, % gravel = % passing 2.36mm sieve, W_L = Liquid Limit (%), I_P = Plasticity Index (%), MMDD = Modified Maximum Dry Density (t/m^3), OMC = Optimal Moisture Content (%).

A summary of laboratory testing on samples taken from the Karratha Industrial site are presented in 5.

Table 5 Laboratory Results arratha Industrial site

Material	Location	Depth	fine	Sand	gravel	W_L	I_P	MMDD	OMC
CLAYEY GRAVEL (GC)	TP 17	1.5-1.9	30			33	10		
	TP 19	1.0-1.5	42			33	18		
	TP20	0.1-0.5	31	20	49				
	TP 22	1.0-1.5	39			24	7		
	TP 23	1.0-1.3						2.35	6.5
	TP25	1.0-1.5	30	26	44				
	TP 27	0.7-1.0	23	30	47				
	TP 31	1.0-1.5	45			29	11		
SILTY GRAVEL (GP)	TP 30	0.2-1.0						1.97	12.0
CLAY (CL, CI)	TP 29	0.1-0.5	64	31	5				
GRAVELLY CLAY (CI)	TP 32	0.2-0.5	69			49	31		

Note: % fine = % passing 0.075mm sieve, % gravel = % passing 2.36mm sieve, W_L = Liquid Limit (%), I_P = Plasticity Index (%), MMDD = Modified Maximum Dry Density (t/m^3), OMC = Optimal Moisture Content (%).

8 RECOMMENDATIONS

8.1 General

It should be noted that the ground encountered by the testpits represent the ground conditions at the location where the tests have been undertaken and as such are an extremely small proportion of the site to be developed. Accordingly, variations to the ground conditions are likely and allowance should be made for variability in the design and construction budgets.

Whilst, to the best of our knowledge, the information contained in this report is accurate at the date of issue, ground conditions including groundwater levels can change in a limited time or due to seasonal fluctuations. For example fill could be added to a site or surface materials removed from a site that will change the thickness of surface materials and depth to the underlying materials. The potential for change in ground conditions should be recognised particularly if this report is used after a protracted delay.

It is also recommended that any plans and/or specifications prepared which relate to the content of this report or amendments to original plans and specifications be reviewed by Coffey to verify that the intent of the recommendations contained in this report are properly reflected in the design.

8.2 Site Classification

Australian Standard AS2870-1996 provides a system of site classification for residential slabs and footing design as follows:

Table 6 General Definition of Site Classes

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay site, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include: Soft soils, such as soft clays or silts or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

The standard also notes that where areas of deep soil moisture changes are anticipated the classification shall be further defined with the suffix –D.

A classification of M-D is judged to be appropriate for the site based on the procedure by Kay (1990). The site could be upgraded to Class S by placement of 0.8m of controlled sand fill over the clay. The sand used should contain not more than 5% passing a 0.075mm sieve.

Creating and maintaining a stable moisture content regime in the reactive clay soils will be necessary for satisfactory footing and standard performance. The following section details the recommended step that should be undertaken to create a stable moisture regime.

8.2.1 Protection of Footings from Moisture Changes

Sub Soil Measures

It is recommended that clays supporting shallow footings be protected from significant changes in their moisture content regimes. Otherwise, significant ground movements that are not able to be accommodated by the structure may take place.

It is recommended that no large native trees be planted any closer to the footings than their likely mature height. If trees are to be planted close to footings, (and this practice is not recommended) then regular pruning of the trees will limit their root growth and reduce their water intake. The Water Authority of Western Australia provides advice on suitable species to plant in the vicinity of services and foundations and recommends minimum planting distances from structures.

It is recommended that a moisture barrier is placed to a distance of 1.0m around the boundary walls to prevent water ingress around the footings. This barrier could consist of either a concrete path or buried polythene.

Purchasers should be provided with a copy of the CSIRO Information Sheet on foundation maintenance (see Appendix C).

Perching Of Groundwater on Subsoil Profiles

Perching of groundwater within the subsoil profile is likely to occur above very low permeability horizons such as weathered rock clayey materials. It is recommended that housing Lot development levels be at least 200mm above the top of kerb level. This will assist the shedding of surface water runoff into the drainage system and away from houses.

Surface Drainage and Run Off

Runoff from upslope of the sites should be collected and diverted away from building structures. The finished surface level of the site should be graded with falls away from structures and their foundations. This will reduce the incidence of water ponding around the footings. A minimum fall of 2% is recommended.

Erosion control measures similar to those set out in the “Erosion and Sediment Control Manual for the Darling Range, Perth Western Australia (2002)” should be adopted.

8.3 Foundations

8.3.1 General

The investigated ground conditions are suitable to support conventional shallow foundation systems comprising pad and strip footings. Due to the highly reactive nature of the clay, movement associated with shrinking/ swelling of clays will affect likely settlement more than elastic or consolidation settlement.

8.3.2 Shallow Footings

It is recommended footings be designed for the class M-D classification. For special footings it is recommended that they be designed for Allowable Bearing Pressure (ABP) to 150KPa. Provided that the strip/pad footings are less than 1.0m/1.5m wide, settlement relating to elasticity and consolidation is expected to be less than 10mm. However settlement is likely to be more affected by shrink/swell of reactive clays. Recommendations in Section 8.2.1 should be adopted, otherwise movement of up to 40mm could occur as a result of moisture variation, (indicative movement for Class M sites, as provided in AS2870).

8.4 Retention Systems

Earth retaining structures should be designed in accordance with the requirements of AS 4678-2002.

It is recommended that retaining walls do not retain clayey soils due to potential swelling of the clayey soils leading to active earth pressures greater than calculated from textbook design.

It is recommended that the excavation for the retaining walls be cut to a nominally 1(vertical): 1.5(horizontal) batter slope. The backfill between the batter slope and the retaining wall should comprise of cohesionless structural fill that complies with the recommendations contained in Section 8.8.8. The cohesionless structural fill should be compacted using a vibratory plate compactor not

exceeding 120kg in mass. The backfill compaction stress that may be developed on the wall using this equipment is assessed to be 12kPa. The reader is referred to Section 8.6.2 for comments on drainage behind the retaining wall.

8.4.1 Design Parameters

The soil parameters recommended for the design of the retaining walls are presented in Table 7.

Table 7 Soil Parameters Recommended for Design of Retaining Walls

Soil Type	Effective Cohesion c kPa	Friction Angle ϕ degrees	Unit Weight γ kN m^3	Active Pressure a	At Rest o	Passive Pressure p
Cohesionless structural fill	0	35	18	0.27	0.5	3.69

Key: c' denotes undrained cohesion (kPa).

Phi' denotes undrained friction angle (degrees)

K_a fully mobilised coefficient of active earth pressure

K_p fully mobilised coefficient of passive earth pressure

K_o at rest earth pressure coefficient

8.4.2 Drainage behind the Retaining Wall

It is recommended that drainage be installed behind each retaining wall to collect perched groundwater from the surface of the clayey soils and any groundwater from within permeable sandy layers in the compacted earthworks platform. The drains should have a 2% fall to a drainage point.

Any groundwater build-up behind the retaining walls will provide an additional surcharge to the retaining wall and may cause softening of the clayey soils resulting in a loss of bearing capacity and increased settlements.

8.4.3 Wall Pressure Displacement Compatibility

Retaining walls supporting structures in close proximity should be designed using the "at rest" earth pressure coefficient (K_o).

8.5 Flexible Pavements

8.5.1 Subgrade C R

Estimates of subgrade CBR have been based on laboratory testing of compacted samples;

A design subgrade California Bearing Ratio (CBR) of 3 is recommended. The adoption of this design value is contingent upon strict compliance with the site preparation recommendations given in Section 8.6

The improved subgrade should be constructed with free draining sand containing not more than 3% fines passing a 0.075mm sieve.

Soft/wet areas in the subgrade should be excavated and replaced with crushed limestone.

8.5.2 Pavement Design

Pavement thickness design should be been based on Austroads Pavement Design Guide (1992)/Main Roads Engineering Road Note 9 (1987)/APRG (1997) Report 21.

The recommended pavement composition is:

Surface	30mm thickness of dense graded asphalt;
	tack coat;
	2 coat primer seal;
	prime;
Base Course	125mm HCTCRB/ Bitumen Stabilised Limestone
Sub Base	225mm Crushed limestone
Subgrade	Clayey material compacted to a Dry Density Ratio of 95% of Maximum Modified Dry Density.

8.5.3 Pavement Materials

Pavement materials should conform to the "Guide to the Selection and Use of Naturally Occurring Materials as Base and Sub Base" jointly published by Main Roads Western Australia and Australian Geomechanics Society (2002).

8.5.4 Re uirements for Subsoil Drainage

Subsoil drains should be installed near road drainage outlets to provide a flow path for any water trapped in the base course.

It is recommended that depressed road drainage systems, successfully used in other areas of Karratha, be adopted for this project.

8.6 Earthworks

8.6.1 General

Earthworks should be carried out in accordance with the principles set out in AS3798-1996.

8.6.2 Removal of Topsoil and Uncontrolled Fill

All organic materials and uncontrolled fill should be stripped and stockpiled.

The investigation intersected organic material to depths varying from 0.1m to 0.4m. Variations to this depth range may be present over the site. The organic material is not suitable for use as structural filling. It is only suitable for landscaping purposes.

It should be noted that ground conditions and particularly groundwater levels may vary with the seasons.

8.6.3 Proof Compaction

Assuming the whole area is to be developed, the site should be stripped to the satisfaction of the Supervising Engineer, the site should be proof compacted using a heavy, self-propelled, pad foot

vibrating roller, capable of operating in variable frequency modes. A Dynapac CA 251D, or equivalent, is recommended (subject to the protection of adjacent buildings from damaging ground vibrations).

The following proof compaction procedure is recommended:

- The entire site should be given a minimum of 4 passes with the roller operating in the low frequency/high amplitude mode. A pass should include a minimum overlap of 20%.
- The site should then be given an additional minimum of 4 passes with the roller operating in the high frequency/low amplitude mode.
- All weak areas, that deform excessively under rolling, should be removed and replaced with clean sand/crushed limestone.
- On completion of vibratory rolling, 2 passes of the site should be made with the roller operating in a static mode. This will compact the sands in the upper 300mm that were disturbed by cyclic mobility.

It is recommended that the proof compaction be monitored by an Engineer experienced in earthworks. If proof compaction is performed following recent rainfall, the need for proof compaction should be assessed by a geotechnical engineer.

If individual lots are to be prepared the above proof compaction method can be replaced with 4 passes of a heavy vibrating plate compactor (LG300). Weak areas should be excavated and replaced with clean sand/ crushed limestone.

8.6.4 Temporary Slopes during Earthworks

Excavated slopes should be constructed not steeper than IV: 1.5H :(soil) and IV: 1.0H (rock);

8.6.5 Suitability of Excavated Materials for Use as Fill

Cohesive soils excavated from site may be used as fill provided it is placed and compacted in layers not exceeding 0.2m thickness and the total thickness of compacted cohesive fill does not exceed 1.5m. Cohesive soils compacted in accordance with Table 8. If not properly compacted the use of cohesive fill can have an adverse effect on site classification.

Topsoil may be used as fill in landscape areas but should not be used as structural fill.

8.6.6 Compaction Re uirements

Earthworks should be compacted to achieve the density requirements set out in Table 8.

Table 8 Compaction Re uirements

Item	Application	Compaction Criteria	
		Minimum density ratio Cohesive soils	Minimum Dry Density Ratio Granular Soil
1	Residential – lot fill, house sites	95% std	95% mod
2	Commercial – fills to support minor loadings, including floor loadings of up to 20 kPa and isolated pad or strip footings to 100 kPa	98% std	96% mod

8.6.7 Cohesionless Structural Filling

If the classification is to be reduced to Class S, cohesionless structural fill complying with the following criteria must be used.

- Containing less than (5%) by weight of soil fractions finer than 0.075mm.
- Having a plasticity index equal to 0%, (i.e. non plastic).

Any sand used for structural filling should comply with the following:

- The sand shall be clean, cohesionless, free draining and free of all silty, organic or any other deleterious inclusions.
- The sand shall contain no more than 5% of fractions finer than 0.075mm.

It is recommended that a 25 kg representative sample(s) of the proposed structural fill be delivered to a NATA. registered soils laboratory for testing at least one week before approval is required.

8.7 Construction Considerations

8.7.1 General

There are a number of activities that must be undertaken during construction to ensure compliance with design and to ensure the smooth running of the project. The following activities should be carried out during the contract.

8.7.2 Dilapidation Survey

It is recommended that contract provision should be made to carry out a dilapidation survey of buildings within a distance of 5m from the site under development. This survey should comprise the following elements:

- Logging of existing cracks in buildings adjacent to the site;
- Placing pins across any significant cracks and measuring widths. This will provide a baseline for construction monitoring;

This information will be useful to quantitatively assess the merit of any claim that the subject development has resulted in damage to other properties.

8.7.3 Protection of Adjacent Structures

Care must be exercised when compacting in the vicinity of existing structures, particularly if vibratory compaction is being carried out.

A Technical Note is attached in Appendix D to assist with selection of compaction equipment when operating near existing structures. The minimum operating distances for the different compaction plant given in this note were suggested by Tynan (1975) from work carried out by the Australian Road Research Board.

8.7.4 Preparation of Footing ases in Sands

All sands disturbed in the bases of footing excavations should be compacted. Any uncontrolled fill must be excavated and replaced.

Where the sand contains more than 5%, the Perth Sand Penetrometer can be used for compaction control provided a correlation is first carried out to assess the number of blows required per 300mm to achieve 95% of Maximum Modified Dry Density (MMDD).

A minimum of 3 Perth Sand Penetrometer tests should be carried out in the base of each footing excavation.

To facilitate compaction, the groundwater should not be any closer than 1m to the base of the footing excavation.

8.7.5 Preparation of Footing ases in Cohesive Soils

The clayey soils are sensitive to trafficking and will lose a significant proportion of their design strength if they are disturbed and remoulded. Excavation techniques involving minimal trafficking and the use of light equipment for final trimming are recommended for these soil types. Any uncontrolled fill must be excavated and replaced.

Excavations for footings should be to the neat dimensions of the footing, with footings poured against the sides of the excavation. The use of framework and backfilling around footings is not recommended for structures founded in cohesive soils.

It is recommended that insitu strength testing including pocket penetrometer and shear vane testing be carried out in the cohesive soils exposed in the bases of the footing excavations to check that no disturbed soils are present.

A minimum of 6 tests are recommended for each footing base. The tests should be carried out by a Geotechnical Engineer.

The bases of footing excavations in cohesive soils should be blinded as soon as practically possible after their testing and approval. A minimum thickness of 50mm of lean mix concrete (min. F'_c = 10 MPa) would suffice. Under no circumstances should the bases of excavations be left exposed overnight.

It is important that the exposure of the clays to climatic drying/wetting be minimised to avoid significant moisture content changes and subsequent foundation movements during moisture equilibration. Otherwise, foundation movements will be greater than allowed for in design.

9 IMPORTANT INFORMATION A OUT YOUR COFFEY REPORT

The reader's attention is drawn to the important information about this report which follows the main text.

10 REFERENCES

The following standards and references were used in the preparation of this report.

AS 1289 Method of Testing Soils For Engineering Purposes.

AS 2870-1996 Residential Slabs and Footings.

AS 3798-1996 Guidelines on Earthworks for Commercial and Residential Developments

AS 4678-2002 Earth Retaining Structures

Agriculture Western Australia (2001) "Erosion and Sediment Control Manual for the Darling Range, Perth Western Australia"

Fang (1992) "Foundation Engineering Handbook".

Kay J N (1990) "Use of the Liquid Limit for Characterisation of Expansive Soil Sites" CE 32 N0 3 IE Aust

Main Roads Western Australia and Australian Geomechanics Society (2002) " A Guide to the Selection and Use of Naturally Occurring Materials as Base and Sub Base in Roads in Western Australia"

Tynan, A.E. (1973) "Ground Vibration, Damaging Effects to Buildings". ARRB Special Report 11.

February 1978 report commissioned by the Department of Industrial Development and the Western Cell Sheet of the 1:10,000 Groundwater and Soil Chemistry Plan

Austroads Pavement Design Guide (1992)/Main Roads Engineering Road Note 9 (1987)/APRG (1997) Report 21.

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SPECIALISTS MANAGING THE EARTH

Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

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SPECIALISTS MANAGING THE EARTH

Important information about your **Coffey** Report

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment.
Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

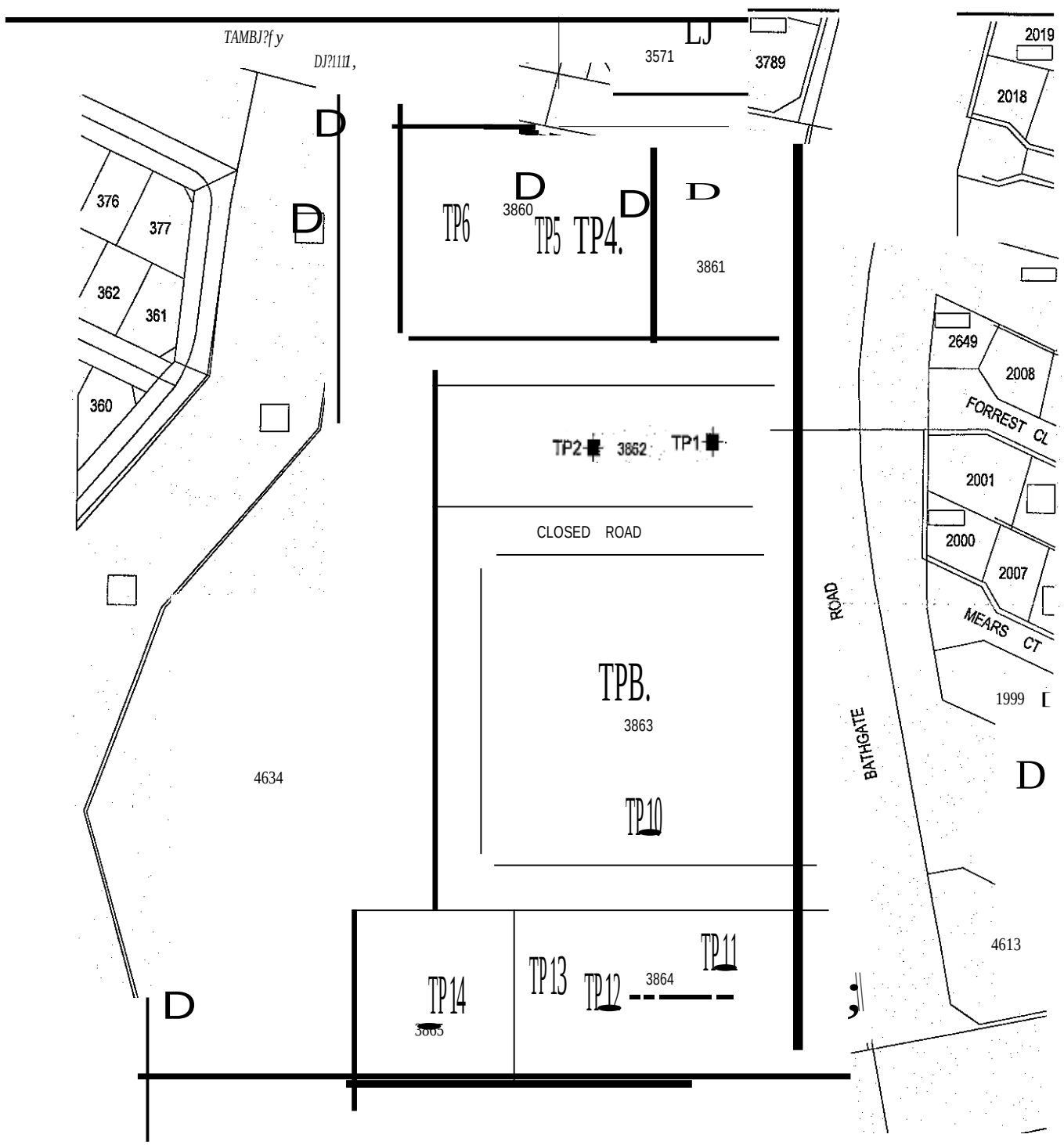
Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Figures



Scale (metres)

LEGEND

● TEST PIT LOCATION

REF;

drawn	LB	coffey geotechnics SPECIALISTS MANAGING THE EARTH	client: WOOD & GRIEVE ENGINEERS
approved	IIIII		project: KARRATHA INDUSTRIAL ESTATE AND TOWNSITE KARRATHA TOWNSITE
date	3/7107		title: TEST LOCATION PLAN
scale	1:2500		
original size	A4		project no; GEOTHERD02828AK fig no: FIGURE 1 rev:

REF:
DWG: F:\Geolechnical\Jobs P2500 to P2999\P2828.11 Karratha Townsae and industrial es1ate\Figures\GH2828AK FIG1 INDUSTRIAL ESTATE.dwg

LEGEND

● TEST PIT LOCATION

0 50 100 150 200

MJ" Scale (metres)

drawn	LB
approved	'>I\
date	3/7/07
scale	1:5000
original size	A4

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geotechnics
SPECIALISTS MANAGING THE EARTH

client: WOOD & GRIEVE ENGINEERS

project: KARRATHA TOWNSITE & INDUSTRIAL ESTATE
KARRATHA INDUSTRIAL ESTATE

title: TEST LOCATION PLAN

project no: GEOTHERD02828AK | fig no: FIGURE2 | rev:

Appendix A

Results of Field Investigation

Test Pit Logs (34 Pages)

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Engineering Log - Excavation

Excavation No.	TP1		
Sheet No.	1 of 1		
Project No.	GH2828AK		
Client	Wood & Grieve Engineers	Date excavatBd	26/6/07
Principal :		Date completed	26/6/07
Project	Karratha Townsite and Industrial Estate	Logged by :	.fD
Location	Karratha Townsite	Checked by :	

Position : E: 480140.000, N: 7706080.000 (50 MGA94) Surface Elevation : 13.03 (AHO)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 2.00m long O.SOm wide

excavation information | material substance

method	penetration	support	groundwater	sample / field test	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture	consistency / relative density	hand penetrometer kPa	structure and additional observations
BH					13.0	0.0			TOPSOIL, brown, rubble, rootlets	O	L		
					12.5	0.5		GC	CLAYEY GRAVEL, low to medium plasticity, brown, gravel sand-clay mixture	O	MD		White band, weathered schist
				1.00m	12.0	1.0							Fines=37%; Sand=24%; Grave1=39%
					11.5	1.5							
					11.0	2.0			EXCAVATION TP1 TERMINATED AT 1.80m Refusal				
					10.5	2.5							
					10.0	3.0							
						3.5							

COFFEY_01.GLB Log EXCAVATION GH2828AK TESTPITS.GPJ DWG31981.GDW 03/08/2007 10:50

method

N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper
E Excavator

support

T Timbering

penetration

No Resistance

water

,100ct..73 Watec Level on Date shown
IJI,-- water inflow
—...,.. water outnow

samples & field tests

USO	Undisturbed Sample 50mm diameter
U63	Undisturbed Sample 63mm diameter
D	Disturbed Sample
B	Bulk Disturbed Sample
E	Environmental Sample
MC	Moisture Content
HP	Hand Penetrometer (UCS kPa)
VS	Vane Shear: P-Peak, R-Remouded (uncorrected kPa)
PBT	Plate Bearing Test

classification symbols & soil description

Based on Unified Classification System

moisture

D - Dry
M - Moist
W - Wet
Wp - Plastic Limit
WL - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VS!	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

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Engineering Log - Excavation

Client	*Wood & Grieve Engineers*	Excavation No.	*TP2*
Principal :		Sheet No.	1 of 1
Project	*Karratha Townsite and Industrial Estate*	Project No.	*GH2828AK*
Location :	*Karratha Townsite*	Date excava1Bd	*26/6/07*
		Date completed	*26/6/07*
		Logged by :	*,{D*
		Checked by :	*lm*

Position : E: 480117.000, N: 7706074.000 (50 MGA94) Surface Elevation : 13.15 (AHD)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 2.00m long 0.50m wide

excavation information	material substance	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa 100 200 300 400	structure and additional observations
	0.0-	FILL, man made waste concrete, rubble, roots	D	L		
1-13.0						
	0.5-	CLAYEY GRAVEL, coarse grained, brown, some blue/green, low to medium plasticity clay	D	MD		
1-12.5						
	1.0-					
-12.0						
	1.5-					
-11.5			M			
l-11.0		EXCAVATION TP2 TERMINATED AT 2.00 m				
	2.5-					
-10.5						
	3.0-					
l-10.0						
	3.5-					
1-9_5						

COFFEY_01.GLB Log EXCAVATION GH2828AK TESTPITS.GPJ DWG31981.GDW 03/08/2007 10:52

mothod
N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper
E Excavator
support
T Timbering

penetration
No Reslstaace
water
Level on Date sho.....,
.....— waler inflow
...,... water
outflow

samples & fieldtests
U50 Undisturbed Sample 50mm diameter
U63 Undisturbed Sample 63mm diameter
D - Disturbed Sample
B - Bulk Disturbed Sample
E Environmental Sample
MC Moisture Content
HP - Hand Penetrometer (UCS kPa)
VS - Vane Shear, P-Peak, R-Remouded (uncorrected kPa)
PBT Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
D D,y
M Moist
W - Wet
Wp - Plastic Limit
WL - Liquid Limit

consistency / relative density
VS Very Soft
S Soft
F - Flrm
St -Stiff
VS! - Very Stiff
H - Hard
VL - Very Loose
L -Loose
MD - Medium Dense
D - Dense
VD - Very Dense

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Engineering Log - Excavation

Excavation No.	TP3		
Sheet No.	1 of 1		
Project No.	GH2828AK		
Client	Wood & Grieve Engineers	Date excavated	26/6/07
Principal :		Date completed	26/6/07
Project	Karratha Townsite and Industrial Estate	Logged by :	JD
Location	Karratha Townsite	Checked by :	:,ll

Position : E: 480083.000, N: 7706076.000 (50 MGA94) Surface Elevation : 13.04 {AHO)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 2.00m long 0.50m wide

excavation information | material substance

depth (m)	graphic log	classification symbol	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	e. c. g. ac.	i" g.	hand penetro-meter kPa	structure and additional observations
0.0			TOPSOIL, with gravel, roots	D	L		
			SCHIST, white, weathered	D	D		
0.5		GC	CLAYEY GRAVEL, brown, with some low to medium plasticity clay	M	MD		
1.0			....white patches of schist all the way down				Trace of weathered schist all the way down WL=39%; Wp=17%; Ip=22%; LS=11%; Moisture=9.8%; Fines=38%
1.5							
2.5			EXCAVATION TP3 TERMINATED AT 2.00 m				
3.0							
3.5							

BH

COFFEY_01.GLB Log EXCAVATION GH2828AK TESTPITS.GPJ DWG12943.GDW 06/08/2007 11:08

molhod

N Natural Exposure
Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper
E Excavator

support
T Timbering

penetration
ui o. r 5
N0 Res;,1a,co
watec
water inflow
water outflow

samples & field tests
U50 Undisturbed Sample 50mm diameter
U63 - Undisturbed Sample 63mm diameter
D - Disturbed Sample
B Bulk Disturbed Sample
E Environmental Sample
MC !vtlisture Content
HP - Hand Penetrometer (UCS kPa)
VS Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
D D,y
M Moist
W - Wot
W, - Plastic Limit
W, - Liquid Limit

consistency / relative density
VS -Very Soft
S - Soft
F -Firm
St -Stiff
VSt - Very Stiff
H - Hard
VL - Very oose
L - Loose
MD - Medium Dense
D - Dense
VD -Very Dense

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Engineering Log - Excavation

Client	*Wood & Grieve Engineers*	Excavation No.	*TP4*
Principal :		Sheet No.	1 of 1
Project	*Karratha Townsite and Industrial Estate*	Project No.	*GH2828AK*
Location :	*Karratha Townsite*	Date excavatBd	*26/6/07*
		Date completed	*26/6/07*
		Logged by :	*JD*
		Checked by :	*lm*

Position : E: 480081.000, N: 7706166.000 (50MGA94) Surface Elevation : 12.81 (AHO)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 2.00m long 0.50m wide

excavation information		material substance					
method / penetration / support / ground water	depth	classification symbol	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture condition	consistency / relative density	hand penetrometer kPa	structure and additional obseivations
BH; Not Observed; 0.40m; 1.00m; 1.50m	0.0		TOPSOIL, roots	D	L		
			GRAVELLY CLAY, fine, white / pale red, chalky	D	F		
			CLAYEY GRAVEL, fine to medium grained, brown	D	MD		
	1.5		SANDY CLAY, brown, with white fine gravel, with pockets of weathered schist	M	St		Fines=50%; Sand=27o/o; Gravel=23%
	2.0		EXCAVATIONTP4 TERMINATED AT 1.70 m Refusal				
	2.5						
	3.0						
	3.5						

COFFEY_01.GLB Log EXCAVATION GH2828AK TESTPITS.GPJ DWG31981.GDW 03/08/2007 10:54

method	penetration	samples & field tests	classification symbols & soil description (Based on Unified Classification System)	consistency / relative density
N Natural Exposure X Existing Excavation BH Backhoe Bucket B Bulldozer Blade R Ripper E Excavator support T Timbering	No Rosista,ce Level on Date shov.n water inflow waterouflow	USO Undisturbed Sample 50mm diameter U63 Undisturbed Sample 63mm diameter D - Disturbed Sample B - Bulk Disturbed Sample E Environmental Sample MC: f....toisture Content HP Hand Pene!rometer (UCS kPa) PBT Plate Bearing Test VS - Vane Shear: P-Peak R-Remoulded (uncorrected kPa)	moisture D •°'Y M f....toist W Wet WP - Plastic Limit WL - Liquid Limit	VS •Very Soft S -Soft F -Firm St Stiff VSt - Very Stiff H •Hard VL •Very Loose L -Loose MD •Medium Dense D -Dense VD •Very Dense

coffey geotechnics

Engineering Log - Excavation

Excavation No.	TP5
Sheet No.	1 of 1
Project No.	GH2828AK
Date excavated	26/6/07
Date completed	26/6/07
Logged by	JD
Checked by :	hn

Client: Wood & Grieve Engineers

Principal :

Project: Karratha Townsite and Industrial Estate

Location: Karratha Townsite

Position : E: 480064.000, N: 7706173.000 (50 MGA94) Surface Elevation : 12.69 (AHO)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 2.00m long 0.50m wide

excavation information	material substance			structure and additional observations
				SMDD=2.05t/m³; OMC=12%; CBR=6o/o

method
N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper
E Excavator

support
T Timbering

penetration
No Res;,ta,ce

wat..-
,,. ,10 Oct. • 73 Watec Level on Date shoVilll
..,. water inflow
1----4 water outflow

samples & field tests
USO Undisturbed Sample 50mm diameter
U63 Undisturbed Sample 63mm diameter
D - Disturbed Sample
B Bulk Disturbed Sample
E Environmental Sample
MC Moisture Content
HP - Hand Penetrometer (UCS kPa)
VS Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT - Plate Bearing Test

classification symbols & soil description Based on Unified Classification System
Moisture
D - Dry
M Moist
W Wet
Wp • Plastic Limit
Wt - Liquid Limit

consistency / relative density
VS -Very Soft
S -Soft
F -Firm
St -Stiff
VS! Very Stiff
H • Hard

VL - Very Loose
L • Loose
MD • Medium Dense
D - Dense
VD -Very Dense

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Engineering Log - Excavation

Client	*Wood & Grieve Engineers*	Excavation No.	*TP6*
Principal :		Sheet No.	1 of 1
Project	*Karratha Townsite and Industrial Estate*	Project No.	*GH2828AK*
Location	*Karratha Townsite*	Date excavated	*26/6/07*
		Date completed	*26/6/07*
		Logged by	*JD*
		Checked by :	*hn*

Position : E: 480034.000, N: 7706178.000 (50 MGA94) Surface Elevation : 12.6 (AHO)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 2.00m long 0.50m wide

excavation information				material substance							
method	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Mnor Components	moisture condition	consistency / relative density	kP,	structure and additional observations
					0.0			TOPSOIL, roots	D	L		
				L. 12.5			GC	CLAYEY GRAVEL, coarse grained, low plasticity, brown	D	MD		Band of white schist
				1-12.0	0.5-							
				L..11.5	1.0-							
			1.50m		1.5-							
			D	-11.0			GC	CLAYEYGRAVEL,medium to coarse grained, medium to low plasticity, red brown, some white weathered schist	M	MD		WL=33%; Wp=17o/o; lp=16%; LS=10.5%; Moisture=11°!o; Fines=38%
			2.00m									
								EXCAVATION TP6 TERMINATED AT 2.00 m				
				1-10.0	2.5-							
				L...9_5	3.0-							
				1-9.0	3.5-							

method	penetration	samples & fieldtests	classification symbols & soil description Based on Unified Classification System	consistency / relative density
N Natural Exposure X Existing Excavation BH Backhoe Bucket R Ripper B Bulldozer Blade E Excavator support T Timbering	!!,!WLL::C5 No Res;staare [redacted] 1--,Z,...J" Ckt, 73 Walec Level on Date shown ....___ water inflow ----4 water outflow	U50 - Undisturbed Sample SOmm diameter U63 - Undisturbed Sample 63mm diameter D Disturbed Sample B Environmental Sample Bulk Disturbed Sample MC - Moisture Content HP Hand Penetrometer (UCS kPa) VS Vane Shear; P-Peak, R-Remouded (uncorrected kPa) PBT Plate Bearing Test	moisture D D,y M Moist W Wet W, - Plastic Limit W, - Liquid Limit	VS - Very Soft S - Soft F - Rnm VSt - Very Stiff St - Stiff H - Hard VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense

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Engineering Log - Excavation

Excavation No.	TP7
Sheet No.	1 of 1
Project No.	GH2828AK
Date excavated	26/6/07
Date completed	26/6/07
Logged by :	JD
Checked by :	Itri

Client: Wood & Grieve Engineers

Principal :

Project: Karratha Townsite and Industrial Estate

Location: Karratha Townsite

Position : E: 480131.000, N: 7706010.000 (50 MGA94) Surface Elevation : 13.43 {AHD)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 2.00m long O.SOm wide

excavation information		material substance					structure and additional observations
penetration / support / ground water			material description SOILIYPE, Plasticity or Particle Characteristic, Colour, Secondary and Mnor Components			kPa	
	0.0		TOPSOIL, rubble roots				
	-13.0	SC	CLAYEY SAND, pale white, weathered,	D	L		
	0.5-	GC	CLAYEY GRAVEL, medium grained, red / brown	D	MD		
	1-12.5	GC	CLAYEY GRAVEL, medium grained, white and brown	D	MD		
	1-12.0						
	1-11.5		EXCAVATION TP7 TERMINATED AT 2.00 m				
	2.5-						
	-10.5						
	3.0-						
	1-10.0						
	3.5-						
	1-9.5						

method

N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper
E Excavator

support
T limbering

penetration

WLLJ: 5 No Reslstaoce

W-
_L,10 0cl, 73Water
Level on Date shown
water inflow
water outflow

samples & field tests

U50 Undisturbed Sample SOmm diameter
U63 Undisturbed Sample 63mm diameter
D Disturbed Sample
8 Bulk Disturbed Sample
E Environmental Sample
MC Moisture Content
HP Hand Penetrometer (UCS kPa)
VS Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT Plate Bearing Test

dassfficatlon symbols & soil description
Based on Unified Classification System

moisture
D - Dry
M - M.'.list
W - Wet
WP - Plastic Limit
W. - Liquid Limit

conSlstency / relative density

VS - Very Soft
S - Soft
F - Firm
St - Stiff
VS! - Very Stiff
H - Hard

VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

coffey e) geotechnics

Engineering Log - Excavation

Excavation No.	TPB
Sheet No.	1 of 1
Project No.	GH2828AK
Date excavatBd	26/6/07
Date completed	26/6/07
Logged by	JD
Checked by :	

Client	Wood & Grieve Engineers
Principal :	
Project	Karratha Townsite and Industrial Estate
Location	Karratha Townsite

Position : E:480111.000, N:7706014.000 (50 MGA94) Surface Elevation : 13.65 (AHO}

Equipment type : Backhoe Method : Backhoe Excavation dimensions ; 2.00m long 0.50m wide

excavation information			material substance						structure and additional obseivations
				classification symbol	SOIL TYPE, Plasticity or Particle Characteristic, material description Colour, Secondary and Minor Components				
		0.0							
		13.5			TOPSOIL, rubble, roots	D	L		
		0.5			SCHIST, medium, pale green and white, weathered with carbonate	D	MD		
				GC	CLAYEY GRAVEL, coarse grained, pale brown, with white, trace of medium grained weathered schist	D	MD		
		1-13.0							
	1.00m	1.0							
		L....12.s							arge angular cobbles down pit wai SMDD=2.08t/m³ OMC=11%;
		1.5							CBR=35%
	1.5om								
		1-12.0							
					EXCAVATION TP8 TERMINATED AT 2.00 m				
		'-11.s							
		2.5							
		1-11.0							
		3.0							
		f-10.s							
		3.5							
		1-10.0							

mothod	penetration	samples & field tests	classification symbols & sell description Based on Unified Classification System	consistency / relative density
N Natural Exposure	No Res;staoce	U50 - Undisturbed Sample 50mm diameter		VS - Very Soft
Existing Excavation		U63 - Undisturbed Sample 63mm diameter		S Soft
BH Backhoe Bucket		D Disturbed Sample		F •Firm
	73 Watec			
B Bulldozer Blade		B Bulk Disturbed Sample	moisture	St -Stiff
R Ripper	water	E - Environmental Sample		VSt - Very Stiff
E Excavator	support		D D,y	H -Hard

Date shown

Content Moisture

T Timbering

HP Hand Penetrometer

water inflow

---<1111 water outflow

(UCS kPa)

VS Vane Shear; P-Peak, R-Remouded (uncorrected kPa)

PBT - Plate Bearing Test

W - Wet

W, - Plastic Limit

W, - Liquid Limit

VL - Very Loose

L - Loose

MD - Medium Dense

D - Dense

VD - Very Dense

coffey geotechnics

Engineering Log - Excavation

Client	*Wood & Grieve Engineers*	Excavation No.	*TP9*
Principal:		Sheet No.	1 of 1
Project	*Karratha Townsite and Industrial Estate*	Project No.	*GH2828AK*
Location	*Karratha Townsite*	Date excavated	*26/6/07*
		Date completed	*26/6/07*
		Logged by	
		Checked by:	

Position : E:480057.000, N:7706012.000 (50 MGA94) Surface Elevation : 13.59 (AHD)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 3.00m long 0.50m wide

excavation information		material substance				
method	penetration	SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	structure and additional observations
BH		TOPSOIL, roots	D	L	
		SCHIST, white, weathered			
		GC CLAYEY GRAVEL, medium grained, row plasticity, brown	D	MD	Schists
		GC CLAYEY GRAVEL, medium grained, brown and white	M	MD	WL=33%; Wp=15%; Ip=18%; LS=11%; Moisture=11.6%; Fines=42%
		EXCAVATION TP9 TERMINATED AT 2.00 m			

COFFEY_01.GLB Log EXCAVATION GH2828AK TESTPITS.GPJ DWG31881.GDW 03/08/2007 10:55

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- Timbering

penetration
- No Resistance
- Level on Date shown
- waler inflow
- water outflow

samples & field tests
- US0 Undisturbed Sample 50mm diameter
- U63 Undisturbed Sample 63mm diameter
- D Disturbed Sample
- B Bulk Disturbed Sample
- E Environmental Sample
- MC Moisture Content
- HP Hand Penetrometer (UCS kPa)
- VS Vane Shear: P-Peak, R-Remouded (uncorrected kPa)
- PBT Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D Dey
- M Moist
- W Wet
- Wp - Plastic Limit
- WL - Liquid Limit

consistency / relative density
- VS Very Soft
- S Soft
- F Finn
- St Stiff
- VS! Very Stiff
- H Hard
- VL Very Loose
- L Loose
- MD Medium Dense
- D Dense
- VD Very Dense

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Engineering Log - Excavation

Excavation No.	TP10
Sheet No.	1 of 1
Project No.	GH2828AK
Date excavated	26/6/07
Date completed	26/6/07
Logged by	JD
Checked by :	Im

Client	Wood & Grieve Engineers
Principal :	
Project	Karratha Townsite and Industrial Estate
Location	Karratha Townsite

Position : E:480118.000, N:7706002.000 (50 MGA94) Surface Elevation ; 14.03 (AHO)
Equipment type : Backhoe Method : Backhoe Excavation dimensions ; 3.00m long 0.50m wide

excavation information	material substance					structure and additional observations
		material description				
		SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components			kPa	
1-14.0		TOPSOIL, roots	D	L		
	s88	FILL	D	L		
		....rubble				
		SCHIST, white, weathered	D	D		
f--13.5	0.5	GC CLAYEY GRAVEL, medium grained, brown / red	M	MD		
1--13.0	1.0					
			M	MD		
f--12.5	1.5	....white blocky and brown cobbles				
		EXCAVATION TP10 TERMINATED AT 1.80 m Refusal				
1--12.0	2.0-					
f--11.5	2.5-					
'-11.0	3.0-					
f--10.5	3.5-					

COFFEY_01.GLB Log EXCAVATION GH2828AK TESTPITS.GPJ DWG31981.GDW 03/08/2007 10:50

method	penetration	samples & field tests	classification symbols & soil description Based on Unified Classification System	consistency / relative density
N Natural Exposure X Existing Excavation BH Backhoe Bucket B Bulldozer Blade R Ripper E Excavator support T Timbering	No R,slsraare wato, water inflow water outflow	USO - Undisturbed Sample 50mm diameter U63 Undisturbed Sample 63mm diameter D Disturbed Sample B - Bulk Disturbed Sample E - Environmental Sample MC Moisture Content HP Hand Penetrometer (UCS kPa) VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa) PBT Plate Bearing Test	moisture D - Dry M Moist W Wet Wp - Plastic Limit Wl - Liquid Limit	VS - Very Soft S -Soft F -Firm St -Stiff VS! -Very Stiff H - Hard VL - Very Loose L - Loose MD - Medium Dense D - Dense VO -Very Dense

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Engineering Log - Excavation

Client	*Wood & Grieve Engineers*	Excavation No.	*TP11*
Principal :		Sheet No.	1 of 1
Project	*Karratha Townsite and Industrial Estate*	Project No.	*GH2828AK*
Location	*Karratha Townsite*	Date excavalBd	*26/6/07*
		Date completed	*26/6/07*
		Logged by :	*JD*
		Checked by:	sr,

Position : E:480110.000, N:7705932.000 (50 MGA94) Surface Elevation : 14.01 (AHD)

Equipment type : Backhoe Method : Backhoe Excavation dimensions :3.00m long 0.50m wide

excavation information | material substance

method	penetration	support	ground water	depth	RL	graphic	USCS	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture	consistency	hand penetrometer kPa	structure and additional observations
BH			Not Observed	14.0	0.0			TOPSOIL, roots, pale white weathered schist	D	L	100 200 300 400	
								SCHIST, white, weathered	D	L		
							CH	GRAVELLY CLAY, coarse, medium plasticity, brown, clay	D	St		
				13.5	0.5							
				13.0	1.0		GC	CLAYEY GRAVEL, medium grained, black, with large angular white blocks of weathered schist	D	MD		
				12.5	1.5							
								EXCAVATION TP11 TERMINATED AT 1.80 m Refusal				
				12.0	2.0							
				11.5	2.5							
				11.0	3.0							
				10.5	3.5							

COFFEY_01.GLB Log_EXCAVATION GH2828AK TESTPITS.GPJ DWG12943.GDW 06/08/2007 11:07

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration
- No Re,;,t,,oe
- wate,
- Location 7.3 Weathered
- water inflow
- water outflow

samples & field tests

USO	Undisturbed Sample 50mm diameter
U63	Undisturbed Sample 63mm diameter
D	Disturbed Sample
B	Bu!k Disturbed Sample
E	Environmental Sample
MC	Moisture Content
HP	Hand Penetrometer(UCS kPa)
VS	Vane Shear: P-Peak, R-Remouded (uncorrected kPa)
PBT	Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D - O,y
- M Moist
- W Wot
- W, - Plastic Limit
- W, - Liquid Limit

consistency / relative density
- VS • Very Soft
- S Soft
- F • Finn
- St Stiff
- VS, - Very Stiff
- H Hard
- VL • Very Loose
- L - oose
- MD - Medium Dense
- D • Dense
- VO • Very Dense

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Engineering Log - Excavation

Client	*Wood & Grieve Engineers*	Excavation No.	*TP12*
Principal :		Sheet No.	1 of 1
Project	*Karratha Townsite and Industrial Estate*	Project No.	*GH2828AK*
Location	*Karratha Townsite*	Date excavatBd	*26/6/07*
		Date completed	*26/6/07*
		Logged by :	*JD*
		Checked by :	5/J..

Position : E: 480067.000, N: 7705927.000 (50 MGA94) Surface Elevation : 14.34 (AHD)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 3.00m long 0.50m wide

excavation information			material substance					
method	penetration	support	ground water		classification symbol	material description SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Mnor Components	moisture condition	consistency / relative density	structure and additional observations
				0.0		TOPSOIL, rubble, roots	D	L	
				L14.0	CL-Cl	CLAYEY SAND, coarse grained, pale brown, layered	D	F	
			0.SOm D	0.5	CL-Cl	SANDY CLAY, medium plasticity, brown and black, trace organics	D	St	Fines=71%; Sand=25°/o; Gravel=4%
BH		Not Observed		1-13.5					
				1.0					
				'°-13.0					
			1.SOm D	15	GC	CLAYEYGRAVEL, coarse grained, pale bfack and white	M	MD	
				1-12.5					
			2.00m			EXCAVATION TP12 TERMINATED AT 2.00 m			
				12.0					
				2.5					
				-11.5					
				3.0					
				11.0					
				3:5					
				..-10.s					

COFFEY_01.GLB Log EXCAVATION GH2828AK TESTPITS.GPJ DWG12943.GDW 06/08/2007 11:08

method

- N Natural Exposure
- A Existing Excavation
- BH Backhoe Bucket
- D Bulldozer Blade
- R Ripper
- E Excavator

support

- T Timbering

penetration

- !s!w ND Res;staoce
- Oct., 73 Watoc

water

- Level on Date shown
- ,....._ water inflow
- -----'1111 water outflow

samples & field tests

USO	Undisturbed Sample 50mm diameter
U63	Undisturbed Sample 63mm diameter
D	Disturbed Sample
B	Bulk Disturbed Sample
E	Environmental Sample
MC	Moisture Content
HP	Hand Penetrometer (UCS kPa)
VS	Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT	Plate Bearing Test

classification symbols & soil description

Based on Unified Classification System

moisture

- D - D,y
- M Moist
- W Wet
- W, - Plastic Limit
- W; - Liquid Limit

consistency / relative density

- VS - Very Soft
- S - Soft
- F - Finn
- St - Stiff
- VS! - Very Stiff
- H - Han:!
- VL - Very Loose
- L - Loose
- MD - Medium Dense
- D - Dense
- VD - Very Dense

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Engineering Log - Excavation

Client	*Wood & Grieve Engineers*	Excavation No.	*TP13*
Principal :		Sheet No.	1 of 1
Project	*Karratha Townsite and Industrial Estate*	Project No.	*GH2828AK*
Location	*Karratha Townsite*	Date excava1Ed	*26/6/07*
		Date completed	*26/6/07*
		Logged by :	*D*
		Checked by :	•WI

Position : E: 480091.000, N: 7705879.000 (50 MGA94) Suriace Elevation : 14.24 (AHD)

Equipmenttype : Backhoe Method : Backhoe Excavation dimensions : 3.00m long O.SOm wide

excavation information		material substance						
				material description				structure and additional observations
				SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components			kPa	
				TOPSOIL, roots	D	L		
	L.14.0		GC.	CLAYEY GRAVEL, coarse grained, brown, few roots	O	L		
	05		GC	CLAYEY GRAVEL, coarae grained, pale brown, trace silt, white clasts of weathered schist	D	MD		
	LSOm	15	GC	CLAYEY GRAVEL, medium to coarse grained, blue brown, trace silt	D	L		
	-1'.s							
	L...12.0	2.5-						
	1-11.5							
		3.0-						
	L...11.0							
		3.5-						
	1-10.5							

EXCAVATION TP13 TERMINATED AT 2.00 m

mothod	penetration	samples & field tests	classification symbols & soil description Based on Unified Classification System	consistency / relative density
N Natural Exposure	No R Jslaaoo	USO - Undisturbed Sample 50mm diameter		VS •Very Soft
R Existing Excavation		U63 Undisturbed Sample 63mm diameter		S Soft
BH Backhoe Bucket		D Disturbed Sample		F •Firm
B Bulldozer Blade	water	B - Bulk Disturbed Sample	moisture	St Stiff
R Ripper		E - Environmental Sample	D - D,y	VS! Very Stiff
E Excavator	Oct.. 73 Watec	MC Moisture Content	M - Moist	H Hard
support	Level on Date shown	HP Hand Penetrometer {UCS kPa)	W Wet	VL •Very Loose
T Timbering	water inflow	VS Vane Shear; P·Peak,	W, - Plastic Limit	L •Loose
	C waler outflow	R·Remouded (uncorrected kPa)	W, - Liquid Limit	MD •Medium Dense
		PBT Plate Bearing Test		D •Dense
				VO •Very Dense

coffey e) geotechnics

Engineering Log - Excavation

Client	*Wood & Grieve Engineers*	Excavation No.	*TP14*
Principal :		Sheet No.	1 of 1
Project	*Karratha Townsite and Industrial Estate*	Project No.	*GH2828AK*
Location	*Karratha Townsite*	Date excavated	*26/6/07*
		Date completed	*26/6/07*
		Logged by	*JD*
		Checked by :	*An*

Position : E: 480057.000, N: 7705861.000 (50 MGA94) Surface Elevation: 13.43 (AHO)

Equipment type : Backhoe Method : Backhoe Excavation dimensions :3.00m long 0.50m wide

excavation information				material substance					
penetration				classification symbol	material description SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa 100 200 300 400	structure and additional observations
	0.10m D		0.0		TOPSOIL roots	D			
				GC	CLAYEYGRAVEL,medium to coarse grained, brown	D			WL=35%; Wp=15%; Ip=20%; LS=10.5 %; Moisture=8.3 11>; Fines=36%
	0.50m	1-1J.O	0.S	CH	GRAVELLY CLAY,low to medium plasticity,brown, large clasts of white weathered schist	M	F		
		i...12.5	1.0						
	1.50m D	-12.0	1.5	GC	CLAYEY GRAVEL,lowtomediumplasticity,pale brown, large clasts of white	M	F		Fines=42%; Sand=22'¥o; Gravel=36%
	1.80m				EXCAVATION TP14 TERMINATED AT 1.80 m Refusal				
		i..11.s	2.0-						
		1-11.0	2.5-						
		L...10.s	3.0-						
		1-10.0	3.5-						
		1-9_5							

mothod	penetration	samples & fieldtests	classlflcatlon symbols & soll description Based on Unified Classification System	consistency / relative density
N Natural Exposure X Existing Excavation BH Backhoe Bucket B Bulldozer Blade R Ripper E Excavator support T Timbering	!s!wu.I5 NoR,s;staoce water ....L.110 Oct., 73 Water --- Level on Date shov.n water inflow ...., water outflow	USO Undisturbed Sample 50mm diameter U63 Undisturbed Sample 63mm diameter D - Disturbed Sample B - Bulk Disturbed Sample E Environmental Sample MC Moisture Content HP Hand Penetrometer {UCS kPa) VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa) PBT Plate Bearing Test	moisture D D,y M Moist W - Wet Wp - Plastic Limit WL • Liquid Limit	VS - Very Soft S Soft F • Flrm St -Stiff VS! - Very Stiff H - Hard VL - Very Loose L -Loose MD • Medium Dense D • Dense VD • Very Dense

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Engineering Log - Excavation

Client	*Wood & Grieve Engineers*	Excavation No.	*TP15*
Principal :		Sheet No.	1 of 1
Project	*Karratha Townsite and Industrial Estate*	Project No.	*GH2828AK*
Location :	*Karratha Townsite*	Date excavated	*26/6/07*
		Date completed	*26/6/07*
		Logged by :	*JD*
		Checked by :	kri

Position : E: 487045.000, N: 7704317.000 (50 MGA94) Surface Elevation : 14 (AHD)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 3.00m long 0.SOm wide

excavation information: method	penetration	support	ground water	samples & field tests	RL (m)	Depth (m)	material substance: material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Mnor Components)	Moisture	Consistency / Density	structure and additional observations
					14.0	0.0	GC LAYEY GRAVEL, medium to coarse grained, dark brown, medium to coarse gravel	D	MD	
			Not Observed		L13.5					
							becoming lighter in colour	D	MD	
					13.0		GC CLAYEY GRAVEL, medium to coarse grained, pale pink / white, large clasts of weathered chlorite schist	D	MD	Schist has carbonate veins
					L12.5	1.5				
				1.60m			EXCAVATION TP15 TERMINATED AT 1.60 m Refusal			
					L12.0	2.0				
					L11.5	2.5				
					L11.0	3.0				
					L10.5	3.5				

mothod

- N Natural Exposure
- X Existing Excavation
- BH Backhoe Socket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration

!!;!WLLJ:5

No Res;,tarn,e

water
- Low Drag Resistance
- water inflow
- ----<III water outflow

samples & field tests

- US0 Undisturbed Sample SOmm diameter
- U63 Undisturbed Sample 63mm diameter
- D Disturbed Sample
- B Bulk Disturbed Sample
- E .. Environmental Sample
- MC M:>isture Content
- HP Hand Penetrometer (UCS kPa)
- VS Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT .. Plate Bearing Test

classffication symbols & soil description
Based on Unified Classification System

moisture
- D .. D,y
- M .. Moist
- W .. Wet
- W, .. Plastic Limit
- W, .. Liquid Limit

consistency / relative density

- VS - Ve!"f SOfl
- S - Soft
- F - Firm
- St - Stiff
- VSt - very stiff
- H - Hard
- VL - Very Loose
- L - Loose
- MD - Medium Dense
- D - Dense
- VD - Very Dense

coffey geotechnics

Engineering Log - Excavation

		Excavation No.	TP16
		Sheet No.	1 of 1
		Project No.	GH2828AK
Client	Wood & Grieve Engineers	Date excavated	26/6/07
Principal :		Date completed	26/6/07
Project	Karratha Townsite and Industrial Estate	Logged by	JD
Location	Karratha Townsite	Checked by :	5fl..

Position : E:487061.000, N:7704289.000 (50 MGA94) Surface Elevation : 13.62 (AHD)

Equipment type : Backhoe Method · Backhoe Excavation dimensions : 3.00m tong 0.50m wide

Excavation information			material substance				structure and additional observations
			material description SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Mnor Components				
	0.0		TOPSOIL, roots	D	MD		
	-13.S		CLAYEY GRAVEL, coarse grained, brown, with white angular clasts of weathered chlorite schist, roots in top 0.1m	D	MD		
	0.S-v,Y						
	'-13.o						
	L...12.s						
Lsem	,.5-						
	L-12.0						
			EXCAVATION TP16 TERMINATED AT 1.80 m Refusal				
	2.0-						
	11·5						
	2·5-						
	L-11.0						
	3.0-						
	L 105						
	3,5						
	L-10.0						

COFFEY_01.GLB Log EXCAVATION GH2828AK TESTPITS.GPJ DWG12943.GDW 06/08/2007 11:08

method	penetration	samples & field tests	classification symbols & soil description	consistency / relative density
N Natural Exposure X Existing Excavation BH Backhoe Bucket B Bulldozer Blade R Ripper E Excavator support T Timbering	!s!wu.:i:5 NoRe,;staac, water Level on Date Established water inflow water outflow	USO - Undisturbed Sample 50mm diameter U63 Undisturbed Sample 63mm diameter D Disturbed Sample B Bulk Disturbed Sample E - Environmental Sample MC - Moisture Content HP Hand Penetrometer (UCS kPa) VS Vane Shear; P-Peak, R-Remouded (uncorrected kPa) PBT - Plate Bearing Test	Based on Unified Classification System moisture D - D,y M - Moist W Wet W, - Plastic Limit W, - Liquid Limit	VS • Very Soft S Soft F Firm St Stiff VS! •Very Stiff H •Hard VL •Very Loose L - Loose MD • Medium Dense D - Dense VD • Very Dense

coffey e) geotechnics

Engineering Log - Excavation

Excavation No.	TP17		
Sheet No.	1 of 1		
Project No.	GH2828AK		
Client	Wood & Grieve Engineers	Date excavated	26/6/07
Principal :		Date completed	26/6/07
Project	Karratha Townsite and Industrial Estate	Logged by :	.'D
Location	Karratha Townsite	Checked by :	/.1n11.

osition : E:487081.000, N:7704248.000 (50 MGA94) Surface Elevation : 13.28 (AHO)

quipment type : Backhoe Method : Backhoe Excavation dimensions : 3.00m long 0.50m wide

xcavation information		material substance	material description Colour, Secondary and Mnor Components SOIL TYPE, Plasticity or Particle Characterislic,	structure and additional observations
	0.0-1	CLAY, Evc GRAVEL medium to coarae grained. low plasticity, brown, trace roots		
	1.00m			
	1.0-		....becoming lighter in colour, with large white/blue clasts of weathered chlorite schist	Schist is low to medium strength and strongly foliated
	1.50m			WL=33%; Wp=23o/o; lp=10%; LS=6%; Moisture=S.9%; Fines=30%
	1.90m		EXCAVATION TP17 TERMINATED AT 1.90m Refusal	
	2.0-			
	2.5-			
	3.0-			
	3.5-			

N Natural Exposure

method

X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper
E Excavator

support

T Timbering

penetration

Oct, 73 Walec
No Re,1,1am,

wate,

Lever on Date shov.n
water inflow
water outflow

USO - Undisturbed Sample 50mm diameter

samples & field tests

U63 - Undisturbed Sample 63mm diameter
D Disturbed Sample
B Bulk Disturbed Sample
E Environmental Sample
MC - Moisture Content
HP Hand Penetrometer (UCS kPa)
VS Vane Shear; P-Peak,
R-Remouded {uncorrected kPa)
PBT - Plate Bearing Test

classification symbols & Soil Description Based on Unified Classification System

moisture

0 - Ory
M - Moist
W - Wet
Wp - Plastic Limit
WL • Liquid Limit

consistency / relative density

vs	- Very Soft
S	-Soft
F	- Firm
St	-Stiff
VSt	- Very Stiff
H	-Hard
VL	- Very Loose
L	- Loose
MO	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

Client	*Wood & Grieve Engineers*	Excavation No.	*TP18*
Principal :		Sheet No.	1 of 1
Project	*Karratha Townsite and Industrial Estate*	Project No.	*GH2828AK*
Location	*Karratha Townsite*	Date excavated	*26/6/07*
		Date completed	*26/6/07*
		Logged by :	*JD*
		Checked by :	*lm*

Position : E: 487095.000, N: 7704187.000 (50 MGA94) Surface Elevation : 12.96 (AHD)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 3.00m long 0.50m wide

excavation information			material substance		
method / penetration / support / ground water			material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components		structure and additional observations
BH	Not Observed	0.5	GC CLAYEY SILTY GRAVEL, dark brown, dusty		
		1.0	...large outcrops of blue grey weathered schist, surrounded by light brown (s;fty) gravel		Schist is low to medium strength and strongly foliated
		1.5	...collapse and big rock in way EXCAVATION TP18 TERMINATED AT 1.40 m Refusal		
		2.0			
		2.5			
		3.0			
		3.5			

method	penetration	samples & field tests	classification symbols & soil description	consistency / relative density
N Natural Exposure X Existing Excavation BH Backhoe Bucket B Bulldozer Blade R Ripper E Excavator	No Resistance	USO Undisturbed Sample 50mm diameter U63 Undisturbed Sample 63mm diameter D Disturbed Sample B Bulk Disturbed Sample E - Environmental Sample MC - Moisture Content HP Hand Penetrometer (UCS kPa) VS Vane Shear; P-Peak, R-Remouded (uncorrected kPa) PBT - Plate Bearing Test	Based on Unified Classification System Moisture O Dry M Moist W Wet Wp - Plastic Limit WL - Liquid Limit	VS - Very Soft S - Soft F - Firm St - Stiff VS! - Very Stiff H - Hard VL - Very loose L - Loose MD - Medium Dense D - Dense VD - Very Dense

support: limbering

water: 10 Oct., 73 Water Level on Date shown; water inflow; 4 water outflow

coffey e) geotechnics

Engineering Log - Excavation

Excavation No.	TP19
Sheet No.	1 of 1
Project No.	GH2828AK
Date excavatBd	26/6/07
Date completed	26/6/07
Logged by :	JD
Checked by :	lm

Client: Wood & Grieve Engineers

Principal :

Project: Karratha Townsite and Industrial Estate

Location: Karratha Townsite

Position : E: 487118.000, N: 7704134.000 (50 MGA94) Surface Elevation : 12.46 (AHD)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 3.00m long 0.50m wide

excavation information			material substance							
method	penetration	support	ground water	g	classification symbol	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture condition	consistency / relative density	hand penetrometer kPa 100 200 300 400	structure and additional observations
				0.0	GC	CLAYEY GRAVEL, medium to coarse grained, low plasticity, brown	D	MD		
				1-12.0 0.5						
				1-11.5 1.0	GC	CLAYEY GRAVEL, coarse grained	D	L		
				-11.0 1.5		....large angular blocks of weathered schist				Schist has carbonate veins
				1-10.5						
						EXCAVATION TP19 TERMINATED AT 2.00 m				
				1-10.0 2.5-						
				1-9_5 3.0-						
				1-9.0 3.5-						
				1-8.5						

method

- N Natural Exposure
- Existing Excavation
- BH Backhoe Bucket
- Bulldozer Blade
- R Ripper
- Excavator

support

- Timbering

water

- ...J!'.... 1 Q Q 1 7 3 Water
- Iii>-- water inflow
- ---oill water outflow

samples & field tests

USO	Undisturbed Sample 50mm diameter
U63	Undisturbed Sample 63mm diameter
O	- Disturbed Sample
B	- Bulk Disturbed Sample
E	Environmental Sample
MC	Moisture Content
HP	Hand Penetrometer (UCS kPa)
VS	Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT	Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture

- 0 - Dry
- M Moist
- W Wet
- Wp - Plastic Limit
- WL - Liquid Limit

consistency / relative density

VS	-Very Soft
S	Soft
F	Firm
St	-Stiff
VS!	- Very Stiff
H	•Hard
Vl	•Very Loose
L	- Loose
MD	•Medium Dense
D	•Dense
VD	•Very Dense

coffey geotechnics

Engineering Log - Excavation

Excavation No.	*TP20*
Sheet No.	1 of 1
Project No.	*GH2828AK*
Client	*Wood & Grieve Engineers*
Date excavatBd	*26/6/07*
Principal :	
Date completed	*26/6/07*
Project	*Karratha Townsite and Industrial Estate*
Logged by :	*JD*
Location	*Karratha Townsite*
Checked by :	

Position : E: 487142.000, N: 7704081.000 (50 MGA94) Surface Elevation : 12.68 (AHD)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 3.00m long 0.50m wide

excavation information			material substance					
			classification symbol	material description SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components			hand penetrometer kPa 100 200 300 400	structure and additional observations
	D	0.0			D	L		Fines=31%:i; Sand-20%; Gravel=49%
		l--12.6			D	MD		
	0.50m D	0.5	GC	CLAYEY GRAVEL, coarse grained, pale, dusty, with angular clasts of weathered schist	D	MD		
		'-12.0						
		1.0-						
		i-11.5						
	1.SOm D	1.5						
		1-11.0						
	2.00m			EXCAVATION TP20 TERMINATED AT 2.00 m				
		l-10.5						
		2.5-						
		1-10.0						
		3.0-						
		9.5						
		3.5-						
		1-9.0						

method	penetration	samples & field tests	classification symbols & soil description Based on Unified Classification System	consistency / relative density
N Natural Exposure X Existing Excavation BH Backhoe Bucket 8 Bulldozer Blade R Excavator Ripper	ND Re,;soce 10 Dot, 73 Wat" Level on Date sho'Ml water inflow water outflow	USO Undisturbed Sample 50mm diameter U63 Undisturbed Sample 63mm diameter D Disturbed Sample 8 Bulk Disturbed Sample MC Moisture Content E Environmental Sample HP Hand Penetrometer (UCS kPa) VS Vane Shear; P-Peak, R-Remouded (uncorrected kPa) PBT Plate Bearing Test	moisture D D,y M Moist W Wet Wp Plastic Limit WL Liquid Limit	VS •Very Soft S Soft F firm St Stiff VS! •Very Stiff H •Hard VL •Very Loose L •Loose MD • Medium Dense D •Dense VD •Very Dense

support: T Timbering

coffey geotechnics

Engineering Log - Excavation

Client	*Wood & Grieve Engineers*	Excavation No.	*TP21*
Principal :		Sheet No.	1 of 1
Project	*Karratha Townsite and Industrial Estate*	Project No.	*GH2828AK*
Location	*Karratha Townsite*	Date excavared	*26/6/07*
		Date completed	*26/6/07*
		Logged by :	*JD*
		Checked by :	*Mn*

Position : E:487180.000, N:7704103.000 (50 MGA94) Surface Elevation : 12.477 (AHO)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 3.00m long 0.50m wide

excavation information		material substance			structure and additional obseivations
			material description		
			SOJL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and MnorComponents		
	1-12.0	0.S-	GC CLAYEY GRAVEL, coarse grained, brown	D MD	
			....interbedded weathered schist	L	
	115	1.0-			
	-11.0	t.5	SCHIST, brown green / white, weathered, with carbonate veins	D L	
	105	2.0-	EXCAVATION TP21 TERMINATED AT 1.80 m Refusal		
	10.0	2·5-			
	1-95	3.o-			
	'-90	3.5			

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nothod
- Natural Exposure
- Existing Excavation
- H Backhoe Bucket
- Bulldozer Blade
- Ripper
- Excavator

support
- "Timbering

penetration
- No Ros;,1a,ce

wateJ"
- Level on Date shown
- waler inflow
- water outflow

samples & field tests
- USO - Undisturbed Sample SOmm diameter
- U63 Undisturbed Sample 63mm diameter
- D Disturbed Sample
- B Bulk Disturbed Sample
- E - Environmental Sample
- MC Moisture Content
- HP Hand Penetrometer (UCS kPa)
- VS Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT - Plate Bearing Test

dasslficatfon symbols & soil description
Based on Unified Classification System

moisture
- D D,y
- M Moist
- W Wet
- Wp - Plastic limit
- WL - Liquid limit

consistency / relative density
- VS - Very Soft
- S -Soft
- F - Finn
- St -Stiff
- VSt - Very Stiff
- H - Hard
- VL -Very Loose
- L - loose
- MD - Medium Dense
- O - Dense
- VD - Very Dense

coffey e) geotechnics

Excavation No.	TP22
Sheet No.	1 of 1
Proiect No.	GH2828AK
Date excavatEd	26/6/07
Date completed	26/6/07
Logged by :	JD
Checked by :	ltn

Engineering Log - Excavation

Client	Wood & Grieve Engineers
Principal :	
Project	Karratha Townsite and Industrial Estate
Location	Karratha Townsite

Position E:487165.000, N:7704155.000 (50MGA94) Surface Elevation : 12.682 (AHD)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 3.00m long 0.50m wide

excavation information					material substance					structure and additional observations
penetration	support	ground water			SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Mnor Components				kPa	
				0.0	TOPSOIL, roots	O	L			
					CLAYEY GRAVEL, coarse grained, brown	D	MD			
					....getting lighter in colour with larger clasts of schist					Wt=24%; Wp=17%; lp=7%; LS=5%; Moisture=2.4%; Fines=39%
					EXCAVATION TP22 TERMINATED AT 2.00m					

mothod	penetration	samples & field tests	classification symbols & soil description Based on Unified Classification System	consistency / relative density
N Natural Exposure	No R;,taooo	USO - Undisturbed Sample 50mm diameter		VS - Very Soft
X Existing Excavation		U63 Undisturbed Sample 63mm diameter		S - Soft
BH Backhoe Bucket		D Disturbed Sample		F - Fim,
B Bulldozer Blade		B Bulk Disturbed Sample		St - Stiff
R Ripper	water	E - Environmental Sample	moisture	VS! - Very Stiff
E Excavator	water inflow	MC - Moisture Content	D - Dry	H - Hard
support	water outflow	HP - Hand Penetrometer (UCS kPa)	M - Moist	VL - Very Loose
T Timbering		VS Vane Shear; P-Peak, R-Remouded {uncorrected kPa)	W Wet	L - Loose
		PBT - Plate Bearing Test	Wp - Plastic Limit	MD - Medium Dense
			Wl - Liquid limit	D - Dense
				VD - Very Dense

coffey e) geotechnics

Engineering Log - Excavation

Excavation No.	TP23		
Sheet No.	1 of 1		
Project No.	GH2828AK		
Client	Wood & Grieve Engineers	Date excavatBd	26/6/07
Principal :		Date completed	26/6/07
Project	Karratha Townsite and Industrial Estate	Logged by	JD
Location	Karratha Townsite	Checked by :	fwi

Position : E:487152.000, N:7704197.000 (50 MGA94) Surface Elevation : 12.89 (AHD)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 3.00m long 0.50m wide

excavation information				material substance						
penetration	support	ground water			classification symbol	material description SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa 100 200 300 400	structure and additional observations
			0.0		GC	CLAYEY GRAVEL, coarse grained, brown, roots	D	MD	TT TT	
	Not Observed		0.5			SCHIST, grey blue, rock with brown silty graver	D	L		Schist is low to medium strength and strongly foliated
		1.00m 0	1.0							SMDD=2.35t/m³; OMC=6.5%; CBR=100%
		1.30m				Collapse, large rock EXCAVATION TP23 TERMINATED AT 1.30 m Refusal				
			1.5							
			2.0							
			2.5							
			3.0							
			3.5							

method
N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper
E Excavator

support
T Timbering

penetration
g! w u.:i:5
No R;t,ace

wate,
10Oct., 73 Water Level on Date shO'NII
water inflow
<1111 water outflow

samples & field tests
USO - Undisturbed Sample 50mm diameter
U63 Undisturbed Sample 63mm diameter
D Disturbed Sample
B - Bulk Disturbed Sample
E - Environmental Sample
MC Moisture Content
HP Hand Penetrometer (UCS kPa)
VS Vane Shear; P-Peak,
PBT Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
D D,y
M Moist
W Wei
W, - Plastic limit
W, - liquid limit

consistency / relative density
VS - Very Soft
S -Soft
F -Firm
St -Stiff
VS, • Very Stiff
H - Hard
VL • Very oose
L - Loose
MO • Medium Dense
D • Dense
VD - Very Dense

coffey geotechnics

Engineering Log - Excavation

Client	*Wood & Grieve Engineers*	Excavation No.	*TP24*
Principal :		Sheet No.	1 of 1
Project	*Karratha Townsite and Industrial Estate*	Project No.	*GH2828AK*
Location	*Karratha Townsite*	Date excavated	*26/6/07*
		Date completed	*26/6/07*
		Logged by :	*JD*
		Checked by :	

Position : E:487135.000, N:7704236.000 (50 MGA94) Surface Elevation : 13.09 (AHO)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 3.00m long 0.50m wide

excavation information	material substance		structure and additional observations
	0.0	TOPSOIL, roots	
	1.0	....becoming lighter with larger clasts of schist	
	1.5	....becoming lighter with larger clasts of schist	
	2.0	EXCAVATION TP24 TERMINATED AT 2.00 m	
	3.0		
	3.5		

method	penetration	samples & field tests	classification symbols & soil description Based on Unified Classification System	consistency / relative density
N Natural Exposure X Existing Excavation BH Backhoe Bucket B Bulldozer Blade R Ripper E Excavator T Timbering support	No R,s;staoc, wat w l10 0ot., 73 Watec Level on Date shown water outflow water inflow	USO - Undisturbed Sample 50mm diameter U63 - Undisturbed Sample 63mm diameter D Disturbed Sample B Bulk Disturbed Sample E Environmental Sample MC - Moisture Content HP Hand Penetrometer {UCS kPa} R·Remouded (uncorrected kPa) VS Vane Shear; P-Peak, PBT - Plate Bearing Test	moisture D D,y M Moist W Wet WL - liquid Limit Wp - Plastic Limit	VS -Very Soft S -Soft F -Firm St -Stiff VS! -Very Stiff H -Hard VL •Very Loose MD -Medium Dense L -Loose D -Dense VD •Very Dense

coffey e) geotechnics

Engineering Log - Excavation

Client	*Wood & Grieve Engineers*	Excavation No.	*TP25*
Principal :		Sheet No.	1 of 1
Project	*Karratha Townsite and Industrial Estate*	Project No.	*GH2828AK*
Location	*Karratha Townsite*	Date excavated	*26/6/07*
		Date completed	*26/6/07*
		Logged by	*JD*
		Checked by :	*'.,tZ*

osition : E: 487129.000, N: 7704322.000 (50 MGA94) Surface Elevation : 13.88 (AHD)

quipment type : Backhoe Method : Backhoe Excavation dimensions : 3.00m long 0.50m wide

excavation information			material substance					structure and additional observations
			SOILTYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components				kPa	
	O.Om	O.O	CLAYEY GRAVEL, medium grained, brown, roots to 0.1m	GC	D	MD		
		0 5	....becoming pale brown, almost white					
			CLAYEY GRAVEL, coarse grained, low plasticity	GC	D	MD		
	1.oom	1.0-	....becoming lighter colour with larger clasts of schist					Fines=30%; Sand=26%; Gravel=44o/o
	1.som	1.s-	....becoming lighter colour					
		2.0-	EXCAVATION TP25 TERMINATED AT 1.90 m Refusal					
		3.5-						

method
N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper
E Excavator

support
T Timbering

penetration
No Ros;,1a,ce

water
110 Oct.. 73 Water evel on Date shov.n
water inflow
water outflow

samples & field tests
USO Undisturbed Sample 50mm diameter
U63 Undisturbed Sample 63mm diameter
D - Disturbed Sample
B Bulk Disturbed Sample
E Environmental Sample
f...C M:listure Content
HP - Hand Penetrometer (UCS kPa)
VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
D - Dry
M - M:list
W - Wet
WP • Plastic Limit
WL - Liquid Limit

consistency / relative density
VS • Very Soft
S - Soft
F - Firm
St Stiff
vst - Very Stiff
H • Hard
VL • Very Loose
L - Loose
MD • Medium Dense
D - Dense
VD - Very Dense

coffey e) geotechnics

Engineering Log - Excavation

Excavation No.	TP26
Sheet No.	1 of 1
Project No.	GH2828AK
Date excava1Bd	27/6/07
Date completed	27/6/07
Logged by :	JD
Checked by :	lrri

Client: *Wood & Grieve Engineers*

Principal:

Project: *Karratha Townsite and Industrial Estate*

Location: *Karratha Townsite*

Position : E:487179.000, N:7704314.000 (50MGA94) Surface Elevation : 13.61 (AHD)

Equipment type : Backhoe Method : Backhoe Excavation dimensions :2.00m long 0.50m wide

excavation information	material substance				structure and additional observations
	GC	CLAYEY GRAVEL, dark brown, some roots to 0.2m	D	MD	
	GC	CLAYEY GRAVEL, low plasticity, dark brown, some clay/silt, with white clasts of schist	D	MD	
1.0		EXCAVATION TP26 TERMINATED AT 1.90 m Refusal			
2.0					
2.5					
3.0					
3.5					

mothod
N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper
E Excavator

support
T Timbering

penetration
No Re,;,ta,oo

Level on Date shown
water inflow
water outflow

samples & field tests
U63 Undisturbed Sample 63mm diameter
D Disturbed Sample
B Bulk Disturbed Sample
E Environmental Sample
MC Moisture Content
U50 Undisturbed Sample 50mm diameter
HP Hand Penetrometer (UCS kPa)
VS Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
D Dey
M Moist
W Wet
Wp Plastic limit
WL Liquid Limit

consistency / relative density
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VS! - Very Stiff
H - Hard
VL - Very oose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

coffey geotechnics

Engineering Log - Excavation

Client	*Wood & Grieve Engineers*	Excavation No.	*TP27*
Principal :		Sheet No.	1 of 1
Project	*Karratha Townsite and Industrial Estate*	Project No.	*GH2828AK*
Location	*Karratha Townsite*	Date excava1Bd	*27/6/07*
		Date completed	*27/6/07*
		Logged by	*JD*
		Checked by :	

Position : E: 487310.000, N: 7704269.000 (50 MGA94) Surface Elevation : 12.64 (AHD)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 3.00m long 0.50m wide

excavation information			material substance		
method / penetration / support / ground water			material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components		structure and additional observations
		12.5	0.0 GC: CLAYEY GRAVEL, coarse grained, brown, some roots to 0.1m, trace silt/clay		
	0.70m D	1-12.0	0.5 ...with schist cobbles		Fines=23%; Sand=24%; Gravel=53%
	1.00m	11.5	1.0		
		1-11.0	1.5 ....schist cobbles becoming larger		
		-10.5	2.0		
		1-,0.0	2.5		
		9.5	3.0		
		1-9.0	3.5		

EXCAVATION TP27 TERMINATED AT 1.70m
Refusal

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method	penetration	samples & field tests	classification symbols & soil description Based on Unified Classification System	consistency / relative density
N Natural Exposure X Existing Excavation BH Backhoe Bucket B Bulldozer Blade R Ripper E Excavator	WLL r5 No Ros;,1a,oo	USO Undisturbed Sample 50mm diameter U63 • Undisturbed Sample 63mm diameter D Disturbed Sample B Bulk Disturbed Sample E Environmental Sample MC - Moisture Content HP • Hand Penetrometer (UCS kPa) VS Vane Shear; P-Peak, R-Remouded (uncorrected kPa) PBT - Plate Bearing Test	moisture D D,y M - M;>ist W • Wet Wp • Plastic Limit WL - Liquid Limit	VS • Very Soft S - Soft F - Firm St - Stiff VS! - Very Stiff H • Hard VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense
support T Timbering	water 10 Oct 73 Water Level on Date shown water inflow water outflow			

coffey e) geotechnics

Engineering Log - Excavation

Excavation No.	TP28
Sheet No.	1 of 1
Project No.	GH2828AK
Date excavatBd	27/6/07
Date completed	27/6/07
Logged by :	JD
Checked by :	":iA

Client	Wood & Grieve Engineers
Principal :	
Project	Karratha Townsite and Industrial Estate
Location	Karratha Townsite

osition : E: 487428.000, N: 7704138.000 (50 MGA94)

Surface Elevation : 11.6 (AHD)

quipment type : Backhoe

Method : Backhoe

Excavation dimensions : 2.00m long 0.50m wide

xcavation information **material substance**

material description

SOILTYPE, P/asticity orParticte Characteristic, Colour, Secondary and Minor Components

structure and additional obseivations

kPa

material description	moisture	consistency / density	structure and additional obseivations
SILT**Y GRAVEL,** medium grained, brown	D	MD	
....weathered schist, brown fines			Orientated *NIE* direction
••••some schist	L		
EXCAVATION TP28 TERMINATED AT 1.90 m Refusal			

method	penetration	samples & field tests	classlflcatfon symbols & soil description	consistency / relative density
N Natural Exposure X Existing Excavation BH Backhoe Buckel B Bulldozer Blade R Ripper E Excavator T Timbering support	No Res;st,ooe wate 10 Oct.. 73 Wato, level on Date shown water inflow water outflow	USO Undisturbed Sample 50mm diameter U63 - Undisturbed Sample 63mm diameter D Disturbed Sample B - Bulk Disturbed Sample E Environmental Sample MC Moisture Content HP Hand Penetrometer (UCS kPa) R-Remouded (uncorrected kPa) VS - Vane Shear; P-Peak, PBT Plate Bearing Test	Based on Unified Classification System moisture D - Dey M - Moist W Wet W; - Plastic Limit Liquid Limit	VS • Very Soft S - Soft F - Firm St Stiff VS, - Very Stiff H • Hard VL - Very loose L - Loose MD • Medium Dense D - Dense VD - Very Dense

coffey geotechnics

Engineering Log - Excavation

Client	*Wood & Grieve Engineers*	Excavation No.	*TP29*
Principal :		Sheet No.	1 of 1
Project	*Karratha Townsite and Industrial Estate*	Project No.	*GH2828AK*
Location	*Karratha Townsite*	Date excavated	*27/6/07*
		Date completed	*27/6/07*
		Logged by :	*JD*
		Checked by :	*fm*

osition : E: 487370.000, N: 7704042.000 (50 MGA94) Surface Elevation : 11.81 (AHO)

quipment type : Backhoe Method : Backhoe Excavation dimensions : 3.00m long 0.50m wide

excavation information penetration	material substance	material description SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	structure and additional observations
0.10m	0.0	CL-Cl GRAVELLY CLAY, brown red, some roots to 0.1m D F	Fines=64%; Sand=31%; Gravel=5%
1-9.5			
2.5-			
"-9.0			
3.0-			

method	penetration	samples & field tests	classification symbols & soil description Based on Unified Classification System	consistency / relative density
N Natural Exposure X Existing Excavation BH Backhoe Buckel B Bulldozer Blade R Ripper E Excavator support T Timbering	!!!wu.:r5 No R,s;staace wat _I._,10 0ct., 73 Water Level on Date shown water inflow wateroutflow	USO Undisturbed Sample SOmm diameter U63 - Undisturbed Sample 63mm diameter D - Disturbed Sample B Bulk Disturbed Sample E Environmental Sample MC Moisture Content HP - Hand Penetrometer (UCS kPa} VS - Vane Shear: P-Peak, R-Remouded (uncorrected kPa) PBT Plate Bearing Test	moisture D D,y M - Moist W - Wet Wp - Plastic Limit WL - Liquid Limit	VS - Very Soft S - Soft F - Firm St - Stiff VSt - Very Stiff H - Hard VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense

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Engineering Log - Excavation

Excavation No.	TP30
Sheet No.	1 of 1
Project No.	GH2828AK
Client	Wood & Grieve Engineers
Date excavated	27/6/07
Principal :	
Date completed	27/6/07
Project	Karratha Townsite and Industrial Estate
Logged by :	JD
Location	Karratha Townsite
Checked by :	

Position : E: 487205.000, N: 7703955.000 (50 MGA94) Surface Elevation : 12.22 (AHO)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 3.00m long 0.50m wide

excavation information | material substance

method	penetration	support	ground water	depth	RL	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)				structure and additional observations
BH			Not Observed	0.20m D	12.0	SILTY GRAVEL, coarse grained, brown, some roots	GP	D	MD	
				1.00m	L11.5					SMDD=1.97t/m³ OMC=12%; CBR=3%
					L11.0	...clasts becoming larger				
				1.50m D		SCHIST, layered, blue / green, weathered, low to medium strength, strongly foliated, trace silt		M	L	
				1.60m		EXCAVATION TP30 TERMINATED AT 1.80 m Refusal				
					L10.0					
					L9.5					

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator
- Timbering

penetration
- No Resistance

water
- Level on Date shown
- water inflow
- water outflow

samples & field tests
- USO - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D Disturbed Sample
- B Bulk Disturbed Sample
- E Environmental Sample
- Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- O Dry
- M Moist
- W Wet
- Wp - Plastic Limit
- WL - Liquid Limit

consistency / relative density
- VS - Very Soft
- S - Soft
- F - Firm
- St - Stiff
- VS - Very Stiff
- H - Hard
- VL - Very Loose
- L - Loose
- MD - Medium Dense
- D - Dense
- VD - Very Dense

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Engineering Log - Excavation

Excavation No.	*TP31*		
Sheet No.	1 of 1		
Project No.	*GH2828AK*		
Client	*Wood & Grieve Engineers*	Date excavated	*27/6/07*
Principal :		Date completed	*2716/07*
Project	*Karratha Townsite and Industrial Estate*	Logged by :	*,ID*
Location	*Karratha Townsite*	Checked by :	*hn*

osition : E: 487591.000, N: 7704125.000 (50 MGA94) Surface Elevation : 10.99 (AHD)

quipment type : Backhoe Method : Backhoe Excavation dimensions : 3.00m long 0.50m wide

excavation information material substance

				material description SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components		structure and tional observations
		0.0		CLAY, EXTREMELY coarse-grained, brown, some roots		
		1	0.5	...with some schist clasts		
	1.00m	10.0	1.0			
				b reased schist content, gravel becoming pale		WL=29o/o; Wp=18%; lp=11%; LS=5%; Moisture=3.7%; Fines=45%
	1.50m		1.5			
		9.0	2.0	EXCAVATION TP31 TERMINATED AT 1.90 m Refusal		
		8.5	2.5			
		s.o	3.0			
		7_5	3.5			

method	penetration	samples & field tests	classification symbols & soil description Based on Unified Classification System	consistency / relative density
N Natural Exposure	N, Reslstaoce	USO Undisturbed Sample SOmm diameter		VS - Very Soft
X Existing Excavation		U63 Undisturbed Sample 63mm diameter		S Soft
BH Backhoe Bucket		D Disturbed Sample		F - Firm
B Bulldozer Blade		B - Bulk Disturbed Sample	moisture	St - Stiff
R Ripper	water	E - Environmental Sample	D D,y	VS, - Very Stiff
E Excavator	Level on Date Shown	MC Moisture Content	M Moist	H - Hard
support	water inflow	HP Hand Penetrometer (UCS kPa)	W Wet	VL - Very oose
T Timbering	.... waler outflow	VS Vane Shear; P-Peak, R-Remouded (uncorrected kPa)	W, - Plastic Limit	L -Loose
		PBT Plate Bearing Test	W, . Liquid Limit	MO - Medium Dense
				D - Dense
				VD - Very Dense

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Engineering Log - Excavation

Excavation No.	*TP32*
Sheet No.	1 of 1
Project No.	*GH2828AK*
Date excavated	*27/6/07*
Date completed	*27/6/07*
Logged by :	*JD*
Checked by :	

Client *Wood & Grieve Engineers*
Principal :
Project *Karratha Townsite and Industrial Estate*
Location *Karratha Townsite*

osition : E:487697.000, N:7704213.000 (50 MGA94) Surface Elevation : 10.49 (AHD)
quipment type : Backhoe Method : Backhoe Excavation dimensions : 3.00m long 0.50m wide

xcavation information material substance

method	RL	depth	graphic log	classification symbol	material description SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	structure and additional observations
BH	10.0	0.0		CI	GRAVELLY CLAY, medium plasticity, dark brown, some roots	D	F	WL=49%; Wp=18°/o; Ip=31%; LS=15%; Moisture=2%; Fines=69%
		0.5			....with schist clasts, cobbles, weathered		MD	
		1.0						
	9.D	1.5						
	8.0	2.5						
	7.5	3.0						
	7.0	3.5						

D

0.50m

method	penetration	samples & field tests	dasslflcatlon symbols & soil description	consistency / relative density
N Natural Exposure X Existing Excavation BH Backhoe Bucket B Bulldozer Blade R Ripper E Excavator support T limbering	wu.r5 ■ ND R,s;staoo, wate, .,. ,10 Oci.• 73 Watec -;:p- Level on Date shown ..... water inflow 1----4 water outflow	USO Undisturbed Sample 50mm diameter U63 Undisturbed Sample 63mm diameter D Disturbed Sample B Bulk Disturbed Sample E Environmental Sample MC Moisture Content HP Hand Penetrometer (UCS kPa) VS Vane Shear; P-Peak, R-Remouded (uncorrected kPa) PST Plate Bearing Test	Based on Unified Classification System moisture D - Dry M - Moist W - Wet Wp - Plastic Limit WL - Liquid Limit	VS - Very Soft S - Soft F - Firm St - Stiff VSt - Very Stiff H - Hard VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense

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Engineering Log - Excavation

Client	*Wood & Grieve Engineers*	Excavation No.	*TP33*
Principal :		Sheet No.	1 of 1
Project	*Karratha Townsite and Industrial Estate*	Project No.	*GH2828AK*
Location	*Karratha Townsite*	Date excavated	*27/6/07*
		Date completed	*27/6/07*
		Logged by :	*JD*
		Checked by :	*fm*

Position E: 487647.000, N: 7704199.000 (50 MGA94) Surface Elevation : 10.77 (AHO}

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 3.00m long 0.50m wide

excavation information | material substance

method	penetration	support	ground water			material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture	consistency	structure and additional observations
				0.1-10.	GC	CLAYEY GRAVEL, dark brown, some roots	D	MD	
				0.S	GC	CLAYEY GRAVEL,pale brown, with schist clasts	D	L	
				1-10.					
				1.0	GC	CLAYEYGRAVEL,pale,lots of chlorite schists	D	L	
				'-9.5					
				1.s-					
				'-9.0		EXCAVATION TP33 TERMINATED AT 1.70 m Refusal			
				2.0-					
				'-8.5					
				2.5-					
				3.0-					
				1-7.5					
				3.5-					
				1-7.0					

COFFEY 01.GLB Log EXCAVATION GH2828AK TESTPITS.GPJ DWG31981.GDW 03/08/2007 10:34

method

- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer B!ade
- R Ripper
- E Excavator
- Limbering

penetration

W LL :Z: 5 No Re,;;taoce

W- ,10 O„ 73Wate,

..,..;,..- Level on Date shown water inflow

r---<III water outflow

samples & field tests

- USO Undisturbed Sample 50mm diameter
- U63 Undisturbed Sample 63mm diameter
- D - DisturbedSample
- B - Bulk Disturbed Sample
- E Environmental Sample
- MC Moisture Content
- HP Hand Penetrometer {UCS kPa)
- VS - Vane Shear; P-Peak, R-Remouded {uncorrected kPa)
- PBT Plate Bearing Test

classification symbols & soil description

Based on Unified Classification System

moisture

- D - Dry
- M - Moist
- W Wei
- Wp • Plastic limit
- WL • Liquid limit

consistency / relative density

- VS - Very Soft
- S -Soft
- F • Rnn
- St -Stiff
- VS! - Very Stiff
- H • Hard
- VI • Very Loose
- L • Loose
- MD • Medium Dense
- D -Dense
- VD • Very Dense

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Engineering Log - Excavation

Excavation No.	TP34		
Sheet No.	1 of 1		
Project No.	GH2828AK		
Client	Wood & Grieve Engineers	Date excavatBd	27/6/07
Principal :		Date completed	27/6/07
Project	Karratha Townsite and Industrial Estate	Logged by :	JD
Location	Karratha Townsite	Checked by :	':,A._

Position : E:487580.000, N:7704298.000 (50 MGA94) Surface Elevation : 11.48 {AHD)

Equipment type : Backhoe Method : Backhoe Excavation dimensions : 3.00m long 0.50m wide

excavation information		material substance		
		material description SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components		structure and additional observations
	1-11.0	..with schist cobbles, becoming lighter in colour	L	
	1-10.5			
	-10.0			
	9.5	EXCAVATION TP34 TERMJNATED AT 2.10 m		
	L...9,0			
	1-8.5			
	L...a.o			

method
N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper
E Excavator
support
T Timbering

penetration
No Resistaoce
wate,
Level on Date shov.n
water inflow
water outflow

samples & fieldtests
USO - Undisturbed Sample 50mm diameter
U63 Undisturbed Sample 63mm diameter
0 Disturbed Sample
B Bulk Disturbed Sample
E - Environmental Sample
MC tv1oisture Content
HP Hand Penetrometer (UCS kPa)
VS Vane Shear: P-Peak, R-Remouded (uncorrected kPa)
PBT Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
D - D.y
M f...bist
W Wet
W, - Plastic Limit
W, - Liquid Limit

consistency / relative density
VS - Very Soft
S -Soft
F -Firm
St -Stiff
VSt - Very Stiff
H - Hard
VL -Very loose
L -Loose
MD • Medium Dense
D • Dense
VD - Very Dense

Appendix B

Results of Laboratory Testing

Particle Size Distribution (8 Pages)

Atterberg Limits & Percent Fines (8 Pages)

Moistue/Density Relationship (4 Pages)

California Bearing Ratio of Remoulded Specimens (4 Pages)

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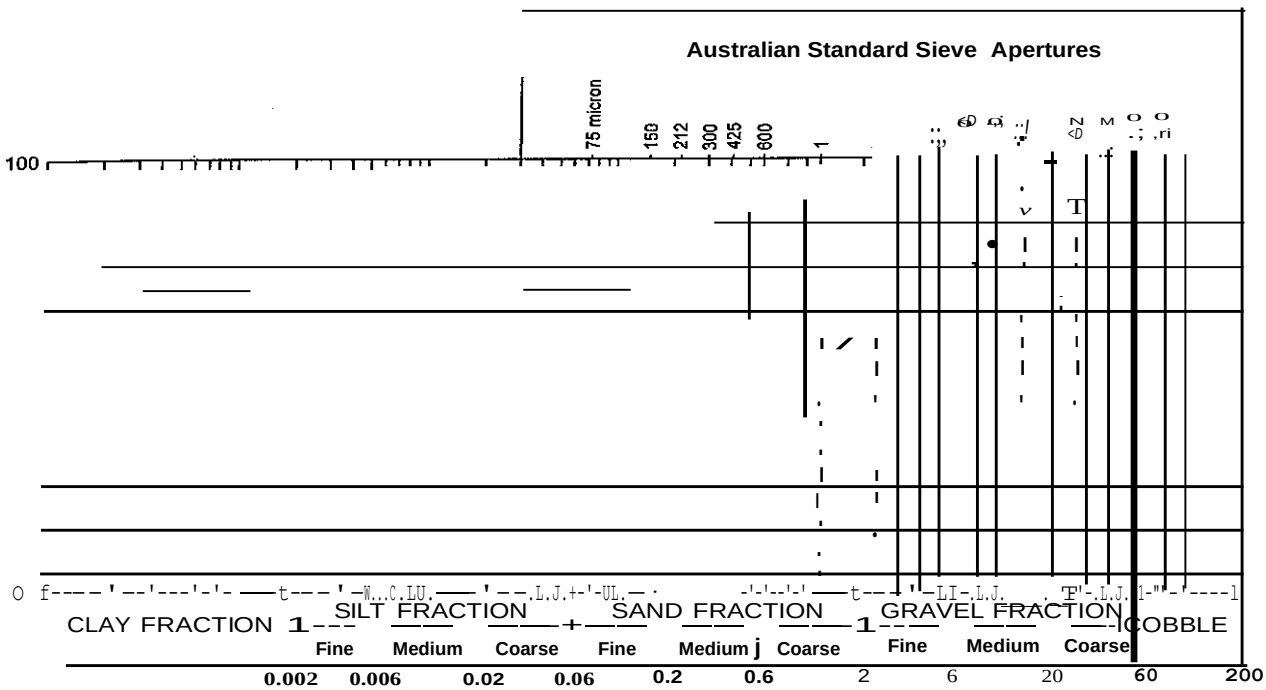
TEST CERTIFICATE

Client: Coffey Geotechnics GEOTHERD02828AK **Report No.:** HERD07S - 03319
Principal: -
Project: Karratha Townsite & Insdustrial Estate **Job No.:** LABTHERD00254AA
Location: Karratha
Sample ID: TP 1, 1.0-1.5m **Date Tested:** *1210112001*

Particle Size Distribution of a Soil

Standard Method of Analysis by Sieving: AS 1289.3.6.1

Sieving				Sieving			
Sieve Size	% Passing	Sieve Size	% Passing	Sieve Size	% Passing	Sieve Size	% Passing
150.0mm		1.18 mm	53				
75.0mm		600 micron	49				
37.5 mm	100	425 micron	47				
19.0 mm	91	300 micron	45				
9.50 mm	81	150 micron	41				
4.75 mm	71	75 micron	37				
2.36mm	61						



Remarks: Sampling Method/s - Submitted by client

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W.Rozmianiec

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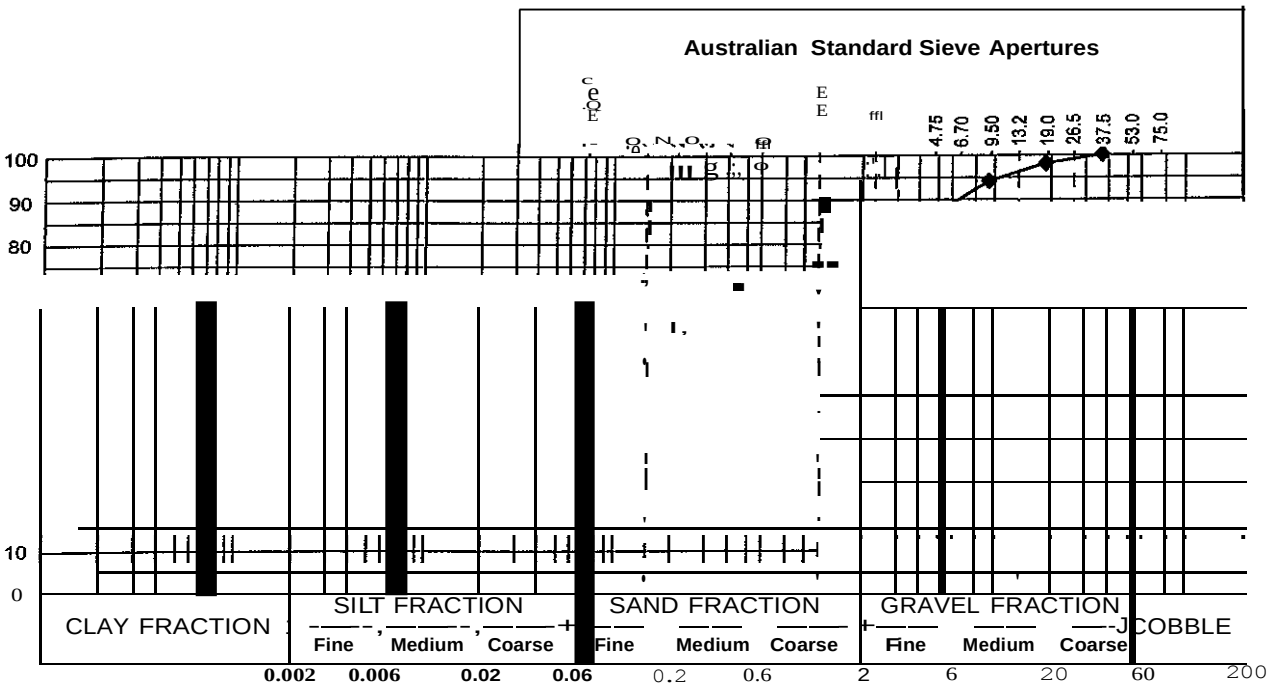
Client: Coffey Geotechnics GEOTHERD02828AK **Report No.:** HERD07S - 03322
Principal: -
Project: Karratha Townsite & Insdustrial Estate **Job No.:** LABTHERD00254AA
Location: Karratha
Sample ID: TP 4, 1.0-1.5m **Date Tested:** 12/07/2007

Particle Size Distribution of a Soil

Standard Method of Analysis by Sieving: AS 1289.3.6.1

Sieving				Sieving			
Sieve Size	% Passing	Sieve Size	% Passing	Sieve Size	% Passing	Sieve Size	% Passing
150.0mm		1.18 mm	71				
75.0mm		600 micron	68				
37.5 mm	100	425	66				
19.0 mm	98	micron	65				
9.50 mm	94	300	57				
4.75 mm	86	micron	50				
2.36mm	77	150 micron					



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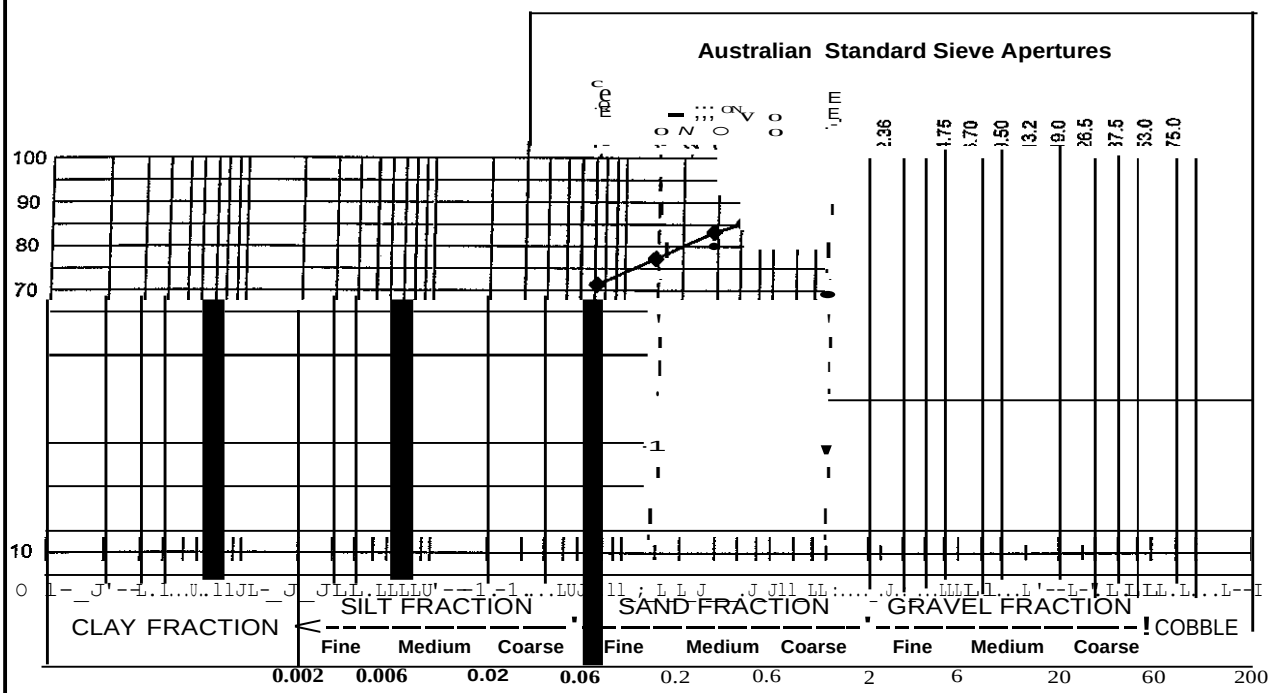
Client: Coffey Geotechnics GEOTHERD02828AK **Report No.:** HERD07S - 03327
Principal: -
Project: Karratha Townsite & Insdustrial Estate **Job No.:** LABTHERD00254AA
Location: Karratha
Sample ID: TP 12. o.5-1.5m **Date Tested:** 12/07/2007

Particle Size Distribution of a Soil

Standard Method of Analysis by Sieving: AS 1289.3.6.1

Sieving				Sieving			
Sieve Size	% Passing	Sieve Size	% Passing	Sieve Size	% Passing	Sieve Size	o/o Passing
150.0mm		1.18 mm	91				
75.0mm		600 micron	86				
37.5 mm		425 micron	85				
19.0 mm	100	300 micron	83				
9.50 mm	99	150 micron	77				
4.75 mm	98	75 micron	71				
2.36mm	96						



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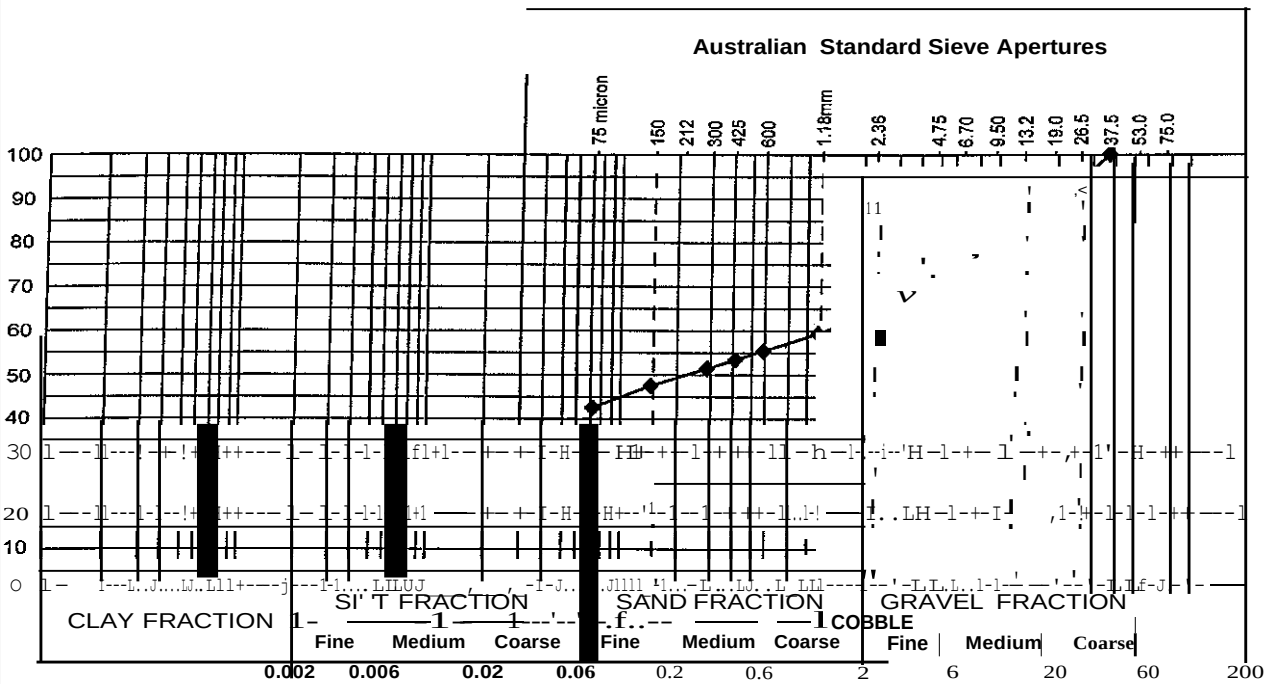
Client: Coffey Geotechnics GEOTHERD02828AK **Report No.:** HERD07S - 03330
Principal: -
Project: Karratha Townsite & Insdustrial Estate **Job No.:** LABTHERD00254AA
Location: Karratha
Sample ID: TP 14, 1.5-1.Bm **Date Tested:** *1210112001*

Particle Size Distribution of a Soil

Standard Method of Analysis by Sieving: AS 1289.3.6.1

Sieving				Sieving			
Sieve Size	% Passing	Sieve Size	% Passing	Sieve Size	% Passing	Sieve Size	% Passing
150.0mm		1.18 mm	59				
75.0mm	100	600 micron	55				
37.5 mm	88	425 micron	53				
19.0 mm	80	300 micron	51				
9.50 mm	71	150 micron	47				
4.75 mm	64	75 micron	42				



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Date: 20/07/2007

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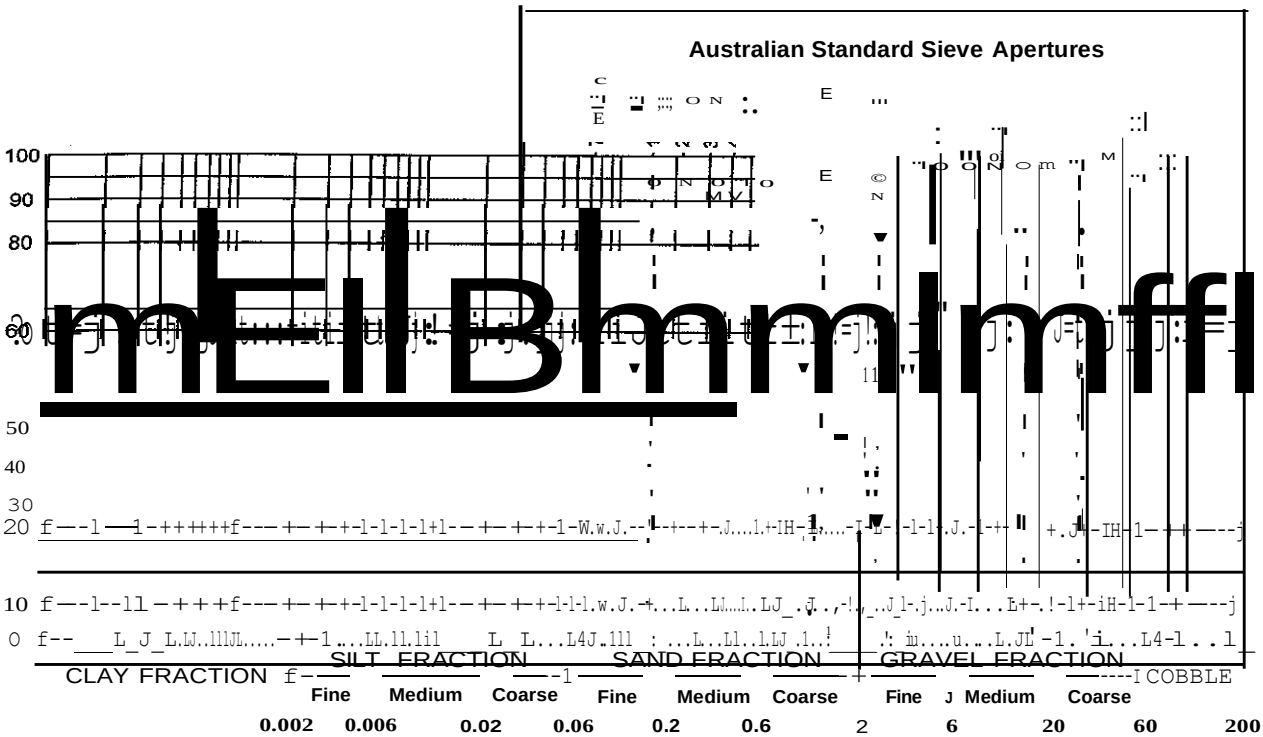
Client: Coffey Geotechnics GEOTHERD02828AK **Report No.:** HERD07S - 03334
Principal: -
Project: Karratha Townsite & Insdustrial Estate **Job No.:** LABTHERD00254AA
Location: Karratha
Sample ID: TP 20, 0.1-0.5m **Date Tested:** *1210112001*

Particle Size Distribution of a Soil

Standard Method of Analysis by Sieving: AS 1289.3.6.1

Sieving				Sieving			
Sieve Size	% Passing	Sieve Size	% Passing	Sieve Size	% Passing	Sieve Size	% Passing
150.0mm		1.18 mm	45				
75.0mm	100	600 micron	42				
37.5 mm	98	425 micron	41				
19.0 mm	91	300 micron	40				
9.50 mm	74	150 micron	36				
4.75 mm	51	75 micron	31				



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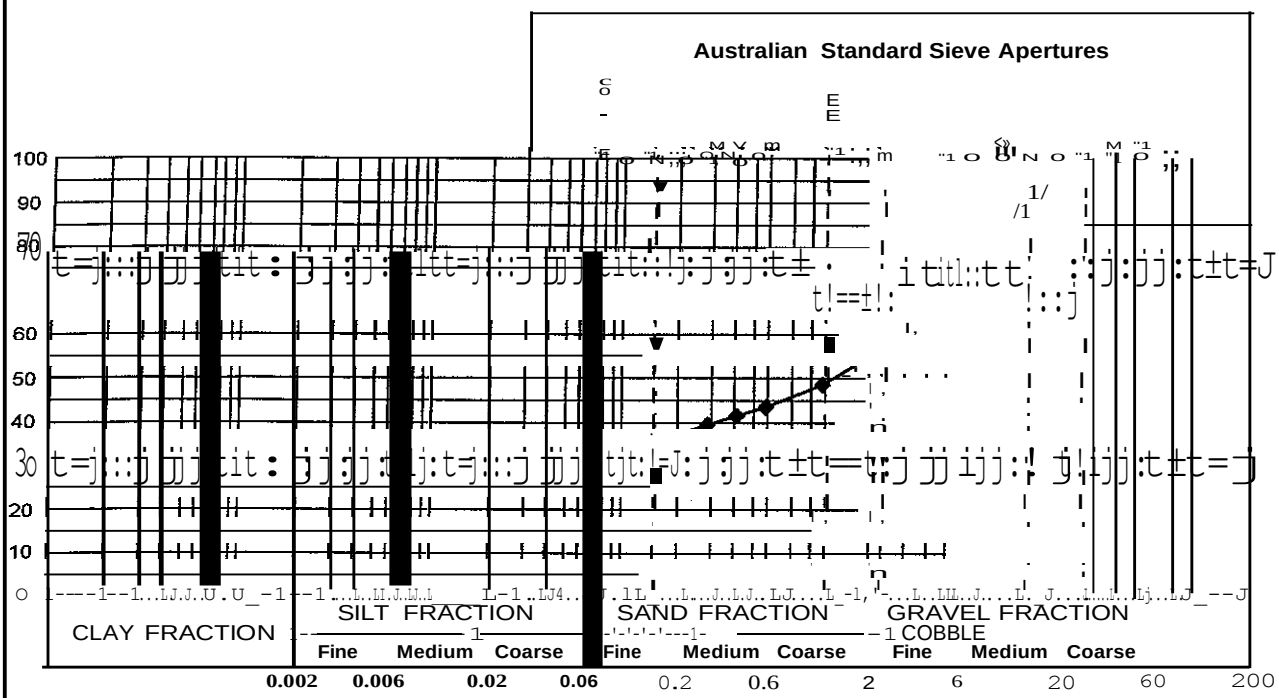
TEST CERTIFICATE

Client: Coffey Geotechnics GEOTHERD02828AK **Report No.:** HERD07S - 03339
Principal: -
Project: Karratha Townsite & Insdustrial Estate **Job No.:** LABTHERD00254AA
Location: Karratha
Sample ID: TP 25, 1.0-1.5m **Date Tested:** 12/07/2007

Particle Size Distribution of a Soil

Standard Method of Analysis by Sieving: AS 1289.3.6.1

Sieving				Sieving			
Sieve Size	% Passing	Sieve Size	% Passing	Sieve Size	% Passing	Sieve Size	o/o Passing
150.0mm		1.18 mm	48				
75.0mm		600	43				
37.5 mm	100	micron	41				
19.0 mm	98	425	39				
9.50 mm	81	micron	35				
4.75 mm	66	300 micron	30				
2.36mm	56	150 micron					



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Date: 20/07/2007

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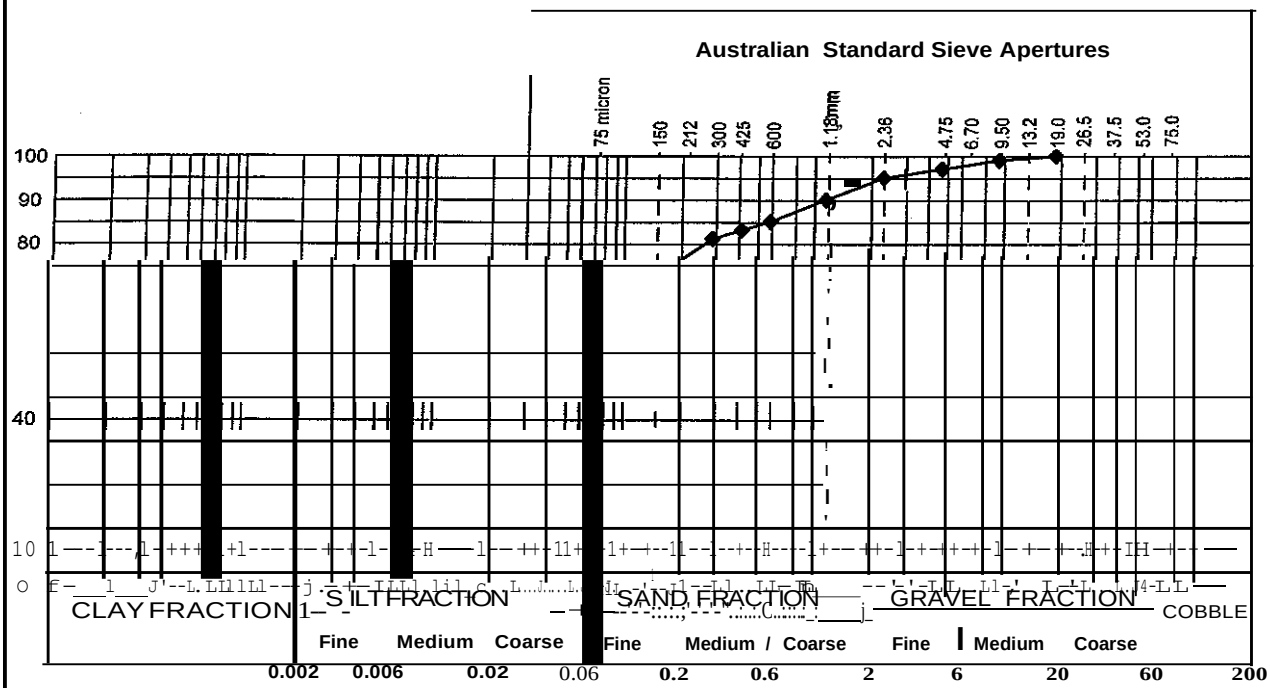
TEST CERTIFICATE

Client: Coffey Geotechnics GEOTHERD02828AK **Report No.:** HERD07S - 03341
Principal: -
Project: Karratha Townsite & Insdustrial Estate **Job No.:** LABTHERD00254M
Location: Karratha
Sample ID: TP 29, 0.1-0.5m **Date Tested:** 12/07/2007

Particle Size Distribution of a Soil

Standard Method of Analysis by Sieving: AS 1289.3.6.1

Sieving				Sieving			
Sieve Size	% Passino	Sieve Size	% Passing	Sieve Size	% Passing	Sieve Size	o/o Passino
150.0mm		1.18 mm	90				
75.0mm		600 micron	85				
37.5 mm		425	83				
19.0 mm	100	micron	81				
9.50 mm	99	300 micron	72				
4.75 mm	97	150 micron	64				
2.36mm	95	75 micron					



Remarks: Sampling Method/s - Submitted by client

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Authorised Signature:

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Date: 20/07/2007

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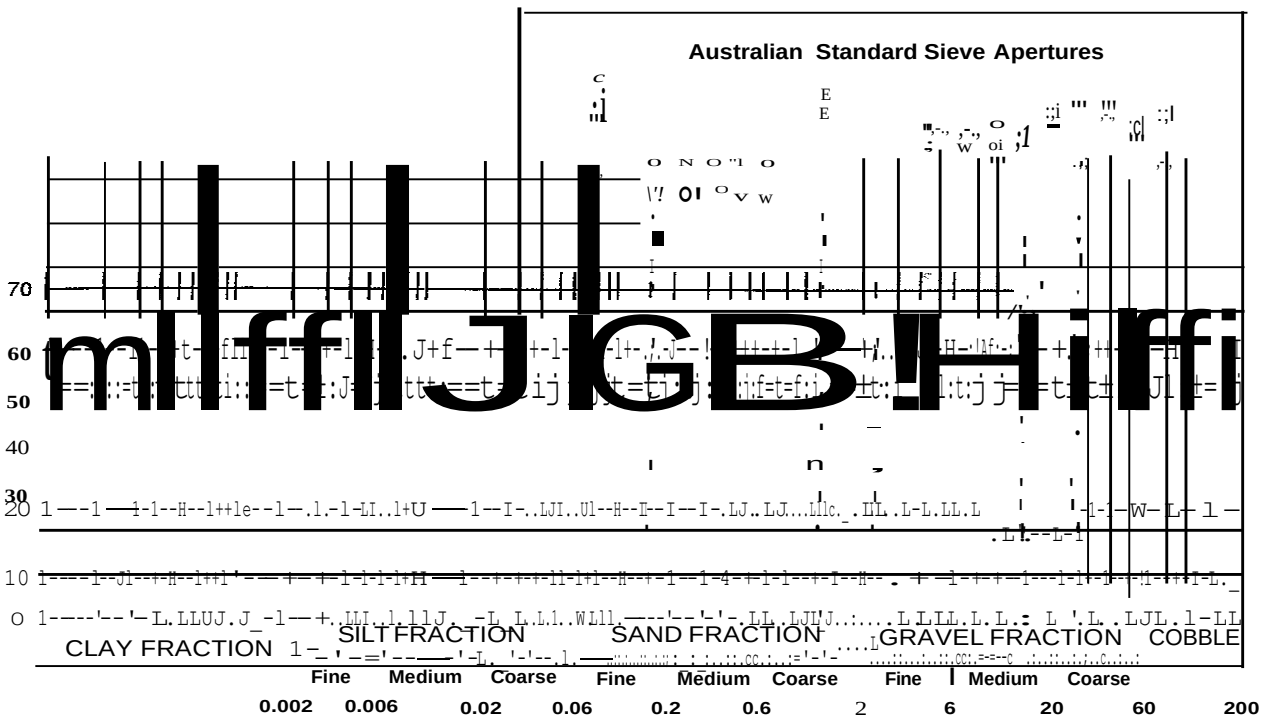
TEST CERTIFICATE

Client: Coffey Geotechnics GEOTHERD02828AK **Report No.:** HERD07S - 03340
Principal: -
Project: Karratha Townsite & Insdustrial Estate **Job No.:** LABTHERD00254AA
Location: Karratha
Sample ID: TP 27, 0.7-1.0m **Date Tested:** 12/07/2007

Particle Size Distribution of a Soil

Standard Method of Analysis by Sieving: AS 1289.3.6.1

Sieving				Sieving			
Sieve Size	% Passing	Sieve Size	% Passing	Sieve Size	% Passing	Sieve Size	o/o Passing
		1.18 mm	41				
150.0mm	100	600 micron	37				
75.0mm	96	425 micron	34				
37.5	78	300	32				
mm 19.0	60	micron	27				
mm	52	150 micron	23				
9.50 mm	47	75 micron					



Remarks: Sampling Method/s - Submitted by client

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Authorised Signature:

W.Rozmianiec

Date: 20/07/2007

NATA Acc. Laboratory No 431

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TEST CERTIFICATE

Client: Coffey Geotechnics GEOTHERD02828AK
Principal: -
Project: Karratha Townsite & Insdustrial Estate
Location: Karratha

Report No.: HERD07S-03320
Job No.: LABTHERD00254M
Date Tested: *1310112001*

Atterberg Limits & Particle Size Distribution (Part - % Fines)

AS 1289.3.1.2, 3.2.1, 3.3.1, 3.4.1 & 3.6.1 (Part)

Laboratory Number	HERD07S-03320
Sample Identification	TP 3, 1.0-1.5m
Description	
Liquid Limit (%)	39
Plastic Limit (%)	17
Plasticity Index (%)	22
Linear Shrinkage (%)	11.0
Sample History	Air Dried
Preparation Method	Dry Sieved
Nature of Shrinkage	Normal
Percent Finer Than 0.075mm (%)	38
Moisture Content (%) AS 1289.2.1.1 (As received)	9.8

Remarks: Sampling Method/s - Submitted by client

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TEST CERTIFICATE

Client: Coffey Geotechnics GEOTHERD02828AK
Principal: -
Project: Karratha Townsite & Insdustrial Estate
Location: Karratha

Report No.: HERD07S - 03324
Job No.: LABTHERD00254AA
Date Tested: *1310112001*

Atterberg Limits & Particle Size Distribution (Part - % Fines)

AS 1289.3.1.2, 3.2.1, 3.3.1, 3.4.1 & 3.6.1(Part)

Laboratory Number	HERD07S -03324
Sample Identification	TP 6, 1.5-2.0m
Description	
Liquid Limit (%)	33
Plastic Limit (%)	17
Plasticity Index (%)	16
Linear Shrinkage (%)	10.5
Sample History	Air Dried
Preparation Method	Dry Sieved
Nature of Shrinkage	Normal
Percent Finer Than 0.075mm (%)	38
Moisture Content (%) AS 1289.2.1.1 (As received)	11.0

Remarks: Sampling Method/s - Submitted by client

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TEST CERTIFICATE

Client: Coffey Geotechnics GEOTHERD02828AK
Principal: -
Project: Karratha Townsite & Insdustrial Estate
Location: Karratha

Report No.: HERD07S - 03326
Job No.: LABTHERD00254AA
Date Tested: 13/07/2007

Atterberg Limits & Particle Size Distribution {Part - % Fines)

AS 1289.3.1.2, 3.2.1, 3.3.1, 3.4.1 & 3.6.1(Part)

Laboratory Number	HERD07S - 03326
Sample Identification	TP 9, 1.0-1.5m
Description	
Liquid Limit (%)	33
Plastic Limit (%)	15
Plasticity Index (%)	18
Linear Shrinkage (%)	11.0
Sample History	Air Dried
Preparation Method	Dry Sieved
Nature of Shrinkage	Normal
Percent Finer Than 0.075mm (%)	42
Moisture Content (%) AS 1289.2.1.1 (As received)	11.6

Remarks: Sampling Method/s - Submitted by client

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Client: Coffey Geotechnics GEOTHERD02828AK
Principal: -
Project: Karratha Townsite & Insdustrial Estate
Location: Karratha

Report No.: HERD07S - 03329
Job No.: LABTHERD00254AA
Date Tested: 13/07/2007

Atterberg Limits & Particle Size Distribution {Part - % Fines)

AS 1289.3.1.2, 3.2.1, 3.3.1, 3.4.1 & 3.6.1(Part)

Laboratory Number	HERD07S - 03329
Sample Identification	TP 14, 0.2-0.5m
Description	
Liquid Limit (%)	35
Plastic Limit (%)	15
Plasticity Index (%)	20
Linear Shrinkage (%)	10.5
Sample History	Air Dried
Preparation Method	Dry Sieved
Nature of Shrinkage	Normal
Percent Finer Than 0.075mm (%)	36
Moisture Content (%) AS 1289.2.1.1 (As received)	8.3

Remarks: Sampling Method/s - Submitted by client

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TEST CERTIFICATE

Client: Coffey Geotechnics GEOTHERD02828AK
Principal: -
Project: Karratha Townsite & Insdustrial Estate
Location: Karratha

Report No.: HERD07S - 03333
Job No.: LABTHERD00254M
Date Tested: *1310112001*

Atterberg Limits & Particle Size Distribution {Part - % Fines)

AS 1289.3.1.2, 3.2.1, 3.3.1, 3.4.1 & 3.6.1(Part)

Laboratory Number	HERD07S - 03333
Sample Identification	TP 17, 1.5-1.9m
Description	
Liquid Limit (%)	33
Plastic Limit (%)	23
Plasticity Index (%)	10
Linear Shrinkage (%)	6.0
Sample History	Air Dried
Preparation Method	Dry Sieved
Nature of Shrinkage	Normal
Percent Finer Than 0.075mm (%)	30
Moisture Content (%) AS 1289.2.1.1 (As received)	5.9

Remarks: Sampling Method/s - Submitted by client

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Date: 20/07/2007
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Client: Coffey Geotechnics GEOTHERD02828AK
Principal: -
Project: Karratha Townsite & Insdustrial Estate
Location: Karratha

Report No.: HERD07S - 03336
Job No.: LABTHERD00254AA
Date Tested: *1310112001*

Atterberg Limits & Particle Size Distribution (Part - % Fines)

AS 1289.3.1.2, 3.2.1, 3.3.1, 3.4.1 & 3.6.1(Part)

Laboratory Number	HERD07S - 03336
Sample Identification	TP 22, 1.0-1.Sm
Description	
Liquid Limit (%)	24
Plastic Limit (%)	17
Plasticity Index (%)	7
Linear Shrinkage (%)	5.0
Sample HistorY	Air Dried
Preparation Method	DrY Sieved
Nature of Shrinkage	Normal
Percent Finer Than 0.075mm (%)	39
Moisture Content (%) AS 1289.2.1.1 (As received)	2.4

Remarks: Sampling Method/s - Submitted by client

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Authorised Signature:

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Client: Coffey Geotechnics GEOTHERD02828AK
Principal: -
Project: Karratha Townsite & Insdustrial Estate
Location: Karratha

Report No.: HERD07S-03345
Job No.: LABTHERD00254AA
Date Tested: *1310112001*

Atterberg Limits & Particle Size Distribution (Part - % Fines)

AS 1289.3.1.2, 3.2.1, 3.3.1, 3.4.1 & 3.6.1(Part)

Laboratory Number	HERDO?S-03345
Sample Identification	TP 31, 1.0-1.5m
Description	
Liquid Limit (%)	29
Plastic Limit (%)	18
Plasticity Index (%)	11
Linear Shrinkage (%)	5.0
Sample History	Air Dried
Preparation Method	Dry Sieved
Nature of Shrinkage	Normal
Percent Finer Than 0.075mm (%)	45
Moisture Content (%) AS 1289.2.1.1 (As received)	3.7

Remarks: Sampling Method/s - Submitted by client

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Authorised Signature:

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Date: 20/07/2007
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Client: Coffey Geotechnics GEOTHERD02828AK
Principal: -
Project: Karratha Townsite & Insdustrial Estate
Location: Karratha

Report No.: HERD07S - 03346
Job No.: LABTHERD00254AA
Date Tested: *1310112001*

Atterberg Limits & Particle Size Distribution (Part - % Fines)

AS 1289.3.1.2, 3.2.1, 3.3.1, 3.4.1 & 3.6.1(Part)

Laboratory Number	HERDO?S -03346
Sample Identification	TP 32, 0.2-0.5m
Description	
Liquid Limit (%)	49
Plastic Limit (%)	18
Plasticity Index (%)	31
Linear Shrinkage (%)	15.0
Sample History	Air Dried
Preparation Method	Dry Sieved
Nature of Shrinkage	Normal
Percent Finer Than 0.075mm (%)	69
Moisture Content (%) AS 1289.2.1.1 (As received)	2.0

Remarks: Sampling Method/s - Submitted by client
Sample bag was not sealed on arrival at the laboratory.

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moisture/density relationship • graph E

job no : LABTHERD00254AA
report no : HERD07S - 03323

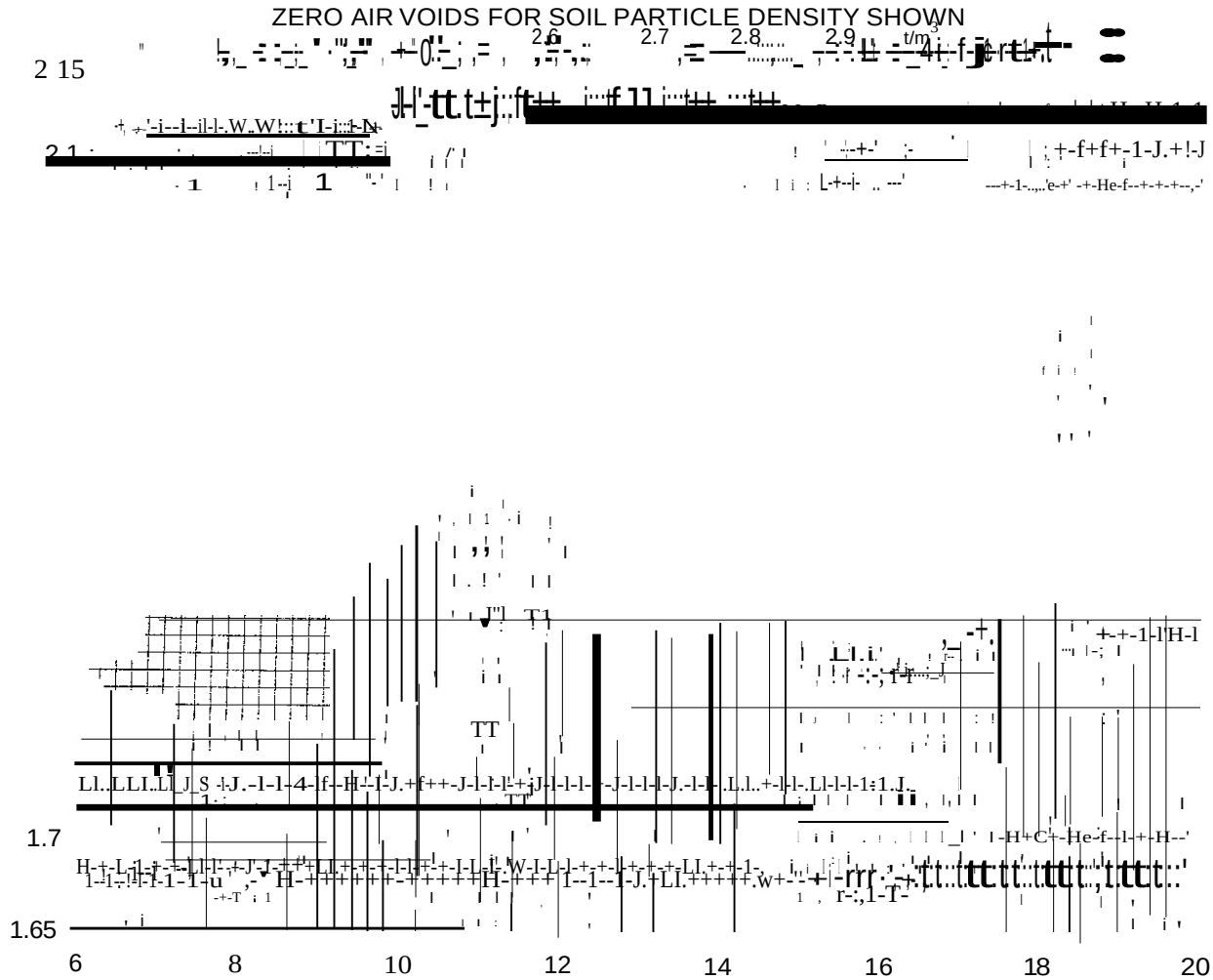
client : Coffey Geotechnics GEOTHERD02828AK
principal : -
project : Karratha Townsite & Industrial Estate
location : Karratha

date : 12/07/2007
laboratory : Herdsman
tested by : KMS
checked by : KMS

test procedure(s) : AS1289.5.2.1
soil particle density : t/m3
sample identification : TP 5, 0.5-1.0m

maximum dry density : 2.05 t/m3
optimum moisture content : 12.0 %
% retained 19mm sieve: 12 %

ZERO AIR VOIDS FOR SOIL PARTICLE DENSITY SHOWN



material classification :

I sufficient material supplied to carry out 4 points.
ampling Method/s - Submitted by client

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Date: 20/07/2007

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moisture/density relationship - graph E

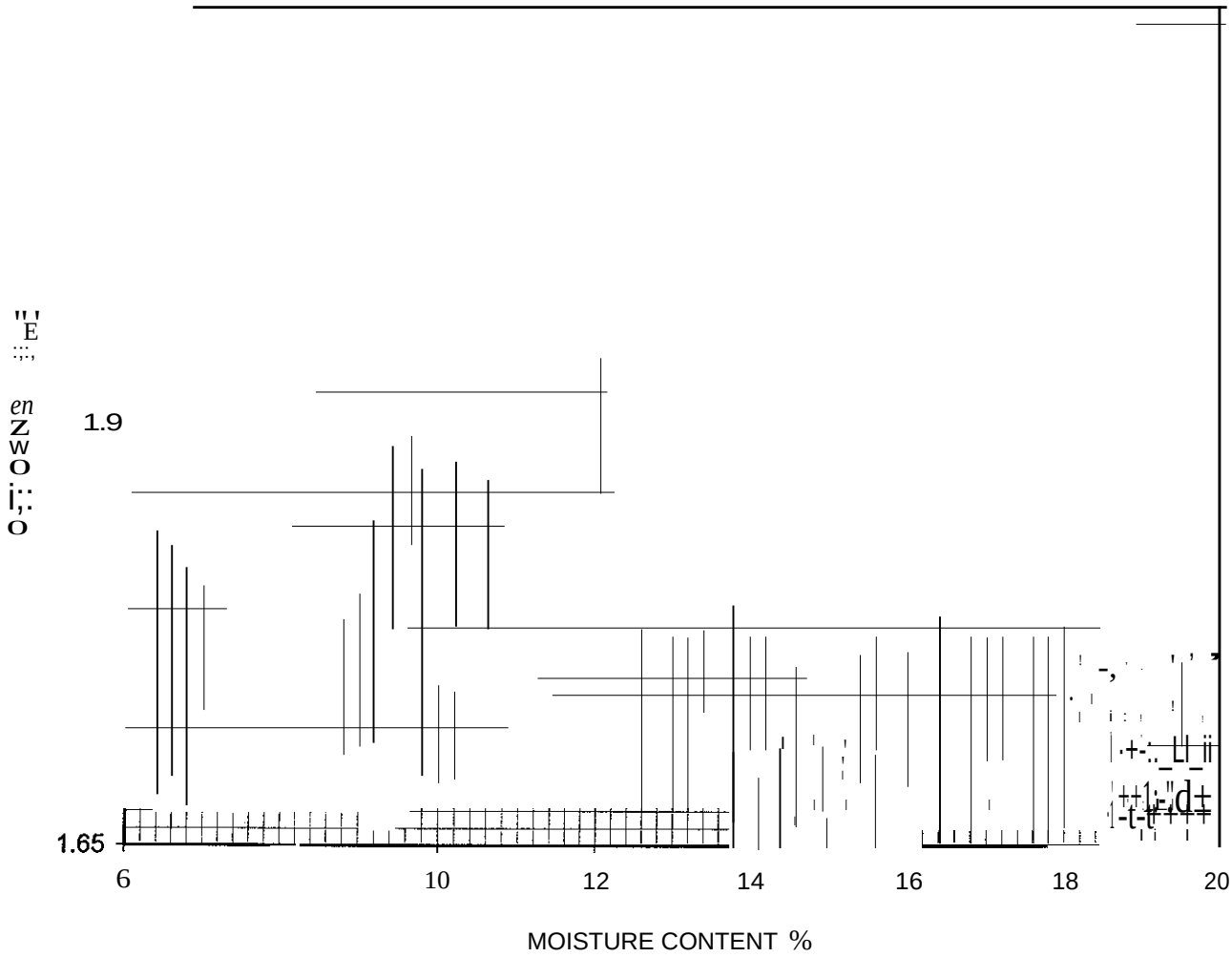
job no : LABTHERD00254AA
report no : HERD07S - 03325

client :	Coffey Geotechnics GEOTHERD02828AK	date :	12/07/2007
principal :		laboratory :	Herdsman
project :	Karratha Townsite & Industrial Estate	tested by :	KMS
location :	Karratha	checked by :	KMS

test procedure(s) :	AS1289.5.2.1	maximum dry density :	2.08	t/m^3
soil particle density :	t/m^3	optimum moisture content :	11.0	%
sample identification :	TP 8, 1.0-1.Sm	% retained 19mm sieve:	12	%

ZERO AIR VOIDS FOR SOIL PARTICLE DENSITY SHOWN

2.6 2.7 2.8 2.9 $1/m^3$



material classification :

ent material supplied to carry out 4 points.
ampling Method/s - Submitted by client

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Authorised Signatory: (W.Rozmianiec)
NATA Accredited Laboratory No. 431
Date: 20/07/2007

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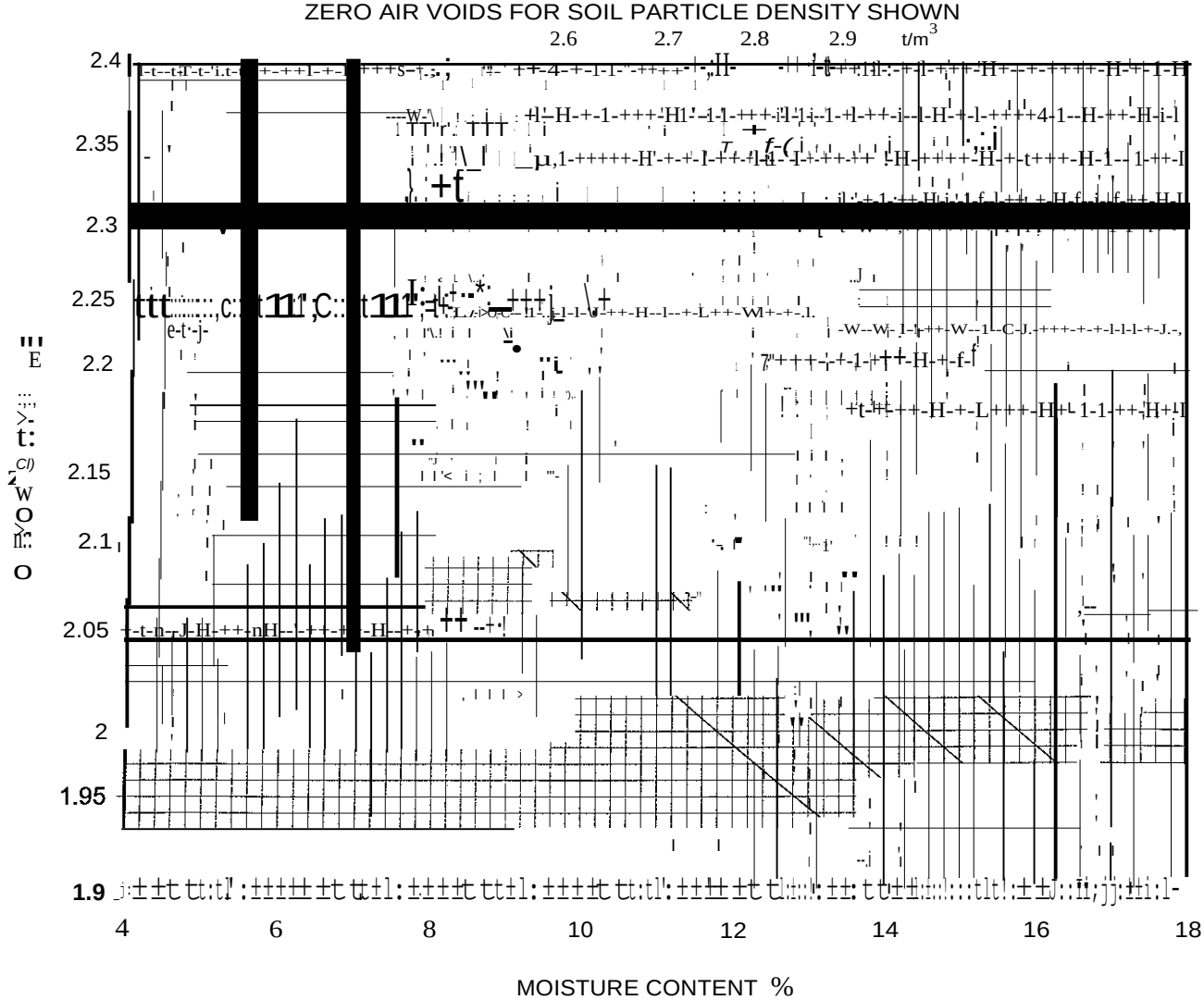
moisture/density relationship - graph E

job no : LABTHERD00254AA
report no : HERD07S - 03337

client :	Coffey Geotechnics GEOTHERD02828AK	date :	12/07/2007
principal :	-	laboratory :	Herdsman
project :	Karratha Townsite & Industrial Estate	tested by :	KMS
location :	Karratha	checked by :	KMS

test procedure(s) :	AS1289.5.2.1	maximum dry density :	2.35	I/ma
soil particle density :	- t1m^3	optimum moisture content :	6.5	%
sample identification :	TP 23, 1.0-1.3m	% retained 19mm sieve:	21	%

ZERO AIR VOIDS FOR SOIL PARTICLE DENSITY SHOWN



material classification :

Insufficient material supplied to carry out 4 points or oversize compaction.
Sampling Method/s - Submitted by client

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Authorised Signatory: (W.Rozmianiec)
NATA Accredited Laboratory No. 431
Date: 20/07/2007

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moisture/density relationship - graph E

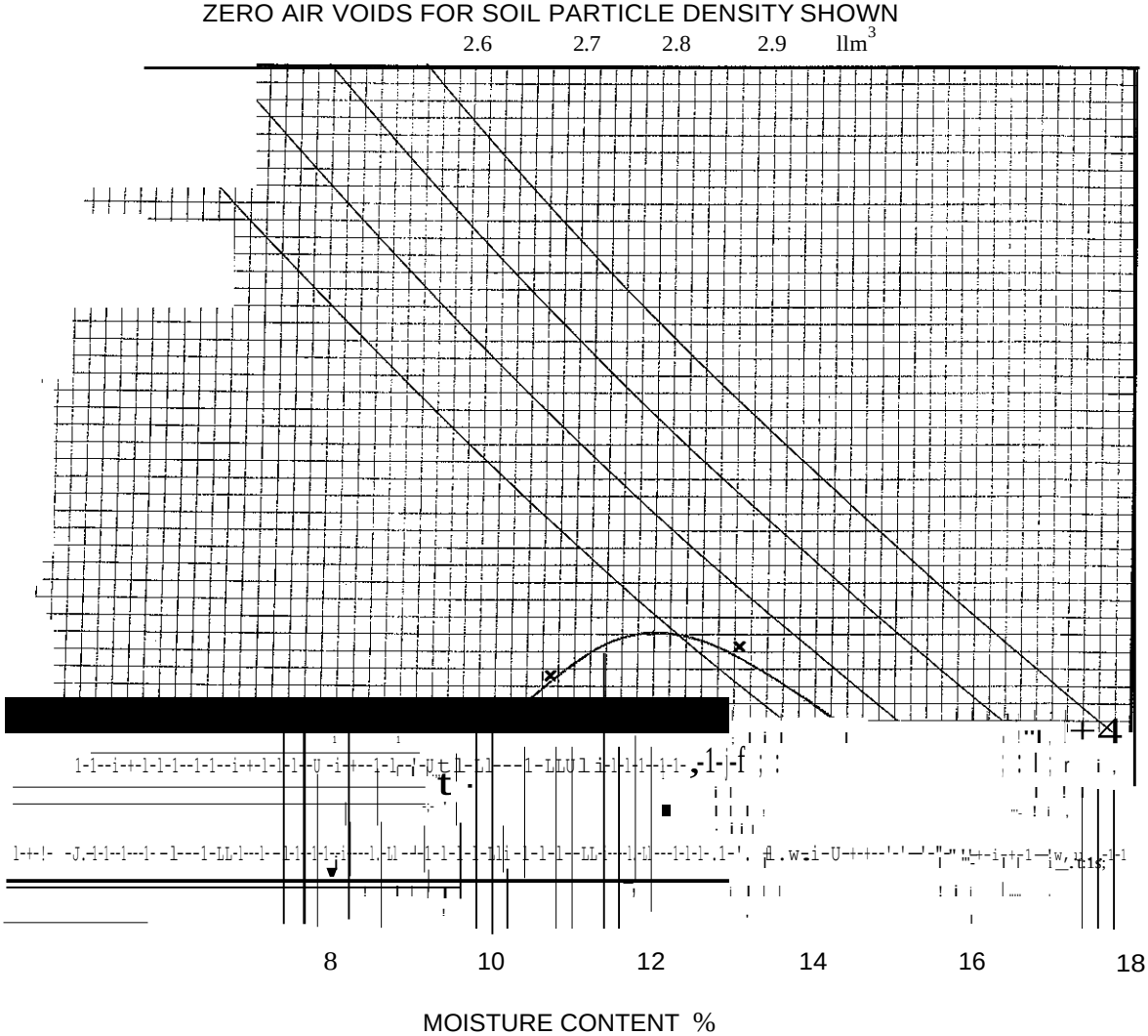
job no : LABTHERD00254AA
re *art* no : HERD07S -03343

client :	Coffey Geotechnics GEOTHERD02828AK	date :	12/07/2
principal :	-	laboratory :	Herdsn
project :	Karratha Townsite & Industrial Estate	tested by :	KMS
location :	Karratha	checked by :	KMS

test procedure(s) : AS1289.5.2.1 maximum dry density : 1.97 t/ms soil particle density : tfm^3 optimum

moisture content : 12.0 % sample identification : TP 30, 0.2-1.0m %

ZERO AIR VOIDS FOR SOIL PARTICLE DENSITY SHOWN



material classification :

I sufficient material supplied to carry out 4 points.
Sampling Method/s - Submitted by client

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NATA Accredited Laboratory No. 431
Date: 20/07/2007

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TEST CERTIFICATE

Client: Coffey Geotechnics GEOTHERD02828AK
Principal: -
Project: Karratha Townsite & Insdustrial Estate
Location: Karratha

Report No.: HERD07S - 03325/1
Job No.: LABTHERD00254AA
Date Tested: 13/07/2007

California Bearing Ratio of Remoulded Specimens

AS1289.6.1.1

SAMPLE IDENTIFICATION		SOAKED	UNSOAKED
SAMPLE NUMBER		HERD07S - 03325	
DEPTH	mm	TP 8, 1.0-1.5	
MATERIAL DESCRIPTION		-	
COMPACTION PROPERTIES			
MAXIMUM DRY DENSITY	Um"	2.08	
OPTIMUM MOISTURE	%	10.8	
TEST CONDITIONS OF SPECIMEN			
DENSITY RATIO REQUIRED	%	95.0	
MOISTURE RATIO REQUIRED	%	100.0	
PERIOD OF SOAKING	days	4	
SURCHARGING OF SPECIMEN	kg	4.5	
COMPACTIVE EFFORT (Modified)	Blows per layer	35	
NUMBER OF LAYERS		5	
MATERIAL RETAINED ON 19mm SIEVE	%	12	
TEST RESULTS			
DRY DENSITY AT COMPACTION	Um"	2.01	
DRY DENSITY AFTER SOAKING	Um^3	2.00	
DRY DENSITY RATIO AT COMPACTION	%		
DRY DENSITY RATIO AFTER SOAKING	%		
MOISTURE CONTENT AT COMPACTION	%	10.1	
TOP 30MM OF SPECIMEN AFTER PENETRATION	%	12.1	
ENTIRE DEPTH OF SPECIMEN AFTER PENETRATION	%	13.1	
MOISTURE RATIO AT COMPACTION	%		
MOISTURE RATIO OF TOP 30MM AFTER PENETRATION	%		
MOISTURE RATIO OF ENTIRE DEPTH AFTER PENETRATION	%		
SWELL OF SPECIMEN DURING SOAKING	%	0.5	
CALIFORNIA BEARING RATIO	%	35	
PENETRATION	mm	2.5	

Remarks: Sampling Method/s - Submitted by client
The material retained on the 19.0mm sieve was excluded from the test sample.

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Authorised Signature:

W Rozmianiec
Date: 20.07.07
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TEST CERTIFICATE

Client: Coffey Geotechnics GEOTHERD02828AK
Principal:-
Project: Karratha Townsite & Insdustrial Estate
Location: Karratha

Report No.: HERD07S - 03337/1
Job No.: LABTHERD00254AA
Date Tested: 13/07/2007

California Bearing Ratio of Remoulded Specimens

AS1289.6.1.1

SAMPLE IDENTIFICATION		SOAKED	UNSOAKED
SAMPLE NUMBER		HERD07S - 03337	
DEPTH	mm	TP 23, 1.0-1.3	
MATERIAL DESCRIPTION		-	
COMPACTION PROPERTIES			
MAXIMUM DRY DENSITY	t!m"	2.35	
OPTIMUM MOISTURE	%	6.5	
TEST CONDITIONS OF SPECIMEN			
DENSITY RATIO REQUIRED	%	95.0	
MOISTURE RATIO REQUIRED	%	100.0	
PERIOD OF SOAKING	days	4	
SURCHARGING OF SPECIMEN	kg	4.5	
COMPACTIVE EFFORT (Modified)	Blows per layer	35	
NUMBER OF LAYERS		5	
MATERIAL RETAINED ON 19mm SIEVE	%	21	
TEST RESULTS			
DRY DENSITY AT COMPACTION	t!m"	2.23	
DRY DENSITY AFTER SOAKING	t!m"	2.23	
DRY DENSITY RATIO AT COMPACTION	%		
DRY DENSITY RATIO AFTER SOAKING	%		
MOISTURE CONTENT AT COMPACTION	%	6.7	
TOP 30MM OF SPECIMEN AFTER PENETRATION	%	9.5	
ENTIRE DEPTH OF SPECIMEN AFTER PENETRATION	%	8.8	
MOISTURE RATIO AT COMPACTION	%		
MOISTURE RATIO OF TOP 30MM AFTER PENETRATION	%		
MOISTURE RATIO OF ENTIRE DEPTH AFTER PENETRATION	%		
SWELL OF SPECIMEN DURING SOAKING	%	0	
CALIFORNIA BEARING RATIO	%	100	
PENETRATION	mm	5.0	

Remarks: Sampling Method/s - Submitted by client
The material retained on the 19.0mm sieve was excluded from the test sample.

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TEST CERTIFICATE

Client: Coffey Geotechnics GEOTHERD02828AK
Principal: -
Project: Karratha Townsite & Insdustrial Estate
Location: Karratha

Report No.: HERD07S - 03343/1
Job No.: LABTHERD00254AA
Date Tested: 13/07/2007

California Bearing Ratio of Remoulded Specimens

AS1289.6. 1.1

SAMPLE IDENTIFICATION		SOAKED	UNSOAKED
SAMPLE NUMBER		HERD07S - 03343	
DEPTH	mm	TP 30, 0.2-1.0	
MATERIAL DESCRIPTION		-	
COMPACTION PROPERTIES			
MAXIMUM DRY DENSITY	Um³	1.97	
OPTIMUM MOISTURE	%	12.2	
TEST CONDITIONS OF SPECIMEN			
DENSITY RATIO REQUIRED	%	95.0	
MOISTURE RATIO REQUIRED	%	100.0	
PERIOD OF SOAKING	days	4	
SURCHARGING OF SPECIMEN	ko	4.5	
COMPACTIVE EFFORT (Modified)	Blows per layer	35	
NUMBER OF LAYERS		5	
MATERIAL RETAINED ON 19mm SIEVE	%	11	
TEST RESULTS			
DRY DENSITY AT COMPACTION	Um³	1.87	
DRY DENSITY AFTER SOAKING	Um³	1.75	
DRY DENSITY RATIO AT COMPACTION	%		" . \}}"f
DRY DENSITY RATIO AFTER SOAKING	%		._._.'.": -:>(
MOISTURE CONTENT AT COMPACTION	%	12.0	
TOP 30MM OF SPECIMEN AFTER PENETRATION	%	27.0	
ENTIRE DEPTH OF SPECIMEN AFTER PENETRATION	%	19.0	
MOISTURE RATIO AT COMPACTION	%		
MOISTURE RATIO OF TOP 30MM AFTER PENETRATION	%		
MOISTURE RATIO OF ENTIRE DEPTH AFTER PENETRATION	%		
SWELL OF SPECIMEN DURING SOAKING	%	7.5	
CALIFORNIA BEARING RATIO	%	3	
PENETRATION	mm	2.5	

Remarks: Sampling Method/s - Submitted by client
The material retained on the 19.0mm sieve was excluded from the test sample.

NATA

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Authorised Signature:

W Rozmianiec
Date: 20.07.07
NATA Acc. Laboratory No 431

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TEST CERTIFICATE

Client: Coffey Geotechnics GEOTHERD02828AK
Principal: -
Project: Karratha Townsite & Insdustrial Estate
Location: Karratha

Report No.: HERD07S-03323/1
Job No.: LABTHERD00254AA
Date Tested: 13/07/2007

California Bearing Ratio of Remoulded Specimens

AS1289.6.1.1

SAMPLE IDENTIFICATION		SOAKED	UNSOAKED
SAMPLE NUMBER		HERD07S - 03323	
DEPTH	mm	TP 5, 0.5-1.0m	
MATERIAL DESCRIPTION		-	
COMPACTION PROPERTIES			
MAXIMUM DRY DENSITY	Um°	2.05	
OPTIMUM MOISTURE	%	12.0	
TEST CONDITIONS OF SPECIMEN			
DENSITY RATIO REQUIRED	%	95.0	
MOISTURE RATIO REQUIRED	%	100.0	
PERIOD OF SOAKING	days	4	
SURCHARGING OF SPECIMEN	kg	4.5	
COMPACTIVE EFFORT (Modified)	Blows per layer	35	
NUMBER OF LAYERS		5	
MATERIAL RETAINED ON 19mm SIEVE	%	12	
TEST RESULTS			
DRY DENSITY AT COMPACTION	Um"	1.96	
DRY DENSITY AFTER SOAKING	Um'	1.92	
DRY DENSITY RATIO AT COMPACTION			
DRY DENSITY RATIO AFTER SOAKING	%		
MOISTURE CONTENT AT COMPACTION	%	11.9	
TOP 30MM OF SPECIMEN AFTER PENETRATION	%	18.1	
ENTIRE DEPTH OF SPECIMEN AFTER PENETRATION	%	17.1	
MOISTURE RATIO AT COMPACTION	%		
MOISTURE RATIO OF TOP 30MM AFTER PENETRATION	%		
MOISTURE RATIO OF ENTIRE DEPTH AFTER PENETRATION	%		
SWELL OF SPECIMEN DURING SOAKING	%	2	
CALIFORNIA BEARING RATIO	%	6	
PENETRATION	mm	2.5	

Remarks: Sampling Method/s - Submrtted by clrent
The material retained on the 19.0mm sieve was excluded from the test sample.

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Appendix C

CSIRO Information Sheet

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO

BTF 18
replaces Information
Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

/ Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of day soil mitigates against chis, but granular (particularly sandy) soil is susceptible.

Consolidation settlement is a feature of day soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to cake many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say lOo/o or more can suffer from erosion.

Saturation

This is particularly a problem in clay soi!S. Saturation creates a bog-like suspension of the soil chat ca.uses it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All days react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different days, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periodS, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

Significant load increase.

- Reduction of lateral support of the soil under the footing due to erosion or excavation.

In day soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most'sand aqd rock.sites with little or !lo ground ·movement from moisture changes
S	Slightly reactive clay sites with only sliiht ground moveinent from mois_ture changes
M	Moderately .reactive day or silt sii:es; which can experience moderate ground movement from moisture changes
H	Highly reactive ·clay sites; which can expei-ience. high gro_u.n_d..m.oveme_nt .from_ ffioisture_,chil.rig {'.S
E	Extremely reactive sites, which can experience'extreme·g·round movenient 'from moistur.e changes-
A to P	Filled sites
p	Sites which include 'soft soils, such .as soft clay or silt·or loose sands; landslie; mirie subsidence; c'ollaP.s.ing Soils; soils subject to erosion; reactive sites subject to abn.ormal moisture conditions or sites wli1ch ·cannot be classified otherwise

Tree root growth

Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.

Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

Differing compaction of foundation soil prior to construction.

Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation

Erosion removes the support from under footings, tending co create subsidence of the part of the stri.tcture under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

Seep cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.

Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

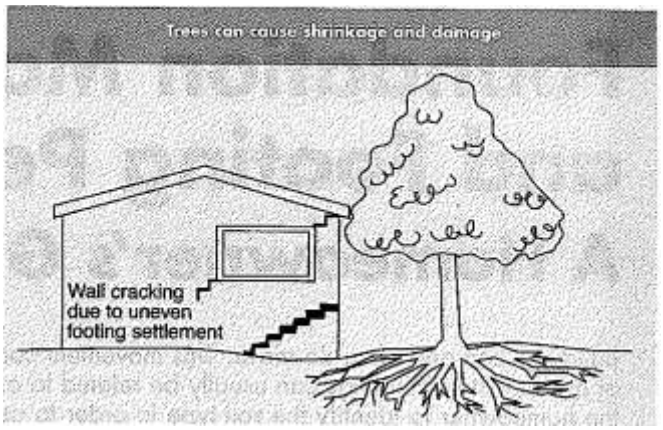
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc,

Seasonal swelling/shrinkage in clay

Swelling founda;.-ion soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots

In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself

Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures

Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such *as* openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it co its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to_separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, chis can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, chat where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to beh:ive as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows alSo encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found ill masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table Cl of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. & these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

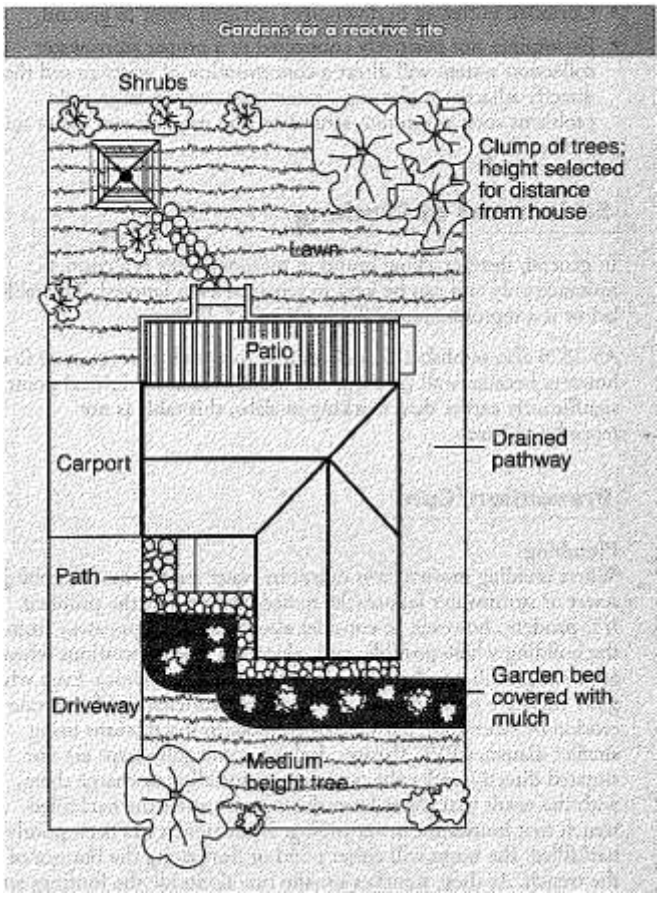
It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

Protection of the building perimeter
It is essential to remember that the soil chat affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1·mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but 'eitsily filled. Doors arid wiridoWS stick 'slight!}'	<5.mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick Service pipes can'fr:i.ctilte'. Weathertightness often impaired	5-15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sectit)ns of walls, especially over doors and windows. Window and door frames distort..Walls lean or bulge noticeably, some loss of bearing in beams. Service ·p_ipes disrupted	15-25 mm but also depend on number of cracks	4



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

Water that is transmitted into masonry, metal or timber building elements causes damage and/ or decay to those elements.

High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.

Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance frc;,m buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density.Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that When the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessa_ry to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

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Appendix D

Technical Note The Effects of Compaction Plant on Adjacent Structures
Tynan 1973

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SPECIALISTS MANAGING THE EARTH

TECHNICAL NOTE

on

THE EFFECTS OF COMPACTION PLANT ON ADJACENT STRUCTURES

TYNAN 1973

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1. INTRODUCTION

Proof compaction techniques have been popular in recent years to prove the ability of the ground to support lightly-loaded structures. These techniques have been used in conjunction with conventional site investigation methods to locate deposits of loose fill and peat and to compact loose sands to depths of 2.5 to 3m.

The advent of heavy compaction equipment has resulted in plant having a static weight in excess of 10 tonnes being readily available for the proof compaction. Safeguards must be exercised when operating this plant in built-up areas to prevent damage to existing structures and to minimise distress and litigation.

The purpose of the note is to provide guide lines for safely operating compaction plant in the vicinity of domestic and/or commercial developments.

2. VIBRATION LIMITS AND HUMAN SENSITIVITY

Damage to residential/commercial structures correlates more closely with the maximum velocity of good vibrations (hereafter referred to as particle velocity) than with displacement or acceleration (Tynan, 1973). Accordingly, particle velocity is the parameter which should be controlled to prevent structural and architectural damage.

Forssblad (1966) suggested that the particle velocity should be limited to 10mm/sec (max) to minimise the risk of damage to adjacent buildings. Forssblad measured and compared vibration levels inside and outside of buildings and found that the particle velocities in the building foundations are 2 to 5 times lower. Ground vibrations with a maximum velocity of 1Omm/sec thereby correspond to vibrations measured in buildings of the magnitude 2 to 5mm/sec.

People are particularly sensitive to vibration. Jackson (1967) comments that a person "who sees any possible human cause for the smallest defect or minor damage may have an associated emotional factor which can magnify any claimed damage by several orders of magnitude". The vibration limits set in the current codes recognise this characteristic.

The Forssblad findings are summarised below. The maximum permissible particle velocities are related to risk of damage and typical human reaction at each vibration level.

TABLE 1 SUMMARY OF VIBRATION EFFECTS

MAXIMUM PERMISSIBLE PARTICLE VELOCITY' mm/sec	EFFECTS ON BUILDINGS	HUMAN REACTION
2	Risk limit for ruins and ancient monuments	Vibrations perceptible
5	Risk limit for "architectural" damage to normal dwelling houses with plastered walls and ceilings.	Vibrations annoying
10	Risk limit for damage to normal dwelling houses.	Vibrations unpleasant
10-40	Risk limit for concrete buildings, industrial buildings etc.	Vibrations unpleasant not to acceptable

Reference: Forssblad (1966)

- vibrations measured in building foundations

3. OPERATING SAFEGUARDS

3.1 Proximity Limits

The Australian Road Research Board (Tynan 1973) suggested that the following proximity limits should be complied with when operating vibrating rollers nex1to residential and commercial structures.

TABLE 2 SUGGESTED PROXIMITY LIMITS FOR THE USE OF VIBRATING ROLLERS TO PREVENT DAMAGE TO BUILDINGS

ROLLER CLASS	ROLLER WEIGHT (STATIC RANGE) AND CENTRIFUGAL FORCE (CF) (TONNES)	RESTRICTION: DISTANCE TO NEAREST BUILDING (METRES)
(i) Very Light	Maintenance and patching rollers, less than 1.25 (CF 1-2)	Generally not restricted for normal road use. (3)*
(ii) Light	1-2 (CF 2-5)	Generally not restricted for normal road use. (5)*
(iii) Light - Medium	2-4 (CF 5-10)	5+ (10)'
(iv) Medium - Heavy	4-6 (CF 10-20)	Not advised for *city* and suburban streets. 10+ (20)*
(v) Heavy	7-11 (CF 20-30)	Restricted. Not advised for built-up areas. 20+ (40)*
(vi) *Very* Heavy	12 and over (CF over 30)	Restricted, major construction rural areas away from structures and buildings.

* Values in brackets are those suggested to keep claims and complaints to an acceptably low level. For no complaints in residential area, these values would possibly be needed to be increased still further.

\+ To prevent architectural and structural damage to buildings.

3.2 Instrumentation/Monitoring

Where the above suggested proximity limits can not be complied with due to access restrictions, it is recommended that the vibrations in the adjacent structures be recorded using standard vibration meters. If damage to adjacent buildings is to be minimised, rolling should then be discontinued when the particle velocities recorded by the vibration meters approach the maximum permissible values presented in Table 1.

3.3 Inspection

A systematic pre-inspection of buildings, with emphasis on existing cracks and defects, is often desirable before starting construction work within or close to residential areas. It may be desirable to make a photographic record of this inspection.

4. SETTLEMENT CONSIDERATIONS

Sands and gravels are the easiest soil types to compact by vibration. A minor increase in density can be achieved at accelerations which are as low as 0.2 to 0.5g (Forssblad). In the frequency range normally used for soil compaction by vibrations, an acceleration of 0.2g corresponds to a particle velocity in the order of 1Omm/sec, which is the same criteria as given with regard to damages directly caused by vibrations. Consequently, the likelihood of vibratory soil compaction generating additional settlements beneath adjacent structures is considered to be very low providing that the above safeguards are adhered to.

Slopes however, may become unstable under vibratory forces. Even very slight vibrations may, under unfavourable circumstances, initiate settlement and movements.

Coffey Geosciences Pty Ltd would be pleased to assist in any aspect of vibration induced damage or in its avoidance.

* * * * *

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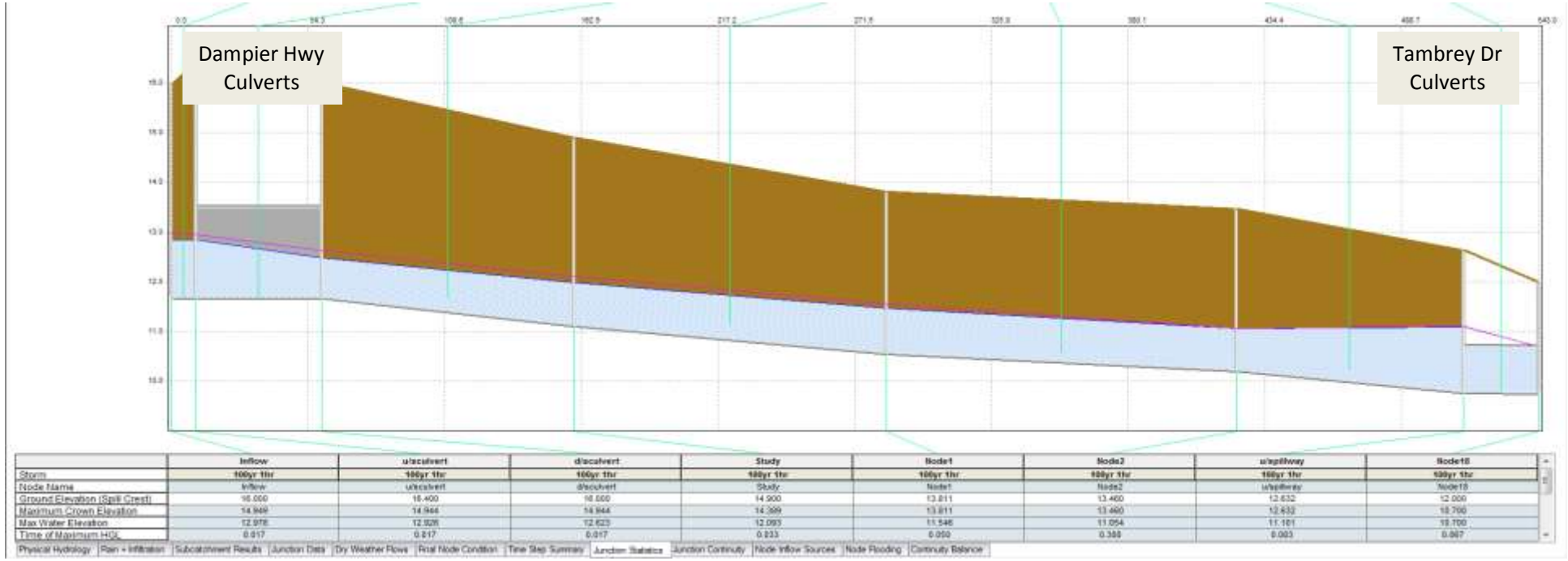
   A E Tynan (1973) Special Report #11 Australian Road Research Board.
2. "Vibratory Soil and Rockfill Compaction" Lars Forssblad (1981).
3. "Investigation of Soil Compaction by Vibration" Lars Forssblad (1966). Division Hydraulics R Inst Tech Stockholm.
4. "Vibrations of Soils and Foundation" Richart et al (1970).
5. "Thresholds of Damage due to Ground Motion" Jackson M M (1967).
   Proc. Int. Symp. Wave Prop. Dyn. Props. Earth Mats. New Mexico.

APPENDIX C – REVISED MODELLING RESULTS

Date :14/2/2013 Job No H12007



	Inflow	u/aculvert	d/aculvert	Study	Node1	Node2	u/spillway	Node10
Storm	100yr 1hr	100yr 1hr	100yr 1hr	100yr 1hr	100yr 1hr	100yr 1hr	100yr 1hr	100yr 1hr
Node Name	Inflow	u/aculvert	d/aculvert	Study	Node1	Node2	u/spillway	Node10
Ground Elevation (Spill Crest)	16.000	16.400	16.000	14.900	13.811	13.460	12.632	12.000
Maximum Crown Elevation	14.949	14.944	14.944	14.399	13.811	13.460	12.632	10.700
Max Water Elevation	12.978	12.926	12.623	12.093	11.546	11.054	11.101	10.700
Time of Maximum HGL	0.017	0.017	0.017	0.033	0.050	0.383	0.083	0.067

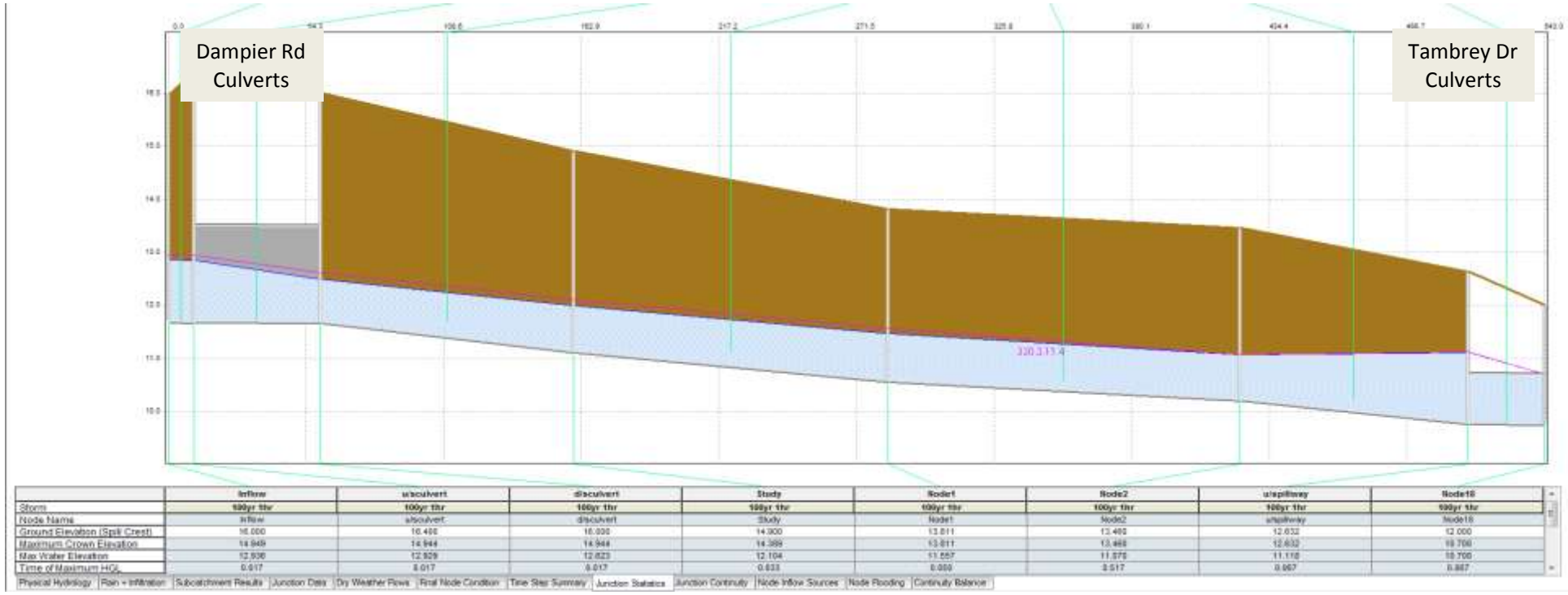
hyd2o

Tambrey Stormwater Modelling

Pre-development drain long section in 1 in 100 year ARI

Figure 1

Date 14/2/2013 Job No H12007



	Inflow	u/sculvert	d/sculvert	Study	Node1	Node2	u/spillway	Node10
Storm	100yr thr	100yr thr	100yr thr	100yr thr	100yr thr	100yr thr	100yr thr	100yr thr
Node Name	Inflow	u/sculvert	d/sculvert	Study	Node1	Node2	u/spillway	Node10
Ground Elevation (Spill Crest)	16.000	16.400	16.000	14.300	13.011	13.468	12.632	12.000
Maximum Crown Elevation	14.949	14.944	14.944	14.399	13.011	13.468	12.632	10.700
Max Water Elevation	12.930	12.929	12.623	12.104	11.557	11.575	11.118	10.700
Time of Maximum HGL	0.017	0.017	0.017	0.033	0.000	0.017	0.067	0.867

Physical Hydrology | Rain + Infiltration | Subcatchment Results | Junction Data | Dry Weather Flows | Final Node Condition | Time Step Summary | Junction Statistics | Junction Continuity | Node Inflow Sources | Node Flooding | Continuity Balance

hyd2o

Tambrey Stormwater Modelling

Post development drain long section in 1 in 100 year ARI

Figure 2

APPENDIX D – KARRATHA COASTAL VULNERABILITY STUDY

Kristy Chandler

From: SMYTHE Toni <Toni.Smythe@water.wa.gov.au>
Sent: Tuesday, 19 February 2013 11:11 AM
To: Kristy Chandler
Subject: FW: FJMTAM02 - Karratha Coastal Vulnerability Study - Tambrey Site
Attachments: FPM Karratha Lots 302 & 500 Bathgate Rd & 3860 Tambrey Dv Nickol enq v2.pdf; ATT00001.txt; ATT00002.htm

Hi Kristy,

Apologies for the delay in getting back to you after our phone conversation, our section has been a bit stretched over the past few weeks.

Following on from our discussion regarding your smaller scale modelling of flood flows in the drainage channel to the west of this site, we are not particularly concerned about the downstream boundary condition used provided that the model extends far enough downstream that the boundary condition does not significantly impact upon flood levels adjacent to the site.

The attached plan shows the estimated 100 year ARI flood levels from the Karratha Coastal Vulnerability Study downstream of the site for your information.

Kind regards,

Toni Smythe
Engineer, Floodplain Management
Department of Water
Phone: (08) 6364 7413
E-mail: toni.smythe@water.wa.gov.au

From: SMYTHE Toni [mailto:Toni.Smythe@water.wa.gov.au]
Sent: Tuesday, 22 January 2013 3:05 PM
To: Kristy Chandler
Subject: RE: FJMTAM02 - Karratha Coastal Vulnerability Study - Tambrey Site

Hi Kristy,

The Department of Water, in carrying out its role in floodplain management, provides advice and recommends guidelines for development on floodplains with the object of minimising flood risk and damage.

The preliminary results of the Karratha Coastal Vulnerability Study show that in this area the 100 year ARI flood level is estimated to range from 13.9 m AHD (at the upstream or southern boundary of the lot) to 10.6 m AHD (downstream or northern boundary). Similarly the estimated 500 year ARI flood level ranges from 14.1 m AHD to 11.2 m AHD.

These flood levels are applicable to both the 2010 and 2110 climate scenarios as predicted sea level rise does not significantly influence flooding at this location. The 500 year ARI coastal inundation (storm surge only) level at 2110 is estimated to be ~9.4 m AHD.

The available contour information shows the natural surface level of the lot to be greater than 11.5 m AHD as shown on the attached plan. Although it is of a regional nature, the modelling indicates that in this area major flows are contained within the drain to the west of the lot.

Please note that this advice is related to storm surge and major flooding only and does not take into account local stormwater drainage (including run-off generated from the lots themselves).

Kind regards,

Toni Smythe
Engineer, Floodplain Management
Department of Water
Phone: (08) 6364 7413
E-mail: toni.smythe@water.wa.gov.au

From: Kristy Chandler [mailto:kristy.chandler@coterra.com.au]
Sent: Tuesday, 22 January 2013 12:52 PM
To: SMYTHE Toni
Subject: FJMTAM02 - Karratha Coastal Vulnerability Study - Tambrey Site

Hi Toni

As per my phone call, we are preparing a LWMS for a new development in Karratha and would like to request some Karratha Coastal Vulnerability Study results.

The site is called Tambrey Neighbourhood Centre – and I attach a location map for your information.

It would be great if you could let me know if the site is located within the Study Area, and if so – what the modelled results indicate habitable floor levels should be.

Thanks again for your help. I'm popping out for an hour meeting now but will be back this afternoon if you require any more information.

Kind regards
Kristy

Kristy Chandler
Lead Hydrologist / Hydraulic Modeller

COTERRA
ENVIRONMENT

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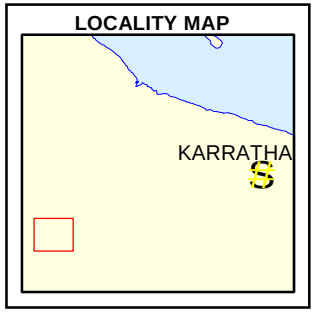
2/460 Roberts Road, SUBIACO WA 6008 | www.coterra.com.au

Lots 302 & 500 Bathgate Rd & Lot 3860 Tambrey Dv
Nickol



LEGEND

- 100 year ARI flood level (m AHD)
- Lots 302, 500 & 3860
- Cadastre, Lot Number

0 25 50 100
Metres

Datum and Projection Information
Vertical Datum: Australian Height Datum (AHD71)
Horizontal Datum: GDA94 MGAz50
Projection: Universal Traverse Mercator (UTM)
Spheroid: Geodetic Reference System (GRS80)

Project Information
Client:
Map Author: Toni Smythe
Task ID: B1305
Compilation date: 19/02/2013
Edition: Version 2

SOURCES

The Department of Water acknowledges the following datasets and their custodians in the production of this map:

Spatial Cadastral Database - Landgate - 06/02/12
Road Centrelines, DLI - Landgate - 13/01/2010
Western Australian Towns - Landgate - 12/07/2001

APPENDIX E – LWMS CHECKLIST

LWMS CHECKLIST

LWMS item	Deliverable	Coterra Comments
Executive Summary		
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements and requirements for BMP and critical control points	Executive Summary
Introduction		
Total water-cycle management – principles and objectives / planning background / previous studies		Sections 1.2 to 1.4
Proposed development		
Structure plan, zoning and land use Key landscape features Previous land use	Site context plan Structure plan	Figures 1 & 5 Figures 2 & 4 Section 2.1
Landscape – proposed public open space areas, public open space credits, water source, bore(s), lake details, irrigation areas (if applicable)	Landscape plan	Figure 3
Design Criteria		
Agreed design objectives and source		Section 1.4
Pre-development environment		
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		Chapter 2.0
Site conditions – existing topography/contours, aerial photo underlay, major physical features	Site condition plan	Sections 2.3 and 2.4 Figures 6 and 7
Geotechnical – topography, soils including ASS and infiltration capacity, test pits	Geotechnical plan	
Environmental – areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contam. sites	Environmental plan plus supporting data where appropriate	Section 2.7 Section 2.4.4
Surface water – topography, 100- year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface-water plan	Section 2.5
Groundwater – topography, predevelopment groundwater levels and water quality, test bore locations	Groundwater plan plus site investigations	Section 2.6
Water sustainability initiatives		
Water efficiency measures – private and public open spaces including method of enforcement		Section 3.3
Water supply (fit-for-purpose) strategy, agreed actions and implementation		Sections 3.1
Wastewater management		Section 3.2
Stormwater management strategy		
Flood protection – peak flow rates, volumes and top water levels at control points, 100-year flowpaths and100-year detention storage areas	100-year-event plan Long section of critical points	Section 4.2 Figure 9
Manage serviceability – storage and retention required for the critical 5- year ARI storm events. Minor roads should be passable in the 5-year ARI event	5-year event plan	Section 4.2 Figure 9

Protect ecology – detention areas for the 1yr/1hr ARI event, areas for water quality treatment and types of agreed structural and non-structural BMP and treatment trains (including indicative locations). Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1-year-event plan Typical cross sections	Section 4.2 Figures 10 and 11
Groundwater management strategy		
Post-development groundwater levels, existing and likely final surface levels, outlet controls, and subsoil drain areas/exclusion zones	Groundwater/subsoil plan	Chapter 5
Actions to address ASS or contamination		Not applicable
The next stage – subdivision and urban water management plans		
Content & coverage of future UWMPs to be completed at subdivision. Include areas where further investigations are required before detailed design.		Section 7.2
Monitoring		
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		Chapter 6
Implementation		
Developer commitments		Section 7.1
Roles, responsibilities, funding for implementation		
Review		

Source: Department of Water (2008) *Interim: Developing a local water management Strategy*

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APPENDIX E

LANDSCAPING STRATEGY

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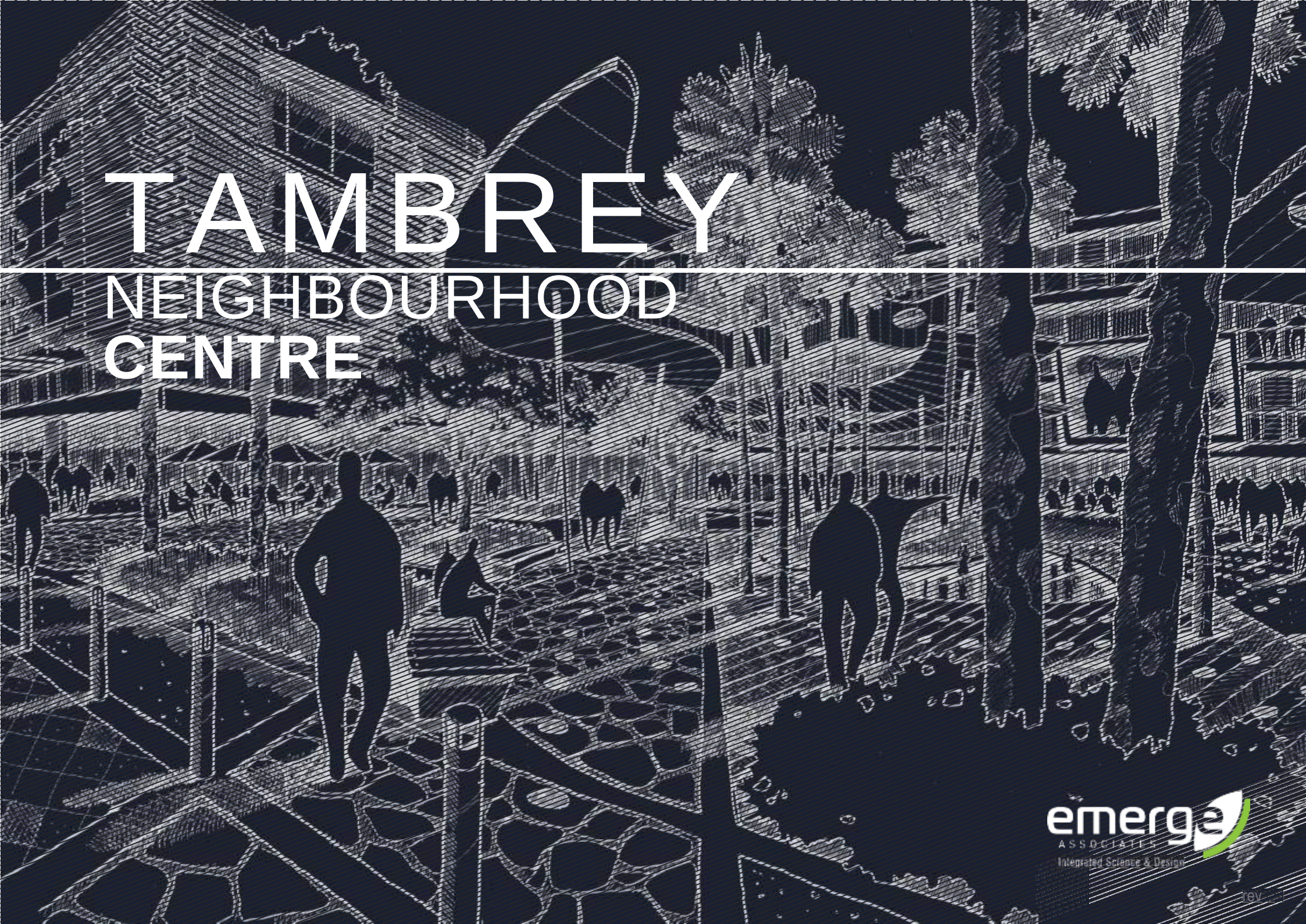
TAMBREY

NEIGHBOURHOOD
CENTRE



emerge
ASSOCIATES
Integrated Science & Design

rev. 1

CONTENTS

1.0. PROJECT INTRODUCTION

1.1 ac ground

PROJECT INTRODUCTION

The design intent of the landscape response of the public realm for the Tambrey Neighbourhood Centre is to create a civic plaza that is to become the focal point of the immediate area and form a vibrant urban public realm. Complimented by an attractive tree lined Main Street with appropriate shade canopies from building awnings, the design is intended to encourage pedestrian activity by being a pleasant and viable option in the often harsh Pilbara weather conditions.

The Pilbara region boasts a large range of unique landscapes including coastal plains and mountain ranges with cliffs and gorges. The landscape design of the Tambrey Neighbourhood Centre as a whole, but in particular the focal civic plaza, including detailed elements within the plaza aims to draw inspiration in the form of a design language that pays homage to the unique local landscapes of the Karratha area.

2.0. DESIGN INTENT

2.1.

PUBLIC REALM

A crucial aspect of the landscape in the Neighbourhood Centre is the design of external public places to ensure that they are filled with activity. The provision of interactive public spaces is intended to permeate a seamless synergy with surrounding urban activities, ie. cafes, bars, shops & alfresco dining. This aims to liven the centre and enrich the experience of the users of these spaces.

To best enhance the public realm the following strategies need to be considered;

Identity

The identity of the public realm refers to those elements that contribute to a positive sense of place and identity that is unique and authentic to Tambrey. Identity can assist with way finding and personal safety whilst fostering community pride.

Strategies include -

- Reinforce and enhance Tambrey's positive attributes, build on its areas of strength and respect the distinctive identity;
- Promote local distinctiveness through use of materials that reflect the relative importance of the location;
- Ensure the identity reflects it's principal role as a Neighbourhood Centre and community hub;
- Celebrates the natural and cultural heritage of the area through public realm elements and public art.

Consistent and Connected Net or

The network refers to the key community and commercial destinations and the connections in between. Defining and reinforcing the connections between each destination and links to the broader community through consistent use of material and contentious routes promotes safety, assists in effective way finding and promotes walking.

Strategies include :

- Create a continuous and linked public realm that is clearly defined and consistent;
- Ensure all public realm development is consistent and coordinated in regards to material selection and function;
- Link activity nodes and destinations within the Neighbourhood Centre;
- Connect to the surrounding network of pedestrian and cycle routes;
- Respond to the main routes of vehicle movement throughout the area;
- Establish a hierarchy of streets and spaces;
- Promote place based intuitive way finding, supported by a simple signage system;
- Use a selective palette of materials to provide a unifying theme and a distinctive sense of identity;
- Ensure accessibility for prams, wheelchairs users and people with disabilities or mobility problems as an integral element of the public realm design.

Activity

Activity can be defined as the events and functions that occur in a public realm that generate and encourage positive social interaction; and the land uses and functions that adjoin public spaces that supports and encourage pedestrian use.

2.1. PUBLIC REALM CONT.

Strategies include :

- Provide space and amenities in order to maintain and enhance activity throughout the day and into the evening;
- Allow uses adjacent to the public realm to spill out and use the public zones, i.e. seating to extend into the street;
- Design spaces to have multiple functions and be flexible, i.e. outdoor markets
- Encourage people to stay longer including more resting areas along streets and in gathering spaces;
- Promote walking as the main mode of transport within the Neighbourhood Centre through the provision of footpaths, slower traffic and adequate shelter;
- Programme and manage activity within the public realm to enliven gathering spaces;
- Provide activities for a range of cultures and age groups including children, young adults and the elderly.

Interest

The public realm should provide enjoyment to the community. This can be achieved through activity, social interaction and the visual environment. A public realm that interests the community will encourage more use and foster community pride.

Strategies include:

- Develop a high quality art culture through the installation of public art
- Enable streets and public spaces to be lively places where people can engage with others in the community;
- Furniture arrangement provides options for different seating groups, i.e. loose furniture;
- Establish consistency and ensure the overall quality, appearance and amenity of the public realm within the Neighbourhood Centre is at its optimum.

Comfort

Comfort responds to the physical arrangement of the public realm to ensure that users are comfortable within the space.

Strategies include:

- Provide protection from the weather along major pedestrian routes and at key stops through canopies and awnings;
- Provide shade in summer and allow sunlight in winter through appropriate tree plantings;
- Use trees to provide a structure and scale to the public realm;
- Provide places for people to rest;
- Position elements within the public realm so that it does not obstruct pedestrian desir e lines or be hazardous to the visually impaired;
- Reduce the number of elements within the public realm to prevent clutter.

Safety and Protection

The design of the public realm is to address the issues of community safety and deter opportunities for crime and anti-social behaviour. Based on the principles of Crime Prevention Through Environmental Design (CPTED) the strategies include:

- Creating well defined routes, spaces and entrances that provide convenient movement;
- Ensure passive surveillance of public spaces to raise the likelihood that an offender can be either deterred, viewed and identified;
- Provide a range of lighting to ensure spaces are well lit at night;
- Promote a sense of community ownership, respect, responsibility and pride;
- Incorporate well designed security features into the public spaces;
- Ensure ongoing maintenance of the public realm to indicate the intolerance for vandalism;
- Provide management of the public realm to ensure there are regular activities in the public realm.

2.1. PUBLIC REALM CONT.

Environment

The urban infrastructure within the Tambrey Neighbourhood Centre needs to respond to the natural systems and environment in order to mitigate emerging environmental issues and to develop healthier places.

Strategies include:

- Design drought tolerant, water efficient landscapes to reduce irrigation needs;
- Use locally native plant species where appropriate in order to maintain and encourage biodiversity and ecology;
- Incorporate water sensitive urban design features in the public realm, including possibly rain gardens, but definitely porous pavements to locally capture and treat stormwater runoff;
- Plant trees to maximise shading of pavements in order to reduce the heat island effect;
- Limit the use of turf to areas of maximum visual and functional benefit to the community;
- Use materials and resources efficiently, i.e. local materials;
- Promote energy efficiency, e.g. solar power where possible.

Management and Maintenance

Ongoing management and maintenance of the public realm plays a significant role in its success. Best practice in management and maintenance can assist safety and foster community pride.

Strategies include:

- Implement an event programme for gathering spaces to ensure the local community uses them regularly, i.e. outdoor markets;
- Select materials and elements that are hardwearing and resistant to vandalism;
- Use best practice construction methods to optimise lifecycle and performance of public realm elements, i.e. Street furniture, fixing methods, paving substrates.

E DESIGN STRATEGIES

- Design public spaces away from the sun during key times
- Celebrates the natural and cultural heritage of the area through public realm elements and public art.
- Link activity nodes and destinations within the Neighbourhood Centre.
- Establish a hierarchy of streets and spaces.
- Use a selective palette of materials to provide a unifying theme and a distinctive sense of identity.
- Provide space and amenities in order to maintain and enhance activity throughout the day and into the evening.
- Allow uses adjacent to the public realm to spill out and use the public zones, i.e. café seating to extend into the street.
- Encourage people to stay longer including more resting areas along streets and in gathering spaces.
- Use trees to provide a structure and scale to the public realm.
- Provide a range of lighting to ensure spaces are well lit at night time.
- Promote a sense of community ownership, respect, responsibility and pride.
- Design drought tolerant, water efficient landscapes to reduce irrigation needs.

2.2.

WATER SENSITIVE URBAN DESIGN

An integrated approach to water management which inputs appropriate water sensitive urban design (WSUD) techniques is required within urban spaces. The Neighbourhood Centre as a whole aims to take a precinct wide approach to sustainable use of all water forms.

Applying WSUD practices become challenging when dealing with the harsh nature of the North West. Dramatic change of weather conditions from major flooding events to comprehensive periods of drought, as well as the impervious nature of local Pindan soils all present unique challenges to a WSUD approach.

Within streetscapes WSUD can be applied through rain gardens infiltration techniques and swale networks to medians and verges. The adoption of Xeriscaping principles can also minimise the need for irrigation.

Within urban spaces – swales and bioretention methods can be used in a more formalised and urban matter to ensure water does not linger and create a mosquito issues within public areas. Swales can be seamlessly used within the urban areas and can become a celebrated design element within the public realm.

As water is a major issue in the North West ensuring suitable WSUD practices are adopted is critical, especially for a successful landscape response.

By adopting WSUD practices within the Neighbourhood Centre successful landscape spaces are created that provided essential aspects of the public realm such as provision of shade, softening of harsh urban environments, greenery and cooling while integrating a modern water wise approach.

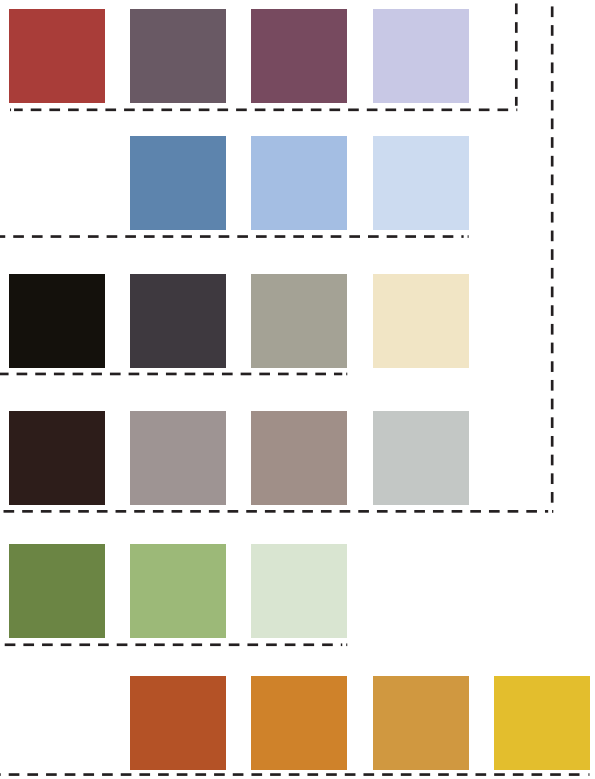
3.0. DESIGN ELEMENTS

3.1.

COLOUR PALETTE

Colours are to be selected from the natural palette of indigenous plant species and local earthy soil/stone tones.

Suitable colours include: Deep reds-browns, dusty oranges, soft greens, light greys, silvers and creams. Bright and light colours should be limited but used as a feature definition.



3.2.

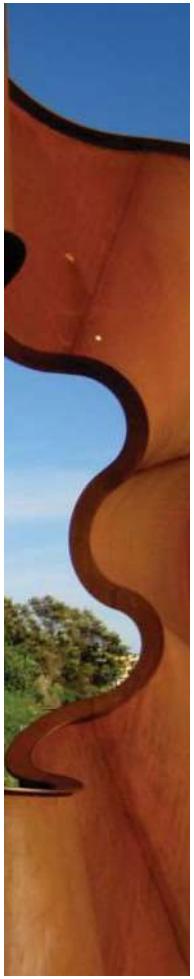
3.3.

WALLS & STEPS

SURFACE TREATMENTS

3.4.

CORTEN STEEL



3.5.

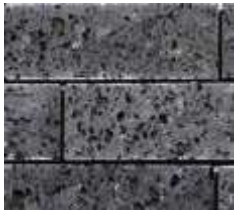
KARRATHA STONE

3.6.

GRAVEL MULCH

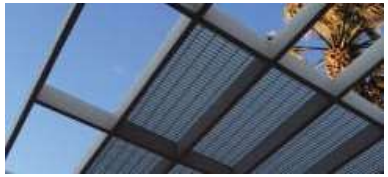
3.7.

BLACK BASALT STONE



3.8.

SHADE STRUCTURES



3.9.

SIGNAGE & WAY FINDING

3.10.

PUBLIC ART

3.11.

LIGHTING

Lighting to the main street is designed to be focused for both vehicular and pedestrian safety. Lighting is also of key importance to allow for activities to occur in the evenings, when the cooler conditions can make the use of public realm more accessible.

LED lighting will be considered for all areas as a maintenance minimisation technique with all lighting scaled to suit the location and its intent. Lighting fixtures have been selected to be robust and enhance the overall appeal of the environment.

SPOT LIGHT

POLE TOP LIGHTING TO VEHICULAR AND PEDESTRIAN AREAS

UPLIGHTING TO FEATURE TREES

PATH LIGHTING TO PEDESTRIAN AREAS

3.12.

STREET FURNITURE

ENVIRON ENCH TA LE RANGE

I E HOOP

PAR LAND IN

PAR LAND TREE GRATE

OLLARD

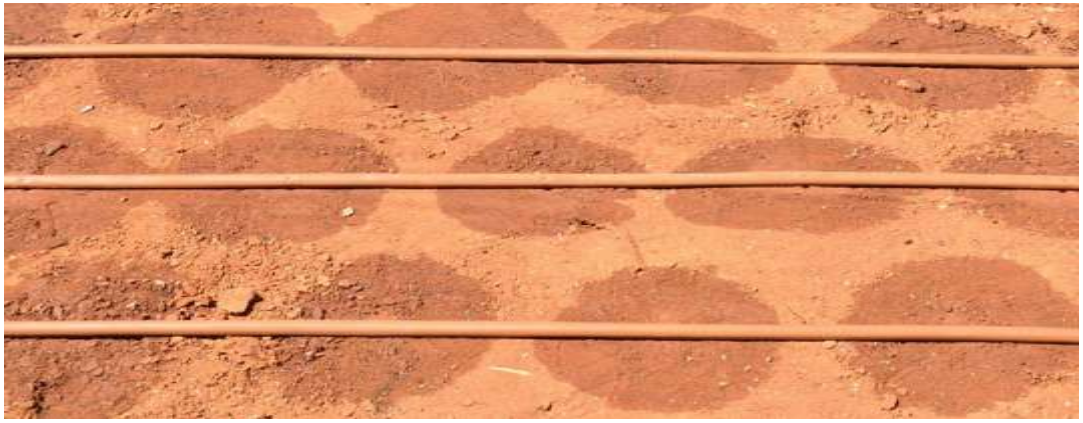
3.13.

IRRIGATION

The landscape masterplan for the Tambrey Neighbourhood Centre has been designed with the reduction of water consumption as a key driving strategy. At this stage, landscaped areas that are to be irrigated will have their water source drawn from mains water supply. Investigations and considerations of recycled water technology will be considered in the progression of the development to detailed design based on viability and budget constraints with the view to alleviate or reduce the requirements to utilise potable water supplies.

No lawn areas are proposed and all garden bed areas will be mulched with gravels or mulches to aid water retention and reduce moisture evaporation. Soil conditioners will also be used in garden beds to add water retention. Not all garden beds are proposed to be irrigated, with areas in drainage swales and other lesser priority areas proposed to be unirrigated areas utilising native and drought tolerant species.

Where irrigation systems are to be installed, a focus on Waterwise accredited systems utilising sub-surface droplet emitters will be used in accordance with the City's current specifications.



4.0. PLANTING PALETTE

4.1. EXOTIC TREES

Planting Palette and Strategy

Plant species are proposed to be predominantly endemic in composition and / or known to be waterwise and tolerant to the harsh Pilbara conditions. Feature amenity areas, such as the Main Street and Civic Plaza will have feature shade trees that will be exotic, but all understorey garden beds will consist of predominantly native species. An emphasis is to be placed on providing trees in the Main Street, Civic Plaza and carparking areas that provide good canopy cover to cool these areas through shade provision. The Poinciana (Delonix regia) and Yellow Flame Tree (Peltophorum pterocarpum) are two such tree species which have been used extensively in Karratha as good urban trees providing great shade cover that can tolerate the harsh Pilbara climate. Generally, all trees in pedestrian areas will be selected to provide shade and colour and where possible be an extension of a coordinated planting program through the greater Karratha area.

Areas on the periphery of the development and also in the minor residential streets will have a stronger emphasis on native tree and shrub plantings. Infill planting to the Bathgate Road verge, the drainage swales / verge on Dampier Hwy and beautification to verge adjacent the existing drainage channel to the west of the development site will be planted entirely with native tree and shrub species.

Final species selection will be determined in accordance with the Shire of Roebourne's approval and availability at nurseries at the submission stage of detailed landscape construction drawings.

It is proposed that the following indicative planting palette will be used for the selection of species for landscape amenity areas of the development and streetscape.

E otic Tree Schedule

Caesalpina ferrea	Leopard Tree
Cupaniopsis anacardiodes	Tuckeroo
Delonix regia	Poinciana
Ficus hillii	Hill's Ficus
Mimusops elengi	Bullet Wood Tree
Peltophorum pterocarpum	Yellow Poinciana
Pongamia pinnata	Indian Beach
Pterocarpus indicus	Rosewood
Tabebuia rosea	Pink Trumpet Tree
Tipuana tipu	Pride of Bolivia

BOTANICAL NAME: Peltophorum pterocarpum
COMMON NAME: Yellow Poinciana

BOTANICAL NAME: Delonix regia
COMMON NAME: Poinciana

BOTANICAL NAME: Tabebuia rosea
COMMON NAME: Pink Trumpet Tree

4.2. LOCAL TREES

Native Tree Schedule

Acacia coriacea	Wirewood
Acacia aneura	Mulga
Adansonia gregorii	Boab
Bauhinia cunninghamii	Jigal Native Bauhinia
Brachychiton acuminatus	Rock Kurrajong
Corymbia flavescens	Cabbage Ghost Gum
Corymbia hamersleyana	Pilbara Bloodwood
Corymbia opaca	Bloodwood
Corymbia terminalis	Inland Bloodwood
Eucalyptus camaldulensis	River Gum
Eucalyptus coolibah	Coolibah
Eucalyptus leucophloia	Snappy Gum
Eucalyptus victrix	Coolibah
Livistona alfredii	Millstream Fan Palm
Melaleuca argentea	Silver Cadjeput
Terminalia canescens	Joolal

BOTANICAL NAME: Corymbia hamersleyana
COMMON NAME: Pilbara Bloodwood

BOTANICAL NAME: Eucalyptus vitrix
COMMON NAME: Collibah

BOTANICAL NAME: Adansonia gregorii
COMMON NAME: - Boab

BOTANICAL NAME: Eucalyptus camaldulensis
COMMON NAME: River Gum

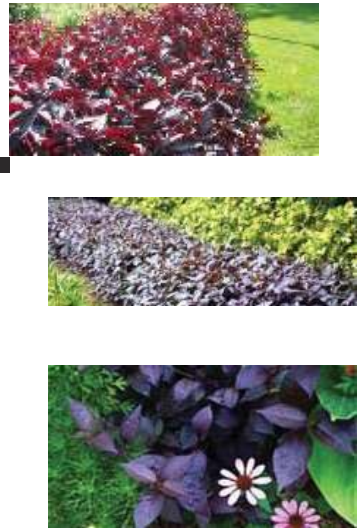
BOTANICAL NAME: Livistona alfredii
COMMON NAME: Millstream Fan Palm

4.3.

SHRUBS & GROUND-COVERS

Shrub Schedule

Acacia gregorii	Gregory's Acacia	Myoporum montanum	Native Myrtle
Acacia hilliana	Hill's Tabletop Wattle	Ptilotus sp.	Mulla Mulla
Allamandra nerifolia	Bush Alamanda	Senna sp.	Cassia
Alternanthera dentata	Purple Knight Alternanthera	Scaevola crassifolia	Thick Leaf Fan Flower
Aristida contorta	Kerosene Grass	Stemodia sp.	Stemodia
Bougainvillea glabra	Paper Flower	Strelitzia reginae	Bird of Paradise
Conostylis candicans	Grey Cottonhead	Swainsona formosa	Sturt Desert Pea
Dianella caerulea	Dianella Cassia Blue	Swainsona pterostylis	Dampier Pea
Eremophila glabra 'Kalbarri Carpet'	Emu Bush	Terminalia supranitifolia	Burrup Terminalia
Erempohila maculata	Spotted Emu Bush	Triodia epactia	Sticky Spinifex
Eremophila microtheca	Heath Like Eremophila	Triodia pungens	Soft Spinifex
Evolvulus pilosus	Blue Eyes	Westringia fruticosa	Native Rosemary
Gomphrena canescens	Batchelors Buttons	Zamia furfuracea	Cardboard Palm
Grevillea stenobotrya	Dune Grevillea		



BOTANICAL NAME: Alternanthera dentata
COMMON NAME: Purple Knight Alternanthera

BOTANICAL NAME: Conostylis candicans
COMMON NAME: Grey Cottonheads

4.3.

SHRUBS & GROUND-COVERS CONT.

BOTANICAL NAME: Grevillea stenobotrya
COMMON NAME: Dune Grevillea

BOTANICAL NAME: Swainsona formosa
COMMON NAME: Sturt Desert Pea

BOTANICAL NAME: Eremophila glabra 'Kalbarri Carpet'
COMMON NAME: - Emu Bush

BOTANICAL NAME: Ptilotus axillaris
COMMON NAME: Mat Mulla Mulla

BOTANICAL NAME: Triodia pungens
COMMON NAME: Soft Spinifex

5.0.
CONCEPT DESIGN

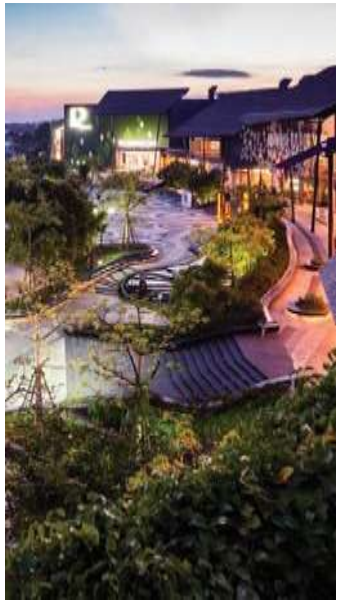
5.1.

OVERALL CONCEPT

1 Main Street
2 Proposed Residential
3 Proposed Pedestrian Path (to connect site to existing residential)
4 Existing Drainage Corridor
5 Carparking
6 Existing Caltex Building
7 Proposed Landscaped Swales
8 Proposed Entry Signs
9 Proposed Shade Shelter
10 Proposed Bike Rack Locations
11 Proposed Commercial / Retail
12 Proposed Short Stay Accomodation
13 Proposed Residential - Mixed Use

5.2.

DESIGN INFLUENCES



River Systems

The river systems of the North West are integrative and diverse network of tributaries. When viewed from an aerial perspective they create interesting and complex pattern meandering patterns across the landscape. The landscape design aims to encapsulate some of the patterns these systems create in a design language legible on the ground plane through the following possible responses;

- Tributaries (through differing paving patterns) could be used as way-finding by guiding people to the main heart of the plaza where life, gathering & vibrancy are to dominate.
- Tributaries can direct stormwater runoff through pedestrian focused areas in an attractive landscape response that could include informal rapids as a source of recreation opportunity.

The possible creation a small urban microcosm ecosystem that fosters flora and fauna common to Pilbara area, through the provision of a rockwork and associated shrub and tree plantings that mimic a Pilbara landscape.

5.2.

DESIGN INFLUENCES

CONT.

arratha Gorge Landscapes

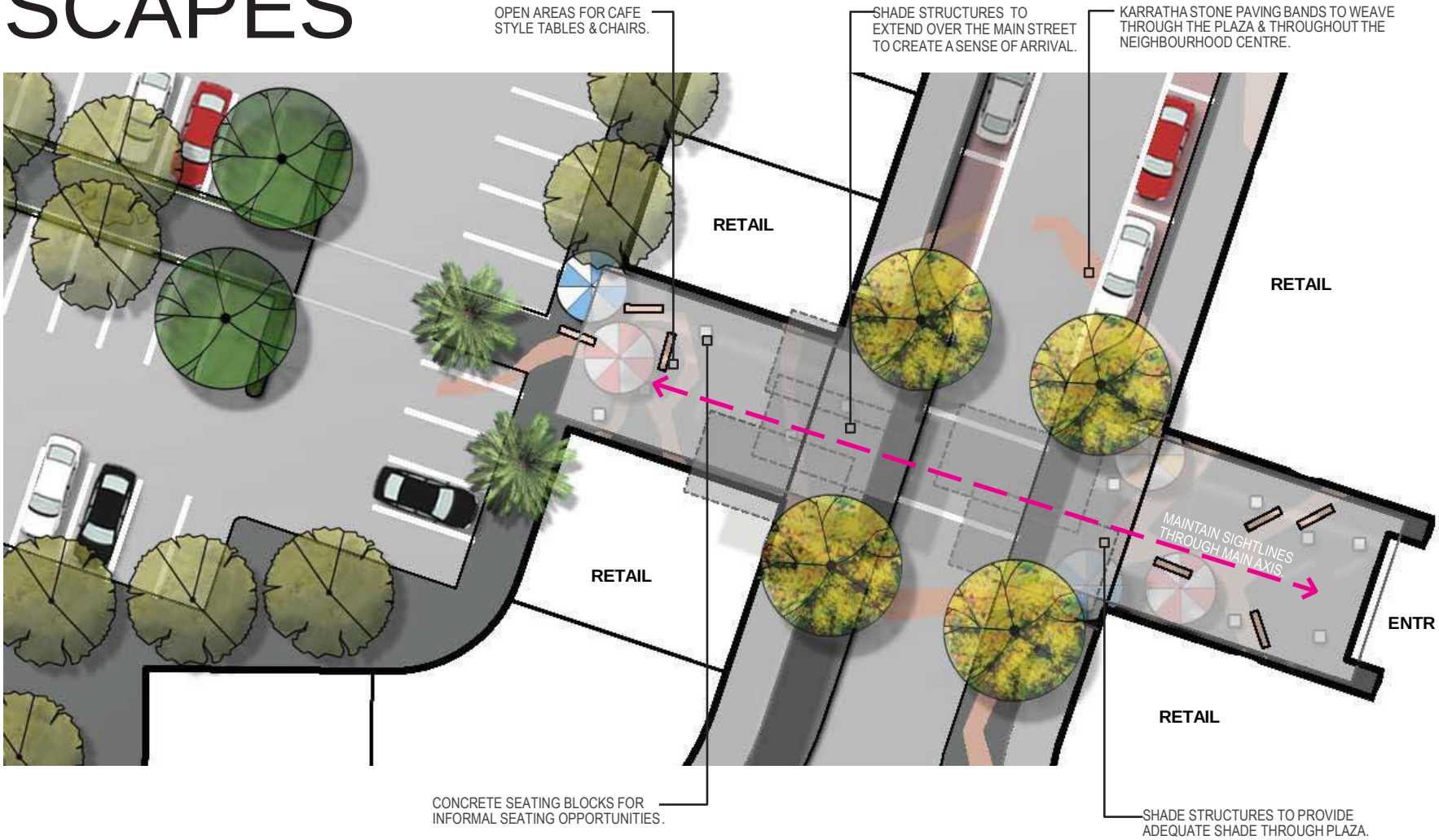
The gorges of the Pilbara region display some of Earth's oldest rock formations as well as creating unique and instantly recognisable scenery. The landscape design response should draw inspiration from these landscapes through the following possible responses;

- Opportunities for interactive landscape designs that reflect the river systems and tidal flats of the Pilbara landscape, whilst also forming attractive stormwater drainage lines through pedestrian focussed areas.
- Incorporating the gorge geology including ridges, furrows or linear marks into design elements such as walls, stairs & paving patterns.

This can be achieved through irregular shaped stairs, angled wall shapes or through a direct interpretation of the geology in the form dry staked / stratified stone garden walls.

5.2.

STREET-SCAPES



5.3. PLAZA CONCEPT

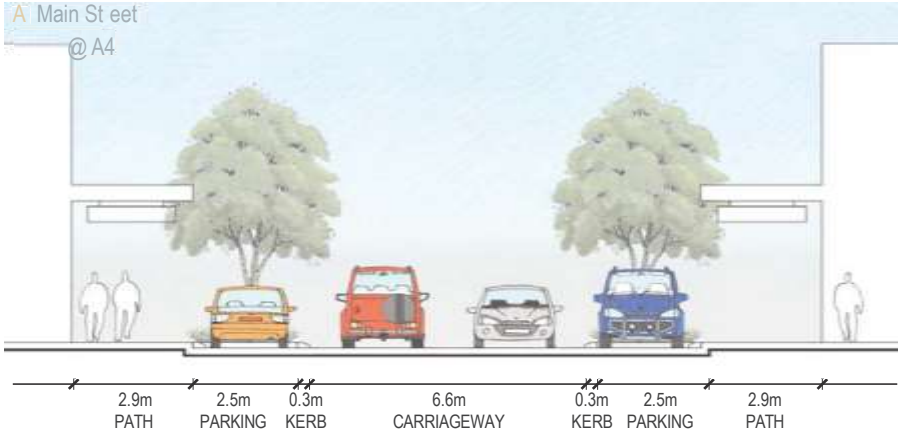
Main Street

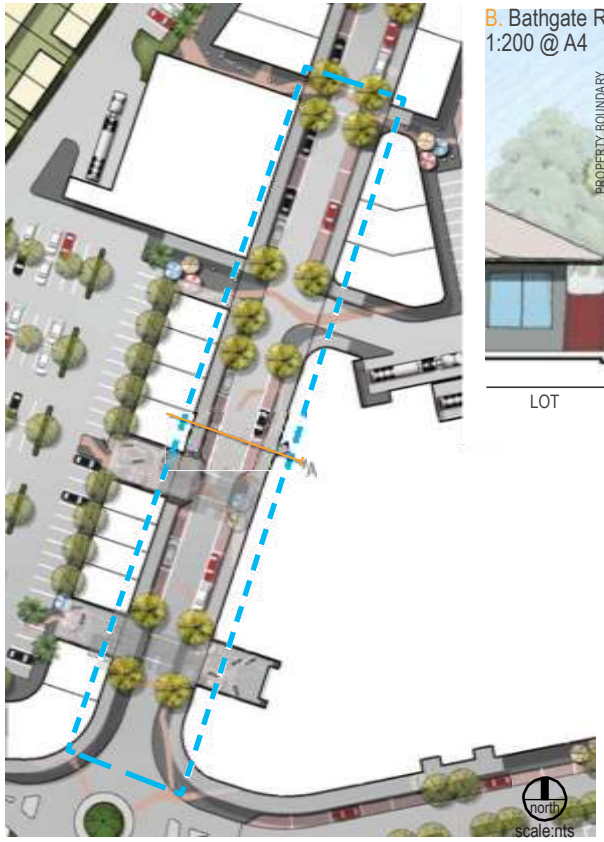
Streetscapes within activity centres and urban areas play a major role in creating a pedestrian focused urban environment as well as creating hierarchy and strong entry focal points.

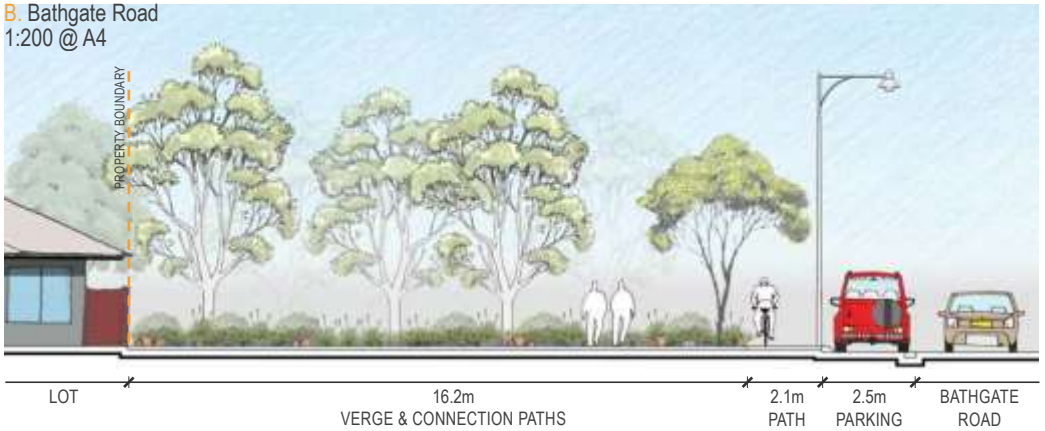
Successful streetscapes look to work seamlessly with surrounding high quality urban spaces with high quality materials, encouraging activation, integrate vehicle provision, trees for hierarchy, aesthetics and shade & creating human scale streetscapes.

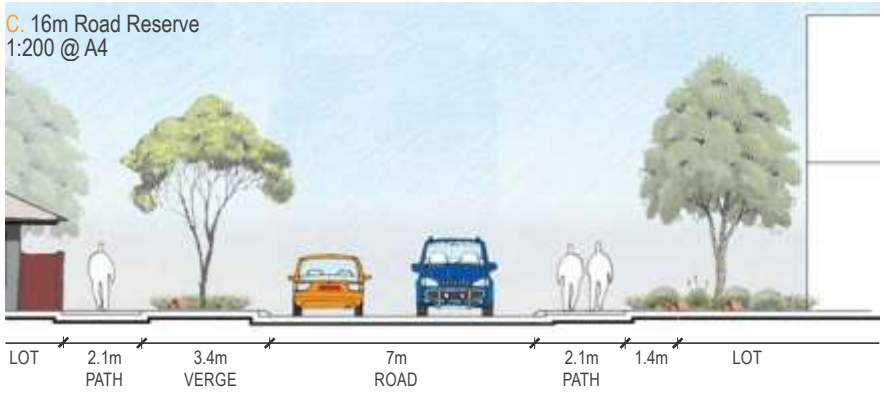
The mainstreet of the Tambrey Neighbourhood Centre shall be designed to provide an urban amenity encouraging the community to use the space for activity and interaction. With a focus on promoting community ownership and pride in the urban environment, the Main Street is to be clearly legible with an active streetscape, connectivity, enhanced pedestrian experience and provide the community with a sense of safety and security to encourage use throughout the day and evening.

The streetscape aims to create an extension to the vibrant heart of the new centre through the provision of the same materials palette for hard and soft landscaping, including street furniture.









E DESIGN STRATEGIES

- Create adequate shading through the integration of trees, shade structures and buildings.
- Tree planting provides shelter from winds and creates a more comfortable space for the public.
- Provide a feeling of activity. Sense of place and stimulus.
- Encourage pedestrians to engage with and cross the street.
- Slows down traffic speeds and enhances pedestrian safety.

5.4. CAR PARKING

Carparking is proposed to be located along the length of the Main Street for convenience access to retail trade located along the street. Parallel parking spaces are located at the same level as the adjacent footpath enabling for ease of access while also allowing pedestrians to be able to cross the road easily.

Larger designated carpark areas are to be provided to periphery of the retail core. These parking areas is anticipated to have shade provided by trees in accordance with the City of Karratha's preferred 1 tree per 6 carbay requirements. In addition, possibly shade canopies could be provided in lieu of trees.

The reduction of heat within a carpark is important especially due to the climatic conditions of the North West. The use of pedestrian pavements around the carpark that are reflective coupled with landscape areas are aimed at decreasing the effects of the bituminous hardstand in the carparking. Large canopy shade trees will ensure heat transfer is somewhat reduced and a more comfortable pedestrian environment created.

Well shaded Carpark

Peltophorum pterocarpum (Yellow Poinciana)

scale:nts

5.5.

DRAINAGE SWALES

Precipitation in the North West in general is both scarce but also heavy in volume during the cyclonic storm periods. Flooding events combined with the impervious nature of local Pindan soils creates large movements of water run-off which needs to be strategically redistributed and redirected through the site.

Linear drainage swales along the verge area to Dampier Hwy are to redirect water run-off from the site to the main existing drain to the West of the site. These drainage swales are to be landscaped in an attractive response utilising local endemic species that can tolerate a level of inundation. It is proposed that these areas will not be irrigated and plant species selected to ensure that they survive and flourish on the natural rainfall patterns of Karratha. The landscaping will be supplemented with the placement of rocks and gravels which will provide a unification technique across the swales to prevent erosion in flooding events. Swales and bioretention methods can be used in a more formalised and urban matter to ensure water does not linger and create a mosquito issue within public areas.

The existing drainage swale to the west of the site is to have an landscaped edge to the development boundary using unirrigated native endemic shrub and tree species. The existing dual use path that runs primarily north south along the drainage swale is to be retained and integrated into the footpath network for the development. Nodal locations are proposed at the major footpath intersections for passive recreation opportunities. The major east west pedestrian network will terminate on a proposed pedestrian bridge crossing over the existing drainage channel to ensure good pedestrian connectivity to the existing Tambrey neighbourhood to the west.

A. Typical Swale Treatment
1:200 @ A4

TAMBREY
NEIGHBOURHOOD
CENTRE

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APPENDIX F

TRANSPORT ASSESSMENT REPORT

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Tambrey Neighbourhood Centre and Mixed Use Site

TRANSPORT ASSESSMENT REPORT FOR
PROPOSED DEVELOPMENT PLAN

Prepared for
THE KARRATHA JOINT VENTURE
LANDCORP

Prepared by
Uloth and Associates
6 July 2015; Revised 18 August 2015

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TECHNICAL APPENDIX

1. INTRODUCTION

The Karratha Joint Venture (KJV) comprises FJM Property Pty Ltd and Raydale Holdings Pty Ltd. The KJV is proposing to develop a Neighbourhood Centre and Mixed Use Site at the corner of Dampier Road and Bathgate Drive in the Karratha locality of Tambrey, as identified in the Locality Plan in Figure 1.

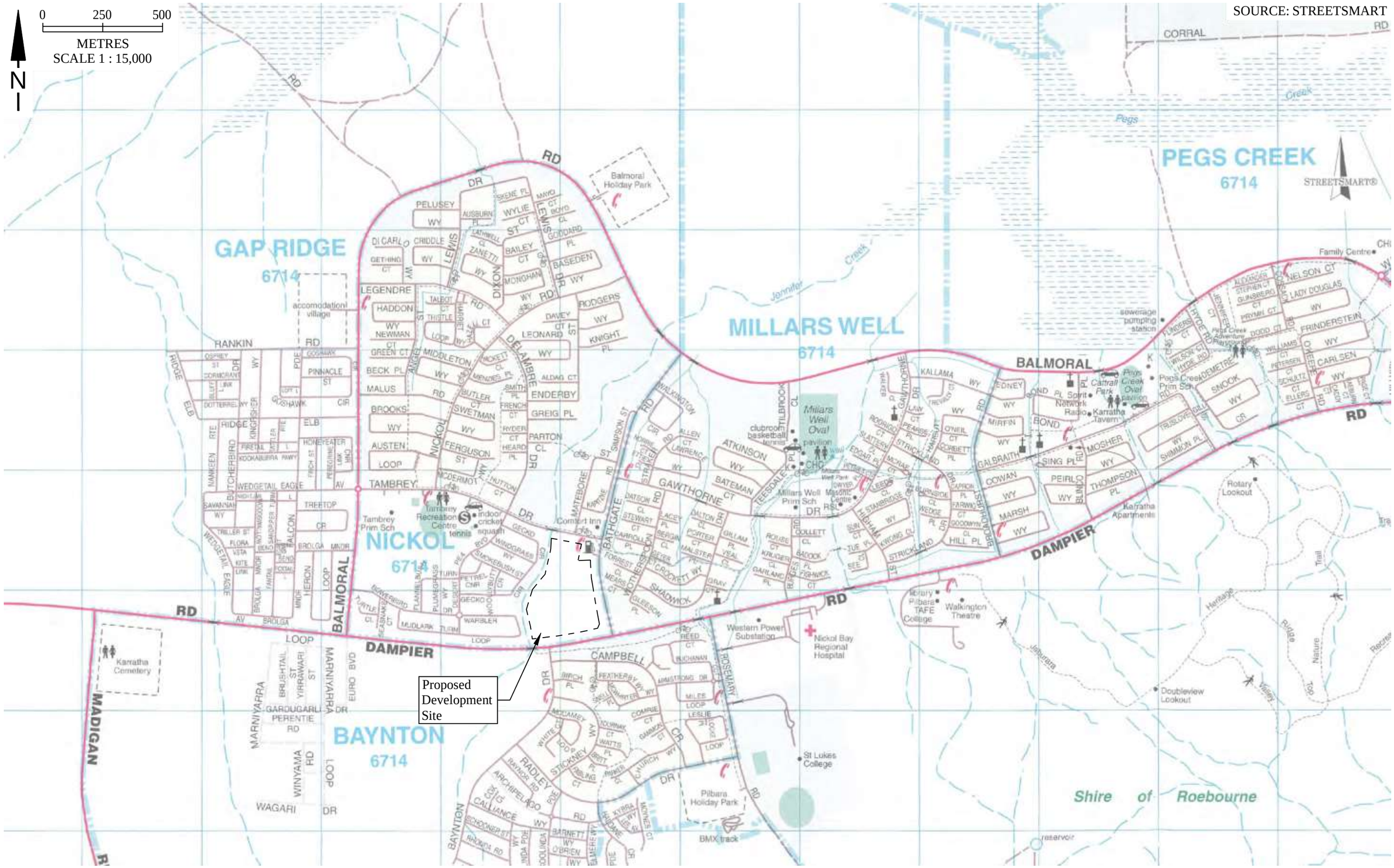
The site is zoned Urban Development, and is identified as Development Area 7 (DA7) by Shire of Roebourne Town Planning Scheme No. 8 (TPS 8). The Western Australian Planning Commission's *Karratha Urban Development Program* identifies the site as a commercial/mixed use zone, to include a Neighbourhood Shopping Centre plus a range of residential dwelling types and other mixed uses, while 'Volume 2: City Growth Plan' of the *Pilbara Cities - Karratha City of the North* project identifies the Centre as a 'lower order District Centre'. TPS 8 also indicates that the site requires the preparation of a Development Plan.

Uloth and Associates has been commissioned to prepare a Transport Assessment Report for the Preliminary Development Plan prepared by Taylor Robinson.

1.1 STUDY OBJECTIVES

The overall objective of this study is to prepare a full Transport Assessment Report for submission in support of the proposed Development Plan and a subsequent Development Application. Specific objectives include the following:

- Provide justification for the proposed access arrangement to the site, particularly the proposed access off Dampier Road, which is a key component to the development of the Main Street.
- Identify future traffic volumes and other transport requirements, in order to recommend an overall road hierarchy (with required road reserves) for the proposed development.
- Confirm the required parking supply for the retail and commercial uses within the core of the proposed development.
- Confirm acceptable intersection operational characteristics for the proposed intersection configurations.
- Identify necessary access arrangements for service vehicles.



Locality Plan and Existing Road Network

PROPOSED TAMBREY NEIGHBOURHOOD CENTRE

FIG. 1

2. STUDY FINDINGS AND CONCLUSIONS

The study findings and conclusions regarding the proposed Tambrey Neighbourhood Centre are documented in this Chapter. Additional information is provided within the Technical Appendix.

2.1 EXISTING SITUATION

The existing situation in the vicinity of the proposed development site is shown in the aerial photograph in Figure A.1 in the Technical Appendix.

- It can be seen in Figure A.1 that Dampier Road (a 'State and Regional Road' in TPS 8) is a 4 lane divided arterial road, with a dual-lane roundabout at Bathgate Road and an unsignalised junction at Baynton Drive (with an intersection spacing of 250 metres).

- Bathgate Road (a 'District Road' in TPS 8) is a 2 lane road with wide gravel shoulders, while Tambrey Drive and Baynton Drive (both 'Local Roads') are kerbed 2-lane roads with footpaths.

- Dampier Road has a 70 kilometre per hour speed limit in the vicinity of the proposed development, while Bathgate Road has a speed limit of 60 kilometres per hour. Both Tambrey Drive and Baynton Drive have 50 kilometre per hour limits as they are local residential streets with no alternative speed signage.

- It is important to note that there is an existing Petrol Station at the corner of Bathgate Road and Tambrey Drive, with 2 access driveways off each road. It is also important to note the significant drainage reserve along the western boundary of the development site, together with a paved dual-use path that runs from Baynton Drive through an underpass beneath Dampier Road and then north to Tambrey Drive, as shown in Figure A.1.

- In order to identify the existing traffic flows in the vicinity of the proposed development Uloth and Associates initially obtained available traffic count data from Main Roads WA, being weekly traffic counts on Dampier Road, Bathgate Road and Baynton Drive, from 2008 and 2009.

- The Dampier Road data shows Thursday as the busiest day of the week. Additional traffic counts were carried out by Uloth and Associates at the Dampier Road junctions with both Bathgate Road and Baynton Drive on Thursday 10 May 2012, in order to identify up to date traffic data.

- The 2012 Thursday peak hour traffic flows and corresponding daily traffic are shown in Figures A.2 and A.3, respectively, in the Technical Appendix (together with estimated flows at Tambrey Drive based on traffic counts previously carried out).

- It can be seen in Figure A.3 that Dampier Road currently carries 14,400 vehicles per day adjacent to the proposed development, falling to approximately 12,500 vehicles per day west of Baynton Drive. It can also be seen that Bathgate Road carries 6,500 vehicles per day north of Dampier Road, while Baynton Drive carries 5,500 vehicles per day south of Dampier Road.

- Tambrey Drive carries 4,400 vehicles per day west of Bathgate Road and 4,900 vehicles per day west of the petrol station access.

- It is important to note that since existing traffic flows are well above 3,000 vehicles per day, both Bathgate Road and Tambrey Drive should already be upgraded to boulevard-style roads, with the provision of painted medians and regular pedestrian refuge islands, even without the proposed development.

- The existing functional road hierarchy in the vicinity of the proposed development is shown in Figure A.4 in Chapter A.1 in the Technical Appendix, initially based on the allocations within TPS 8 but also taking into account the likely classifications under Liveable Neighbourhoods.

2.2 PROPOSED DEVELOPMENT

The Preliminary Development Plan for the proposed Tambrey Neighbourhood Centre and Mixed Use Site, as prepared by Taylor Robinson Architects, is shown in Figure A.5 in the Technical Appendix.

- It can be seen in Figure A.5 that the proposal is to create a Main Street Neighbourhood Centre, with the Main Street running from Dampier Road to Tambrey Drive, with access also off Bathgate Road.

- It is important to note that earlier concept plans suggested the Main Street should connect to Dampier Road midway between Bathgate Road and Baynton Drive. However the plan was modified on the basis of the intersection spacing requirements discussed below in Section 2.4.1.

- The proposed Centre includes a Primary Retail area fronting the central portion of the Main Street, with Commercial development extending further along the Main Street. The plan also includes Food and Beverage at the corner of the Main Street and Dampier Road plus Fast Food sites at the corner of Dampier Road and Bathgate Road, together with Residential along Bathgate Road and along the western boundary adjacent to the drainage reserve.

- The overall plan also includes a total parking provision of 909 spaces within areas accessible by the general public, including a parking provision of 806 spaces within the proposed Retail development areas of Zones 3b, 4 and 6 (with 154 spaces west of the Main Street and 652 spaces east of the Main Street).

- The proposed land uses are shown in Table A.1 in Chapter A.2 in the Technical Appendix, based on Land Use Zones identified in Figure A.6. Anticipated future trip generation for the overall development is also shown in Table A.1, indicating a future daily traffic generation of 13,520 vehicles per day on a Thursday, with 1,372 vehicle trips during the PM peak hour.

2.3 PARKING REQUIREMENTS

Parking requirements for the non-residential uses within Zones 3b, 4 and 6 of the proposed development are calculated in Table A.2 in Chapter A.2 in the Technical Appendix.

- It can be seen in Table A.2 that the sum of the parking demand for each individual land use type results in an overall requirement for 753 spaces. However, it is also important to acknowledge that the peak parking demands for the Restaurant and Tavern are expected to occur on a Saturday night, while the peak for the Fast Foods is expected to occur on a Friday evening, neither of which will clash with the peak parking period for the retail and commercial uses.

- Table A.2 therefore also shows a Shared Parking analysis under the assumption that the Restaurant, Tavern and Fast Foods are all expected to generate 50 percent of their peak demand during the peak period of the remainder of the Centre.

- On the basis of this shared parking analysis, it is estimated that the proposed commercial developments will generate an overall peak parking requirement for 660 spaces, resulting in an overall surplus of 249 spaces.

2.4 INTERSECTION SPACING AND ACCESS

The intersection spacing requirements adjacent to the proposed development are discussed in this chapter, together with the resulting access arrangements for the proposed Centre.

2.4.1 Main Street Connection to Dampier Road

- In Guide *to Road Design - Part 4A: Unsignalised and Signalised Intersections*, Austroads specifies Safe Intersection Sight Distance (SISD) as the minimum standard that should be provided on a major road at any intersection, in order to provide sufficient distance for the driver of a vehicle on the major road to observe a vehicle from the minor road moving into a collision situation, and to stop before reaching the collision point.

- On the basis of this definition, it is recommended that the SISD is a suitable measure to adopt for the minimum acceptable separation between intersections.

- The SISD for a speed of 70 kilometres per hour is 151 metres, while the SISD for a speed of 60 kilometres per hour is 123 metres (using a reaction of 2.0 seconds in Table 3.2 of the Austroads Guide), reducing further to 97 metres at 50 kilometres per hour and 73 metres at 40 kilometres per hour.

- The existing intersection spacing along Dampier Road is 250 metres, from the eastbound give way line at the Bathgate Road roundabout to the centre line of Baynton Drive. If a new road was constructed between these 2 intersections, the resulting intersection spacing would be a maximum of just 125 metres, which is insufficient for the existing 70 kilometre per hour speed limit, and is therefore unacceptable.

- However, it is important to note that the development of the Neighbourhood Centre will attract significant traffic movements from the residential area south of Dampier Road, accessed via Baynton Drive, which will create significant weaving issues within Dampier Road under the current intersection arrangements, with high traffic volumes carrying out the right-left stagger between Baynton Drive and Bathgate Road.

- Taking into account the agreed vision for the Neighbourhood Centre to be focussed around a central 'Main Street' (and the resulting requirement for a highly connected precinct with direct access off Dampier Road) it was therefore recommended to pursue the connection of the Main Street to Dampier Road opposite Baynton Drive, with the construction of a new roundabout to control the resulting 4-way intersection.

- In addition to avoiding the construction of an additional conflict point along Dampier Road, this new roundabout will allow north-south traffic between Baynton Drive and the new Centre to safely cross Dampier Road, without having to use the regional road at all for this local shopping trip.

- The construction of a roundabout at Baynton Drive also improves the existing weaving manoeuvre for southbound traffic from Bathgate Road to Baynton Drive, by removing the existing left turn lane in Dampier Road and hence increasing the available weaving length for this manoeuvre.

2.4.2 Access off Bathgate Road

- The proposed access roads off Bathgate Road provide intersection spacings of approximately 110 metres from Tambrey Drive and approximately 80 metres from the Dampier Road roundabout, which are suitable for design speeds of approximately 55 kilometres per hour and 45 kilometres per hour, respectively.

2.4.3 Access off Tambrey Drive

- The recommended minimum intersection spacing along Tambrey Drive is 97 metres, for a travel speed of 50 kilometres per hour.

- With the existing junction at Matebore Street located 120 metres west of Bathgate Road, the only logical location for an intersection with the proposed Main Street is to create a 4-way intersection at Matebore Street, with the construction of a small roundabout, as is currently proposed in Figure A.5.

2.5 FUTURE TRAFFIC FLOWS

- As noted above in Section 2.2 it is expected that the fully developed Centre could generate a total of 13,520 vehicle trips per day on a Thursday with 1,372 vehicle trips during the PM peak hour.

- Taking into account the existing distribution of residential areas in the vicinity of the proposed Centre, and the planned additional residential growth throughout the assumed catchment area, it is expected that the future traffic flows generated by the proposed development will travel to/from the Centre via the following approach routes:
  - Dampier Road, west: 30 percent
  - Baynton Drive, south: 20 percent
  - Tambrey Drive, west: 20 percent
  - Bathgate Road, north: 17 percent
  - Dampier Road, east: 12 percent
  - Matebore Street, north: 1 percent

- A traffic assignment process was then carried out for each of the proposed land use zones within the Neighbourhood Centre, resulting in the distribution of future peak hour development traffic flows as shown in Figure A.7 in the Technical Appendix, and the future internal daily traffic flows as shown in Figure A.8.

- It can be seen in Figure A.8 that the Main Street is anticipated to carry 7,200 vehicle trips per day at the southern end, with 2,900 vehicle trips through the retail core and 3,300 vehicle trips at the northern end. It can therefore be seen that approximately 53 percent of the overall Neighbourhood Centre traffic will access via the proposed Dampier Road - Baynton Drive connection.

- Total future traffic flows were then also determined, by taking into account the anticipated growth of surrounding residential areas, together with the long term forecast of 31,000 vehicles per day on Dampier Road west of Bathgate Road, as published in the 'Volume 2 - City Growth Plan' report of the *Pilbara Cities - Karratha City of the North Project*.

- It is therefore assumed that existing traffic flows (excluding the proposed development) will increase as follows:
  - Tambrey Drive, west: 10 percent
  - Bathgate Road, north: 25 percent
  - Baynton Drive, south: 30 percent

  And Dampier Road is assumed to increase to a long term total of 31,000 vehicles per day, including the proposed development.

- The resulting total future daily traffic flows adjacent to the proposed Tambrey Neighbourhood Centre are therefore as shown in Figure A.9 in the Technical Appendix. It can be seen that Bathgate Road is expected to increase to between 8,000 and 9,000 vehicles per day in the long term, while Tambrey Drive is expected to carry 5,300 vehicles per day west of Bathgate Road and 8,000 vehicles per day west of the proposed Centre.

- The corresponding future PM peak hour traffic flows are shown in Figure A.10 in the Technical Appendix.

2.6 INTERSECTION OPERATIONAL ANALYSES

- Initial analysis showed that if the proposed Neighbourhood Centre and Mixed Use Site is developed with access only off Bathgate Road and Tambrey Drive (that is without the proposed Main Street connection to Dampier Road), then the right turn movements into Dampier Road from both Bathgate Road and Baynton Drive will fall to low (and ultimately unacceptable) Levels of Service as traffic flows on Dampier Road continue to increase.

- These intersection operational characteristics together with the weaving issues that would result, as discussed above in Section 2.4.1, suggest that an acceptable situation can only be achieved if a new roundabout is constructed at Dampier Road - Baynton Drive, with a northern leg connection to the proposed Neighbourhood Centre.

- Detailed intersection operational characteristics for the resulting recommended plan are shown in Tables A.3 to A.8 in Chapter A.4 in the Technical Appendix.

- Tables A.3 and A.4 confirm that if the Main Street is connected to Dampier Road, as proposed, then the Dampier Road roundabouts at Bathgate Road and Baynton Drive will both operate at overall Levels of Service A and B during the future Thursday PM peak hour, indicating good operating conditions with short traffic delays. Table A.5 then shows that the Bathgate Road - Tambrey Drive junction will operate at an acceptable Level of Service C during the long term future PM peak hour, while Tables A.6 to A.8 show that the remaining access roads into the Centre will also operate at acceptable Levels of Service.

2.7 PUBLIC TRANSPORT AND PEDESTRIAN/CYCLIST FACILITIES

- Figure 83 in the Karratha City of the North 'Volume 2 - City Growth Plan' report shows proposed bus route alignments for Karratha running in an east-west loop both north and south of Dampier Road. However, with the proposed development of the Tambrey Neighbourhood Centre and Mixed Use Site being a major destination at the western end of the Karratha Town Site, it is suggested that the future bus routes could be modified to provide a 'figure 8' loop at the western end in order to provide bus stops within the Main Street of the proposed Neighbourhood Centre.

- Possible future bus routes could therefore operate as shown in Figure 2 in Chapter 3 Recommendations, with possible bus stops located in the middle of the Main Street.

- Pedestrian routes will be provided along each of the public roads within the proposed Neighbourhood Centre, with additional routes also provided on an east-west orientation linking to the existing pedestrian routes adjacent to the Centre. The currently proposed future path network following the construction of the overall Centre is shown in Figure 3 in Chapter 3 Recommendations.

- On-street cycle lanes are typically required under Liveable Neighbourhoods for streets carrying in excess of 3,000 vehicles per day. It is therefore necessary to provide cycle lanes on the southern part of the Main Street, immediately north of Dampier Road. However, in order to reduce the overall road width for the remainder of the Main Street, it is suggested that no on-street cycle lanes should be provided north of the first roundabout. Cyclists can instead be accommodated within the traffic lanes, or upon the extensive path network also proposed.

2.8 ROAD HIERARCHY AND ROAD RESERVES

- In order to provide an acceptable network of public roads, it is proposed that the main street running between Dampier Road and Tambrey Drive should be a public road together with the east-west connection from the main street to Bathgate Road at the northern end and the residential street adjacent to the drainage reserve at the western boundary.

- With possible bus routes running along the Main Street together with on-street parking and a requirement for footpaths along the retail frontages, it is recommended that the Main Street should be classified as a Neighbourhood Connector A under Liveable Neighbourhoods. However, with low traffic volumes (less than 3,000 vehicles per day), it is not necessary to provide on-street cycle lanes, and neither is it proposed to provide a median.

- It is also proposed to provide indented on-street parking, rather than full parking lanes, thus allowing a reduction of the typical Liveable Neighbourhoods cross-section down to 18 metres.

- The east-west road linking to Bathgate Road should be defined as Access Street B, while the residential street to the west of the Main Street should be Access Street C, both with cross-sections in accordance with the general requirements of Liveable Neighbourhoods.

- The overall recommended road hierarchy for the proposed Neighbourhood Centre and Mixed Use Site is shown in Figure 4 in Chapter 3 Recommendations, while the necessary road and intersection modifications to accommodate the proposed development are shown in Figure 5.

3. RECOMMENDATIONS

The following recommendations are drawn from the study findings and conclusions documented above in Chapter 2 and additional information provided in the Technical Appendix:

- It is recommended to construct a north-south Main Street between Tambrey Drive (at Matebore Street) and Dampier Road as the overall spine road for the proposed Neighbourhood Centre and Mixed Use Site, as proposed in the Preliminary Masterplan in Figure A.5 in the Technical Appendix, with 2 access locations off Bathgate Road, as also shown.

- It is recommended to make provision for bus routes to operate along the full length of the Main Street, with a possible overall Bus Route alignment as shown in Figure 2.

- Possible bus stop locations in the Main Street are shown in Figure 3, together with the proposed future pedestrian network both within the Centre and linking to the existing facilities adjacent to the site.

- It is recommended to provide on-street cycle lanes only within the most southern portion of the Main Street, immediately north of Dampier Road but only as far as the first roundabout.

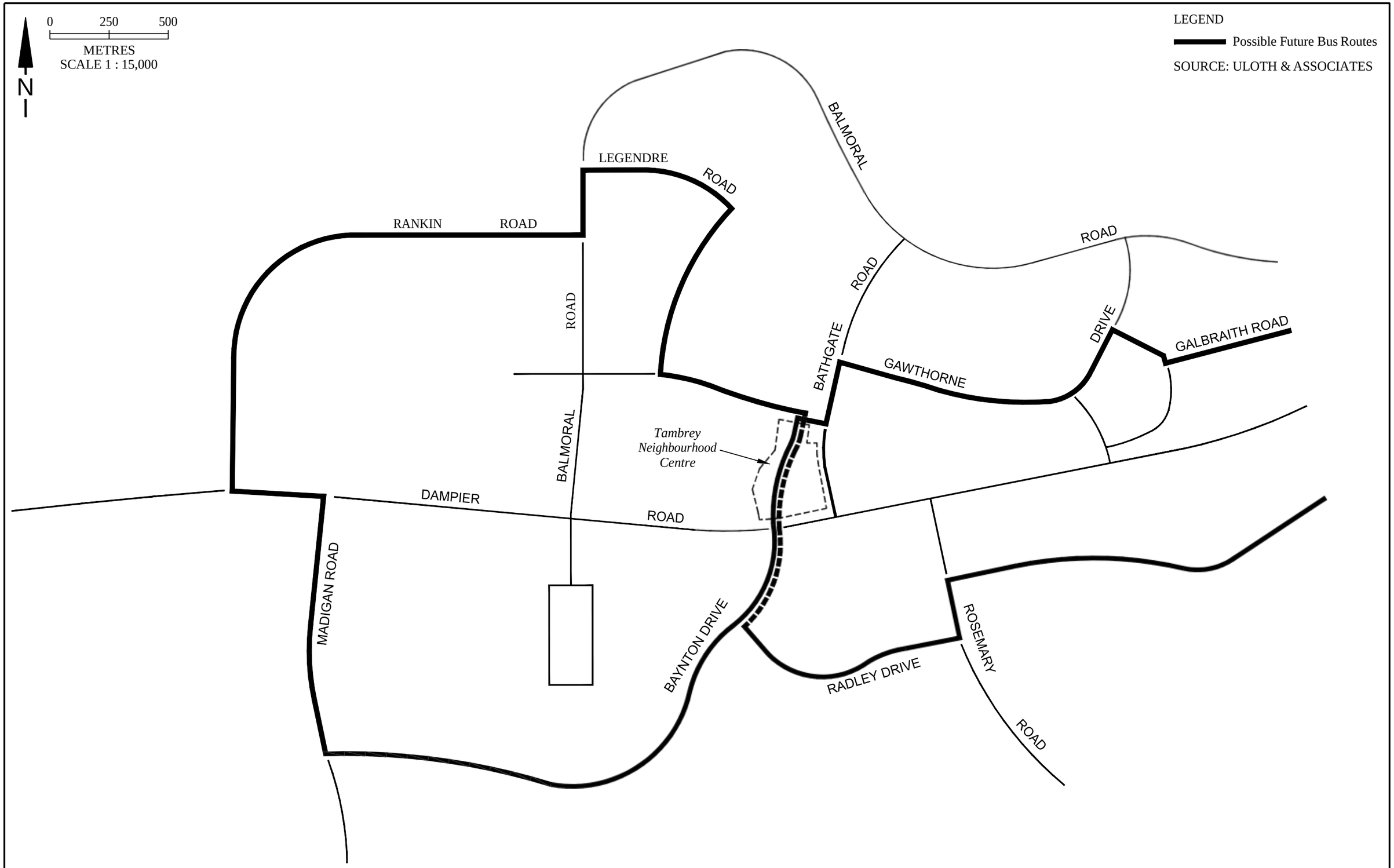
- The recommended future road hierarchy is shown in Figure 4, as follows:
  - It is recommended that the proposed Main Street should be classified as Neighbourhood Connector A with a road reserve of 18 metres.
  - It is recommended that the east-west access road linking the Main Street to Bathgate Road at the northern end should be classified as Access Street B, while the residential streets to the west of the Main Street should be Access Street C, as shown in Figure 4.

- It is recommended to provide a minimum of 660 parking spaces for shared use by all non-residential land uses within the proposed central core, in accordance with the Shared Parking analysis documented in Chapter A.2 in the Technical Appendix.

- It is important to acknowledge that on the basis of existing traffic flows along Bathgate Road and Tambrey Drive, both of these roads should be upgraded, even if the currently proposed development does not proceed. It is recommended that Bathgate Road should be upgraded to a 2 lane boulevard between Dampier Road and Tambrey Drive, with a 6 metre travel lane in each direction separated by a 2.0 metre flush (painted) median, as indicated in Figure 5, with regular pedestrian refuge islands to facilitate crossing. It is also recommended to upgrade Tambrey Drive to this same standard between Bathgate Road and the existing roundabout at Desert Pea Boulevard, as also indicated in Figure 5.

- Figure 5 also shows the recommended layout of the new roundabout at Dampier Road - Baynton Drive with a connection to the proposed Main Street, together with a concept plan for a new roundabout at Tambrey Drive - Matebore Street at the northern end of the Main Street.

- Modifications to car park layouts and internal intersections are also shown in Figure 5, based on the various swept path requirements identified in Figures A.11 to A.14 in the Technical Appendix.



Possible Future Bus Routes

IN THE VICINITY OF PROPOSED TAMBREY NEIGHBOURHOOD CENTRE

FIG. 2

Future Path Network and Bus Stops

PROPOSED TAMBREY NEIGHBOURHOOD CENTRE

FIG. 3

LEGEND

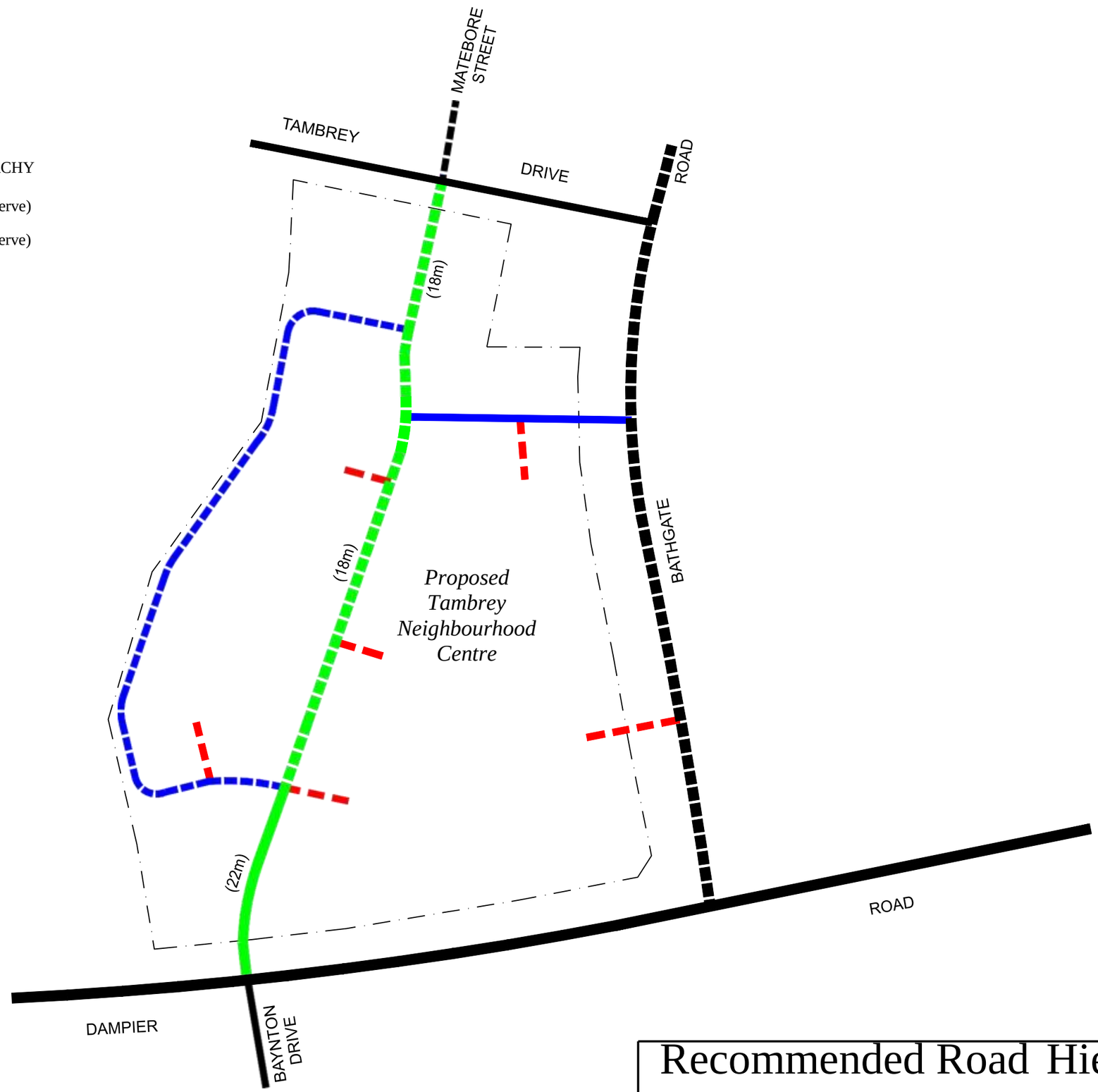
EXISTING ROAD HIERARCHY

- Primary Distributor
- District Distributor
- Local Distributor
- Access Road

RECOMMENDED FUTURE HIERARCHY

- (22m) Neighbourhood Connector A (22m Reserve)
- (18m) Neighbourhood Connector A (18m Reserve)
- Access Street B
- Access Street C
- Access Driveway

SOURCE: ULOTH & ASSOCIATES
DATE: AUGUST 2015



Recommended Road Hierarchy

PROPOSED TAMBREY NEIGHBOURHOOD CENTRE

FIG. 4

Recommended Road and Intersection Modifications

PROPOSED TAMBREY NEIGHBOURHOOD CENTRE

FIG. 5

TECHNICAL APPENDIX

The Technical Appendix documents the existing roads and traffic flows adjacent to the proposed development site, together with the concept plan, future traffic, traffic operational evaluations and service vehicle swept path requirements for the proposed Neighbourhood Centre.

A.1 EXISTING ROADS AND TRAFFIC

Figure A.1 is an aerial photo showing the existing situation in the vicinity of the proposed Tambrey Neighbourhood Centre development site.

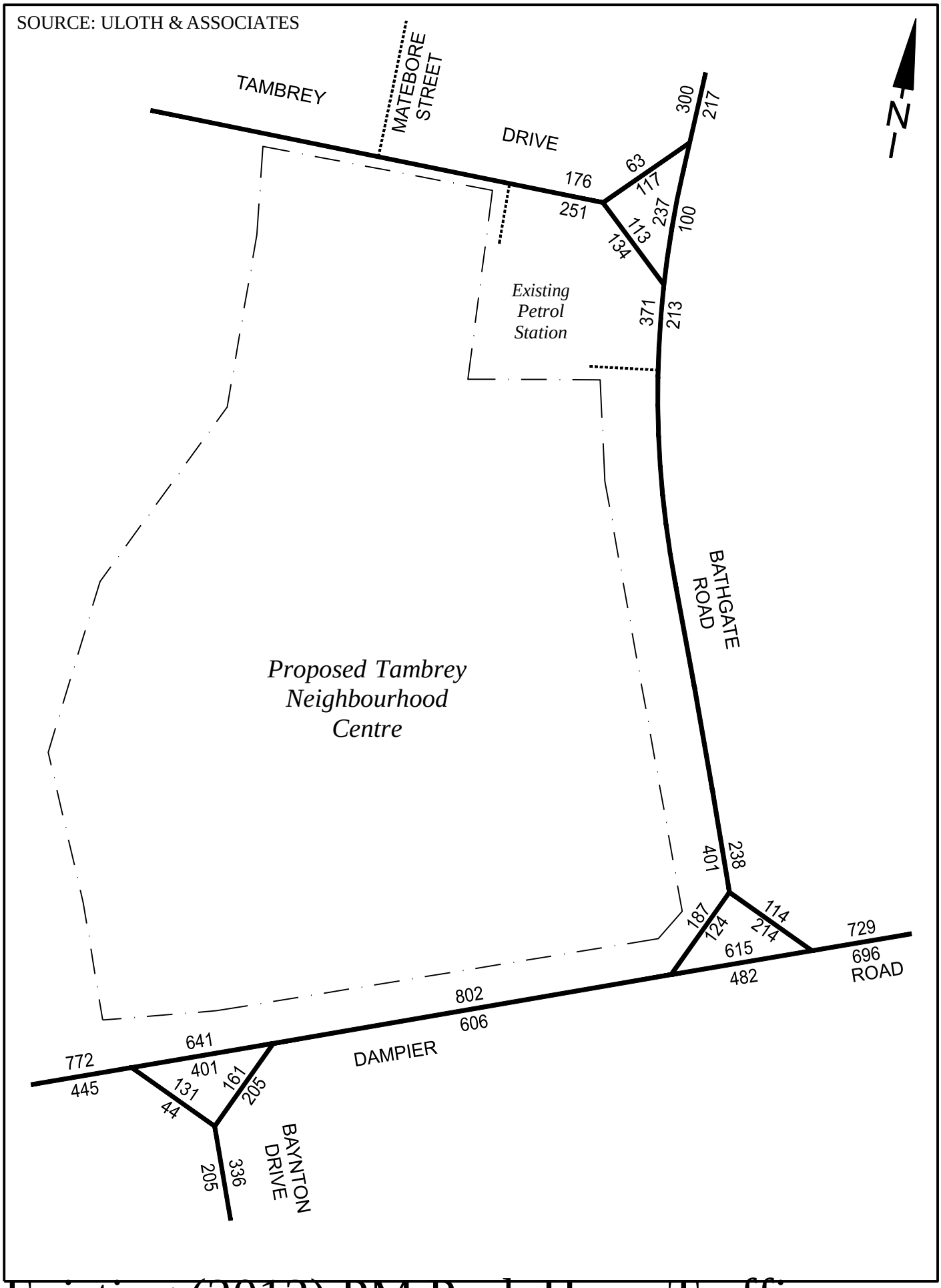
Figures A.2 and A.3 shows the existing PM peak hour and daily traffic flows in the vicinity of the proposed Neighbourhood Centre, based on peak period turning movement counts carried out by Uloth and Associates, factored up to daily flows according to 24 hour counts obtained from Main Roads WA.

Figure A.4 shows the existing functional road hierarchy in the vicinity of the proposed development.

Existing Situation and Development Site

PROPOSED TAMBREY NEIGHBOURHOOD CENTRE

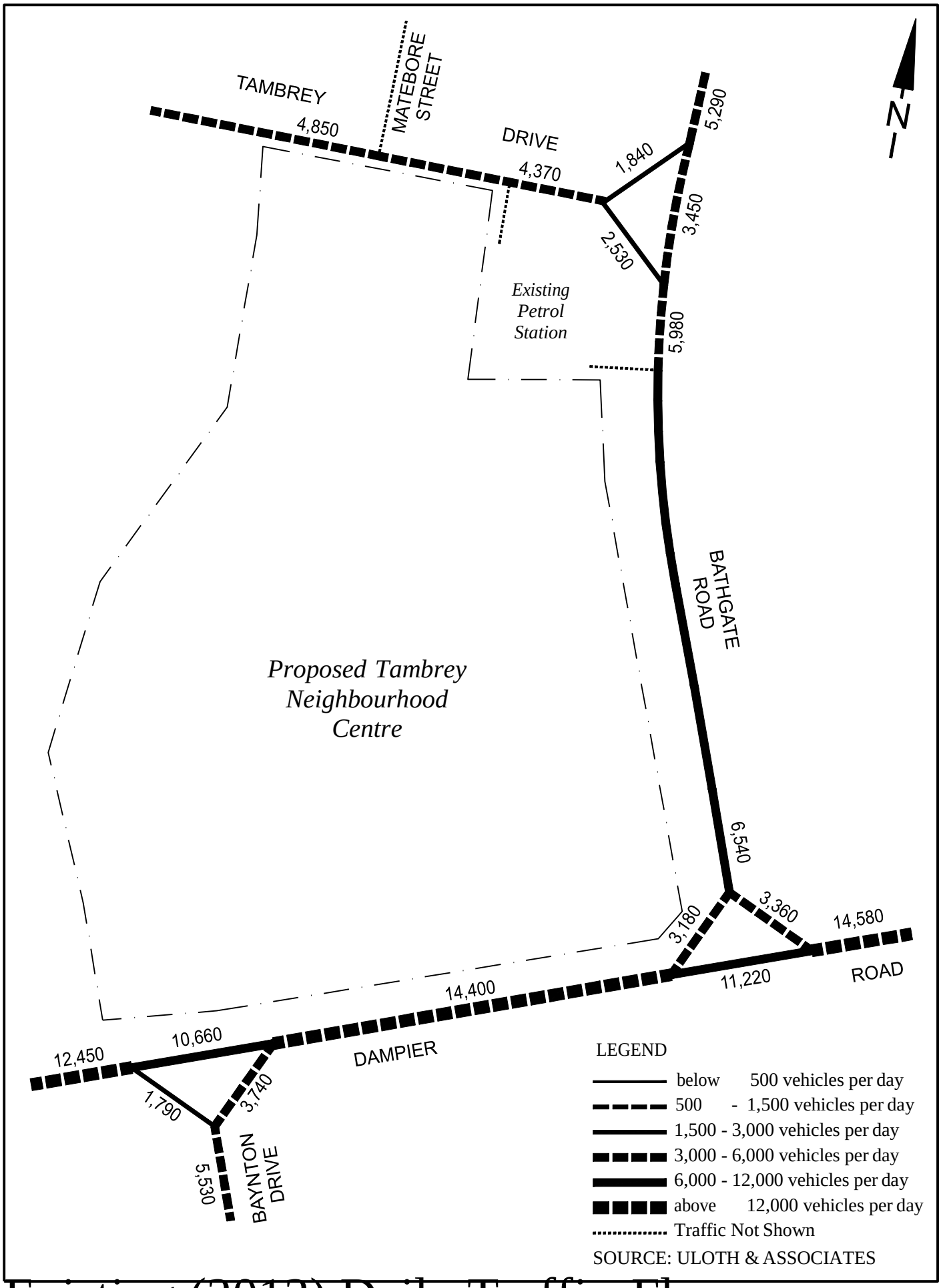
FIG.
A.1



Existing (2012) PM Peak Hour Traffic

FIG. A.2

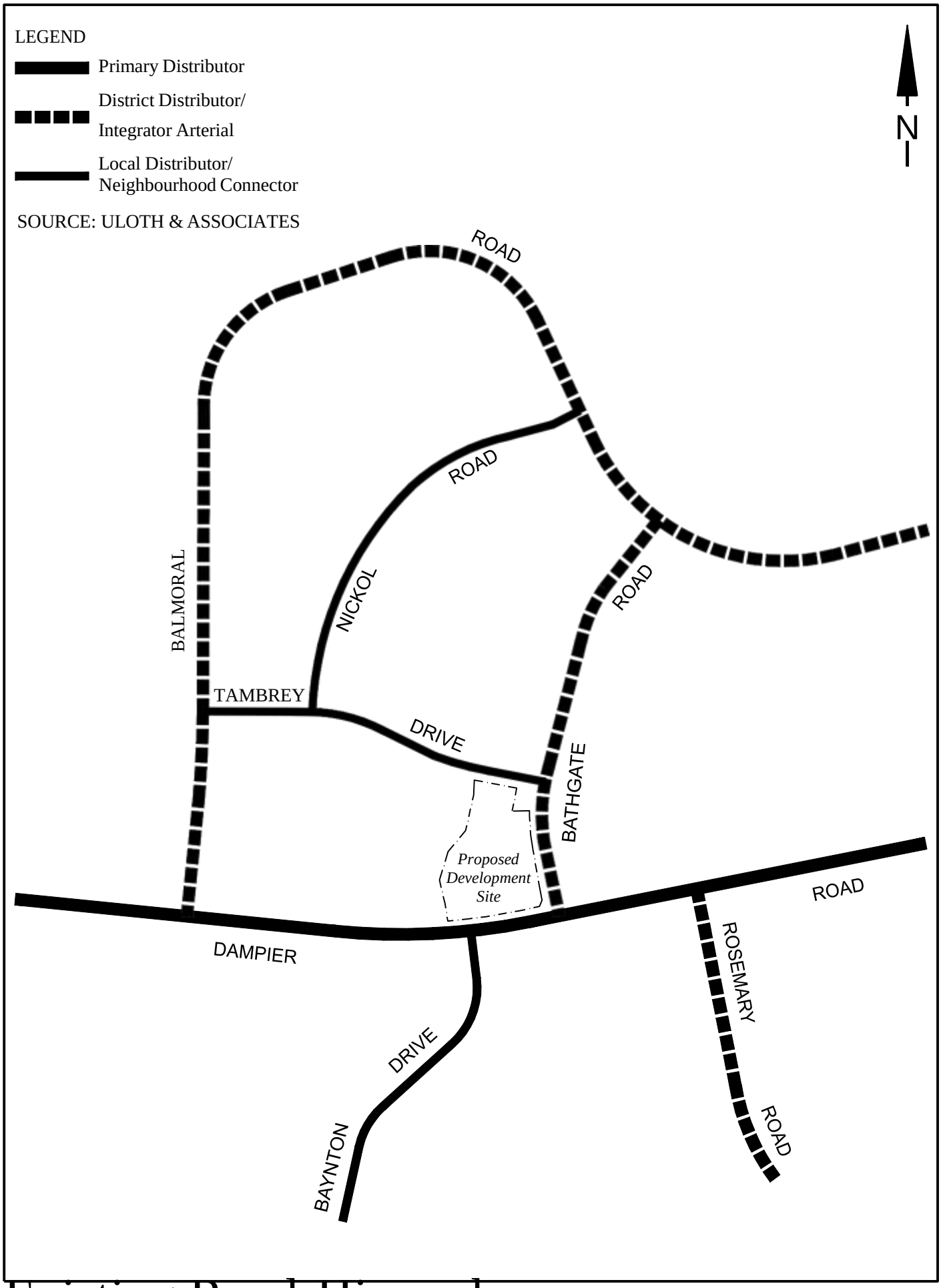
ADJACENT TO PROPOSED DEVELPOMENT SITE



Existing (2012) Daily Traffic Flows

ADJACENT TO PROPOSED DEVELOPMENT SITE

FIG. A.3



Existing Road Hierarchy

IN THE VICINITY OF PROPOSED DEVELOPMENT

FIG.
A.4

A.2 PROPOSED DEVELOPMENT

Figure A.5 shows the Preliminary Development Plan for the proposed Tambrey Neighbourhood Centre as prepared by Taylor Robinson, while Figure A.6 provides an overlay showing a breakdown of the site into 6 Land Use Zones. Table A.1 shows a possible land use scenario within each of the 6 identified land use zones, based on a current concept plan (which may be subject to change). Table A.1 also shows the anticipated future Thursday traffic generation for the proposed Centre, calculated in accordance with industry-standard trip generation rates.

TABLE A.1
FUTURE LAND USE AND ESTIMATED TRIP GENERATION
PROPOSED TAMBREY NEIGHBOURHOOD CENTRE

LAND USE DATA					TRIP GENERATION	
Land Use Category by Zone [1)]	Description	Commercial Area (m²)		Residential Dwellings	PM Peak Hour (vehs/hr)	Daily (vpd)
		Retail	Non-Retail			
• Zone 1						
- Residential (Mixed Use)	Medium Density (R40):	-	-	17	9	90
	High Density (R60):	-	-	12	3	30
• Zone 2						
- Short Stay	Apartments:	-	-	30	12	90
- Commercial	Car Wash (4 stalls):	-	200	-	32	430
• Zone 3a						
- Residential	Medium Density (R40):	-	-	26	13	130
• Zone 3b						
- Retail	Specialty and Mini-Majors:	1,655	575	-	170	1,740
- Commercial	Commercial/Office:	-	380	-	11	90
• Zone 3c						
- Residential (Mixed Use)	Commercial/Office:	-	675	-	20	170
	Residential (R60):	-	-	60	14	160
• Zone 4						
- Retail	Supermarket & Specialties:	6,100	1,585	-	584	5,990
- Gym		-	310	-	28	140
- Commercial	Commercial/Office:	-	230	-	7	60
- Medical	Medical Centre (5 practitioners):	-	345	-	38	350
• Zone 5						
- Residential	Medium Density (R40):	-	-	21	11	110
• Zone 6						
- Food & Beverage	Tavern & Restaurant:	470	510	-	235	1,290
- Fast Food	Fast Food:	275	255	-	186	2,650
• TOTAL		8,500	5,065	166	1,372	13,520

Note: 1) Land Use Zones as shown in Figure A.6

Source: Land Use Data - Taylor Robinson
Trip Generation - Uloth and Associates

Table A.2 shows the calculation of parking requirements, initially as the sum of parking demands for each individual land use, but then also as part of a Shared Parking analysis, taking into account the fact that peak parking demands for the Restaurants, Tavern and Fast Foods will not coincide directly with the peak of the remaining retail and commercial uses.

TABLE A.2
ANTICIPATED FUTURE PARKING REQUIREMENTS - ZONES 3B, 4 AND 6
PROPOSED TAMBREY NEIGHBOURHOOD CENTRE

	PARKING REQUIREMENTS			
	TPS Calculation		Shared Parking Analysis	
LAND USE AND AREA	Rate	Number of Spaces	Percent at Overall Peak Time	Total Peak Parking Demand
• Shops – 9,915 m² NLA[1)]	1 per 20m²	496	100%	496
• Gym	1 per 10m²	31	100%	31
• Medical – 345 m² (5 Consulting Rooms, 8 employees)	11 for 5 rooms + 1 per employee	19	100%	19
• Commercial – 610 m² [2)]	1 per 30m²	21	100%	21
• Fast Food – 530 m² (185 m² Seating Area, 345 m² Non-Seating Area)	1 per 5m² [3)] seating area, + 7 per 100m² non-seating (less 50% of non-seated within drive-through lane)	50	50%	25
• Tavern – 640 m² (60 m² Bar, 515 m² Lounge/Beer Garden	1 per 2m² Bar + 1 per 5m² Lounge/Beer Garden	98	50%	49
• Restaurant – 340 m² (208 m² Dining Area)	1 per 6m² Dining area	38	50%	19
• Total		753 spaces		660 spaces

Notes: 1) Specialty and Mini-Majors in Zone 3b plus Supermarket and Specialities in Zone 4.
2) Excludes car wash and Zone 3C (assumed to be self-sufficient)
3) Alternative rate is proposed for Fast Food since the TPS rate for Take Away Food Outlet is not deemed to be appropriate.

Source: Uloth and Associates

FIG.
A.5

preliminary development plan
Tambrey Neighbourhood Centre
KARRATHA

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F 08 9388 6177

1:2000 @A3 / 1:1000 @ A1
15017
17 08 15
drawn by FG

SK1 A

FIG.
A.6

preliminary development plan
Tambrey Neighbourhood Centre
KARRATHA

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F 08 9388 6177

1:2000 @A3 / 1:1000 @ A1
15017
17 08 15
drawn by FG

SK1 A

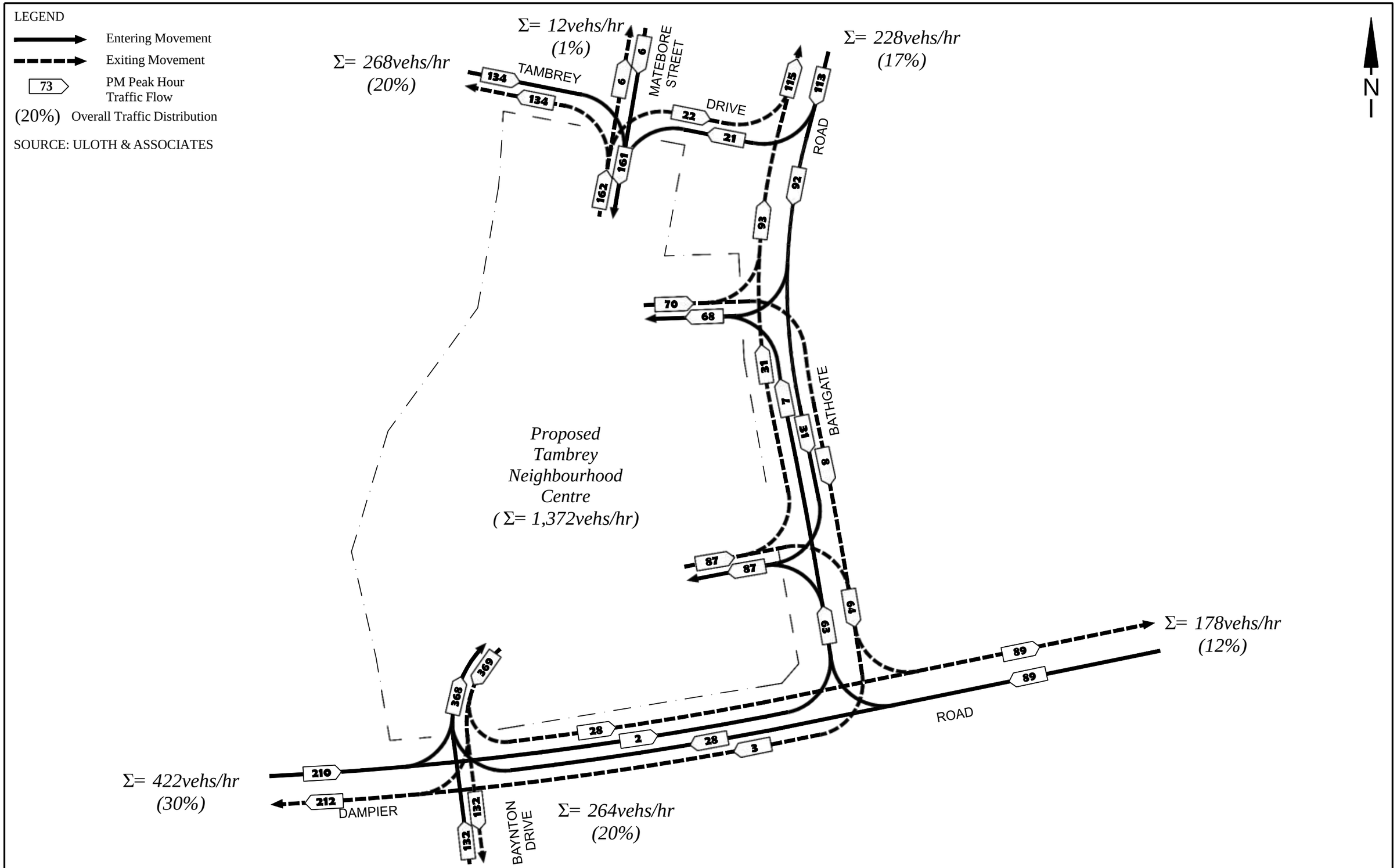
A.3 FUTURE TRAFFIC

As noted in Section 2.5, the anticipated distribution of traffic travelling to and from the proposed Centre is as follows:

- Dampier Road, west: 30 percent
- Baynton Drive, south: 20 percent
- Tambrey Drive, west: 20 percent
- Bathgate Road, north: 17 percent
- Dampier Road, east: 12 percent
- Matebore Street, north: 1 percent

The estimated future development traffic flows are therefore as shown in Figures A.7 and A.8, taking into account the overall external distribution and the specific travel routes within the Centre to and from each of the 6 identified land use zones.

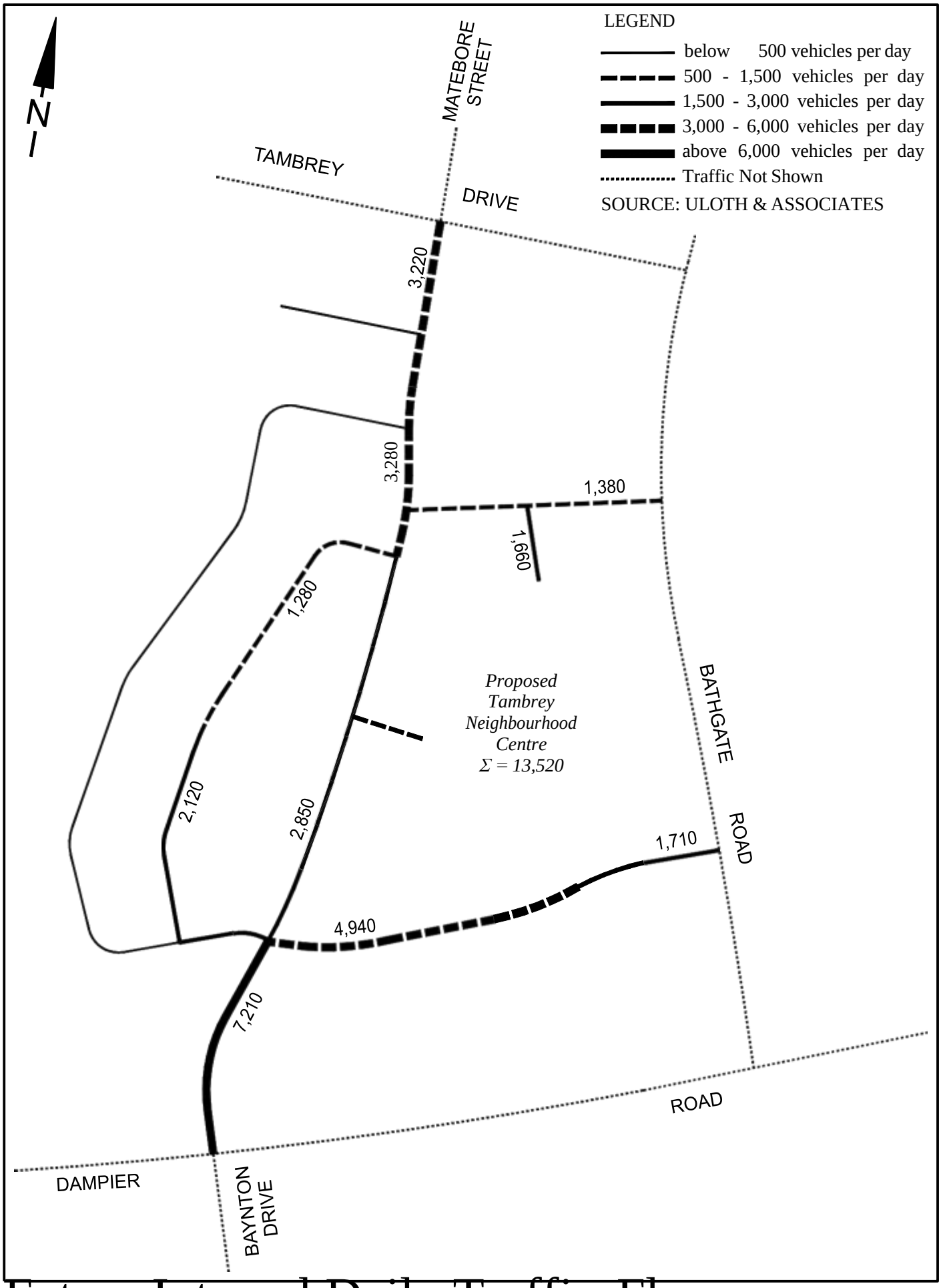
When combined with the anticipated growth of non-development traffic adjacent to the Centre, the total future daily traffic flows are as shown in Figure A.9, while the corresponding PM peak hour traffic flows are as shown in Figure A.10.



Future Distribution of Development Traffic

PROPOSED TAMBREY NEIGHBOURHOOD CENTRE

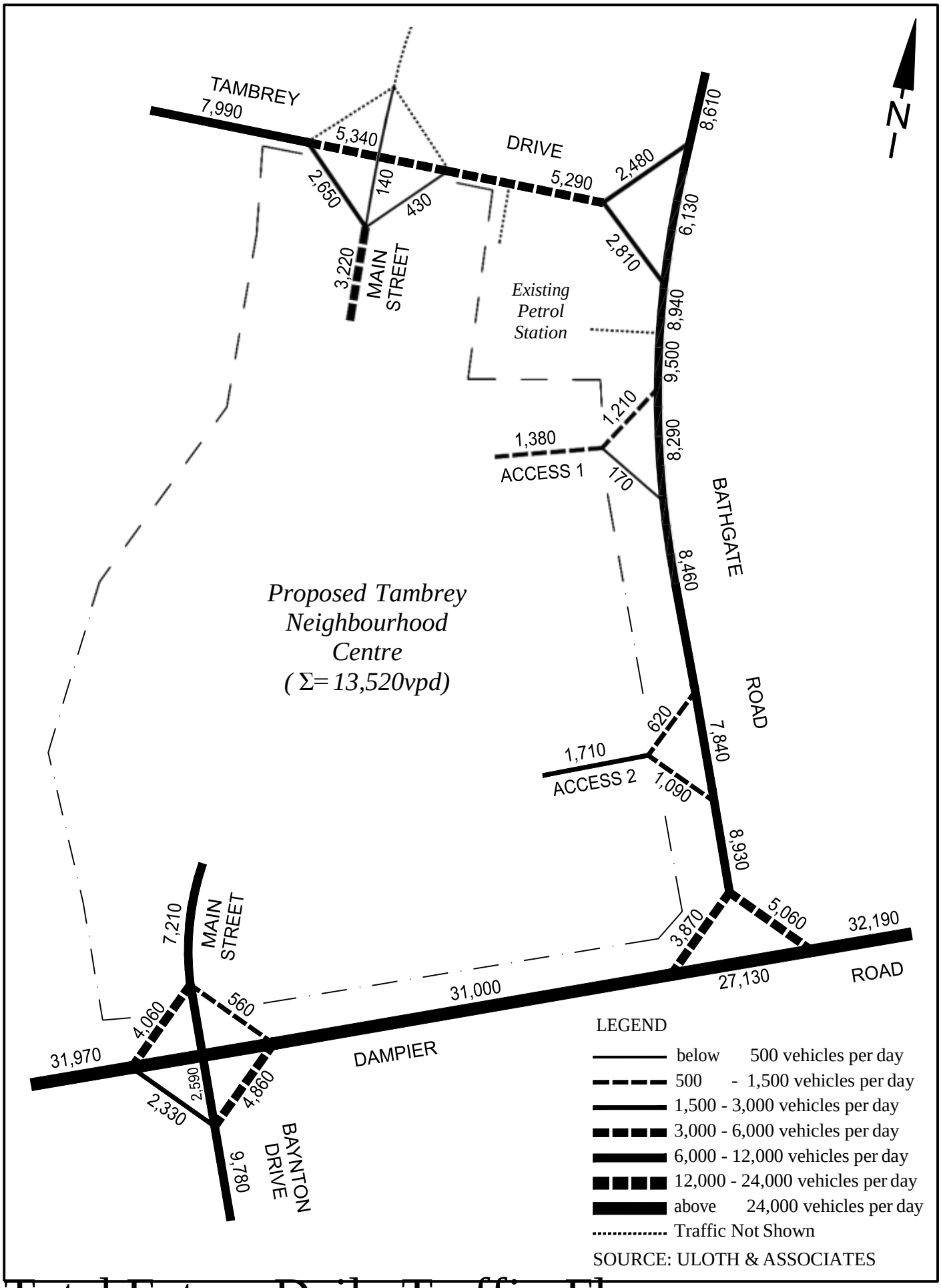
FIG. A.7



Future Internal Daily Traffic Flows

FIG. A.8

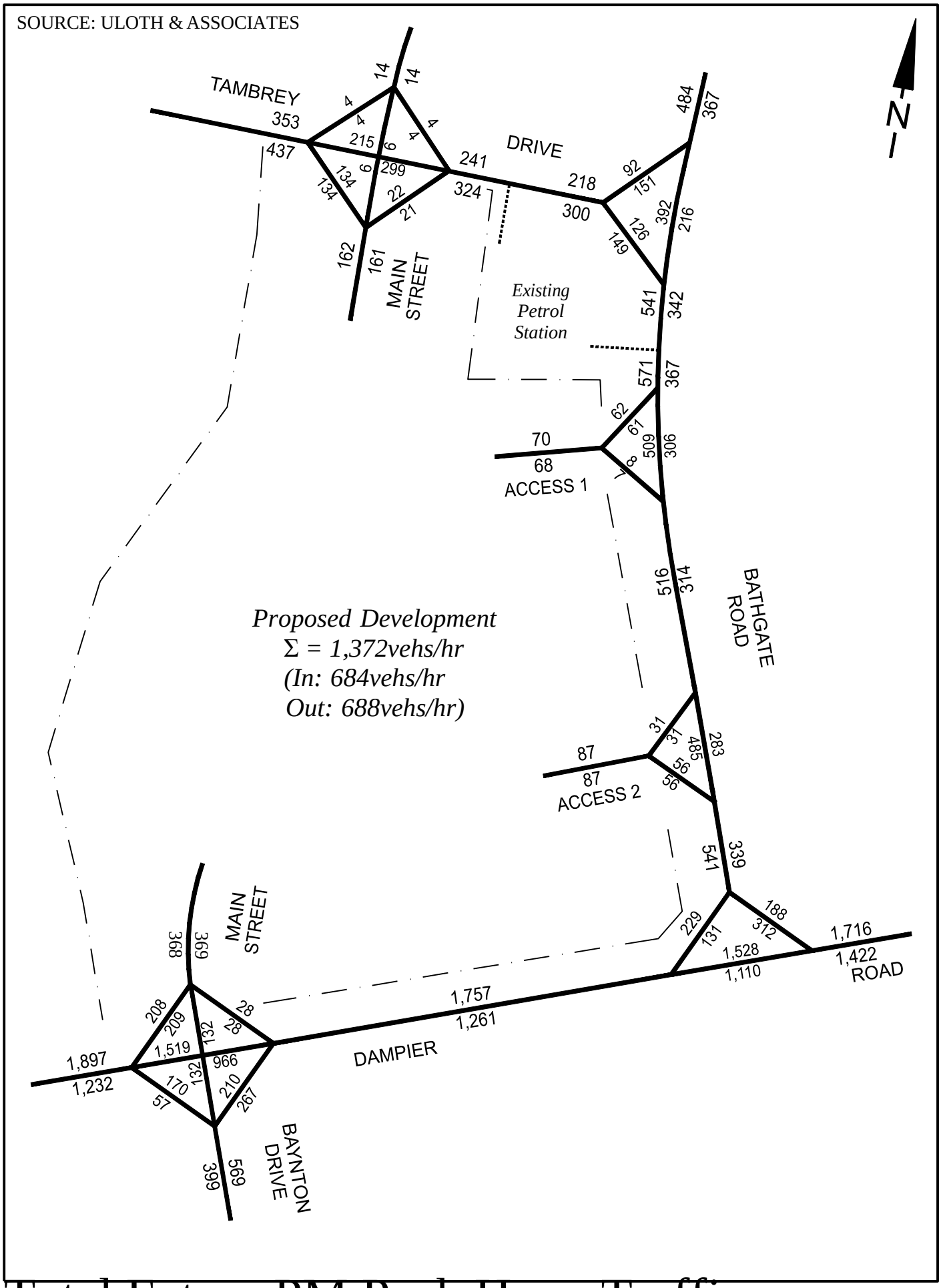
PROPOSED TAMBREY NEIGHBOURHOOD CENTRE



Total Future Daily Traffic Flows

WITH PROPOSED TAMBREY NEIGHBOURHOOD CENTRE

FIG. A.9



Total Future PM Peak Hour Traffic

FIG. A.10

PROPOSED TAMBREY NEIGHBOURHOOD CENTRE

A.4 INTERSECTION OPERATIONAL CHARACTERISTICS

Tables A.3 to A.8 show the long term future intersection operational characteristics for the recommended access scenario, on the basis of the future PM peak hour traffic as shown in Figure A.10.

TABLE A.3
OPERATIONAL CHARACTERISTICS FOR RECOMMENDED DAMPIER ROAD - BAYNTON DRIVE 4-WAY ROUNDABOUT – FUTURE THURSDAY PM PEAK HOUR WITH PROPOSED TAMBREY NEIGHBOURHOOD CENTRE

ITEMS	OPERATIONAL CHARACTERISTICS PM Peak Hour					
No. of Approach Lanes: N E S W	2 2 2 2					
Max X Value	0.936					
Average Delay (sec)	13.7					
Level of Service	B					
Approach	Move-ment	X-Value	Max. Queue (veh)	Max. Queue m	Avrge Delay (sec)	Level of Serv.
Bayton Drive - north	LT	0.670	4.3	31	25.6	C
	R	0.576	4.2	30	23.2	C
Dampier Road - east	LT	0.692	6.1	46	7.6	A
	TR	0.692	5.9	45	8.7	A
Baynton Drive - south	LT	0.382	2.1	15	9.4	A
	R	0.324	1.8	13	13.1	B
Dampier Road - west	LT	0.936	20.1	152	14.5	B
	TR	0.936	19.7	148	17.7	B

Notes: Level of Service calculations are based on Average Delay and Degree of Saturation.
Underlined X-values denote maximum values.

Source: Uloth and Associates

TABLE A.4
OPERATIONAL CHARACTERISTICS FOR EXISTING DAMPIER ROAD - BATHGATE ROAD 3-WAY ROUNDABOUT – FUTURE THURSDAY PM PEAK HOUR WITH PROPOSED TAMBREY NEIGHBOURHOOD CENTRE

ITEMS	OPERATIONAL CHARACTERISTICS PM Peak Hour					
No. of Approach Lanes: N E S W	2 2 - 2					
Max X Value	0.841					
Average Delay (sec)	9.0					
Level of Service	A					
Approach	Move-ment	X-Value	Max. Queue (veh)	Max. Queue m	Avrge Delay (sec)	Level of Serv.
Bathgate Road - north	L	0.401	2.4	18	10.0	A
	R	0.455	2.5	19	18.2	B
Dampier Road - east	T	0.593	5.3	40	4.5	A
	TR	0.593	5.2	39	7.4	A
Dampier Road - west	LT	0.841	13.8	104	10.1	B
	T	0.841	13.5	103	11.3	B

Notes: Level of Service calculations are based on Average Delay and Degree of Saturation. Underlined X-values denote maximum values.

Source: Uloth and Associates

TABLE A.5
OPERATIONAL CHARACTERISTICS FOR UNSIGNALISED BATHGATE ROAD - TAMBREY DRIVE JUNCTION – FUTURE THURSDAY PM PEAK HOUR WITH PROPOSED TAMBREY NEIGHBOURHOOD CENTRE

ITEMS	OPERATIONAL CHARACTERISTICS PM Peak Hour					
No. of Approach Lanes: N E S W	2 - 1 2					
Approach	Move-ment	X-Value	Max. Queue (veh)	Max. Queue m	Avrge Delay (sec)	Level of Serv.
Bathgate Road - north	T	0.122	0.0	0	0.0	A
	R	0.172	0.7	5	8.4	A
Bathgate Road - south	LT	0.309	0.0	0	1.6	A
Tambrey Drive - west	L	0.128	0.4	3	7.8	A
	R	0.354	1.5	11	16.1	C

Notes: Level of Service calculations are based on Average Delay and Degree of Saturation. Underlined X-values denote maximum values.

Source: Uloth and Associates

TABLE A.6
OPERATIONAL CHARACTERISTICS FOR TAMBREY DRIVE - MATEBORE STREET
4-WAY ROUNDABOUT – FUTURE THURSDAY PM PEAK HOUR
WITH PROPOSED TAMBREY NEIGHBOURHOOD CENTRE

ITEMS	OPERATIONAL CHARACTERISTICS PM Peak Hour					
No. of Approach Lanes: N E S W Max X Value Average Delay (sec) Level of Service	1 1 1 1 0.305 6.2 A					
Approach	Move-ment	X-Value	Max. Queue (veh)	Max. Queue m	Avrge Delay (sec)	Level of Serv.
Matebore Street - north	LTR	0.017	0.1	1	7.7	A
Tambrey Drive - east	LTR	0.305	1.8	13	5.8	A
Main Street - south	LTR	0.183	1.0	7.4	7.1	A
Tambrey Drive - west	LTR	0.268	1.8	13	6.1	A

Notes: Level of Service calculations are based on Average Delay and Degree of Saturation.
Underlined X-values denote maximum values.

Source: Uloth and Associates

TABLE A.7
OPERATIONAL CHARACTERISTICS FOR UNSIGNALISED BATHGATE ROAD - ACCESS 1 JUNCTION – FUTURE THURSDAY PM PEAK HOUR WITH PROPOSED TAMBREY NEIGHBOURHOOD CENTRE

ITEMS	OPERATIONAL CHARACTERISTICS					
	PM Peak Hour					
No. of Approach Lanes: N E S W	2 - 1 2					
Approach	Move-ment	X-Value	Max. Queue (veh)	Max. Queue m	Avrge Delay (sec)	Level of Serv.
Bathgate Road - north	T R	0.173 0.067	0.0 0.3	0 2	0.0 8.0	A A
Bathgate Road - south	LT	0.291	0.0	0	0.1	A
Entry 1 - west	L R	0.093 0.025	0.3 0.1	2 1	8.1 14.3	A B

Notes: Level of Service calculations are based on Average Delay and Degree of Saturation. Underlined X-values denote maximum values.

Source: Uloth and Associates

TABLE A.8
OPERATIONAL CHARACTERISTICS FOR UNSIGNALISED BATHGATE ROAD - ACCESS 2 JUNCTION – FUTURE THURSDAY PM PEAK HOUR WITH PROPOSED TAMBREY NEIGHBOURHOOD CENTRE

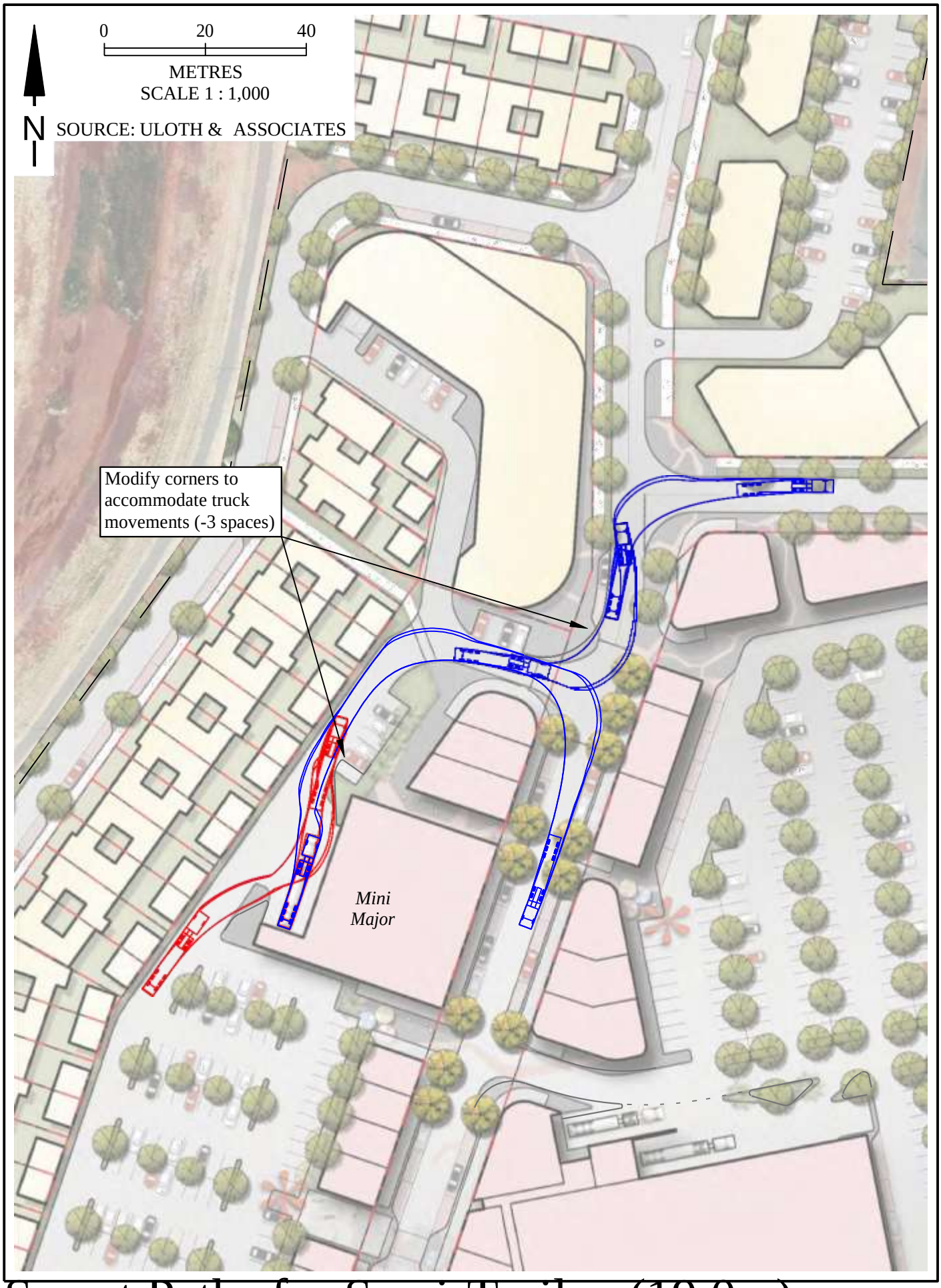
ITEMS	OPERATIONAL CHARACTERISTICS					
	PM Peak Hour					
No. of Approach Lanes: N E S W	2 - 1 2					
Approach	Move-ment	X-Value	Max. Queue (veh)	Max. Queue m	Avrge Delay (sec)	Level of Serv.
Bathgate Road - north	T R	0.160 0.035	0.0 0.1	0 1	0.0 8.1	A A
Bathgate Road - south	LT	0.307	0.0	0	0.6	A
Entry 2 - west	L R	0.046 0.161	0.1 0.5	1 4	7.9 14.1	A B

Notes: Level of Service calculations are based on Average Delay and Degree of Saturation. Underlined X-values denote maximum values.

Source: Uloth and Associates

A.5 SERVICE VEHICLE ACCESS

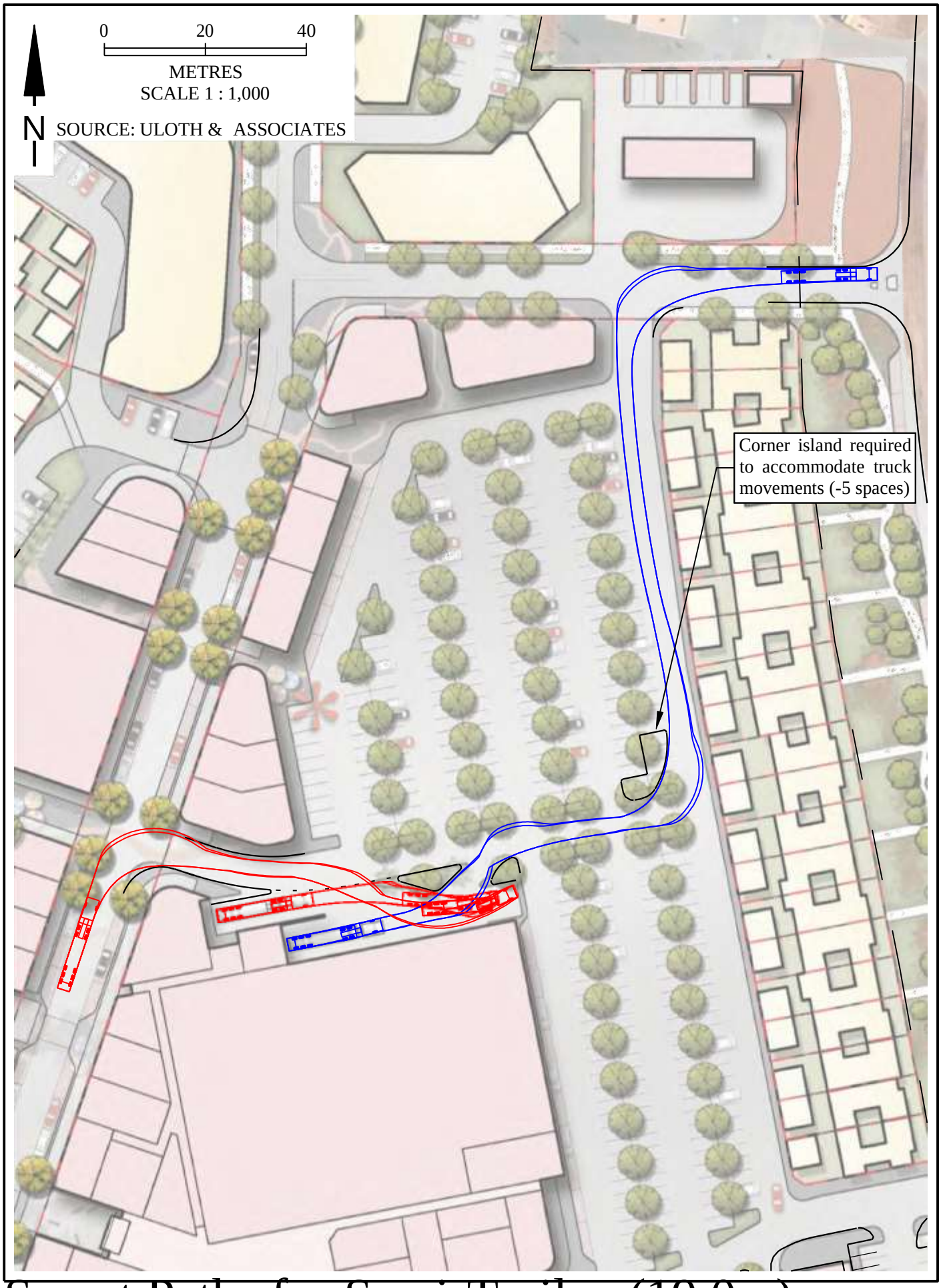
Figures A.11 to A.14 show the swept paths for service vehicles accessing the various loading/service areas across the proposed development, together with necessary modifications to ensure that all required movements can be accommodated.



Swept Paths for Semi-Trailer (19.0m)

ACCESSING PROPOSED MINI MAJOR

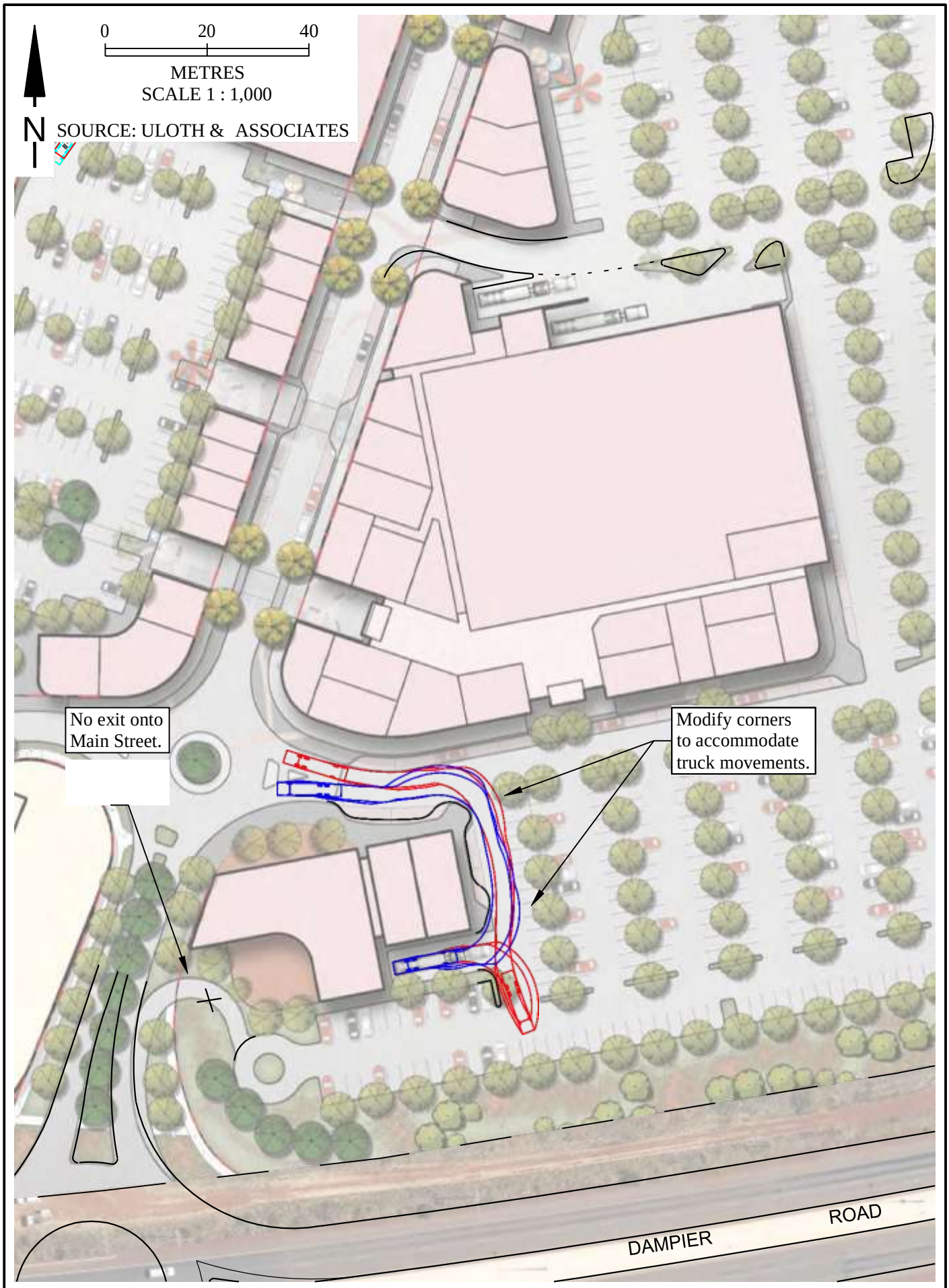
FIG. A.11



Swept Paths for Semi-Trailer (19.0m)

ACCESSING PROPOSED SUPERMARKET

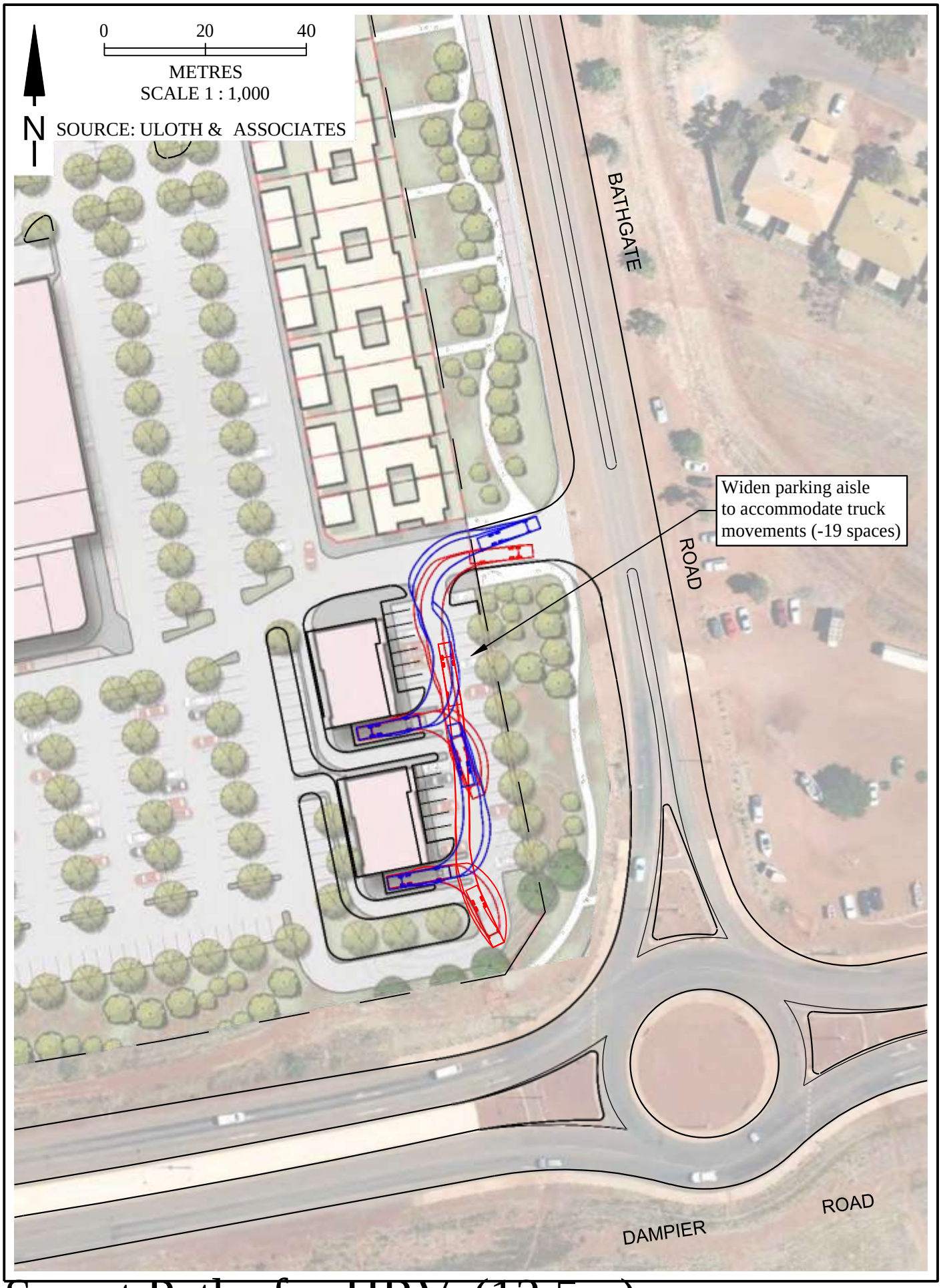
FIG. A.12



Swept Paths for HRV (12.5m)

ACCESSING PROPOSED TAVERN / RESTAURANT

FIG. A.13



Swept Paths for HRV (12.5m)

ACCESSING PROPOSED FAST FOODS

FIG.
A.14

APPENDIX G

RETAIL NEEDS ASSESSMENT AND ECONOMIC ANALYSIS REPORT

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Tambrey Neighbourhood Centre Mixed Use Site, Karratha WA

Retail Sustainability Assessment

July 2015

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MacroPlan Dimasi

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Owen Pethica, Research Assistant

Table of contents

Executive summary

The key findings and conclusions from the analyses of this report are summarised as follows:

i. Tambrey Neighbourhood Centre (TNC) is proposed to be developed in the western part of Karratha to serve the substantial existing population as well as the significant population growth occurring in the area. The TNC is planned to be a mixed-use development including retail, commercial, residential and community uses.

ii. For the retail component of the TNC, the draft masterplan proposes to include a full-line supermarket of 3,800 sq.m, two mini-major tenants totalling some 1,500 sq.m, and a supporting provision of retail specialty space. The total retail floorspace of the centre is expected to be around 8,500 sq.m upon completion.

iii. The primary trade area, which the TNC will serve, contains a present population of 11,710, forecast to grow to 15,360 by 2026.

iv. The sales potential of the retail component of the TNC is estimated at $69 million in 2017/18. The total retail expenditure market generated by primary trade area residents is estimated at $218 million, while the retail expenditure of the total Karratha City population will be $461 million at that time. FIFO workers will add further to the overall demand for retail facilities within the town.

v. The estimated market shares which the TNC will achieve are 25.8% of the primary sector expenditure, and 13.5% of the total retail expenditure by the City of Karratha population.

vi. The analysis shows that whilst retailers within Karratha are expected to be impacted by the TNC, those retailers are estimated to achieve sales of $417 million in 2020/21, which is a $33 million increase on their estimated sales at 2014/15.

vii. Existing Karratha City Centre retailers are expected to be impacted to a small degree by the TNC, however they are still expected to experience net growth in their sales potential over the next 6 years (three years post development of the TNC).

viii. The analysis shows that in 2017/18, existing retailers in Karratha would be expected to experience an aggregate impact of around $48 million or 11.4%. These average trading impacts, when weighed against the positive economic and social impacts that will be generated by the development of the TNC, and the overall growth in the Karratha market, are considered reasonable and will not threaten the viability of existing retailers within Karratha. Overall, the analysis presented in this report shows that the TNC would not in any way compromise the future role or strength of the Karratha City Centre.

ix. The other proposed uses at Tambrey, including residential, commercial and ancillary, will help to reinforce the convenience role of the centre and help to achieve the objectives of the Karratha City of the North Plan. Those uses will not detract from the primacy of the City Centre.

x. The new neighbourhood centre will be conveniently located in the growing and underserviced western Karratha area. It will therefore greatly improve amenity for local area residents, with shopping and service facilities being provided in an accessible location within the local area. The quality of life of western Karratha residents will be improved as a result.

xi. The provision of facilities such as the TNC is an important step towards enabling the growth of Karratha that is envisaged under both the Shire of Roebourne Town Planning Scheme and the Karratha City North Plan.

Introduction

This report presents a Retail Sustainability Assessment (or Economic Impact Assessment) for the development of a new mixed use neighbourhood centre at Tambrey, a western suburb of Karratha, the major town in the resource rich Pilbara region in north-west Western Australia.

The report considers the potential economic and related effects of the proposed Tambrey Neighbourhood Centre on the surrounding centres, addressing the economic impacts and benefits of the proposal from a net community benefit perspective. The report is presented in six sections as follows:

- **Section 1** examines the locational context of the proposed Tambrey Neighbourhood Centre (TNC), as well as the broader region of significance to, and overall planning framework for, the centre.
- **Section 2** provides a discussion of the local and economic context of Karratha, including a review of the residential market.
- **Section 3** examines the trade area which is likely to be served by the proposed TNC, including current and projected population and retail spending levels within the trade area. An assessment of the Fly-in-Fly-out (FIFO) population in the region is also provided.
- **Section 4** describes the competitive environment within which the proposed TNC will operate.
- **Section 5** outlines our assessment of the sales potential for the proposed centre, and presents an economic impact assessment for the proposal. The likely trading impacts on other facilities throughout the surrounding region, particularly the Karratha City Centre, are considered, as are the employment and other economic effects of the proposed development.
- **Section 6** presents the key findings and conclusions from this study.

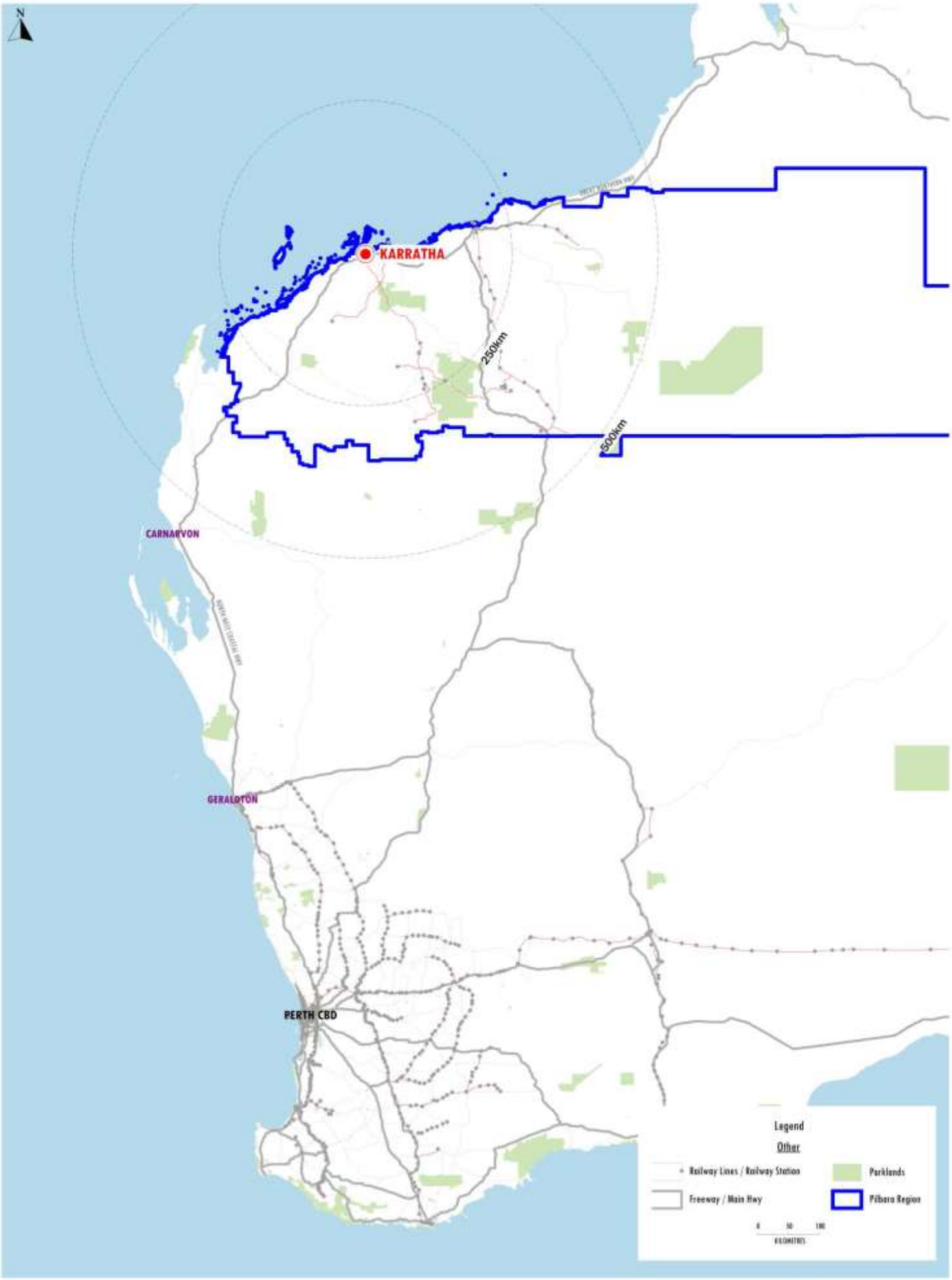
Section 1: Site location and proposed development

This section of the report examines the Tambrey Neighbourhood Centre (TNC) site and the surrounding context, as well as the relevant planning framework. The proposed development which will make up the centre is also detailed.

1.1 Site location and regional context

Karratha is a major regional town located in the Pilbara region of north-west Western Australia, within the City of Karratha (formerly the Shire of Roebourne), and approximately 1,500 km north of Perth (refer Map 1.1). In addition to Karratha, the City of Karratha includes the smaller towns of Dampier, Wickham, Roebourne, Point Samson and Cossack. It is one of four local government areas that make up the Pilbara, a resource-rich region which is a key driver of Australia's economic growth.

Regional access to Karratha is provided by the North West Coastal Highway, which is the main carriageway in the region, or via Karratha Airport which is Western Australia's busiest regional airport for passenger movements. With a resident population of around 20,000 people, Karratha services the accommodation and administrative needs of the major resource projects in the Pilbara, as well as providing for the shopping needs of local and broader region residents, workers and businesses.



Map 1.1: Karratha

Regional context

MacroPlanDimasi

Over time, Karratha is expected to become the major economic centre for the Pilbara, underpinned by the resources sector, but also through broader planning and revitalisation initiatives proposed for the town, in particular the Karratha City of the North Plan, discussed further in Section 1.3 of this report. Some of the other growth initiatives in Karratha include the following:

- The Karratha Airport provides a vital air link to the Pilbara region with some 800,000 passengers passing through the terminal building each year. The $35-million Stage 2 redevelopment of the airport terminal was recently completed, providing an enhanced travel experience, and will both extend the useful life and improve the functionality of the airport. Such initiative will enable extensive planning to be undertaken for the long term future capacity and land use at the airport. The fully redeveloped airport is expected to be completed by September 2015.

- The Karratha Leisureplex is a state-of-the-art sport and leisure facility incorporating a fitness centre, an aquatic centre, indoor and outdoor courts as well as playing fields and other facilities. This $64-million facility opened in mid 2013, as part of the State Government's ongoing Pilbara Cities initiative, providing a major entertainment venue for Karratha residents.

- The provision of community facilities, as well as family and child related services and other specialist health providers, have been enhanced in recent years, with the completion of the Frank Butler Community Centre and the Pam Buchanan Family Centre. Such services are essential to support Karratha as the regional destination for the region.

- Infrastructure works within the Karratha City Centre have been generally completed, which included the extension of Sharpe Avenue and the realignment and improvement of other city centre streets. This initiative has delivered a more integrated and easily accessible city centre, allowing for the development of new retail, commercial and residential opportunities, for example the construction of a new mixed-use facility (The Quarter) which is currently underway.

- Planning is underway for a new Karratha arts and community precinct, which will house an arts theatre, an outdoor event space, a library, and rooftop terrace. The objective of this initiative will be to provide a modern public complex, reflecting Karratha's vision as the future City of the North and its residents' needs.

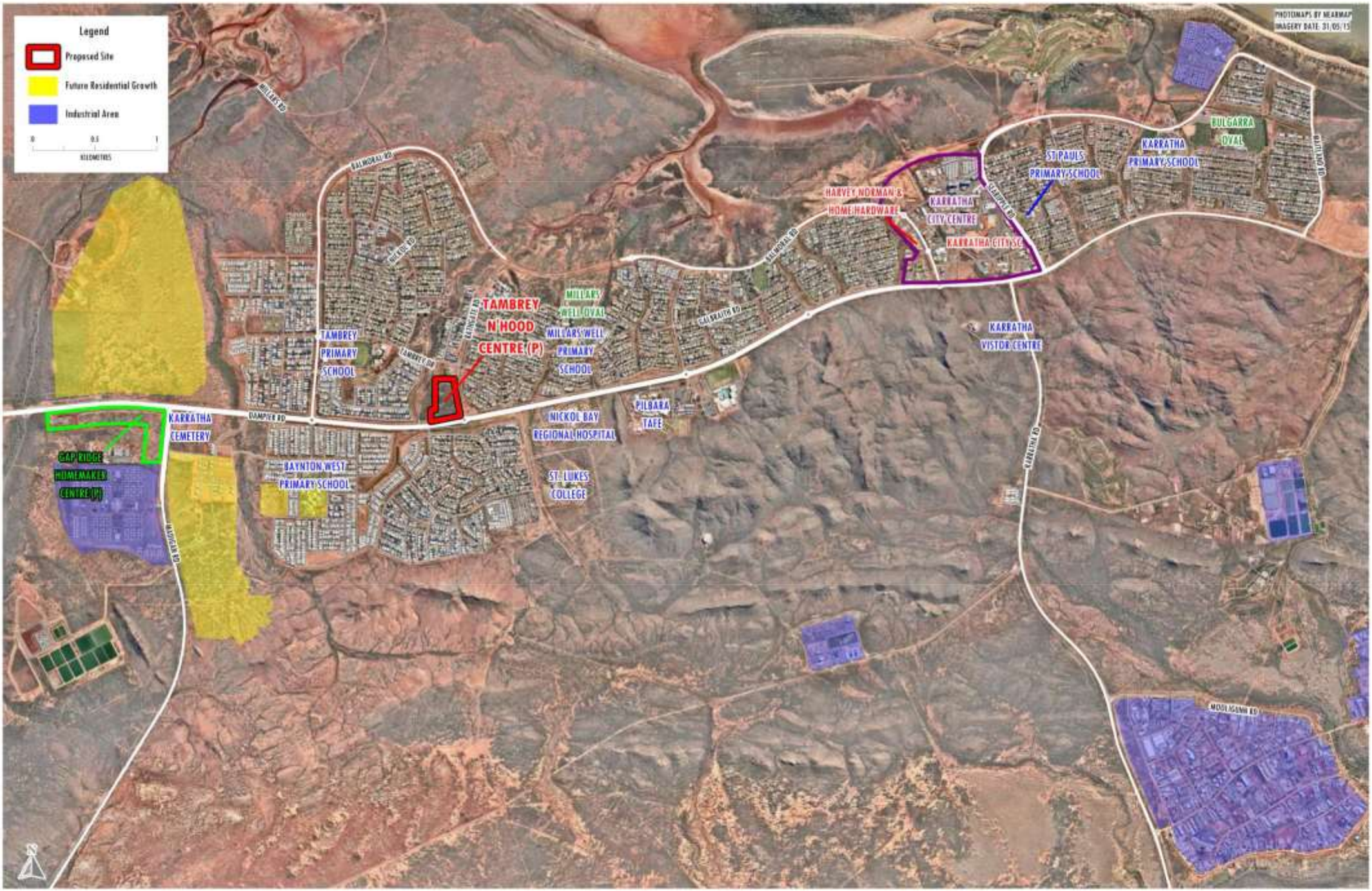
- Karratha residents and visitors to the city will also have access to an improved leisure offer, with the redevelopment of the existing golf course as a potential resort style golf facility. Detailed construction designs are underway, following the adoption of the masterplan.

- A Karratha Revitalisation Strategy (KRS) was recently released by Council, which will provide the overarching framework, in line with the Pilbara Cities vision for Karratha, for the revitalisation and future development of the established suburbs of Bulgarra (west of the City Centre), and Pegs Creek and Millars Well (located between Tambrey and the City Centre). Some of the outcomes envisaged in the KRS are to improve the amenity and infrastructure within the identified areas; increase the density and diversity of dwellings; improve streetscapes and neighbourhood character with the creation of vibrant town centres/community hubs; decrease overall travel time of residents; and provide improved recreation and public spaces in those areas.

  The KRS recognises the influence of market forces, priorities and availability of resources, and as such does not provide a specific timeframe for the implementation of the strategy. However, the strategic long term vision in the KRS will ensure that appropriate plans and actions are implemented, which will steer the City towards becoming the main regional city in the Pilbara.

The main retail facilities in Karratha are provided at Karratha City SC located in the City Centre, which is the largest shopping centre in the Pilbara region. It is anchored by a Kmart discount department store, and Woolworths and Coles supermarkets, together with a broad provision of specialty traders.

The site for the proposed TNC is located on the north-western corner of Dampier and Bathgate Roads, approximately 4.5 km west of the Karratha City Centre (refer Map 1.2). Dampier Road is the major western entry into Karratha, as well as being the link between the airport and the City Centre. Bathgate Road connects at its northern end with Balmoral Road, which 'circumscribes' the residential areas on the northern side of Dampier Road, also linking with the City Centre to the east. The TNC site therefore enjoys excellent visibility and is easily accessible for both local and broader region residents, as well as visitors to Karratha.



Map 1.2: Tambrey Neighbourhood Centre

Site location

1.2 Planning framework

There are two planning documents which are relevant for the future development of the Tambrey site. These documents are summarised below.

Shire of Roebourne Town Planning Scheme (TPS) No. 8

The Shire of Roebourne TPS 8 provides the overarching planning document guiding the development of land within the Council area. Its purposes (as set out on page 6) are, amongst others, to zone land within the Council area as defined within the Scheme; and to control and guide land use and development.

The Tambrey site is identified as Development Area 7 in the Shire of Roebourne TPS 8. Some of the specific conditions attached to the site (page 78 of the TPS) are as follows:

- To provide for commercial, holiday accommodation, medium density residential, aged persons and/or mixed used (commercial/residential) development;
- The amount of retail floorspace shall be determined based on an Economic Impact Assessment which shall also consider economic impacts on the Karratha City Centre.
- Provision of retail floorspace is to be commensurate with a Neighbourhood Centre, delivered in stages and capped at an ultimate maximum retail floorspace of 8,500 sq.m NLA.

Karratha Primary Trade Area Retail & Commercial Strategy (SGS, 2009)

The Karratha Primary Trade Area Retail & Commercial Strategy (the Retail Strategy) was prepared for Council in 2009 to guide the optimum structure for retail and commercial floorspace within the council area. The study was "motivated by a need to consider the implications for retail and commercial land use of continued growth pressures experienced in the West Pilbara as a result of its strategic position as a major centre for mining and petroleum exports".

The main points to note in the Retail Strategy are as follows:

- Substantial potential is identified for additional retail and commercial floorspace to be added to the council area, with the bulk of this floorspace to be added in the town of Karratha. The Retail Strategy indicates scope and need for the addition of 23,300 sq.m of retail floorspace and around 21,400 sq.m of commercial floorspace may be added by 2020.

- The Retail Strategy supports the need to expand the Karratha City Centre; establish a neighbourhood shopping centre in Nickol (Tambrey); and develop a bulky goods precinct at Gap Ridge.

- The Retail Strategy proposes an increase of around 6,550 sq.m of retail floorspace in the City Centre across primarily the non-food category; together with a sizeable increase of 16,200 sq.m of office floorspace.

- The Retail Strategy provides for the development of a neighbourhood centre in Nickol (Tambrey), with a retail floorspace allocation of 8,100 sq.m. This centre is to be anchored by a full-scale supermarket, together with a supporting range of retail specialties.

- The addition of a bulky goods precinct is indicated in the Retail Strategy at Gap Ridge, with an initial floorspace of 5,500 sq.m. An expansion of the centre is possible under the Retail Strategy, with the ultimate floorspace allocation to be in the order of 12,000 sq.m after 2020.

- Moderate amounts of additional retail and commercial floorspace are proposed under the Retail Strategy in the other towns within the Shire, namely Dampier, Wickham, Roebourne and Point Samson.

The scale of retail facilities now proposed for the TNC (refer Section 1.4) is therefore in line with the Retail Strategy, as well as with the Shire of Roebourne TPS 8.

A third initiative was released in 2010 to plan for the regional transformation of Karratha, discussed in greater detail below.

1.3 Karratha City of the North Plan

The *Karratha City of the North Plan* (KCN) was released in June 2010 by the State Government and the City of Karratha (Shire of Roebourne), in response to the shared Pilbara Cities vision for Karratha. The KCN provides the broad guidelines and spatial strategies for the transformation of Karratha from a resource town into a regional city.

The KCN plans for an aspirational target population of 50,000 permanent residents for Karratha, which is well beyond current population forecasts. This population level is not based on population projections, but rather provides a key threshold in the transformation of the city. The planning for such a critical mass of people should ensure that the appropriate level of services and amenities and more normalised market conditions are reached in the region.

The KCN comprises three documents, namely the *Implementation Plan*, the *City Growth Plan* and the *City Centre Master Plan*. The City Growth Plan (CGP) incorporates a spatial plan for new industrial, commercial and residential growth areas for Karratha, together with the infrastructure requirements to enable that growth. The CGP is illustrated in Figure 1.1 following and is briefly summarised below:

- The Karratha City Centre is proposed to be expanded and revitalised with new vehicular links to facilitate access from throughout Karratha.
- New community facilities, including retail, leisure, sporting, education and heath, are proposed throughout Karratha to service the expected growing demand.
- A number of vehicular thoroughfares are proposed as part of the CGP, which will facilitate access to all parts of Karratha, including to/from the airport and other surrounding employment areas.
- A number of localities have been identified which will cater for the short to medium term population housing demands in Karratha. These areas are situated to the east and west of

the Karratha urban area, and comprise expansions to existing neighbourhoods as well as the creation of new local communities.

- Longer-term residential growth areas are also designated to enable the successful transformation of Karratha into a regional city with a target population of 50,000.

The KCN therefore provides the necessary planning strategy and framework for Karratha to grow to a genuine regional city servicing the north-west region of Western Australia. In particular, the strategies in place should ensure that Karratha's economy will become much more diversified in the future, and be less reliant on the mining industry. Such a transformation will promote Karratha as the predominant city in the Pilbara region, though Hedland also has its own growth aspirations which it will continue to pursue.

Against this background, the proposed TNC will play a key role in serving the needs of the growing communities to the west of Karratha, as envisaged by the CGP. It will be the main centre for the daily and weekly shopping needs of the surrounding population, while their major non-food shopping would still be directed to the Karratha City Centre.

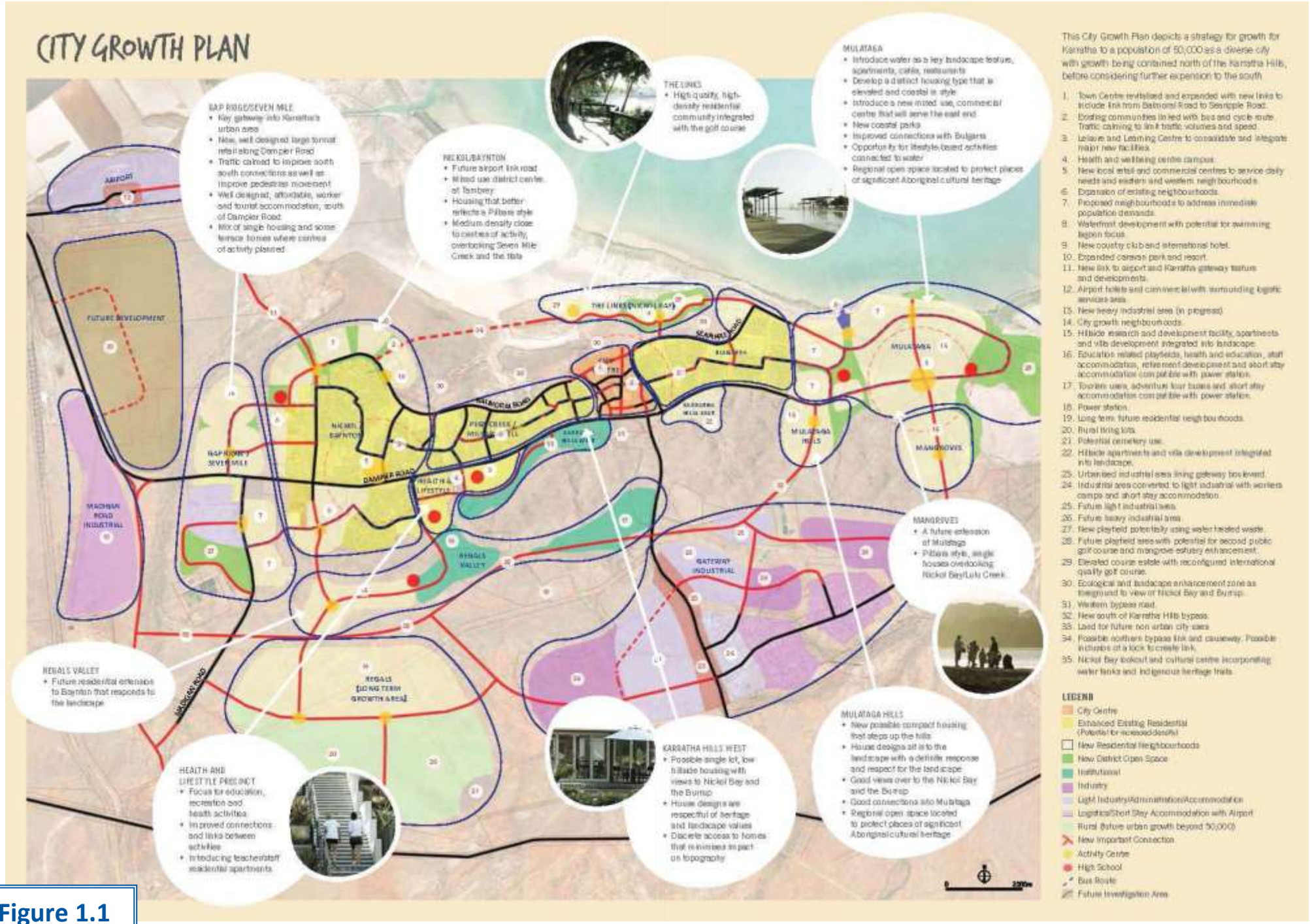

CITY GROWTH PLAN
This City Growth Plan depicts a strategy for growth for Karratha to a population of 50,000 as a diverse city with growth being contained north of the Karratha Hills, before considering further expansion to the south
1. Town Centre revitalised and expanded with new links to include link from Balmoral Road to Searipple Road.
2. Existing communities linked with bus and cycle route. Traffic calming to limit traffic volumes and speed.
3. Leisure and Learning Centre to consolidate and integrate major new facilities.
4. Health and wellbeing centre campus.
5. New local retail and commercial centres to service daily needs and eastern and western neighbourhoods.
6. Expansion of existing neighbourhoods.
7. Proposed neighbourhoods to address immediate population demands.
8. Waterfront development with potential for swimming lagoon focus.
9. New country club and international hotel.
10. Expanded caravan park and resort.
11. New link to airport and Karratha gateway feature and developments.
12. Airport hotels and commercial with surrounding logistic services area.
13. New heavy industrial area (in progress).
14. City growth neighbourhoods.
15. Hillside research and development facility, apartments and villa development integrated into landscape.
16. Education related playfields, health and education, staff accommodation, retirement development and short stay accommodation compatible with power station.
17. Tourism uses, adventure tour buses and short stay accommodation compatible with power station.
18. Power station.
19. Long term future residential neighbourhoods.
20. Rural living lots.
21. Potential cemetery use.
22. Hillside apartments and villa development integrated into landscape.
23. Urbanised industrial area lining gateway boulevard.
24. Industrial area converted to light industrial with workers camps and short stay accommodation.
25. Future light industrial area.
26. Future heavy industrial area.
27. New playfield potentially using water treated waste.
28. Future playfield area with potential for second public golf course and mangrove estuary enhancement.
29. Elevated course estate with reconfigured international quality golf course.
30. Ecological and landscape enhancement zone as foreground to view of Nickol Bay and Burrup.
31. Western bypass road.
32. New south of Karratha Hills bypass.
33. Land for future non urban city uses.
34. Possible northern bypass link and causeway. Possible inclusion of a lock to create link.
35. Nickol Bay lookout and cultural centre incorporating water tanks and indigenous heritage trails.
LEGEND
City Centre
Enhanced Existing Residential (Potential for increased density)
New Residential Neighbourhoods
New District Open Space
Institutional
Industry
Light Industry/Administration/Accommodation
Logistics/Short Stay Accommodation with Airport
Rural (future urban growth beyond 50,000)
New Important Connection
Activity Centre
High School
Bus Route
Future Investigation Area
GAP RIDGE/SEVEN MILE
• Key gateway into Karratha's urban area
• New, well designed large format retail along Dampier Road
• Traffic calmed to improve north south connections as well as improve pedestrian movement
• Well designed, affordable, worker and tourist accommodation, south of Dampier Road
• Mix of single housing and some terrace homes where centres of activity planned
NICKOL/BAYNTON
• Future airport link road
• Mixed use district centre at Bayntery
• Housing that better reflects a Pilbara style
• Medium density close to centres of activity, overlooking Seven Mile Creek and the tidal
THE LINKS
• High quality, high-density residential community integrated with the golf course
MULATAGA
• Introduce water as a key landscape feature, apartments, cafés, restaurants
• Develop a distinct housing type that is elevated and coastal in style
• Introduce a new mixed use, commercial centre that will serve the east end
• New coastal parks
• Improved connections with Bulgarra
• Opportunity for lifestyle based activities connected to water
• Regional open space located to protect places of significant Aboriginal cultural heritage
MANGROVES
• A future extension of Mulataga
• Pilbara style, single houses overlooking Nickol Bay/Lulu Creek
REGALS VALLEY
• Future residential extension to Bayntyn that responds to the landscape
HEALTH AND LIFESTYLE PRECINCT
• Focus for education, recreation and health activities
• Improved connections and links between activities
• Introducing teacher/staff residential apartments
KARRATHA HILLS WEST
• Possible single lot, low hillside housing with views to Nickol Bay and the Burrup
• House designs are respectful of heritage and landscape values
• Discrete access to homes that minimises impact on topography
MULATAGA HILLS
• New possible compact housing that steps up the hills
• House designs sit in to the landscape with a definite response and respect for the landscape
• Good views over to the Nickol Bay and the Burrup
• Good connections into Mulataga
• Regional open space located to protect places of significant Aboriginal cultural heritage
AIRPORT
FUTURE DEVELOPMENT
MADIGAN ROAD INDUSTRIAL
GAP RIDGE/SEVEN MILE
NICKOL BAYNTON
DAMPIER ROAD
BALMORAL ROAD
SEARIPPLE ROAD
THE LINKS (NICKOL BAY)
MULATAGA
MULATAGA HILLS
MANGROVES
REGALS VALLEY
REGALS (LONG TERM GROWTH AREA)
GATEWAY INDUSTRIAL
MADIGAN ROAD

Figure 1.1

1.4 Proposed Tambrey Neighbourhood Centre development

The TNC is proposed to be developed under a draft masterplan, which is illustrated in Figure 1.2 following, with Table 1.1 summarising the indicative centre composition. The key features of the proposed development are described as follows:

- The development is proposed to incorporate a mix of uses, including retail, commercial and residential facilities (permanent and short-stay accommodation), as well as other community uses.
- A core retail precinct will be centrally provided within the development, accessible via a new 'main-street' through the site, with the main centre building to be located on the eastern side of the main street.
- Also fronting 'main-street' will be an array of premises comprising a mixture of commercial and retail facilities.
- A mix of residential options is proposed surrounding the core retail component. The western section could provide for a number of grouped housing facilities, while the northern part could also include short stay accommodation services.
- The southern part of the development, fronting Dampier Road, is proposed to provide a number of food and beverage options, including take away and fast-food outlets, cafés and restaurants.
- Other community facilities are also proposed to be developed at the site, including a medical centre and a gymnasium, to complement the retail offer and the other uses.

The TNC therefore will be an attractive development incorporating a mix of uses, which are designed to support and complement the uses offered on a much larger scale at the Karratha City Centre. The focus of this report is the retail component of the TNC.

The Tambrey site has a retail floorspace allocation of 8,500 sq.m, under the Shire of Roebourne Town Planning Scheme 8, as indicated previously. The supportability of this floorspace incorporating the proposed uses at the Tambrey site, particularly for retailing, is examined throughout the remainder of this report.

Table 1.1
Tambrey N'hood Centre - indicative proposed composition*

Category	Tambrey N'hood Centre GLA (sq.m)	(% of retail)
Major tenants		
Supermarket	3,800	44.7%
Total majors	**3,800**	**44.7%**
Mini-majors	1,540	18.1%
Retail specialities		
Food & liquor	1,080	12.7%
Food catering	1,130	13.3%
Apparel	0	0.0%
Household	0	0.0%
Leisure	250	2.9%
General	600	7.1%
Retail services	100	1.2%
Total retail spec.	**3,160**	**37.2%**
Total centre - retail	**8,500**	**100.0%**
Non-retail/commercial**	5,065	
Total centre	**13,565**	

**Excluding residential floorspace*
***Includes medical centre, gymnasium, non-retail (such as Australia Post, banks, travel agent, real estate agent), carwash, and BOH*
Source: GMPM; MacroPlan Dimasi

notional building use plan
Tambrey Neighbourhood Centre
KARRATHA

TAYLORROBINSON

234 railway pde
west leederville
T 08 9388 6111
F 08 9388 6177

15017
25 06 15
drawn by FG

SK1

Figure 1.2

Section 2: The Karratha economy

This section of the report provides background information for Karratha, including a review of the State and local economy and the Karratha residential market.

2.1 Western Australian economy

Since 2008, the global economic environment has experienced significant volatility. Australia as a whole, however, and Western Australia in particular, have weathered the storm of international economic volatility well. Western Australia's Gross State Product (GSP) grew by 5.5% in 2013-14, making it the second fastest growing state/territory in Australia, behind the Northern Territory.

The importance of Western Australia to the national economy has increased substantially over recent years. Western Australia's proportion of national GDP was 16.7% in 2013/14, up from 15.5% in 2010/11. This contribution to Australia's economy is higher per capita, given that Western Australia has just 10.5% of the nation's population.

Labour market conditions remain strong in Western Australia, with seasonally-adjusted employment growing by 1.2% in annual average terms over the year ended May 2015. WA currently has the lowest unemployment rate of all of the states, at 5.1%.

Retail trade growth in the state has weakened in recent times, with $2,779 million of retail sales being recorded in April 2015. Over the year ended April 2015, retail trade in Western Australia has increased by 2.1%, lagging the national average of 4.9%.

The Western Australian economy is largely driven by the resources sector, with Western Australia accounting for 40.7% of all Australian exports in 2012-13. However, the services sector in the state is also growing quickly in terms of employment, particularly driven by health expenditure and tourism.

Strong levels of economic growth are forecast to continue in Western Australia for the next decade, driven by continuing demand for resources, and therefore continued investment in the mining and mineral processing sector. Over the year ended March 2015, $81 billion was invested in private new capital in the mining sector.

Recent movements in commodity prices have dampened growth in the state, but volumes of major exports continue to increase. Coal output increased by almost 25% from 2013 to 2014, with lead, zinc and manganese production also increasing.

PwC's Mine 2015 industry report found that the top 40 miners globally reduced their exploration spending by 53% from 2013 to 2014. This is indicative of the oversupply of bulk commodities such as coal and iron ore, as well as flagging demand from China as the country's growth moderates, and suggests that mining investment will fall over the coming years.

Of particular note is the fact that only one in four workers associated with mining operations in Western Australia is directly employed in the mining sector. The remainder are employed in a range of industrial and services sectors that provide supply chain and technical support to the mining sector, and thereby benefit from economic multiplier effects.

In summary, Western Australia will continue to grow at a reasonable pace, though growth will be considerably lower than its boom-time peaks whilst the economy rebalances away from its prior mining investment focus. This growth in turn will have significant beneficial effects on the broader State economy, including a dampening effect on unemployment rates and a continuing boost to population growth.

2.2 Mining activity

This section examines the large amount of mining activity occurring throughout Australia, mainly in Western Australia and Queensland. Table 2.1 summarises the levels of engineering activity (which incorporates infrastructure projects as well as mining) for each state and territory of Australia. It details engineering work completed and engineering activity underway and not yet complete (future work). Proposed activity is not included, as extensive data are not collated for future projects.

Not surprisingly, by far the majority of activity is occurring in Western Australia and Queensland. Some $42.4 billion or 34% of all engineering activity completed in FY14 was in Western Australia.

The mining industry continues to be a significant contributor to the Australian economy, particularly coal, iron ore and increasingly natural gas. The growth in the industry has led to substantial population growth in the mining centres around Australia, including Karratha, however it has also placed increasing pressure on infrastructure and housing prices. This pressure has reduced somewhat as the commodity cycle has turned over the past two years.

The boom in the mining industry was being driven primarily by demand from the emerging economies of China and India. Chinese demand for Australia's major exports in iron ore and coal has flagged from its cyclical peak in 2011-12, but Chinese growth continues at more moderate pace.

Japan is the largest market for Australian LNG producers, and has been experiencing reasonable growth of late, after experiencing near-on two decades of economic stagnation. If Indian growth increases in the future, it is expected that it will become a major consumer of Australian LNG and iron ore.

Table 2.1
Building & engineering activity by state

	Population 2014[1]		Engineering Activity[2]			
			Work done		Future work	
	('000)	%	FY14 $m	%	$m	%
Australia	**23,488**		**125,643**		**170,401**	
NSW	7,434	32%	19,681	16%	34,400	20%
VIC	5,815	25%	10,205	8%	21,897	13%
QLD	4,795	20%	42,832	34%	102,696	60%
WA	2,573	11%	42,406	34%	N/A	N/A
SA	1,686	7%	5,394	4%	7,294	4%
ACT	425	2%	889	1%	2,036	1%
TAS	515	2%	1,168	1%	2,078	1%
NT	245	1%	3,068	2%	N/A	N/A

1. ABS - Regional Population Growth, Australia, 2013-14 (cat. no. 3218.0)
2. ABS - Engineering Construction Activity Australia Mar 2012, Cat. no. 8762.0

In recent years there has been enormous capital investment in a range of mining projects, with the majority occurring in regional Western Australia and Queensland. Generally during the construction period of projects, mining companies source a large proportion of their labour requirements from Fly-in-Fly-out (FIFO) workers (at least 75%). The proportion of FIFO workers typically decreases during the operational period, although it usually continues to be a significant amount of the workforce.

There is no reliable information on the total number of FIFO workers in Australia, though some estimates put the number at between 50,000 and 75,000. FIFO workers are mostly based in purpose-built temporary accommodation, with all basic requirements provided, such as food. Typically FIFO workers are residentially based in the capital city, with *The Chamber of Minerals and Energy WA* estimating that 80% of all FIFO workers in Western Australia are based in Perth.

The mining boom in both Western Australia and Queensland has already driven and will further drive rapid growth in a number of the key population centres around the mining regions in each state. The Pilbara and Geraldton regions in Western Australia are expected to benefit the most.

Mining is a key employment sector for Western Australia, and it will continue to be well into the future. Some of the major mining projects in the Pilbara have a remaining life span of about 15 years; while other existing and planned projects will continue for up to 80 years, providing long-term stability in the region.

However, one of the features of the mining industry is that while it attracts vast amounts of capital expenditure as noted in Table 2.1, it is not a huge generator of ongoing direct jobs over the long term. Large numbers of jobs are created during the construction and setup phase, but the number of operational jobs created on a long term basis is relatively modest. In this regard, Table 2.2 attached shows Australia's employment patterns by industry, highlighting the fact that the mining sector accounts for approximately 229,000 jobs, or only around 2.0% of total employment. In contrast, mining contributes some 7.2% of Australia's gross domestic product.

Table 2.2
Employment by Industry (000's)*

	NSW/ACT		QLD		VIC		WA		SA		NT/TAS		AUSTRALIA	
Industry	No.	% of Total	No.	% of Total	No.	% of Total	No.	% of Total	No.	% of Total	No.	% of Total	No.	% of Total
Agriculture, Forestry and Fishing	74	2.0%	60	2.6%	75	2.5%	30	2.1%	46	5.6%	14	3.6%	298	2.6%
Mining	**38**	**1.0%**	**66**	**2.8%**	**10**	**0.4%**	**96**	**6.9%**	**11**	**1.4%**	7	**1.8%**	**229**	**2.0%**
Manufacturing	267	7.2%	174	7.4%	288	9.7%	88	6.3%	73	8.9%	23	5.9%	913	7.8%
Electricity, Gas, Water and Waste Services	36	1.0%	31	1.3%	38	1.3%	16	1.2%	11	1.4%	6	1.6%	139	1.2%
Construction	321	8.7%	207	8.8%	251	8.4%	158	11.3%	64	7.9%	33	8.3%	1,034	8.9%
Wholesale Trade	134	3.6%	72	3.1%	114	3.8%	42	3.0%	21	2.6%	10	2.5%	393	3.4%
Retail Trade	377	10.2%	258	10.9%	317	10.7%	124	8.9%	87	10.7%	37	9.5%	1,201	10.3%
Accommodation and Food Services	274	7.4%	177	7.5%	205	6.9%	85	6.1%	55	6.7%	28	7.3%	824	7.1%
Transport, Postal and Warehousing	189	5.1%	126	5.3%	158	5.3%	75	5.3%	42	5.2%	19	4.8%	609	5.2%
Information Media and Telecommunications	83	2.2%	29	1.2%	60	2.0%	13	0.9%	13	1.6%	5	1.4%	204	1.8%
Financial and Insurance Services	160	4.3%	62	2.6%	107	3.6%	32	2.3%	25	3.1%	6	1.6%	392	3.4%
Rental, Hiring and Real Estate Services	68	1.8%	49	2.1%	49	1.6%	28	2.0%	10	1.2%	6	1.5%	209	1.8%
Professional, Scientific and Technical Serv.	354	9.6%	191	8.1%	275	9.3%	111	8.0%	53	6.5%	23	5.8%	1,007	8.7%
Administrative and Support Services	131	3.6%	77	3.3%	113	3.8%	48	3.4%	27	3.3%	11	2.9%	407	3.5%
Public Administration and Safety	199	5.4%	153	6.5%	150	5.0%	86	6.1%	52	6.4%	57	14.5%	697	6.0%
Education and Training	286	7.7%	194	8.2%	242	8.2%	103	7.4%	60	7.4%	32	8.3%	918	7.9%
Health Care and Social Assistance	485	13.1%	288	12.2%	348	11.7%	166	11.9%	121	14.9%	50	12.8%	1,458	12.5%
Arts and Recreation Services	66	1.8%	42	1.8%	62	2.1%	29	2.1%	15	1.8%	8	2.1%	222	1.9%
Other	156	4.2%	102	4.3%	108	3.6%	69	4.9%	29	3.5%	15	3.9%	480	4.1%
Total	**3,698**	**100%**	**2,359**	**100%**	**2,971**	**100%**	**1,401**	**100%**	**812**	**100%**	**392**	**100%**	**11,633**	**100%**

**Year ending May 2015*
Source: ABS; MacroPlan Dimasi

2.3 The local economy

The Pilbara region in north-west Western Australia incorporates the mining centres of Karratha and Port Hedland, and is one of the most resource rich regions of Australia. The latest Government of Western Australia Economic Profile measures Gross Regional Product of the Pilbara as $34.9 billion. This accounts for 13.2% of Western Australia's Gross State Product, and 2.2% of Australia's GDP.

There is a range of very significant mining projects either under construction or planned in the Pilbara, and this is driving regional employment opportunities. Figure 2.1 following illustrates the locations of the various major resource projects in the Pilbara region, as sourced from the Department of State Development.

Some of the major projects in the Pilbara region include the following:

- Gorgon LNG – GJV (estimated to cost $43 billion), committed: Around 5,500 direct jobs are estimated to be created during construction, and when operational some 300 permanent jobs are expected to be created. The first cargo of LNG is expected later in 2015.
- Pluto LNG – Woodside ($15 billion), committed: 5,000 jobs during construction, 300 operational jobs.
- Wheatstone LNG – Chevron ($29 billion), committed: 5,500 jobs during construction, 400 operational jobs.
- Browse FLNG – Previously mooted as a joint venture project headed by the Western Australian state government and Woodside, the Browse resources will now be tapped using a Floating LNG concept.


INSET A
SCALE 1:1 200 000
50 km
MINERAL SYMBOLS
Precious mineral
Precious metal
Steel alloy metal
Speciality metal
Base metal
Iron
Alumina
Coal or lignite
Uranium
Industrial mineral
Processing plant
PETROLEUM SYMBOLS
Gas field
Oil field
Oil and gas field
Significant gas field discovery
Significant oil field discovery
Significant oil and gas field discovery
Processing plant
INFRASTRUCTURE SYMBOLS
Radio-astronomy observatory
Port
Irrigation/Water/Desalination
Power plant
Larsen Deep
Noblige
Larsen
Chandon
Yellowglen
Jansz
Io
Urania
Io South
Toporoa
Geryon
Eurytion
Pluto
Eris
Xena
Iago
Wheatstone
Pemberton
Wilcox
Winchester
Brunello
Balnaves
Chrysaor/Dionysus
Maenad
Orthrus
Julimar
Bravo
Briseis
Glencoe
Nimblefoot
Equus
The Grafter
Achilles
Acme
West Tryal Rocks
Clio
Clio South
Clio North
Satyr
Mentorc
Chester
Pontus
Gorgon
Rosella
Rosella North
Halyard
Spar
Sappho
Bianchi
Zola
Antiope
Tallaganda
John Brookes
Wonnich
Wonnich Deep
Maitland
Bambra
Bambra East
Harriet
North Alaimos
Ulidia
Lee
Rose
Monty
Josephine
Baker
Simpson
Rankin Court
South Plato
Double Island
Gorgon LNG
Barrow Island
West Cycad
Victoria
Pedirka
Little Sandy
Narvik
Pasco
Flinders Shoal
Ramillies
Nimrod
Nasutus
Cyrano
Mardie
South Chervil
Cadell
Australind
Saladin
Crest
Cowle
Corowa
Quitrim
Blencathra
Coniston
Novara
Van Gogh
Vincent
Eskdale
Enfield
Stybarrow
Crosby
Stickle
Macedon
Laverda
Pyrenees
Black Pearl
Scafell
Ravensworth
Leatherback
Skate
Onslow
Roller
Coaster
Zeitburton North
Onslow Salt
Wheatstone LNG
Macedon Gas
Mutineer
Exeter
Fletcher
Finucane
Eaglehawk
Lambert Deep
Hermes
Lambert
Searipple
Athena
Egret
Angel
Capella
Montegue
Cossack
Perseus
Persephone
Wanaea
Forestier
Ajax
North Rankin
Gaea
Hurricane
Keast
Goodwyn
Goodwyn 5/Pueblo
Echo/Yodel
Tidepole
Rankin/Sculptor
Dockrell
Dixon/W.Dixon
Sage
Saffron
Reindeer
Gnu
Caribou
Corvus
Waldoo
Tusk
Stag
Oryx
Chamois
NWSV LNG
Pluto LNG
Cape Lambert
Anketell
Yara Pilbara Fertilisers
Yara Pilbara Nitrates
Dampier
Dampier Salt
Cape Lambert
Sherlock Bay
Cape Preston
Cape Preston East
Devil Creek Gas
Maitland River
Radio Hill
Wheindo Zn Cu
Munni Munni Pt Pd
Balmoral South
Mesa A – Warramboo
Mesa J
Middle Robe Mesas
WEST
NORTH
SHELF

Opportunities to ensure the prolonged growth of the region lie in industries such as healthcare and specialist manufacturing. Healthcare and social assistance is currently Western Australia's biggest employer, accounting for 11.9% of all jobs in the state. As the population ages, demand for, and thus employment in these sectors will grow. Tourism has also been floated as a possible alternative source of employment.

One of the major challenges facing Western Australia is the retention of the skilled workers who came to the state during the mining boom. It is argued that WA could forge a strong specialist manufacturing industry specialising in areas such as mining automation and renewable energy.

The *2015 - 2025 WA Resources Sector Outlook* report, prepared by Deloitte Access Economics for the Chamber of Minerals and Energy of Western Australia (CMEWA) in November 2014, states that the workforce in the Pilbara is expected to decrease by 14,300 workers by 2020 from around 55,000 in 2014, comprising a reduction of 17,900 construction workers and increase of 3,600 operational workers. The contraction of the Pilbara workforce to 2020 is expected to be driven by a decrease in the FIFO workforce.

2.4 Residential market

This sub-section provides a brief overview of the residential market in Karratha, including for the rental and property sales markets.

Rental market

Table 2.3 and Chart 2.1 following show the trend in the number of rental properties advertised in Karratha, as well as the average weekly rental costs. The main points to note are as follows:

- There is reasonable supply of one-bedroom properties, with rents averaging approximately $500 over the past 12 months.

- The number of properties with two or more bedrooms advertised for rent remained relatively constant over the past 12 months. Rents for these properties averaged around $680 per week.

- The supply of three-bedroom properties has decreased markedly since June 2014, with numbers of four or more bedroom properties dwindling relatively more slowly. Properties with three or more bedrooms have seen weekly rental yields fall almost $150 over the course of nine months, with four-bedroom properties seeing similar decreases in rent.

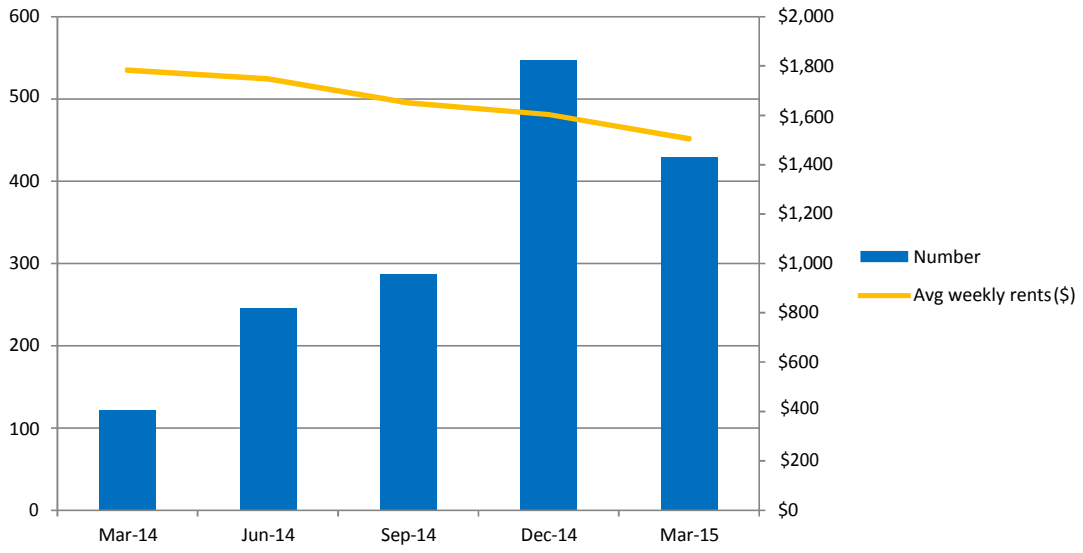
- Generally, therefore, the number of advertised properties for rent has decreased over recent times, but rental prices have fallen in tandem. Rental prices in Karratha still significantly exceed those in other regional areas.

Table 2.3
Karratha - Advertised rental properties by property type

Property type	Quarter	Number	Avg weekly rents ($)
One bedroom	Jun-14	62	$569
	Sep-14	46	$502
	Dec-14	37	$475
	Mar-15	56	$468
Two bedroom	Jun-14	41	$668
	Sep-14	42	$688
	Dec-14	45	$706
	Mar-15	44	$642
Three bedroom	Jun-14	190	$824
	Sep-14	174	$773
	Dec-14	168	$701
	Mar-15	136	$668
Four bedroom and above	Jun-14	170	$1,174
	Sep-14	143	$1,070
	Dec-14	164	$1,052
	Mar-15	154	$1,012
Total	**Jun-14**	**463**	**$905**
	Sep-14	**405**	**$838**
	Dec-14	**414**	**$820**
	Mar-15	**390**	**$772**

Source: Pilbara Housing and Land Snapshot (March 2015)

Chart 2.1
Karratha - Advertised rental properties



Source: Pilbara Housing and Land Snapshot (March 2015)

Residential property sales

Chart 2.2 following illustrates the number of property sales and average house prices in Karratha from the March 2009 quarter to the March 2015 quarter. Average house prices in Karratha increased significantly in 2009, from around $632,000 to a peak of $945,000 in June 2010, as demand levels outstripped supply. Prices have fallen steadily since then, with the average house price now sitting at roughly $500,000.

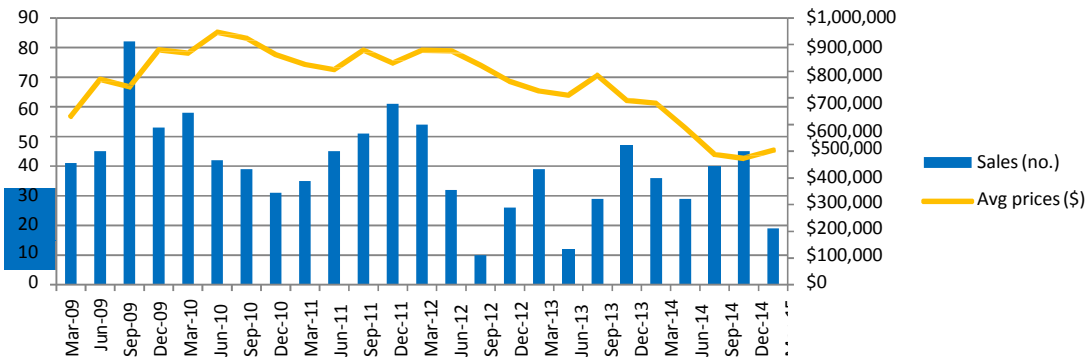
There has been an average of 45-50 dwellings sold per quarter in Karratha between 2009 and 2015, with a peak of 82 houses sold in the September 2009 quarter. The most recent quarter, however, saw only 19 settlements, a multi-year low.

Residential supply and demand

Current proposed residential projects (refer Table 2.4) will deliver just under 24,000 residential lots in Karratha over the long term, enabling the town to achieve the Karratha City of the North plan for an aspirational population target of 50,000 residents. The majority of the growth in the housing stock is proposed to occur over the short term, with growth slowing over the longer run.

Chart 2.2

Karratha - Average house prices and number of sales



Source: Pilbara Housing and Land Snapshot (October 2012)

Table 2.4

Karratha - Major future dwelling growth

Locality/area				Total
Town centre	820	820	876	2,516
Bulgarra	1,260	426	0	1,686
Nickol/Baynton	2,166	1,853	0	4,019
Mulataga	3,415	731	731	3,760
Mulataga Foot Hils	0	580	0	580
Mangroves	0	778	778	1,556
Gap Ridge/Seven Mile	1,657	1,997	0	3,654
Pegs Creek/Millars Well	1,098	0	0	1,098
Health & Lifestyle	416	0	0	416
Regals Valley	425	0	629	1,054
Regals	171	0	0	171
Karratha Foot Hills	0	209	280	489
Airport	0	312	0	312
The Links	0	245	762	1,007
Gateway Industrial	374	0	0	374
Total	11,802	7,951	4,056	**23,809**

Source: Karratha City of the North Plan: City Growth Plan

Section 3: Trade area analysis

This section of the report details the trade area that is expected to be served by the proposed Tambrey Neighbourhood Centre (TNC), including the population, spending levels and socio-demographic profile of permanent residents; as well as the additional FIFO population.

3.1 Trade area definition

The extent of a trade area or catchment for any centre is shaped by a number of important factors, which are described as follows:

i. The relative attraction of the centre in question as compared with alternative retail facilities. The factors that determine the strength and attraction of any shopping centre are primarily the scale and composition of the centre, in particular the major trader (or traders) that are included within it; the layout, ambience and presentation of the centre; and carparking, including access and ease of use.

ii. While the strength and appeal of a centre directly impact on the breadth of customer draw, the proximity and attraction of competitive retail centres serves to restrict a centre's ability to extend its trade area. Thus, the locations, compositions, quality and scale of competitive retail facilities all serve to define the extent of the trade area which the centre in question is effectively able to serve.

iii. The available road network and public transport service, and how they operate to effect ease of use and access to the centre in question, are also important factors impacting on a centre's relative attractiveness.

iv. Significant physical barriers which are difficult to negotiate or which take considerable time to cross can often act to delineate the boundaries of the trade areas able to be served by specific centres.

Taking all of the above into account, the Tambrey trade area is influenced in particular by the following:

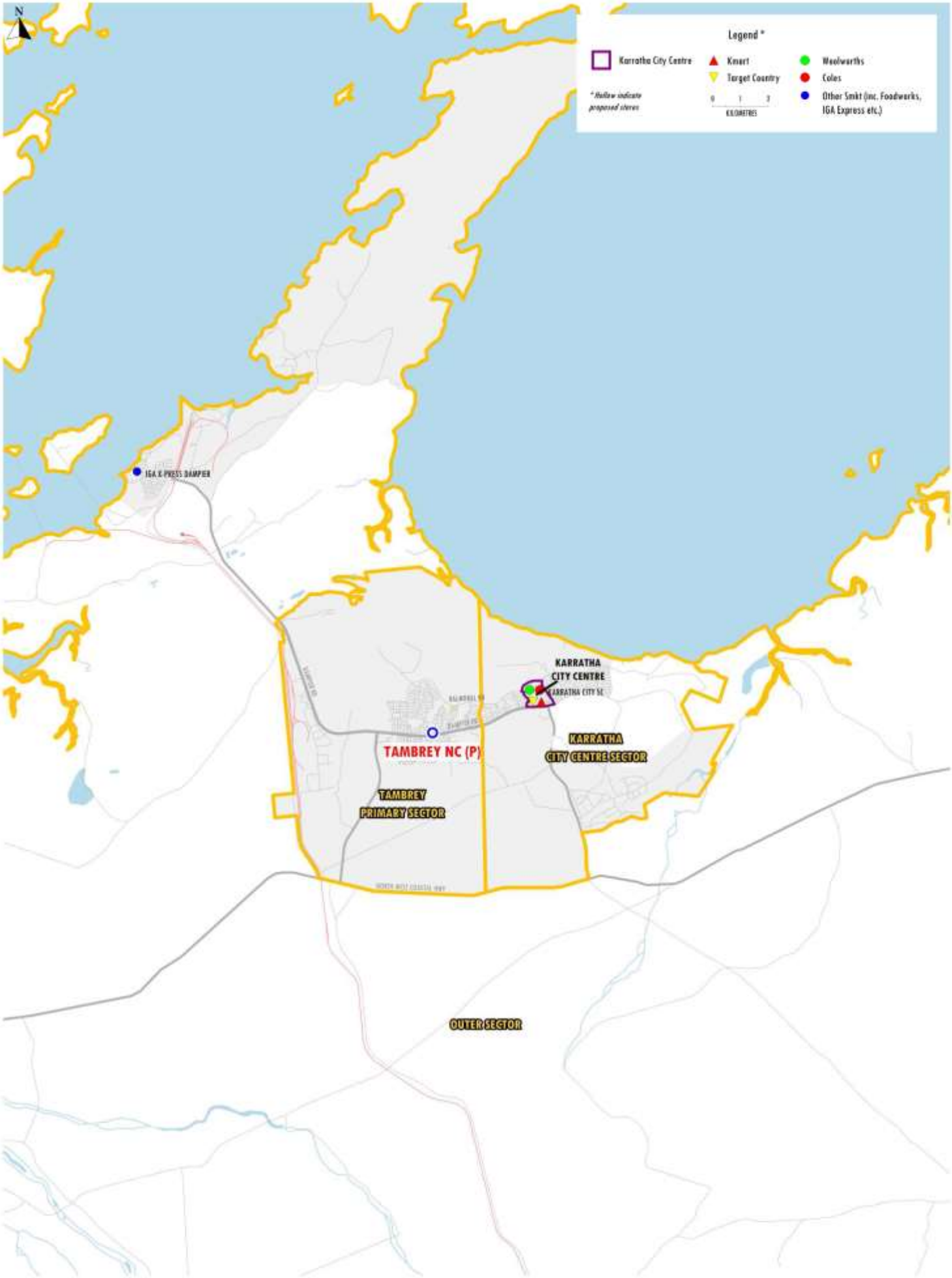
- The regional role of Karratha in this north-western region of Western Australia, providing the major retailing, administrative and employment facilities for the surrounding population.
- The ease of access and high visibility of the neighbourhood centre site, reflecting its location on the corner of Dampier and Bathgate Roads, and the proposed main street access off Dampier Road.
- The proposed tenant mix at the centre, which is expected to contain a supermarket and a range of specialty traders.
- The locations of competitive facilities in Karratha, which are concentrated within the City Centre to the east, particularly Karratha City SC.

On this basis, the trade area of relevance to the TNC has been defined as a **primary trade area**, as illustrated on the attached Maps 3.1 and 3.2, encompassing the western residential areas of Karratha, including Nickol, Millars Well, Stove Hill and Baynton. The TNC will be well located to serve the food and grocery shopping needs of primary sector residents, reflecting its easy accessibility and central location within the surrounding residential areas.

In addition, given the predominant role of Karratha as the main retail destination in the region, for the purposes of analysis, we have also defined two additional sectors, described as follows:

- The **Karratha City Centre sector** incorporates the eastern portion of the Karratha urban area, including Pegs Creek, Bulgarra and Mulataga.
- The **outer sector** incorporates the remainder of the City of Karratha, including the towns of Dampier and Wickham.

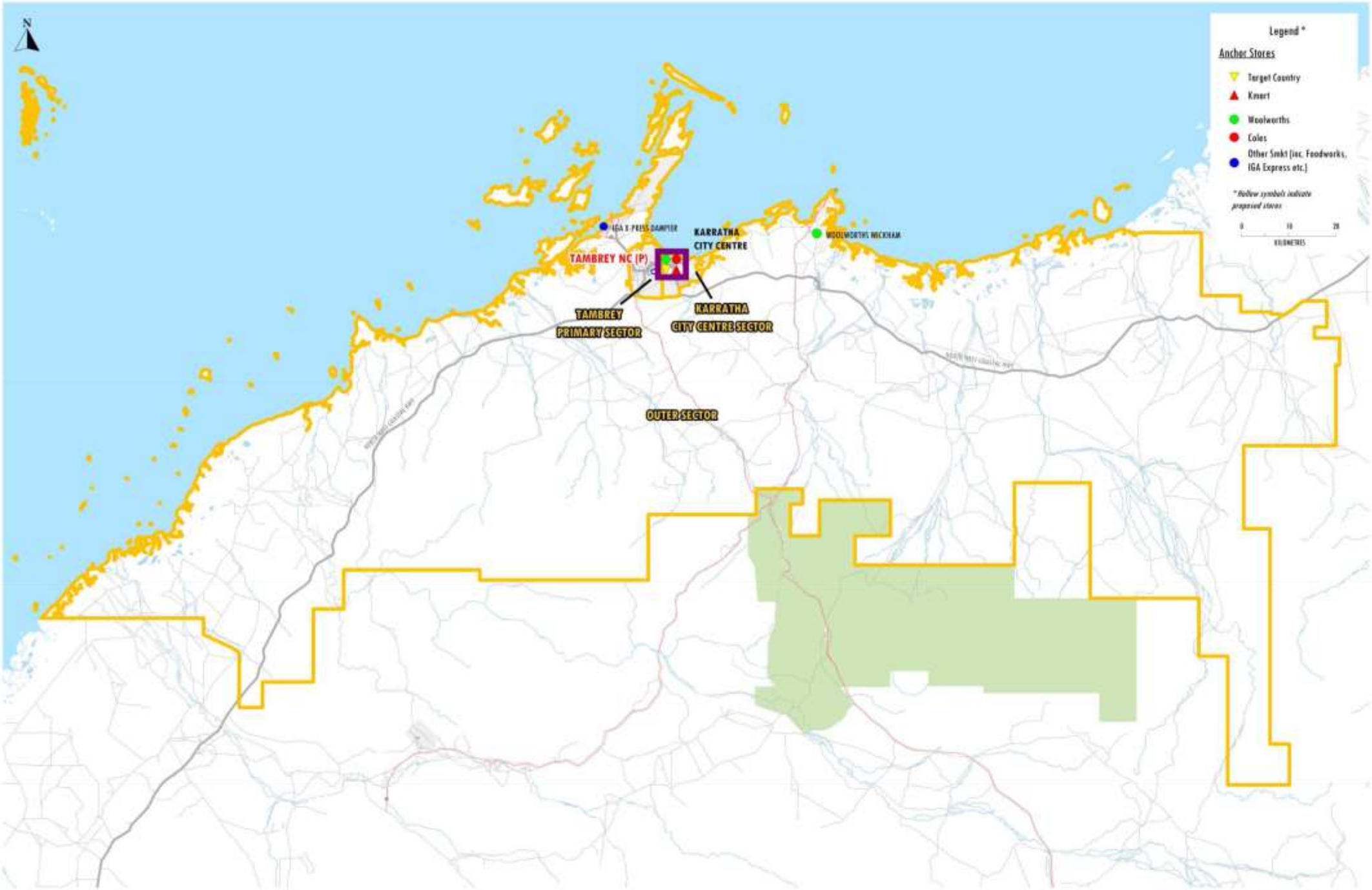
The TNC may attract some business from these surrounding areas, particularly from Dampier residents located to the north-west. However, the bulk of these residents' expenditure, particularly non-food and higher-order expenditure, would still be directed to facilities located in the City Centre, reflecting the primary retail role of the Karratha City Centre, with the TNC to provide a supporting role.



Map 3.1: Tambrey Neighbourhood Centre

Trade area and competition

MacroPlanDimasi



Map 3.2: Tambrey Neighbourhood Centre

Trade area and competition

MacroPlanDimasi

3.2 Trade area permanent population

Table 3.1 details the existing and projected population levels within the defined Tambrey primary trade area and also for the total City of Karratha. The City of Karratha population is estimated at some 26,380 residents, including 11,710 residents in the primary sector. The primary sector therefore contains close to 45% of the City's population, and is a very substantial and growing catchment to support the TNC, but which in turn needs the TNC to be delivered for amenity and convenience.

Population growth in the City has been strong between the two census years, averaging around 3.7% per annum, which is higher than the Western Australia average growth rate of about 2.7% over the same period. The majority of this growth has been occurring in the primary sector, on the back of the growth in the mining sector over those years.

More recently, however, a slowdown in the demand for residential stock has generally been observed, due to a broad softening in the commodities sector and a slowdown in construction activity as well as in the broader economy. These weaker conditions are likely to have some adverse effects on the short (and possibly medium) term outlook for population growth in Karratha.

However, the longer term opportunities are considered to be positive, underpinned by the broad initiatives completed and planned as part of the Karratha City of the North plan, which will transform the city into a more diversified and genuine regional hub for the region.

A number of growth areas have been identified for potential residential development or extension of existing neighbourhoods to facilitate the City of the North plan, including the areas to the west of the Tambrey site. Other localities at the edge of the urban area have also been designated to accommodate future neighbourhoods, including longer-term growth areas at Gap Ridge/Seven Mile and the Mulataga/Mangroves localities situated at the western and eastern edges of the Karratha urban area respectively.

Table 3.1
Tambrey trade area population, 2006-2026*

	Estimated population			Forecast population		
Trade area sector	2006	2011	2015	2018	2021	2026
Primary	7,660	9,910	11,710	13,060	14,110	15,360
Other sectors						
• Karratha City Centre	6,780	7,100	7,700	8,300	9,350	11,100
• Outer	5,290	6,610	6,970	7,210	7,390	7,690
Total other	12,070	13,710	14,670	15,510	16,740	18,790
City of Karratha	**19,730**	**23,620**	**26,380**	**28,570**	**30,850**	**34,150**
	Average annual growth (no.)					
Trade area sector		2006-11	2011-15	2015-18	2018-21	2021-26
Primary		450	450	450	350	250
Other sectors						
• Karratha City Centre		64	150	200	350	350
• Outer		264	90	80	60	60
Total other		328	240	280	410	410
City of Karratha		**778**	**690**	**730**	**760**	**660**
	Average annual growth (%)					
Trade area sector		2006-11	2011-15	2015-18	2018-21	2021-26
Primary		5.3%	4.3%	3.7%	2.6%	1.7%
Other sectors						
• Karratha City Centre		0.9%	2.0%	2.5%	4.1%	3.5%
• Outer		4.6%	1.3%	1.1%	0.8%	0.8%
Total other		2.6%	1.7%	1.9%	2.6%	2.3%
City of Karratha		**3.7%**	**2.8%**	**2.7%**	**2.6%**	**2.1%**

**As at June*
Source: ABS Census 2011; WA Tomorrow, 2015; Forecast.id; MacroPlan Dimasi

Furthermore, the Karratha Revitalisation Strategy outlined previously and under consideration at Council, will allow for increased residential density and better infrastructure within the more established suburbs, helping to maintain a sustained growth outlook for Karratha as a city to live and work.

Taking the above into account, the population of the City of Karratha is projected to reach around 31,000 residents by 2021 and over 34,000 residents by 2026. The average annual increase in the total trade area population is expected to be in the range 700-800 people, or some 2.4% per annum, over the period to 2026. The primary trade area is expected to contain around 15,360 residents by 2026.

While the population level in the City of Karratha is not projected to reach the aspirational target of 50,000 people over this timeframe, the strong commitment and planning which are already in place for Karratha should provide the necessary impetus to enable continued investment and drive sustained population growth.

3.3 Socio-demographic profile

The attached Chart 3.1 and Table 3.2 detail the socio-demographic profile of the Tambrey primary trade area population and for the City of Karratha, based on the 2011 Census of Population and Housing, highlighting the following:

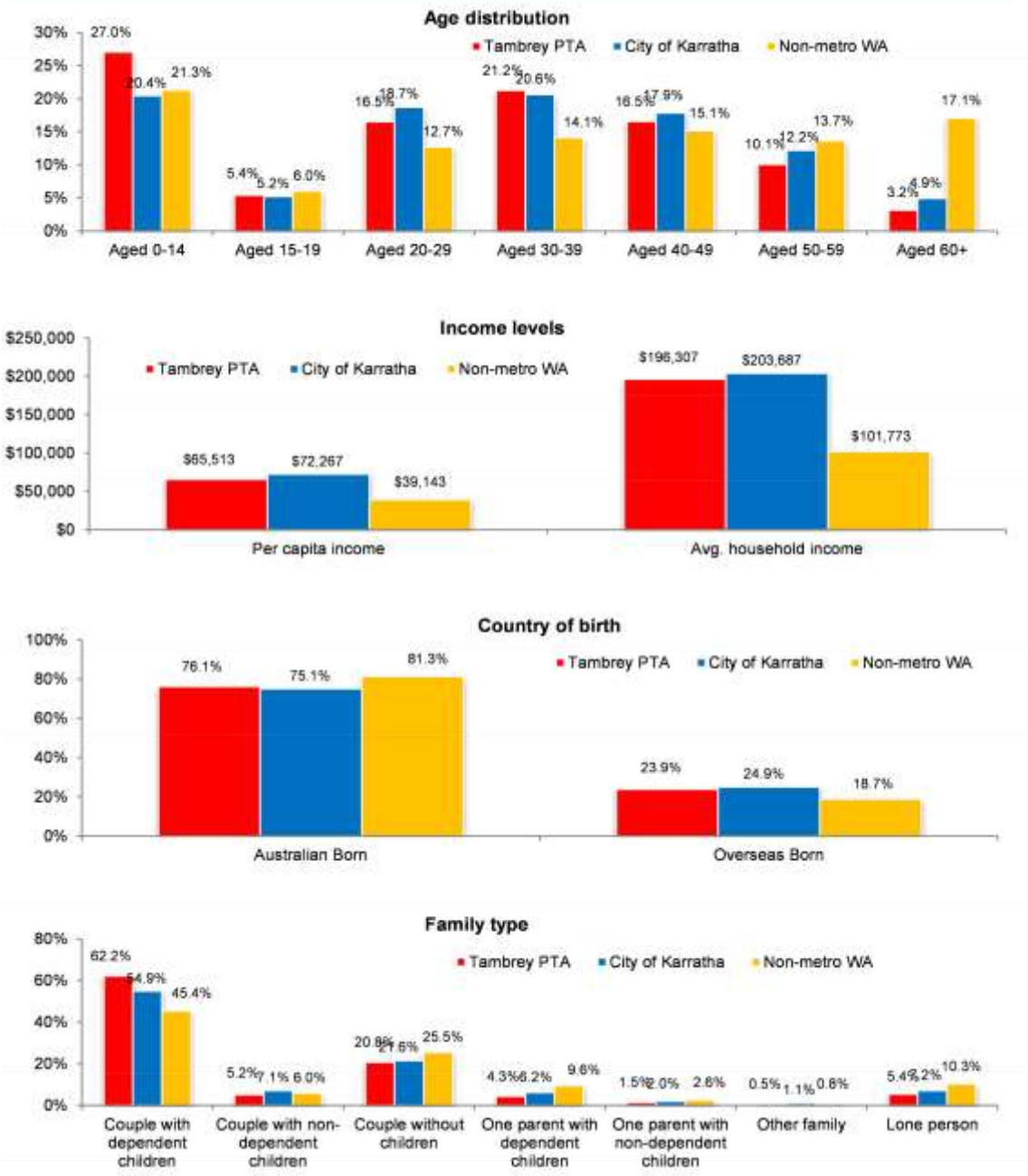
- The average age of residents in the primary trade area, at 28.9 years, is significantly below the non-metropolitan Western Australia average of 36.7 years, reflecting the above average proportion of children and residents aged 20-39 years old, as well as the significantly below average proportion of residents aged 60 years and over.
- Income levels in the primary sector are well above the respective non-metropolitan Western Australia benchmarks, reflecting the high wages typically associated with the mining sector.
- Home ownership levels throughout the primary sector are well below the non-metropolitan Western Australia average, reflecting the predominance of rental accommodation among residents who work primarily in the mining industry, as well as the very high prices of houses in the region.
- Primary sector residents are predominantly Australian born, though with an above average proportion of overseas born residents.

- The distribution of family types throughout the primary trade area indicates an above average proportion of traditional families with children.

In summary, the Tambrey primary trade area is reflective of a residential area of a regional town, comprised of traditional families in their early to mid life stages, who earn high income levels and are attracted by the employment opportunities in the mining and related sectors.

Chart 3.1

Tambrey trade area - socio-demographic profile, 2011



Source: ABS Census of Population & Housing, 2011; MacroPlan Dimasi

Table 3.2

Tambrey trade area - socio-demographic profile, 2011

Census item	Primary sector	Other sectors		City of Karratha	Non-metro WA avg.
		Karratha City Centre	Outer		
Per capita income	$65,513	$78,024	$76,208	$72,267	$39,143
Var. from Non-metro WA benchmark	*67.4%*	*99.3%*	*94.7%*	*84.6%*	
Avg. household income	$196,307	$197,941	$221,491	$203,687	$101,773
Var. from Non-metro WA benchmark	*92.9%*	*94.5%*	*117.6%*	*100.1%*	
Avg. household size	3.0	2.5	2.9	2.8	2.6
Age distribution (% of population)					
Aged 0-14	27.0%	15.8%	15.5%	20.4%	21.3%
Aged 15-19	5.4%	5.0%	5.2%	5.2%	6.0%
Aged 20-29	16.5%	21.2%	19.3%	18.7%	12.7%
Aged 30-39	21.2%	19.9%	20.6%	20.6%	14.1%
Aged 40-49	16.5%	17.8%	19.9%	17.9%	15.1%
Aged 50-59	10.1%	14.2%	13.2%	12.2%	13.7%
Aged 60+	3.2%	6.1%	6.3%	4.9%	17.1%
Average age	28.9	33.6	34.0	31.8	36.7
Housing status (% of households)					
Owner (total)	18.4%	32.2%	29.3%	25.6%	62.6%
• Owner (outright)	6.3%	12.6%	15.1%	10.7%	31.3%
• Owner (with mortgage)	12.1%	19.6%	14.2%	14.9%	31.3%
Renter	80.6%	66.2%	69.5%	73.2%	36.4%
Other	1.0%	1.6%	1.2%	1.2%	1.1%
Birthplace (% of population)					
Australian born	76.1%	72.5%	76.3%	75.1%	81.3%
Overseas born	23.9%	27.5%	23.7%	24.9%	18.7%
• Asia	6.4%	7.6%	8.3%	7.3%	2.9%
• Europe	7.6%	8.8%	6.7%	7.7%	9.4%
• Other	9.9%	11.1%	8.7%	9.9%	6.5%
Family type (% of households)					
Couple with dep't children	62.2%	47.9%	52.8%	54.9%	45.4%
Couple with non-dep't child.	5.2%	9.1%	7.3%	7.1%	6.0%
Couple without children	20.8%	24.8%	18.7%	21.6%	25.5%
One parent with dep't child.	4.3%	5.1%	10.2%	6.2%	9.6%
One parent w non-dep't child.	1.5%	1.9%	2.8%	2.0%	2.6%
Other family	0.5%	1.0%	2.2%	1.1%	0.8%
Lone person	5.4%	10.2%	6.0%	7.2%	10.3%

Source: ABS Census of Population & Housing, 2011; MacroPlan Dimasi

3.4 Trade area spending

MacroPlan Dimasi estimates retail expenditure capacity generated by trade area residents based on information sourced from Market Data Systems (MDS), which utilises the detailed micro-simulation model of household expenditure behaviour for all residents of Australia. The model takes into account information from a wide variety of sources, including the regular ABS Household Expenditure Survey, National Accounts Data, Census Data and other information.

MarketInfo data is considered to be an accurate, indeed the best available, detailed measure of retail expenditure capacity and behaviour, and is widely relied on in the retail industry. Total retail expenditure is detailed in a number of categories, as follows:

- Take-home food and groceries – goods typically sold in supermarkets and specialty fresh food stores.
- Packaged liquor – packaged beer, wine and spirits such as those purchased at bottle-shops and liquor outlets. The combination of take-home food and groceries and packaged liquor is referred to as FLG expenditure.
- Food catering – cafes, take-away outlets and restaurants, including liquor consumed on such premises.
- Apparel – clothing, footwear, fashion and accessories.
- Household Goods – giftware, electrical, computers, furniture, homewares, and hardware goods.
- Leisure – sporting goods, music, DVDs, games, books, newsagents and film processing/photography.
- General Retail –pharmaceutical goods, cosmetics, toys, florists, mobile phones.
- Retail Services – retail services such as key cutting, shoe repairs, hair and beauty.

Chart 3.2 presents a comparison of retail spending behaviour of the Tambrey primary trade area residents with non-metropolitan Western Australia averages. All retail spending estimates in this report are expressed in constant 2014/15 dollars (i.e. excluding retail inflation), and including GST.

The total level of retail expenditure per person for the primary trade area population in 2015 is estimated at $16,589, which is around 18% above the non-metropolitan Western Australia average. Per capita expenditure on retail goods for this population is above average across all categories, particularly across the non-food categories.

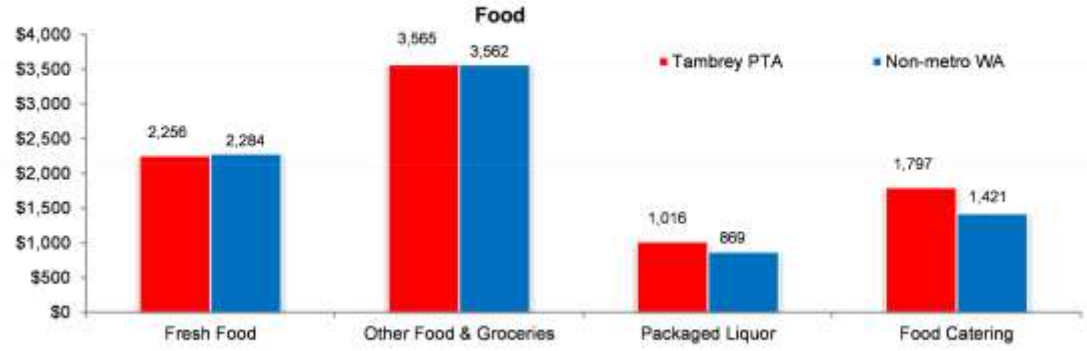
Table 3.3 following presents estimates of total retail expenditure generated by the population within the primary trade area and for the total City of Karratha. This table also shows the projected real growth in available retail expenditure, taking into account the forecast population levels for each sector.

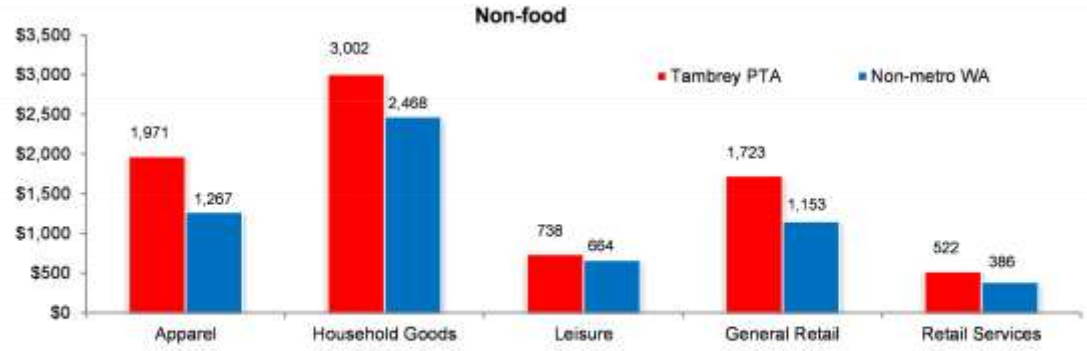
Total available retail expenditure within the City is forecast to grow in real terms from the current levels of $414 million to a projected total of $603 million at 2026. This level of growth represents an average annual real growth rate of between 3% – 3.5% per annum over the forecast period to 2026. The primary sector population is expected to generate around $281 million in retail expenditure by 2026.

Table 3.4 details the projected retail spending of the Tambrey primary trade area population by key commodity group. It is estimated that primary sector residents currently spend $99 million on retail food items and $91 million on retail non-food goods and services. Over the forecast period to 2026, retail expenditure on food is expected to increase to $150 million, while non-food spending is forecast to increase to $131 million, expressed in constant 2014/15 dollar terms.

Chart 3.2

Tambrey trade area - retail spending per person, 2014/15*





*Including GST
Source: MarketInfo; MacroPlan Dimasi

Table 3.3

Tambrey main trade area - retail expenditure ($M), 2015-2026*

Year ending June	Primary sector	Other sectors		City of Karratha
		Karratha City Centre	Outer	
2015	190.2	126.6	97.4	414.2
2016	199.2	130.4	99.3	428.9
2017	208.2	134.8	101.2	444.2
2018	217.8	139.4	103.3	460.5
2019	226.8	145.4	105.3	477.4
2020	235.0	152.7	107.2	494.9
2021	243.6	160.6	109.2	513.4
2022	251.6	168.5	111.3	531.3
2023	258.6	176.3	113.4	548.3
2024	265.9	184.4	115.6	565.9
2025	273.4	192.9	117.8	584.1
2026	281.1	201.9	120.0	603.0
Average annual growth ($M)				
2015-2026	8.3	6.8	2.1	17.2
Average annual growth (%)				
2015-2026	3.6%	4.3%	1.9%	3.5%

**Constant 2014/15 dollars & including GST*

Source: MarketInfo; MacroPlan Dimasi

Table 3.4
Tambrey primary trade area - retail expenditure by product group ($M), 2015-2026*

Year ending June	FLG	Food catering	Apparel	Household goods	Leisure	General retail	Retail services	**Total retail**
2015	78.4	20.6	22.6	34.4	8.5	19.8	6.0	190.2
2016	82.2	21.7	23.6	36.0	8.8	20.6	6.3	199.2
2017	86.0	22.8	24.6	37.6	9.2	21.5	6.6	208.2
2018	90.1	24.0	25.6	39.3	9.6	22.4	6.9	217.8
2019	93.9	25.1	26.6	40.9	9.9	23.2	7.2	226.8
2020	97.4	26.2	27.4	42.3	10.3	24.0	7.4	235.0
2021	101.1	27.3	28.3	43.8	10.6	24.8	7.7	243.6
2022	104.5	28.4	29.1	45.1	10.9	25.5	8.0	251.6
2023	107.6	29.4	29.8	46.3	11.2	26.1	8.2	258.6
2024	110.7	30.4	30.6	47.6	11.4	26.7	8.5	265.9
2025	114.0	31.4	31.3	48.9	11.7	27.4	8.7	273.4
2026	117.3	32.5	32.1	50.2	12.0	28.0	9.0	281.1
Average annual growth ($M)								
2015-2026	3.5	1.1	0.9	1.4	0.3	0.8	0.3	8.3
Average annual growth (%)								
2015-2026	3.7%	4.2%	3.2%	3.5%	3.2%	3.2%	3.7%	3.6%

**Constant 2014/15 dollars & including GST*
Source: MarketInfo; MacroPlan Dimasi

Retail expenditure category definitions:

- FLG: take-home food and groceries, as well as packaged liquor.
- Food catering: expenditure at cafes, take-away food outlets and restaurants.
- Apparel: clothing, footwear, fashion accessories and jewellery.
- Household goods: giftware, electrical, computers, furniture, homewares and hardware goods.
- Leisure: sporting goods, music, DVDs, computer games, books, newspapers & magazines, stationery and photography equipment.
- General retail: pharmaceutical goods, cosmetics, toys, florists, mobile phones and pets.
- Retail services: hair & beauty, optical goods, dry cleaning, key cutting and shoe repairs.

3.5 Fly-in-Fly-out population

As outlined previously, FIFO (Fly-in-Fly-out) workers generally account for a large proportion (at least 75%) of the workforce required during the construction phase of resource projects. That proportion typically decreases during the operational period, though it generally continues to be a significant share of the total workforce.

In general, FIFO workers reside in purpose-built temporary accommodation, with all basic needs, such as food or peripheral requirements such as work uniforms, provided on site by the mining company. As a result, the expenditure of FIFO workers is not generally directed to the retail facilities located within the mining town, other than in areas such as entertainment and some convenience retailing. In particular, it is not expected that FIFO workers would direct a sizeable proportion of their expenditure on homemaker/bulky goods to the available facilities.

However, the mining companies which employ these workers typically pay on behalf of the FIFO workers for the provision of their requirements. This amount of business therefore is additional to the business generated by the resident population, which has been detailed in the previous sub-section.

There are difficulties in estimating employment numbers by resource companies due to their variable nature and other confidentiality issues. At June 2014, there were an estimated 13,000 FIFO beds located in Karratha, which equates to 50% of the total resident population. The December 2010 *Karratha Regional Hotspots* report estimates that transient workers (including FIFO) account for a significant proportion of the local population, adding between 10% and 25% to the resident population, with FIFO workers estimated at around 4,000-6,000 in Karratha. Data from the 2011 Census of Population and Housing showed a difference of around 7,000 on Census night in the measured population of Roebourne Shire based on "usual residence" as compared with the population "enumerated", i.e. the number in the Shire on Census night.

The *2015 - 2025 WA Resources Sector Outlook* report, prepared by Deloitte Access Economics for the Chamber of Minerals and Energy of Western Australia (CMEWA) in November 2014, states that the workforce in the Pilbara is expected to decrease by 14,300 workers by 2020 from around 55,000 in 2014, comprising a reduction of 17,900 construction workers and increase of 3,600 operational workers. The contraction of the Pilbara workforce to 2020 is expected to be driven by a decrease in the FIFO workforce; however, the report also suggests that approximately 75% of the resources sector workforce in the Pilbara is expected to be on FIFO arrangements by 2020.

A report released in February 2013 from a parliamentary inquiry on FIFO, entitled "*Cancer of the Bush or salvation of our cities: Fly-in, fly-out and drive-in, drive-out workforce practises in Regional Australia*", has pointed towards a lack of "authoritative national data" available on the use of FIFO.

Despite this finding, the inquiry pointed towards various independently conducted studies by private groups which generally can be used to provide insight into the breadth and depth of FIFO workforces; though, with the more recent trends observed in the commodities sector, the findings in those studies may not materialise as "projected" and could be revised downwards. These studies include the following:

- A survey by the Australian Mines and Metals Association (AMMA) of their member companies, which highlighted the following:
  - 75% of respondents expected their FIFO workforce to grow over the next 2 years;
  - 51% expected growth in the next 5 years; and
  - 43% expected growth in the next 10 years.
- The CMEWA growth outlook report, which points towards an overall increase in the proportion of FIFO workers in the operations phase over the period to 2020.
- A number of submissions made to the inquiry also underlined the increasing need for FIFO due to the local skill shortages in the remote locations where mining operations are typically located.

The number of FIFO workers in Karratha, though expected to decline over the longer term based on the most recent studies, will still contribute to the retail market, but is not factored in as a key driver of demand for neighbourhood centre facilities as now proposed at Tambrey. It is the existing resident population, as detailed throughout this report, that creates the underlying need and demand for the new TNC, augmented by future resident population growth.

3.6 Retail floorspace demand

This sub-section of the report provides an analysis of the retail floorspace demand which would be generated by the trade area and broader region population, i.e. by considering the whole of the City of Karratha. The amount of retail floorspace that would be required, in all centre types and all forms of retail outlets, to properly serve the Tambrey trade area population can be estimated at various dates, based on the expected population and retail expenditure growth.

The estimated provision of retail floorspace per person throughout Australia at present is 2.2 – 2.4 sq.m. There are no official figures measuring retail floorspace on a national basis, with the Australian Bureau of Statistics having ceased the 5-yearly Retail Census in 1991/92.

However, having regard to data previously available from retail censuses, and also allowing for the estimated amounts of retail floorspace which have been built over the past 15 years, a figure in the range of 2.2 – 2.4 sq.m is a robust estimate.

A figure in this range is also borne out by information available for Perth, where the State Government Department of Planning oversees regular surveys of retail floorspace provision across the metropolitan area, and similarly for Canberra, where regular floorspace surveys are also undertaken by the Territory Government. Most recent results for Canberra show a level of provision which is in the order of 2.8 sq.m per person.

The level of retail floorspace provision has increased steadily over the past 50 years, since suburban shopping centres first started to be developed throughout Australia. The 1991/92 data from the Retail Census showed a level of provision nationally in the order of 1.7 sq.m per person. Over the past 20 years, this level of provision is estimated to have increased by around 1.5% annually.

The steady increase in retail floorspace per capita has reflected both supply and demand considerations. On the supply side, development trends within the retail industry have seen the introduction of new store types on an ongoing basis, to improve consumers' amenity and shopping experience, but also to differentiate stores from the competition. On the demand side, real incomes of Australian residents have improved steadily over the years due to the generally increasing economic wellbeing of the population, which have translated in their growing demands for an ever more diverse range of retail experiences. The extensive provision of bulky goods/homemaker floorspace (e.g. Joondalup Homemaker Centre or South Central in Perth), or the factory outlet space which is now readily apparent throughout most part of Australia (e.g. at Harbour Town at West Perth), simply did not exist a decade ago.

Table 3.5 following details the indicative amount of supportable retail floorspace that would be required to meet the growing needs of the resident population of the City and also allowing for FIFO requirements, as well as the projected future under/over supply of retail floorspace based on a constant retail floorspace per capita provision of 2.25 sq.m per person.

The bulk of the existing retail floorspace within the total trade area is currently provided at the Karratha City Centre, particularly at Karratha City SC, which totals an estimated 45,700 sq.m of floorspace. The remainder of the floorspace is provided at the smaller supermarket centres in the towns of Wickham and Dampier.

Adopting this approach, the total retail floorspace that would be needed to serve Karratha residents in 2018 would be over 64,000 sq.m. By 2026, the indicative supportable floorspace is projected to increase to around 77,000 sq.m.

Table 3.5
City of Karratha - resident retail floorspace demand, 2011 - Capacity
(Based on a constant average per capita floorspace requirement)

Area/Item	Year 2011	2015	2018	2021	2026	Capacity
Retail space per capita (sq.m)	2.25	2.25	2.25	2.25	2.25	2.25
Population (No.)	23,620	26,380	28,570	30,850	34,150	50,000
Total resident retail floorspace demand (sq.m)	**53,150**	**59,360**	**64,280**	**69,410**	**76,840**	**112,500**
FIFO requirements (at 10% of total)	5,906	6,596	7,142	7,712	8,538	12,500
Total retail floorspace demand (sq.m)	**59,056**	**65,956**	**71,422**	**77,122**	**85,378**	**125,000**
Total existing and proposed						
• Existing facilities	45,700	45,700	46,700	58,700	61,700	61,700
• Proposed facilities	0	1,000	12,000	3,000	0	0
- City Centre additions*		1,000	3,500	3,000		
- Tambrey N'hood Centre			8,500			
Total retail floorspace supply (sq.m)	**45,700**	**46,700**	**58,700**	**61,700**	**61,700**	**61,700**
Under (-)/Over (+) supply	**-13,356**	**-19,256**	**-12,722**	**-15,422**	**-23,678**	**-63,300**

**Assuming for some retail additions as part of the Karratha City of the North Revitalisation and other minor retail within residential buildings*
Source: MacroPlan Dimasi

The above floorspace analysis indicates that even after allowing for the retail floorspace proposed at the TNC (at 8,500 sq.m) and assuming some retail additions as part of the initiatives of the Karratha City of the North Revitalisation, there will still be a substantial undersupply of floorspace to serve the City of Karratha. Other local and neighbourhood centres are planned to be developed in the longer term (e.g. at Mulataga to the north-east), which will serve the future communities in their respective catchments. These centres will help to alleviate the floorspace undersupply, and will play localised roles, not competing with or being effectively substitutable for the TNC.

The retail floorspace demand and supply analysis also suggests that there is potential to increase the retail floorspace allocation of the TNC (which is currently at 8,500 sq.m) to adequately service the neighbouring growing communities in the future, and further alleviate the projected undersupply of retail floorspace. Any proposed increase in retail floorspace allocation would need to have regard to the resultant network of retail centres (which may also be expanded) to ensure consistent growth and viability of each centre.

Sensitivity analysis

The retail floorspace supply and demand analysis presented in this section assumes a sustained average annual growth rate of around 2.4% for the City of Karratha population. Even allowing for a lower population growth forecast, of say 1.5% per annum, there will be still a large amount of unmet demand for retail floorspace in the future, estimated to be in the order of 20,000 sq.m at 2026.

In summary, the level of undersupply of retail floorspace within the City of Karratha will continue to increase in the future with ongoing resident population growth. There is therefore ample scope for a neighbourhood centre to be developed at the Tambrey site, particularly as the need and demand for that centre is effectively in place now.

Section 4: Competition

This section of the report considers the competitive environment within which the proposed Tambrey Neighbourhood Centre (TNC) will operate. Table 4.1 summarises the competitive facilities in the region, while the previous Maps 3.1 and 3.2 illustrate their locations.

Table 4.1
Tambrey N'hood Centre - schedule of competing retail facilities

Centre	Retail GLA (sq.m)	Major traders	Dist. by road from Tambrey N'hood Centre (km)
Karratha	**41,000**		4.5
• Karratha City SC	22,300	Kmart (6,000), Woolworths (4,160), Coles (4,220)	
• Other City Centre	18,700		
Wickham	2,600	Woolworths (1,900)	50
Dampier	2,100	IGA Xpress (200)	16.5
Hedland			230
• South Hedland Square	15,000	Kmart (6,520), Coles (4,700)	
• Port Hedland Bld	6,400	Woolworths (3,700)	

Source: Karratha Retail and Commercial Strategy (SGS, 2009); Property Council of Australia; MacroPlan Dimasi

4.1 Karratha City Centre

The town of Karratha is destined to remain the predominant regional centre serving the surrounding population, including the towns of Dampier, Wickham, Roebourne and Point Samson. Within Karratha itself, the Karratha City Centre contains the major concentration of retail facilities, catering for both the food and non-food shopping needs of its broad catchment. The TNC is expected to play a supporting role to the City Centre, serving the food and convenience needs of its local catchment, with the higher-order retail needs of residents still directed to the City Centre.

The Karratha City Centre is the main focus for retail, commercial, administrative and other community purposes in Karratha and for the broader Pilbara region. The City Centre is generally focused on both sides of Sharpe Avenue, with Karratha City SC located on its eastern side and strip retailing provided on the western side.

Karratha City SC is the main fully enclosed shopping centre for Karratha residents and is anchored by a Kmart discount department store and a Target Country, as well as Coles and Woolworths supermarkets. The centre also has an extensive mix of specialty traders, with a large number of national tenants, including the following:

- Bakers Delight
- Betts Shoes
- Commonwealth Bank
- Crossroads
- EB Games
- ED Harry
- Jamaica Blue
- Jays Jays
- Jeans West
- Just Jeans
- Muffin Break
- OPSM
- Price Attack
- Prouds
- Red Dot Store
- Retravision
- Sanity
- Smokemart
- Subway
- Telstra Shop
- Wendy's

Karratha City SC anchors the Karratha City Centre and serves the major food and non-food retail needs of Karratha residents.

The remainder of the City Centre, which is generally located within the precinct bounded by Sharpe Avenue, Warambie Road, Searipple Road and Welcome Road contains other peripheral retail and service facilities. These facilities complement the strong retail role of Karratha City SC in the region.

In addition, a number of other major uses, incorporating commercial, administrative and accommodation facilities are provided in the City Centre, including the following:

- Residential towers at the northern end of Sharpe Avenue – Pelago West and Pelago East.
- Transient accommodation facilities (Warambie Estate) to the north of the Pelago developments.

- A street-based retail plus peripheral retail development (Karratha Village) situated on the western side of Sharpe Avenue. Some of the tenants in this precinct include:
  - Department of Commerce Office Government of WA
  - Horizon Power
  - Karratha Florist
  - North West Accountants Pty Ltd
  - REFAP (Real Employment For Aboriginal People)
  - The Mortgage Gallery
  - A dental clinic
  - A physiotherapy centre
  - HB Hair
  - Just You day spa/beauty salon
  - Land Surveys Pty Ltd
  - Ray White
  - Spectacles 241
  - Westpac Bank
  - A medical clinic – Sonic HealthPlus
- The Karratha Business Centre located to the west of Karratha City SC, on the western side of Sharpe Avenue, incorporating a number of banking and commercial facilities.
- An essentially commercial precinct located to the east of Karratha City SC, and generally bounded by Welcome Road to the south and Searipple Road to the east. This precinct contains a series of buildings, with tenants including:
  - National Australia Bank
  - Bank West
  - ANZ Bank
  - Department of Transport
  - Department of Child Protection
  - Dentist- Pilbara Dental Care
  - Various employment agencies
  - The office of Pilbara Echo
  - The Pilbara District Office of the Department of Agriculture and Food
  - Program Integrated Workforce
  - Department of Housing
  - Department of Education and Training
  - Tax agents - ITP
  - Tax accountants
  - Real estate agencies

The City Centre has also undergone major civil works to upgrade and revitalise the current infrastructure, delivering:

- A more functional city centre that is easy to get around for vehicles and pedestrians;
- A better road layout that is legible and easily navigable;
- Extensive landscaping with shrubs and trees lining the streets;
- Shaded areas, through a combination of shades structures and street trees;
- Paved verges with high quality finishes including bridge balustrade over drainage crossings; and
- Attractive street furniture including benches, bike racks, bins, bollards and signage.

In particular, the realignment and reconstruction of Sharpe Avenue, with its extension through to Warambie Estate to the north and Dampier Road to the south, creating a convenient north-south thoroughfare through the City Centre has now been completed. A new east-west link (Karratha Terrace) to the north of Karratha City SC, together with other realignments and reconstructions, have significantly simplified vehicular accessibility to and within the City Centre.

Construction is also underway on a new commercial and retail building (The Quarter), located on the corner of Warambie Road and Sharpe Avenue. Stage 1 of the development will include a four-storey retail and commercial building, a decked car park, a new public square and 46 service worker apartments, which will benefit the local community with the delivery of a new and modern social hub for the City. A future stage is envisaged to include a proposed hotel and a second commercial building.

The Karratha City Centre, therefore, will clearly remain the predominant destination for retail and other commercial uses for Karratha and broader region residents as well as recreation. The infrastructure works currently underway or proposed will help in transforming Karratha into a genuine regional city, in line with the vision in the City of the North plan.

The TNC will be located to the west of the City Centre and will be able to conveniently serve the residential areas at the western end of Karratha. The TNC will play a supporting role to the retail facilities within the Karratha City Centre, which will remain the main destination for both residents' and FIFO workers' retail expenditure.

Initial civil works are also underway for a new bulky goods centre (Gap Ridge Homemaker Centre), to be developed a short distance west of the TNC site. This development however would serve a different role in the retail environment of Karratha, with limited competitive bearing on either the proposed TNC or the City Centre.

4.2 Beyond Karratha

Beyond Karratha, the other major town in the region is Hedland, located some 240 km to the east, incorporating the urban areas of Port Hedland and South Hedland. South Hedland Square is the second largest centre (behind Karratha City SC) serving the regional population base. It is anchored by a Kmart discount department store and a Coles supermarket, together with around 25-30 specialty shops.

The main shopping centre in Port Hedland is Port Hedland Boulevard SC, which is anchored by a Woolworths supermarket and a Harvey Norman store.

Section 5: Economic and social impacts and benefits

This section of the report considers the sales potential for the proposed Tambrey Neighbourhood Centre (TNC), as well as the likely economic impacts that can be anticipated following the development of the centre.

The sales performance of any particular retail facility – be it an individual store or a collection of stores provided in a shopping centre – is determined by a combination of the following factors:

- The quality of the facility, with particular regard to the major trader/traders which anchor the centre; the strength of the tenancy mix relative to the needs of the catchment which it seeks to serve; the physical layout and ease of use; the level of accessibility and ease of parking; and the atmosphere/ambience of the centre.
- The size of the available catchment which the centre/store serves determines the upper limit to the likely sales potential achievable by any centre or store.
- The locations and strengths of competitive retail facilities and the degree to which these alternative facilities are able to effectively serve the needs of the population within the relevant trade area.

The likely sales potential for the proposed development of the TNC is now considered, taking all of these factors into account.

5.1 Projected centre sales and market shares

Prior to being able to consider the question of potential economic benefits and impacts that will arise from the development of the TNC, the necessary first step is to quantify the likely level of sales which the centre can reasonably expect to achieve. The development is expected to commence around 2015-16, with the first full year of trading for the centre assumed to be 2017/18. All sales forecasts in this report are presented in constant 2014/15 dollars (i.e. excluding inflation) and including GST.

Table 5.1 following details the projected market shares likely to be achieved by the TNC from each trade area sector in 2017/18. Market shares are calculated as a result of the following steps:

i. The total sales of each component of the centre (major stores, mini-majors and specialty stores) are split into food and non-food sales, taking account of the typical sales distribution for each retailer type.

ii. The total sales that are generated by the centre from each trade area sector are then estimated, taking into account the likely shopping patterns of trade area residents.

iii. The total available retail expenditure within each trade area sector is calculated, based on the MarketInfo estimates.

iv. The market shares achieved by the centre, of both food and non-food expenditure in each trade area sector, are then calculated by dividing ii. above by iii.

Following the development of the TNC which is expected to contain a supermarket and a range of specialty traders, the centre is projected to achieve estimated market shares of total retail spending across the trade area of 25.8% from the primary sector, and 2.4% across the combined other sectors.

Table 5.1
Tambrey N'hood Centre - Estimated market shares, 2017/18*

	Retail spend ($M)			Centre sales ($M)			Market share		
Trade area	Food	Non-food	Total	Food	Non-food	Total	Food	Non-food	Total
Primary	114.1	103.8	217.8	45.5	10.7	56.2	39.9%	10.3%	25.8%
Other sectors									
• Karratha City Centre	76.1	63.3	139.4	2.0	0.5	2.5	2.7%	0.8%	1.8%
• Outer	57.9	45.4	103.3	2.7	0.6	3.4	4.7%	1.4%	3.3%
Total other	133.9	108.8	242.7	4.8	1.1	5.9	3.6%	1.0%	2.4%
Total TA	**248.0**	**212.5**	**460.5**	**50.3**	**11.8**	**62.1**	**20.3%**	**5.5%**	**13.5%**
Sales from beyond TA				5.6	1.3	6.9			
Total centre sales				**55.9**	**13.1**	**69.0**			

**Constant 2014/15 dollars & including GST*
Source: MarketInfo; MacroPlan Dimasi

The sales projections for the centre are based on the sales projections undertaken for the majors, including for the new supermarket, the new mini-major tenants, with the specialty sales forecasts then taking into account the majors performance. The projections also take into account an indicative tenancy mix, as currently proposed for the centre.

The TNC's market share of available retail expenditure from the trade area is forecast at 13.5% of available trade area retail expenditure. In other words, around 87% of available trade area retail expenditure would still be directed to all other retail facilities, and in particular to the Karratha City Centre.

With regards to non-food spending, the forecast trade area market share for the TNC would be 5.5%. The bulk of regional non-food retail expenditure would therefore be available to be directed to all other retail facilities, and in particular to the Karratha City Centre which would be expected to attract a much higher market share of non-food retail expenditure than the TNC.

Table 5.2 details the potential sales for the TNC in 2017/18, by broad tenancy type. The sales projections are based on an indicative tenancy mix for the centre and reflect the market shares outlined in Table 5.1. The projected sales estimates also take into account sales by similar retailers in comparable centres, as well as average sales levels achieved by each category of tenant in single supermarket based centres throughout Australia. Total retail sales at the centre are projected at $69 million, including $41.3 million in supermarket sales and $22.9 million in retail specialty sales, reflecting an average productivity level of $7,230 per sq.m for the retail specialty space.

Table 5.2
Tambrey N'hood Centre - Centre sales potential by retail category, 2017/18*

Category	Tambrey N'hood Centre		
	GLA	Est. sales	
	(sq.m)	($'000)	($/sq.m)
Major tenants			
Supermarket	3,800	41,316	10,873
Total majors	3,800	41,316	10,873
Mini-majors	1,540	4,838	3,141
Retail specialties			
Food & liquor	1,080	9,903	9,170
Food catering	1,130	6,908	6,113
Apparel	0	0	0
Household	0	0	0
Leisure	250	1,362	5,448
General	600	4,249	7,082
Retail services	100	437	4,366
Total retail spec.	3,160	22,859	7,234
Total centre - retail	**8,500**	**69,012**	**8,119**

**Constant 2014/15 dollars & including GST*
Source: MacroPlan Dimasi

5.2 Assessment of likely economic impacts

The proposed development of the TNC is likely to result in a range of economic impacts. From a trading point of view, some impacts are likely to be experienced by competitive retailers throughout the trade area, and these impacts are quantified later in Section 5.3.

At the same time however, the development of the TNC will also result in a range of economic benefits. The key positive impacts for the development will include the following:

i. Improved shopping choice, convenience and amenity

The TNC development will provide a convenient food, grocery and convenience shopping destination for surrounding residents. The centre will be anchored by a full-scale supermarket and a range of supporting specialty shops.

The new neighbourhood centre will be conveniently located in the rapidly growing and underserviced western Karratha area. It will therefore greatly improve amenity for local area residents, with shopping and service facilities being provided in an accessible location within the local area. The quality of life of western Karratha residents will be improved as a result.

The provision of facilities such as the TNC is an important step towards enabling the growth of Karratha that is envisaged under both the Shire of Roebourne Town Planning Scheme and the Karratha City of the North Plan.

ii. Employment creation

The TNC will create a sizeable number of additional jobs in the region, both for the construction and related industries during the construction phase, and for the economy generally once the centre is completed.

Table 5.3 presents our estimates of the number of additional employment opportunities likely to be created by the development of the TNC.

Based on the amount and nature of the floorspace to be incorporated in the proposed development, we estimate that some 380 jobs will be accommodated at the centre. It

may be argued that some job losses will occur at other centres as a result of the TNC. In determining the employment opportunities therefore, we have allowed for 5% of the additional employment that is likely to be created by the TNC to be absorbed in job losses at other impacted centres, thus resulting in a projected net employment increase of 360 jobs.

Table 5.3
Tambrey N'hood Centre - estimated centre employment levels

Type of use	Estimated employment per '000 sq.m	Tambrey N'hood Centre GLA (sq.m)	Tambrey N'hood Centre Employment (persons)
Supermarket	40	3,800	152
Mini-majors	25	1,540	39
Specialty shops	60	3,160	190
Total centre[1]		**8,500**	**380**
Net increase[2]			**361**

1. Excludes non-retail components
2. Net increase includes an allowance for reduced employment levels at impacted centres, estimated at 5% of the total increase
Source: MacroPlan Dimasi

Table 5.4 then utilises the estimated net level of job creation at the TNC as a result of the development, together with ABS input/output multipliers, to calculate the likely total employment stimulus that can be attributed to the centre. The capital costs for the development are estimated at $45 million.

Utilising appropriate ABS input/output multipliers, we estimate that for the construction phase of TNC, some 192 direct jobs and a further 308 multiplier induced jobs will be created, which includes both full-time and part-time work. Again applying the ABS input/output multipliers, the additional 360 jobs created by centre employment will create an estimated 144 further jobs in the broader economy.

Thus, the development of the TNC will create a substantial stimulus to employment throughout the surrounding region.

Table 5.4

Tambrey N'hood Centre - estimated future additional employment levels*

Original stimulus	Direct employment (long-term)	Direct employment (const'n period)	Supplier employment multiplier effects	Total	
Centre employment[1]	361		144	506	
Construction of project ($45m. est. capital costs)		192	308	500	Job years[2]
Total	**361**	**192**	**452**	**1,006**	

** Employment totals include both full-time and part-time work*
1. Indicates the estimated number of net additional ongoing jobs as a result of the proposed development
2. Indicates the estimated number of jobs over the life of the construction project, for the equivalent of one year
Source: MacroPlan Dimasi

5.3 Broad trading impacts at 2017/18

A number of factors need to be taken into account in the consideration of the likely broad trading impacts of the proposed development of the TNC on other retail facilities, both within and beyond the trade area.

Such projections must be considered as indicative only, for the simple reason that it is very difficult to predict with certainty the precise impact on any one retailer or any one centre that will result from a change to the retail structure serving a particular area or region. The impacted centre or retailer has a number of possible actions which it may be able to take for example, which may mitigate the extent of impact, or may eliminate it altogether. Expansions and improvements may be undertaken at other centres and other locations throughout the region, and all of those factors can change the nature of the impact.

It is reasonable for the purposes of impact analysis to therefore consider the likely broad changes in competitive circumstances, and in particular the changes in availability of retail expenditure for competitive centres that can reasonably be expected to result from the development such as now proposed for the TNC.

These broad changes effectively set the market conditions within which all competitive centres will operate as a result of the proposed TNC development, and reasonable conclusions can then be drawn about the possible impacts and subsequent consequences of these broad changes in market conditions.

Table 5.5 presents a summary of the growth in the retail spending generated by the trade area population, together with projected sales for the TNC, as well as for retailers throughout the trade area. All figures are expressed in constant 2014/15 dollars and include GST.

Part 1 of the table summarises the forecast growth in the Tambrey trade area retail spending, indicating an increase in real terms from $414 million in 2014/15 to $461 million in 2017/18 and $513 million in 2020/21. In 2014/15, trade area retailers are projected to achieve sales of $428 million, with an estimated $14 million of net additional expenditure being captured by trade area retailers (in part generated by the FIFO population).

Part 2 then details the projected sales for trade area retailers at 2017/18, assuming the development of the TNC proceeds. Sales for the TNC are projected at $69 million in 2017/18. Total retail sales for other retailers within Karratha are forecast at $374 million at 2017/18, while other trade area retailers (outside Karratha) are projected to achieve total retail sales of $43 million. Overall, retailers within the trade area are estimated to achieve sales of $428 million in 2014/15, increasing to $486 million in 2017/18 and $540 million in 2020/21.

While retailers within Karratha are expected to be impacted by the TNC, with a net sales drop of $10.5 million in 2017/18 compared with 2014/15, those retailers are estimated to achieve sales of $417 million in 2020/21, which is a $33 million increase on the estimated sales in 2014/15. This analysis shows that while existing Karratha City Centre retailers are expected to be impacted to a degree by the TNC, they are still expected to experience solid growth in sales potential over the next 6 years (three years post development of the TNC).

Part 3 of the table calculates the likely sales for trade area retailers assuming that the TNC is not developed. Under this scenario, 2017/18 sales for Karratha retailers and other trade area retailers are projected at $422 million and $46 million respectively.

Part 4 finally details the estimated average trading impact of the proposed development of the TNC on all other retailers in the trade area. As compared with the scenario where the TNC is not developed, it is estimated that the other retail facilities in Karratha would be impacted by around $48 million in 2017/18, estimated to be around 11.4% of their combined sales volume at that date. Other trade area retailers are estimated to experience a smaller impact of around $2.9 million.

The trading impact on other retailers within Karratha from the development of the TNC would result from a redirection of primarily food and grocery expenditure and some convenience shopping as well as cafe/restaurant and take-away food expenditure, to the new centre for Tambrey residents; while almost all non-food spending will still be directed to the Karratha City Centre. The average trading impacts would therefore be noticeable, but not dramatic and would not threaten the viability of other retail facilities in the City Centre.

Retailers within the City Centre would be expected to recover quickly from their impacted levels after an initial period of adjustment, given the strong growth outlook in the region combined with the undersupply of retail floorspace in the region.

Table 5.5
Tambrey N'hood Centre - trading impact assessment, 2015-2021*

	2014/15	2017/18	2020/21	Change (2015-18)		Change (2015-21)	
	$M	$M	$M	$M	%	$M	%
Part 1 : Estimated retail spending market (with Tambrey N'hood Centre development)							
TA expenditure	414.2	460.5	513.4	46.3	11.2%	99.2	23.9%
Net captured expenditure	13.7	25.4	26.5	11.7	86.0%	12.9	94.2%
Est. retail sales to TA retailers	427.9	485.9	539.9	58.1	13.6%	112.0	26.2%
Part 2 : Calculation of MTA retail sales (with Tambrey N'hood Centre development)							
Tambrey N'hood Centre	0.0	69.0	77.2	69.0	n.a	77.2	n.a
Karratha CC Retailers	384.3	373.7	417.1	-10.5	-2.7%	32.8	8.5%
Other trade area retailers	43.6	43.2	45.7	-0.4	-0.9%	2.1	4.8%
Est. retail sales to TA retailers	427.9	485.9	539.9	58.1	13.6%	112.0	26.2%
Part 3 : Calculation of MTA retail sales (without Tambrey N'hood Centre development)							
Karratha CC Retailers	384.3	422.0		37.7	9.8%		
Other trade area retailers	43.6	46.1		2.5	5.7%		
Est. retail sales to TA retailers	427.9	468.1		40.2	9.4%		
Part 4 : Est. sales impact from Tambrey N'hood Centre development, 2017/18							
Karratha CC Retailers				-48.3	-11.4%		
Other trade area retailers				-2.9	-6.3%		
Total				-51.2	-10.9%		

**Constant 2014/15 dollars & including GST*
Source: MacroPlan Dimasi

5.4 Non-retail uses at Tambrey Neighbourhood Centre

While retail will be the main use at the TNC, the centre is also proposed to incorporate other uses, including primarily a mix of residential uses, as well as small amounts of other potential ancillary uses. The implications of providing those facilities at Tambrey, including any impacts on the Karratha City Centre, are discussed below.

Residential/short-stay accommodation

The Draft Development Plan for the TNC proposes to include around 166 dwellings, including medium to higher density, and other apartments and short-stay accommodation facilities.

Demand for residential lots in Karratha has softened in recent years, with employment opportunities in the area in decline as the mining industry moves from the construction phase to the operational phase. However, against the backdrop of the *Karratha City of the North Plan*, discussed previously in this report, a relatively small amount of additional residential development which will form part of the TNC will have a positive net economic benefit for Karratha. The residential component of the TNC will be well integrated into the development, which also offers a neighbourhood centre, commercial uses and other related ancillary uses. In part, the residential component will help to provide activation at the centre, helping to create a vibrant community hub for the locality.

The retail and residential uses will occupy the bulk of the TNC site, with small amounts of other ancillary uses to include some commercial floorspace, health and medical uses, entertainment and a potential childcare centre. These ancillary uses are discussed further below.

Commercial uses

The TNC is proposed to incorporate around 1,300 sq.m of commercial/office floorspace. This floorspace will be provided subject to market demand.

The amount of commercial space proposed at the TNC is therefore minor, representing only about 4% of the existing commercial floorspace in Karratha, which is estimated to be in the order of 30,000 sq.m. Furthermore, the implementation of the *Karratha City of the North Plan* will provide future redevelopment sites which are expected to increase significantly the amount of commercial floorspace provided within the Karratha City Centre. The commercial component at Tambrey, therefore, will not have any impact on the City Centre as the main administrative centre.

Childcare centre

At Census 2011, the number of infant children aged 0-4 years old was estimated at some 1,060 in the primary sector, or close to 11% of the total resident population at that date. This indicates significant need and scope for childcare facilities to locate within the primary sector in order to service the young households in the region.

In addition to the number of infant children within the primary trade area at 2011, the strong population growth within the area, which between 2006 and 2011 averaged 3.7% annually, and is projected to continue at rates of around 2.5% annually, is likely to see the number of infant children within the primary trade area increase strongly, particularly with the vision for Karratha to become a city for families to live and work.

The proposed childcare centre at Tambrey will be centrally located within, and will be able to be conveniently accessed from, the existing and growing residential areas of western Karratha. The childcare facility will support the convenience role of the TNC and therefore will not detract in any way from the primacy of the Karratha City Centre.

Map 5.1 attached shows the locations of childcare centres throughout the Karratha urban area.

Map 5.1: Tambrey Neighbourhood Centre

Medical centres and childcare facilities

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Health and medical uses

Other uses which are proposed at the TNC include health and medical uses, such as a medical centre, a dental clinic and a veterinary facility. These ancillary health facilities will provide a convenient and closer-to-home destination for the surrounding community for their health requirements, complementing the existing facilities in the Karratha City Centre.

Map 5.1 previously also shows the locations of the various medical centres currently provided within Karratha, highlighting the following:

- The existing medical centre facilities provided in Karratha are all situated within the central area, generally within or near the Karratha City Centre.
- There are no facilities at present provided within western Karratha, even though this is the growth area of the Karratha urban area.
- As noted previously in this report, within western Karratha there is already a large number of infant children, and that number is growing expected to increase.

  There is therefore a clearly evident need for convenient medical facilities to be provided as part of the TNC.
- The provision of such medical facilities will not detract in any way from the successful function and continued growth of the Karratha City Centre, which is well provided with a range of medical facilities.

In summary, the other proposed uses at the TNC, including residential, commercial and ancillary, will help to reinforce the convenience role of the centre and will not detract from the primacy of the City Centre.

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APPENDIX H

CAR PARKING TABLE

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TENANCY NO. ADDRESS	USE AS PER SCHEME	CAR PARKING RATE	DAY TIME <6PM DEMAND (50% for off peak uses – restaurants, tavern etc)	EVENING >6PM DEMAND (50% for off peak uses – shops, offices etc)

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