Town of
Port Hedland

Town of Port Hedland
Town Planning Scheme No. 5
(District Scheme)

Amendment No. 84

Reclassifying Crown Reserve 31506 and portion of Reserve 29044 Styles Road, Port Hedland and Johnson Lane (road reserve) from 'Other Public Purposes: Energy' and 'Parks and Recreation' to 'Urban Development' and rezoning Crown Reserve 30768, Crown Reserve 31462 and portion of Johnson Lane and portion of Reserve 30768 and portion of Unallocated Crown Land Lot 340 Styles Road, Port Hedland from 'Rural' to 'Urban Development'

FORM 2A

Planning and Development Act 2005

RESOLUTION TO ADOPT AMENDMENT TO LOCAL PLANNING SCHEME

Town of Port Hedland

Town Planning Scheme No. 5

Amendment No. 84

Resolved that the Local Government pursuant to section 75 of the *Planning and Development Act 2005*, amend the above Local Planning Scheme by:

1. Reclassifying Crown Reserve 31506 (Lot 5755) and portion of Reserve 29044 (Lot 300) Styles Road, Port Hedland and Johnson Lane (road reserve) from 'Other Public Purposes: Energy' and 'Parks and Recreation' to 'Urban Development'.
2. Rezoning Crown Reserve 30768 (Lot 5966), Crown Reserve 31462 (Lot 5770) and portion of Johnson Lane and portion of Reserve 30768 (Lot 556) and portion of Unallocated Crown Land Lot 340 Styles Road, Port Hedland from 'Rural' to 'Urban Development'.
3. Amending the Scheme Maps accordingly.
4. Amending Appendix 10 – Urban Development Additional Development Requirements as shown below:

No.	Description of Land	Conditions
Pretty Pool ~~2~~	~~Lots 1732, 1444 and Part Lot 552 Athol Street~~ Land bound by Gray Street, Wilson Street, Cooke Point Road, Athol Street and the Indian Ocean, excluding Pretty Pool Creek 1 Development Area	Subdivision and development of the land shall be in accordance with the requirements of Structure Plan(s) endorsed by the Western Australian Planning Commission, which shall address the following requirements: 1. Land identified in the Structure Plan(s) will be restricted to a built height limit that prevents light spill onto Cemetery Beach and Pretty Pool Beach and adjacent area. 2. The finished development level of all habitable use shall be a minimum of 6.7 metres Australian Height Datum. 3. Adequate coastal erosion and flood inundation protection and management measures approved by the Town of Port Hedland to comply with the Town of Port Hedland adopted Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) and provisions of the State Planning Policy No. 2.6 'State Coastal Planning Policy'. 4. Environmental Management Plans addressing the following shall be prepared, adopted and implemented to the satisfaction of the Town of Port Hedland on advice from the relevant State Government agency: a) Construction management b) Foreshore Management c) Mangrove Management

		d) Drainage and nutrient management e) Marine turtle management f) Acid Sulfate Soil management (if required) g) Other management plans as considered necessary on the advice from the relevant State Government agency.

The amendment is Standard under the provisions of the *Planning and Development (Local Planning Schemes) Regulations 2015* for the following reason(s):

- Amendment is consistent with the objectives of the Town of Port Hedland Pilbara's Port City Growth Plan and Town of Port Hedland Draft Local Planning Strategy; and
- Amendment will have minimal impact on land in the scheme area and it will not result in any significant environmental, social, economic or governance impacts on land in the scheme area.

Dated this ______________________ day of ____ 2020

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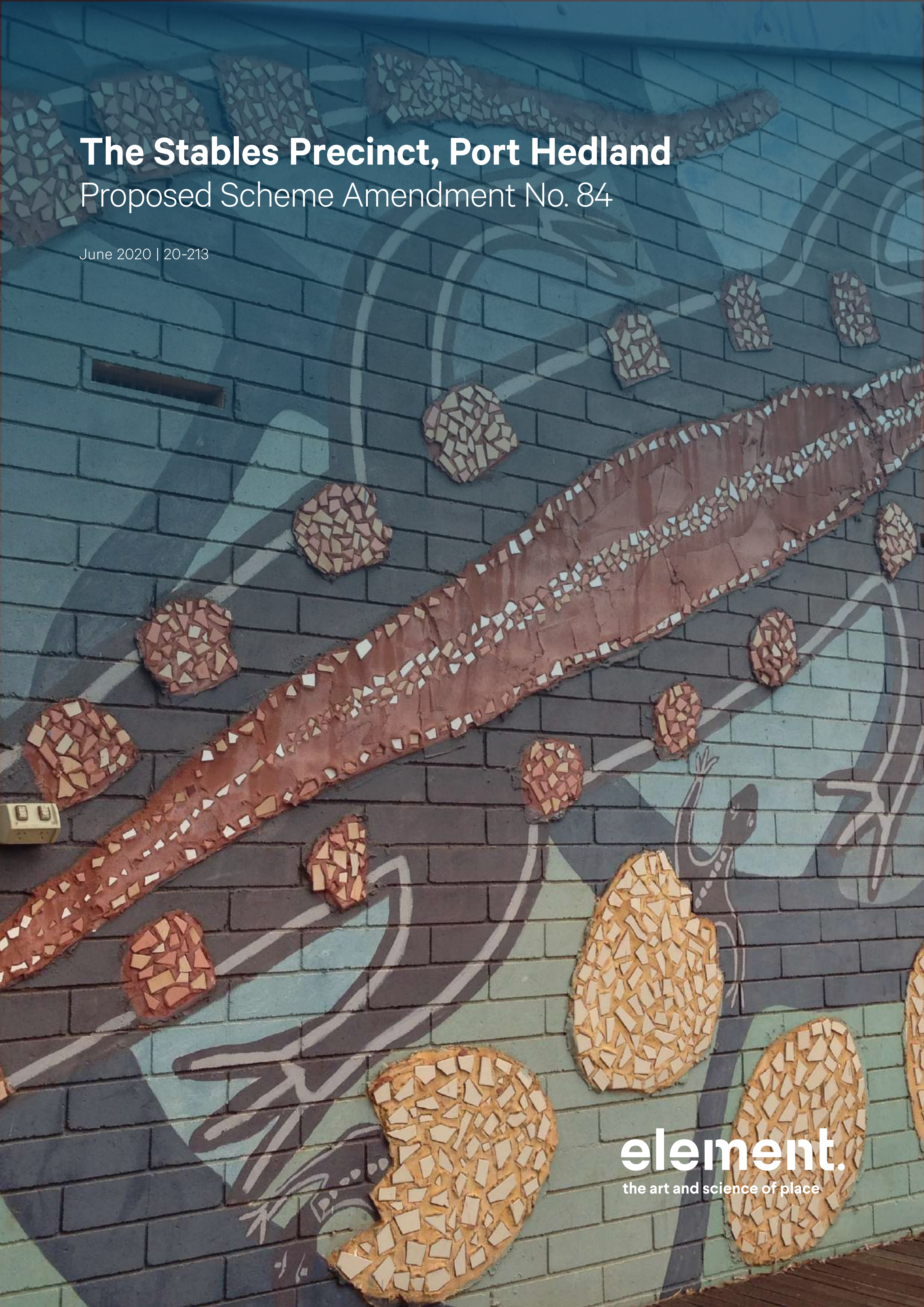
(Chief Executive Officer)



The Stables Precinct, Port Hedland

Proposed Scheme Amendment No. 84

June 2020 | 20-213

element.
the art and science of place

We would like to acknowledge the Kariyarra, Ngarla, and Nyamal people as the Traditional Custodians of the Town of Port Hedland lands. We recognise their strength and resilience and pay our respects to their Elders past and present.

Document ID: /Volumes/Graphics/2020/20-213 Port Hedland, Stables Structure Plan and Scheme Amendment/20-213 The Stables Scheme Amendment 84 Folder/20-213 The Stables Scheme Amendment 84.indd

Issue	Date	Status	Prepared by	Approved by
1	28.05.20	Draft	Justin Page	Matt Raymond
2	12.06.20	Draft	Justin Page	Matt Raymond

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Contents

1. Introduction

This report has been prepared by **element**, on behalf of DevelopmentWA, to request an amendment to the Town of Port Hedland Town Planning Scheme No. 5 (TPS5) as it relates to a portion of land in the 'East End' of Port Hedland that is generally bound by Pretty Pool Creek to the north, the Pretty Pool residential area to the east, Styles Road to the south, and Cooke Point Road to the west (the subject site). Specifically, the proposed scheme amendment seeks to reclassify and rezone the subject land (also known as 'the Stables') by:

1. Reclassifying Crown Reserve 31506 (Lot 5755) and portion of Reserve 29044 (Lot 300) Styles Road, Port Hedland and Johnson Lane (road reserve) from 'Other Public Purposes: Energy' and 'Parks and Recreation' local reservations to 'Urban Development' zone.
2. Rezoning Crown Reserve 30768 (Lot 5966), Crown Reserve 31462 (Lot 5770) and portion of Johnson Lane and portion of Reserve 30768 (Lot 556) and portion of Unallocated Crown Land Lot 340 Styles Road, Port Hedland from 'Rural' zone to 'Urban Development' zone.
3. Modify Appendix 10 – 'Urban Development Additional Development Requirements' of TPS5 to reflect the proposed 'Urban Development' zoning over the subject site, introduce appropriate development controls and incorporate the land into the existing 'Pretty Pool 2' precinct.

The reclassification/rezoning to 'Urban Development' will facilitate future subdivision and development in accordance with an endorsed structure plan.

The proposed Amendment seeks to facilitate the redevelopment of the subject site for primarily residential purposes, in accordance with the strategic direction for the area under the Town of Port Hedland's Port City Growth Strategy. Development would be guided by an approved structure plan which would plan to take into consideration environmental and cultural values of the Stables site and the natural environmental and amenity of Pretty Pool Creek.

The proposed Amendment is the first step in the statutory planning redevelopment process. No subdivision or development will be contemImaged until a structure plan is prepared and approved by the Western Australian Planning Commission.

This Amendment is proposed concurrent with a proposed structure plan, so that the two proposed planning instruments can be considered in parallel. This will ensure that the more comprehensive design and investigations undertaken at structure planning level can and will inform the final 'Urban Development' zone boundaries of the Amendment.

This report provides an overview of the subject site and the proposed Amendment, along with an analysis of the relevant planning considerations. This report is also accompanied by a number of detailed technical reports as appendices. These reports address the various environmental, geotechnical, engineering and heritage matters that are relevant to future development on the subject site.

1.1 Project Background

The growth of Port Hedland since the 1960's has largely been driven by the iron ore industry. Today Port Hedland is the largest bulk export port in the world for iron ore, with an export output of 247 million tonnes during 2012 and 513 million tonnes in 2019. Future export volume is forecast by the Port Hedland Industries Council to be 700 million tonnes by 2027. As a result of a significant increase in port operations and export movements in the last decade, concerns have been raised as to the public health risk of iron ore dust in the West End of Port Hedland.

The WA Department of Health undertook investigations into the issue of dust in West End and published the report *Port Hedland Air Quality Health Risk Assessment for Particulate Matter* (February 2016). The report concluded that there is sufficient evidence suggesting the possible negative effects on human health from dust in West End. The Department recommended improved dust management, monitoring controls and land use planning measures to reduce community exposure to dust.

In October 2018 the WA State Government adopted a whole of government approach to dealing with the management of dust in Port Hedland. This includes a proposed Improvement Plan and Scheme (IP50) that seeks to reduce the number of residential land use in the West End of Port Hedland.

As part of the Town of Port Hedland Draft Local Planning Strategy, future residential growth areas have been identified in the east-end of Port Hedland that fall outside of IP50. The Stables site is one of those identified areas for potential future residential development.

This Amendment follows the previous Scheme Amendment No. 77 for the same land, which also proposed to rezone the site to 'Urban Development'. Amendment No. 77 was refused by the Minster for Planning in May 2017, primarily on the basis of an inconsistency with State Planning Policy 2.6 – State Coastal Planning Policy (SPP2.6). That inconsistency was the Town of Port Hedland had not (at that time) completed a Coastal Hazard Risk Mapping and Adaption Plan (CHRMAP). A CHRMAP informs the viability (including any adaptation measures) for locating future residential areas in the context of coastal processes and flood inundation, arising from climate change and forecast sea level rise.

In April 2019 the Town of Port Hedland adopted a CHRMAP for Port Hedland that identifies and assesses coast hazard risks, culminating in a recommended adaptation pathway to address the identified short-term and long-term risks to the area. The findings of the adopted CHRMAP provide a framework to guide future development of the Port Hedland town site. The CHRMAP informs proposed finished development levels and mitigation measures and strategies that will be necessary for development on land which is subject to coastal and tidal impacts.

The Town's adopted CHRMAP and subsequent technical erosion and flood modelling undertaken for the site supports the development of the Stables site for residential use.

Thus this Amendment follows on from the previous Amendment No. 77 as a new proposal. The Amendment report provides the planning context and rationale to support the Stables site as a potential area for future urban development.

The proposed urban development zone will provide the TPS5 statutory framework for the preparation and approval of a structure plan. The structure plan will determine future land uses and design layout and planning, environmental and heritage outcomes. These will inform the planning decision making for future subdivision and development approvals for the Stables site.

2. Subject Site

2.1 Site Description

2.1.1 Site Location

The subject site comprises a portion of land in the Port Hedland that is generally bound by Pretty Pool Creek to the north, the Pretty Pool residential area to the east, Styles Road to the south, and Cooke Point Road to the west.

The Stables site is located approximately 5.5 kilometres east of the Port Hedland Town Centre, in the East End of Port Hedland.

Refer to Figure 1 – Location Plan

2.1.2 Site Tenure

The subject site comprises a number of Crown Land parcels, totalling 27.16 hectares. This includes both Unallocated Crown Land and Crown Reserves vested in the Town and the Regional Power Corporation (Horizon Power).

Refer to Figure 2 – Aerial and Cadastral Plan

A detailed description of the land in the subject site is provided in Table 1.

Table 1 – Land Description

Lot	Survey	Crown Reserve	Management Order
Pt 300	P53035	R29044 for 'Caravan Park and Equestrian Activities'	Town of Port Hedland
Pt 340	P72895	Vacant Crown Land	N/A.
Pt 556	P74214	R30768 for 'Recreation'	Town of Port Hedland
5755	P216870	R31506 for 'Electricity Sub Station and Weather Station'	Regional Power Corporation (Horizon Power)
5770	P188290	R31462 for 'Equestrian Activities'	Town of Port Hedland
5966	P188290	R30768 for 'Recreation'	Town of Port Hedland

It is understood that temporary leases over portions of Crown Reserve 31462 have also been granted by the Town to the Port Hedland Pony Club, the Port Hedland Turf Club and several individual stable operators. It is also understood that there is a sublease arrangement between the Port Hedland Pony Club and the Care for Hedland organisation to provide for a Community Garden on Lot 5770.

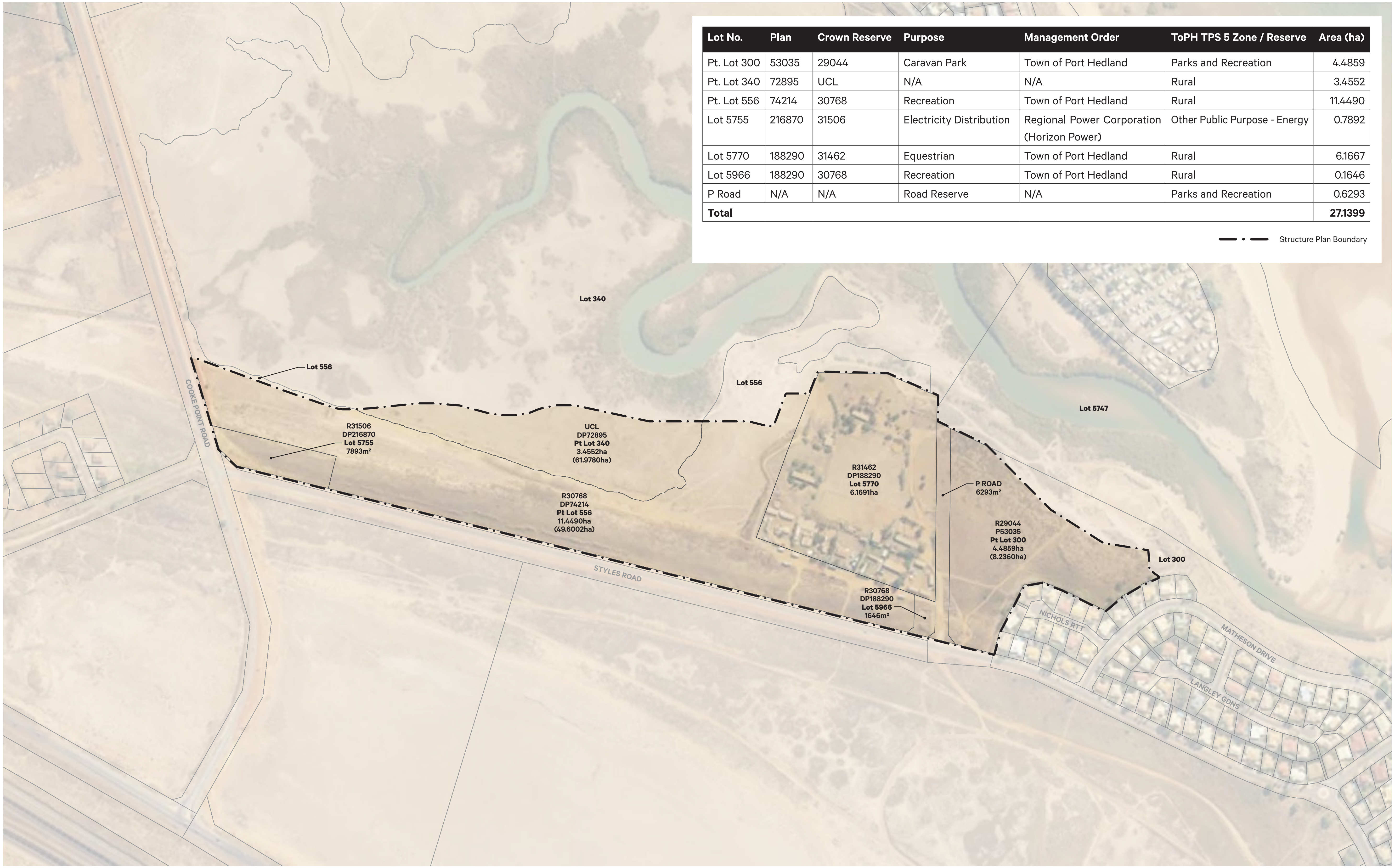
In formulating this Amendment, Development WA has undertaken consultation with all relevant management authorities and lessees, who have expressed no objections to the proposed Amendment.

2.1.3 Site Zoning

The majority of the subject site is currently zoned 'Rural' under the Town's TPS5, with the exception of Lot 5755, which is reserved for 'Other Public Purposes – Energy', and Lot 5770, which is reserved for 'Parks and Recreation'. In addition, there is also an existing local road reserve through the site (Johnson Lane) which is unconstructed and forms part of the Amendment area.

Source: RPS, 2015 - modified

Figure 1. Location Plan



Lot No.	Plan	Crown Reserve	Purpose	Management Order	ToPH TPS 5 Zone / Reserve	Area (ha)
Pt. Lot 300	53035	29044	Caravan Park	Town of Port Hedland	Parks and Recreation	4.4859
Pt. Lot 340	72895	UCL	N/A	N/A	Rural	3.4552
Pt. Lot 556	74214	30768	Recreation	Town of Port Hedland	Rural	11.4490
Lot 5755	216870	31506	Electricity Distribution	Regional Power Corporation (Horizon Power)	Other Public Purpose - Energy	0.7892
Lot 5770	188290	31462	Equestrian	Town of Port Hedland	Rural	6.1667
Lot 5966	188290	30768	Recreation	Town of Port Hedland	Rural	0.1646
P Road	N/A	N/A	Road Reserve	N/A	Parks and Recreation	0.6293
Total						**27.1399**

Figure 2. Aerial and Cadastral Plan

2.1.4 Surrounding Context

Within the context of the Town of Port Hedland and East End, the subject site is identified as potential future residential land, being a potential stage of the existing Pretty Pool residential development.

Styles Road forms the southern boundary of the site with undeveloped rural land on the southern side of Styles Road extending to the railway line and Wilson Street.

Cooke Point Road forms the western boundary of the site and is the major entry road servicing urban areas in the east-end from Wilson Street. To the north and north-east is the natural area of Pretty Pool Creek, which includes mangroves along the creek and estuarine tidal flats.

Pretty Pool – High Amenity Residential Living

Pretty Pool residential area lies directly adjacent to the east and south-east and contains predominantly low density single residential dwellings.

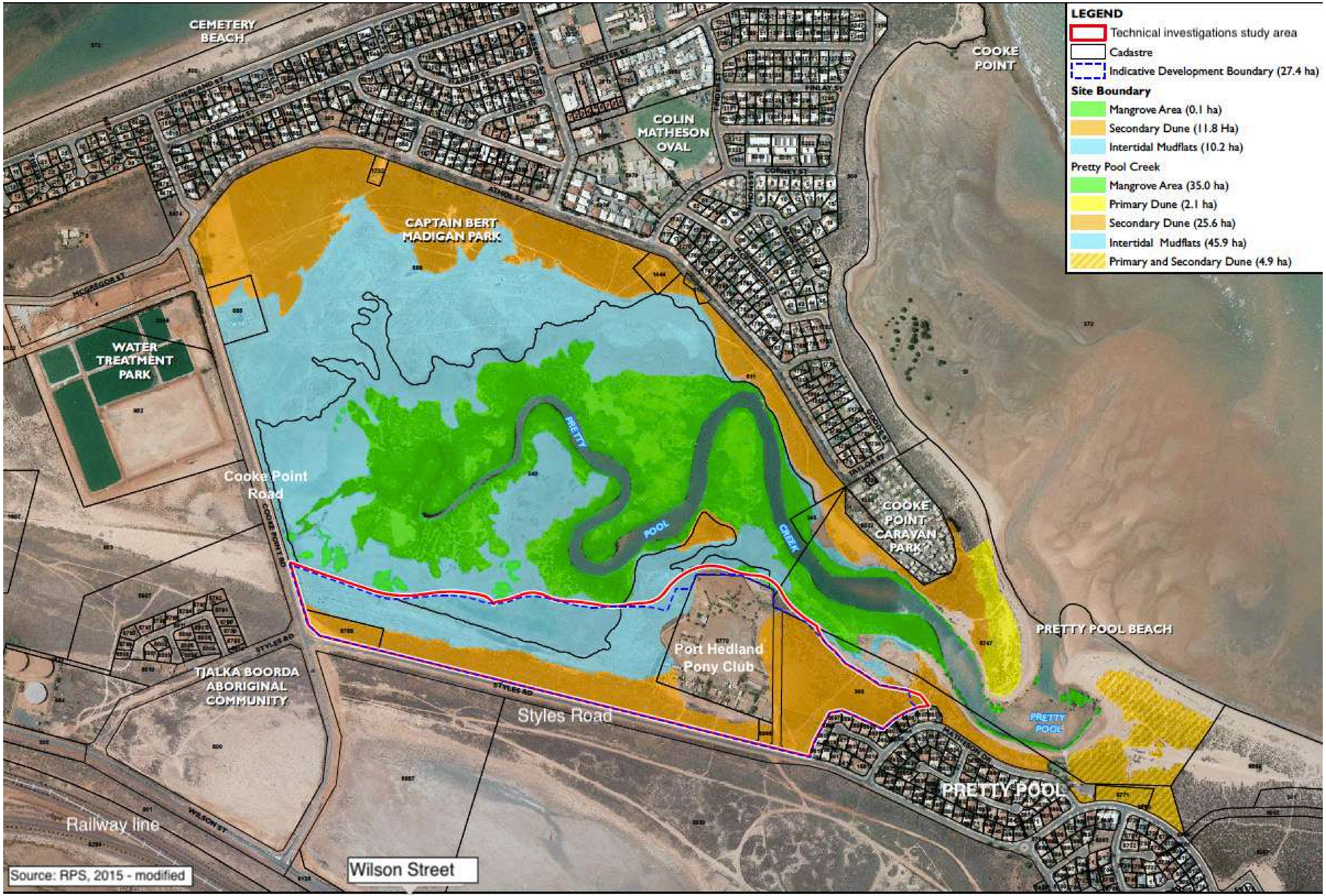
The locality of Pretty Pool is considered to have high amenity for residential living. The more recent development in Pretty Pool to the far south-east encompassing Dowding Way demonstrates a strong market demand for residential living in Pretty Pool. It also demonstrates a market demand for more contemporary residential accommodation (i.e. multiple dwellings, rear loaded laneway lots) within the east-end of Port Hedland in proximity to areas of natural environment and amenity.

The Stables site has high amenity being in proximity to Pretty Pool Creek and having uninterrupted views of Pretty Pool Creek on the higher parts of the site. It also forms part of an existing community and is near the gateway into Port Hedland.

Refer to Figure 3 – Surrounding Context

Plate 1. Single dwellings (such as these in Panjya Parade, Pretty Pool) will be the predominant form of housing for the Stables development site (Source: Google Maps)

Plate 2. Multiple dwellings (such as these in Dowding Way, Pretty Pool) is an emerging contemporary form of housing in the east-end of Port Hedland, however unlikely to be appropriate for the Stables development site, due to potential light spill impacting turtle nesting at Pretty Pool Beach. (Source: Google maps)



Source: RPS, 2015 - modified

Figure 3. Surrounding Context

Plate 3. Port Hedland Pony Club (Source: RPS, 2015)

Plate 4. Vacant land east of Pony Club with existing residential in background (Source: DevelopmentWA, 2020)

2.1.5 Existing Use

The subject site comprises primarily of vacant, unimproved landholdings. However, Lot 5770 is utilised by various organisations, including the Port Hedland Pony Club and Port Hedland Turf Club, for the agistment of horses and recreational equestrian activities. This includes various buildings and structures on Lot 5770 to facilitate this existing use, including stables and other ancillary buildings.

The western portion of the site is undeveloped and this comprises of the limestone ridge that runs parallel adjacent to Styles Road.

2.1.6 Site General Description

Topography varies across the site, from a high point of approximately 8 metres AHD in the coastal dune system in the north-eastern corner of the subject site, to a low point of approximately 2.4 metres AHD at the estuarine flats adjacent to Pretty Pool Creek. In addition to the coastal dunes and estuarine environments, the subject site is also characterised by a limestone ridge that runs parallel to Styles Road and small areas of mangrove habitat in proximity to the most northern boundary of the Amendment area.

The soil conditions at the site have been assessed and categorised into three areas in the accompanying geotechnical report. The geotechnical investigations are included as an appendix in the Local Water Management Strategy. Essentially the geological characteristics are described in Table 2 and in Figure 4 – Geological Formations.

Table 2 - Soil and Ground Conditions

Plate 5. View from Cooke Point Road verge lookng east (with Styles Road intersection to the far right) with estuarine deposits on the far left and limestone ridge in the centre (Source: Coffey, 2015)

Plate 6. View from western end on top of the limestone ridge looking east (Source: DevelopmentWA, 2020)

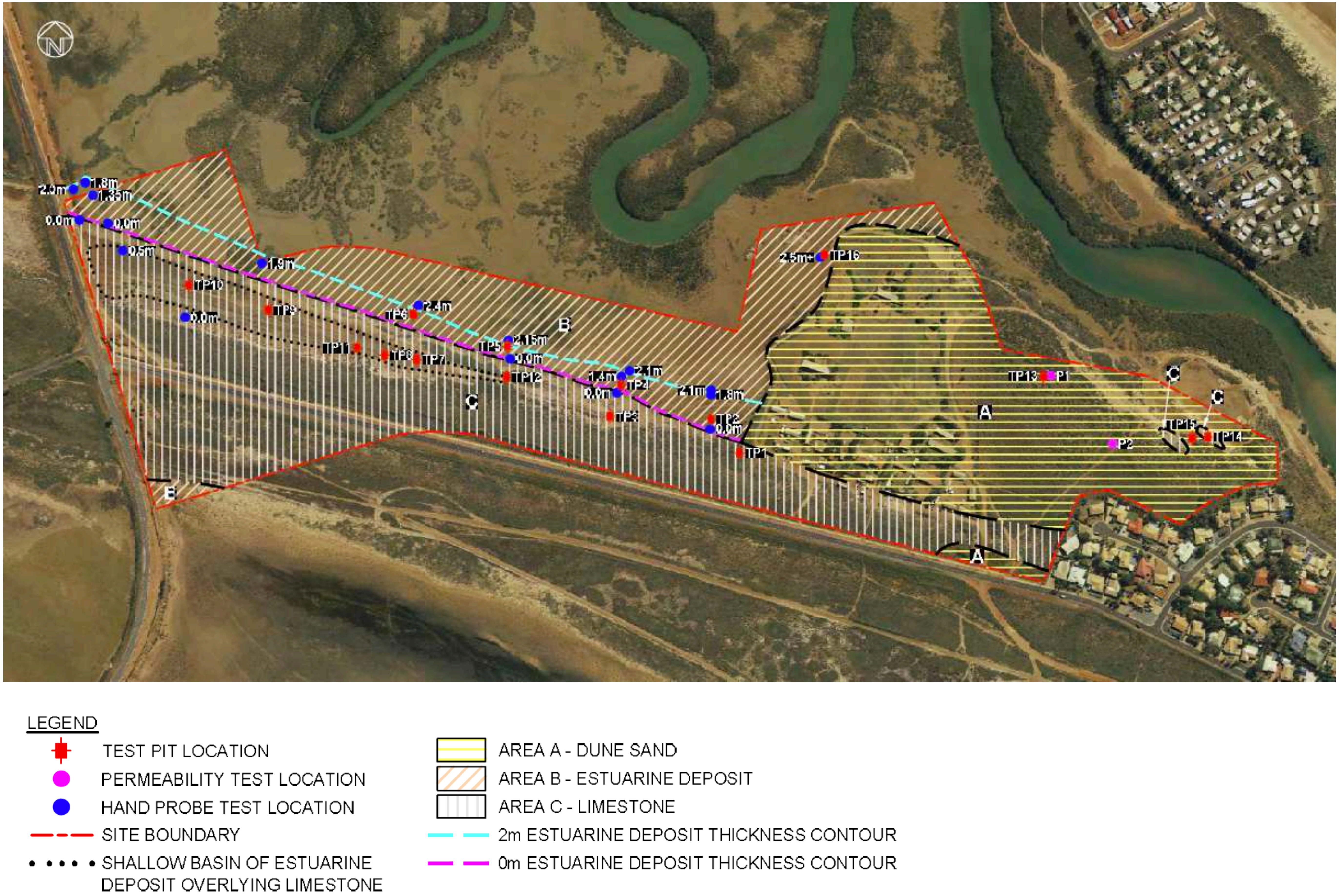


Figure 4. Geological Formations

Area	Unit	Description
A	Dune Sand	Fine to coarse grained sand with trace silt and gravels and shell, loose to medium dense
B	Estuarine Deposits	Sandy Clay/Clay: low to high plasticity grey and brown, generally very soft to soft, stiff to hard in some areas
C	Limestone	Pale brown/yellow, well to very well cemented, low to high strength, occasional voids.

Refer to Appendix 1 – Environmental Assessment Report (Geographical Report part of the appendices)

Refer to Figure 4 – Geological Formations

Groundwater levels were also assessed and identified at approximately R.L. 2.5 metres AHD to R.L. 3.0 metres AHD across the subject site. This generally coincides with a groundwater level perched on the estuarine deposits identified above. This results in the potential for significant changes in groundwater levels, particularly after heavy rain events during the wet season. Groundwater levels across the site generally lie at 0.9m - 1.9m or deeper below existing natural ground levels.

An overview of general site opportunities and constraints is provided.

Refer to Figure 5 – Opportunities and Constraints Plan

2.1.7 Cultural Heritage Significance

Previous heritage investigations were undertaken in 2015 including consultation with the Traditional Owners of the land, the Kariyarra people. Four separate sites or places of cultural heritage significance on the subject site were identified. This includes three engraving sites and one midden site. These are proposed to be preserved within future public open space as part of development of the subject site – as shown in the preliminary development concept plans, which will be discussed in this report.

The details of the identified aboriginal heritage sites are further discussed in the the *Report on Aboriginal Heritage Advice for the Stage 3 East Port Hedland Project* (Anthropos Australis WA, May 2015)

Refer to Appendix 3 – Report on Aboriginal Heritage Advice for the Stage 3 East Portland Hedland Project

The protection of Aboriginal heritage will be an important ongoing consideration during later stages of planning for the future development of the subject site. This is likely to involve ongoing engagement with the local Marapikurrinya people. The protection of identified heritage assets will be ensured via the preparation of a Cultural Heritage Management Plan to support the future development of the area, which will include consideration of:

- Establishing a set of work procedures for the subject site that align with Department of Planning, Lands and Heritage (DPLH) Guidelines and the aspirations of the Traditional Owners;
- Ensuring that construction is undertaken in a manner that protects Aboriginal heritage assets, by retaining these assets in areas of proposed public open space;
- Liaising with Marapikurrinya Pty Ltd, as the representatives of the Traditional Owners, regarding

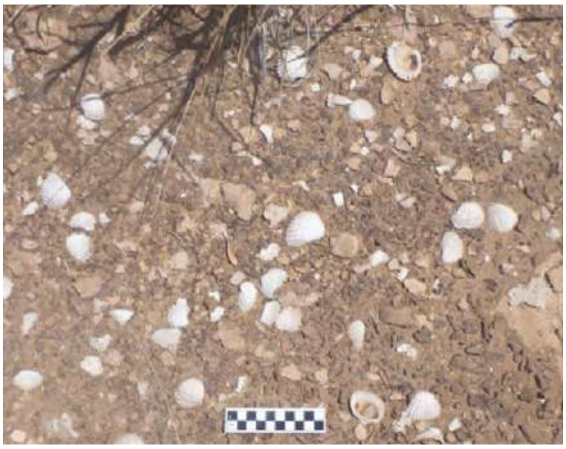


Plate 7. Photograph of aboriginal midden (Source: Anthropos Australis, 2015)

Plate 8. Photograph of aboriginal engraving on rock (Source: Anthropos Australis, 2015)

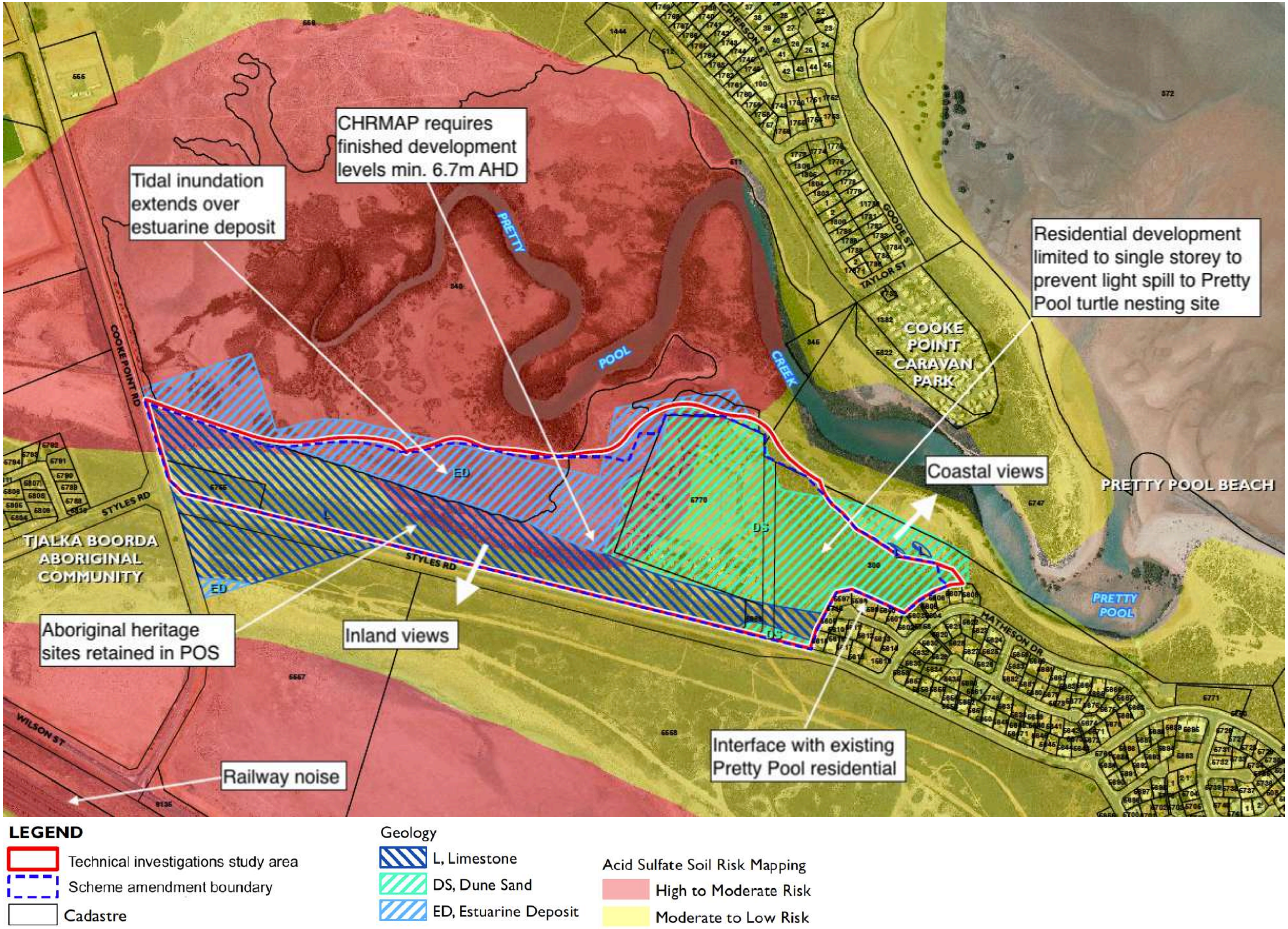


Figure 5. Opportunities and Constraints Plan

Sites found containing Aboriginal heritage midden and engravings

Boundary for technical studies investigations

Source: Cardno, 2015 - modified

Figure 6. Aboriginal Sites

Aboriginal heritage management during the pre-construction, construction, post construction and post-development stages of the project;

- Ensuring that discoveries of previously unidentified Aboriginal sites or objects are dealt with in accordance with the requirements of the *Aboriginal Heritage Act 1972*, including the implementation of appropriate Stop Work Procedures; and
- Creating opportunities for the enhancement of identified Aboriginal cultural assets, with the active engagement and participation of the Marapikurrinya people at all times.

Refer to Figure 6 – Aboriginal Sites

3. Pre-lodgement consultations

This Amendment follows on from the previous Amendment No. 77 for the Stables site and is generally a similar proposal. Extensive consultation with key stakeholders was undertaken for Amendment No. 77, including the Port Hedland Pony Club, Port Hedland Turf Club, Care for Hedland, Horizon Power and Town officers. There was an understanding from the key stakeholders that the Stables site is earmarked for future urban development and that relocation of the existing leaseholder activities on the site would be required at some point in the future.

Amendment No. 77 was lodged with the Town of Port Hedland and initiated by Council in June 2015. The EPA did not require formal assessment of Amendment No. 77 and the proposal was subsequently advertised to the community and external agencies. All of the matters raised in submissions were found to be planning considerations for structure planning and subdivision decision making. These considerations have been acknowledged, including the reasons for refusal of Amendment No. 77 by the Minister (primarily in relation to absence of an adopted CHRMAP) and have been taken into account in the preparation of this Amendment.

More recently, consultations in relation to the future potential of the site for urban development, have been undertaken as part of the overall preparation of the Town of Port Hedland Draft Local Planning Strategy and then more specific to the Stables site, direct consultation again with key stakeholders.

3.1 Town of Port Hedland Draft Local Planning Strategy

During the recent **Shaping Hedland's Future** engagement campaign, the Town asked the community their priorities and insights regarding future housing growth within Port Hedland. The purpose of this exercise was to understand how to best plan for land to accommodate future residential population growth and development based on availability of services, proximity to existing developed land and consideration of constraints.

The results from this engagement were used to inform the preparation of the Draft Local Planning Strategy for the Town. The draft strategy identifies up to seven potential residential growth areas, being; the Telstra tower site, the former recreation centre and detention centre sites, the remediated wastewater treatment plant site, Athol Street site, the Stables site, Pretty Pool Stage 3A and a portion of the McGregor Street sporting precinct.

Community and stakeholders were asked to consider what was their preferred staging for future housing in Port Hedland and why. In relation to the Stables site, those people who engaged in the conversation at meetings, events or through the online community survey:

- Acknowledged that only a portion of the Stables site would likely be suitable for staged housing, when considering storm surge inundation and the need to conserve the natural environmental assets (i.e. mangrove environment).
- Reinforced the significance of Aboriginal heritage, and the priority to maintain access to and protect significant cultural assets.

While there was general support for a staged development across suitable portions of the Stables site, more investigation was seen to be required to understand the constraints or opportunities within this broadly defined area.

Any future staged housing development for the site will require further discussion with the Town, technical experts, key stakeholders and community groups and this would be part of the structure planning process.

3.2 Recent pre-lodgement consultations with key stakeholders

The following Table 3 is a list of key stakeholders that were consulted during the preparation of the Amendment.

Table 3. Key Stakeholder Consultations in May/June 2020

Stakeholder	Comments	Actions
Department of Planning, Lands and Heritage	Amendment rationale needs to address CHRMAP considerations and potential for provision of an adequate foreshore for coastal protection infrastructure. Progressing the Amendment concurrent with structure planning of the Stables site is logical and would inform the final boundaries for the 'Urban Development' zone. In context of Town's current draft Local Planning Scheme No. 7 being progressed, the Amendment can proceed independently – as a modification to LPS7 at Minister final approval stage.	Noted. Technical reports to be updated to reflect CHRMAP.
Port Hedland Pony Club	Port Hedland Pony Club raised no objections and acknowledges the site is earmarked for future urban development, in context of existing lease arrangements.	Noted.
Port Hedland Turf Club	Port Hedland Turf Club raised no objections and acknowledges the site is earmarked for future urban development, in context of existing lease arrangements.	Noted.
Department of Water and Environment Regulation	DWER raised no objections at this preliminary stage. A formal review and assessment will be undertaken once the amendment is referred to DWER for comment.	Noted.
Kariyarra Aboriginal Corporation	Scheduled meeting wtih the Kariyarra Board on 24th June. Initial consultation undertaken with Elder Diana Brown. Diana commented on maintaining an adequate buffer from high environmental and heritage values of Pretty Pool Creek.	Noted.
Horizon Power	Raised no objections at this preliminary stage. Continued discussions will occure to update land assets within the site.	Noted.
Care for Hedland	Raised issues regarding protection of mangrove habitat and turtle nesting areas. Care for Hedland provide a formal written submission in due course.	Noted.

4. Proposed Scheme Amendment

The Amendment proposes to reclassify/rezone the subject site from 'Rural', 'Parks and Recreation' and 'Other Public Purpose – Energy', to 'Urban Development'. The requested Amendment will facilitate the future subdivision and development of the land residential purposes, following preparation of a structure plan for endorsement by the WA Planning Commission. The proposed reclassification and rezoning of land is shown in the **scheme amendment map.**

The Amendment also proposes modifications to Appendix 10 of TPS5, which will provide for appropriate planning considerations at the structure planning, subdivision and development stages of future development. These modifications will ensure that required environmental investigations are carried out as part of the structure planning process for the subject site, in accordance with the established framework for the Pretty Pool area under TPS5.

The proposed amendments to Appendix 10 involve updating both the name of the development area to 'Pretty Pool' rather than 'Pretty Pool 2', and the description of the land, to reflect the broader area. This will provide consistency across future development areas and ensure that the requirement for relevant environmental studies applies to the remaining undeveloped areas of Pretty Pool.

The proposed amendments to TPS5 will ensure that the site is appropriately zoned for future residential development and establishes a framework for comprehensive planning to guide the future development of the subject site via the structure planning process. This is consistent with the planning framework applicable to the subject site.

4.1 Preliminary Development Concept Plan

The former Amendment No. 77 proposal included two preliminary development concept plans, to illustrate examples as to how the subject site could be developed. These concept plans develop the whole urban development zone for residential use.

Refer to Figure 7 – Preliminary Development Concept Plans

These concept plans are provided in this report as background information only. It is anticipated that with the concurrent structure planning and scheme amendment, the development footprint for residential use will be reduced.

The structure planning process will consider an appropriate mix of low and medium density residential development, consistent with the established character of surrounding residential development in the localities of Pretty Pool to the east and Cooke Point to the north. The structure planning will also consider and respond to the requirements of the WAPC Liveable Neighbourhoods.

Matters to consider include:

- The distribution of residential density across the subject site consistent with the Town's aspirations for the area;
- The integration of established roads with the proposed internal road network;
- The provision of public open space to service the area, which has been informed by the location of places of identified cultural heritage significance;
- The role that public open space will play in urban water management, noting the unique climate and high rainfall events in the area;
- The interface with Pretty Pool Creek and the provision of public access via the proposed public road network, in recognition of the role Pretty Pool Creek can play in providing a high level of amenity for future residents and creating a unique sense of place;

- Providing a high level of passive surveillance of streets and public spaces, in accordance with the principles of crime prevention through environmental design; and

The Town's CHRMAP considerations will also inform the structure planning and design outcomes, including provision of appropriate coastal protection infrastructure and finished development levels to mitigate against coastal flood inundation. Accordingly, the ultimate form and layout of development will be further explored as part of the structure plan process.

OPTION 1 — LAND USE / LOT YIELD ANALYSIS

GROSS DEVELOPABLE AREA	27.16HA	MEDIUM DENSITY R40	4.44HA
CARAVAN PARK	4.2HA	ROADS	7.13HA
GROSS RESIDENTIAL AREA	22.96HA	R20 129 LOTS @ 700SQM	
PUBLIC OPEN SPACE	2.36HA (10%)	R40 148 LOTS @ 300SQM	
LOW DENSITY R20	9.03HA	**TOTAL LOT YIELD**	**277**

OPTION 2 — LAND USE / LOT YIELD ANALYSIS

GROSS DEVELOPABLE AREA	27.16HA	MEDIUM DENSITY R40	4.12HA
CARAVAN PARK	4.3HA	ROADS	6.72HA
GROSS RESIDENTIAL AREA	22.86HA	R20 138 LOTS @ 700SQM	
PUBLIC OPEN SPACE	2.36HA (10%)	R40 137 LOTS @ 300SQM	
LOW DENSITY R20	9.66HA	**TOTAL LOT YIELD**	**275**

Figure 7. Preliminary Development Concept Plans

5. Planning Framework

5.1 State Planning Framework

5.1.1 State Planning Strategy 2050

The State Planning Strategy 2050 is the State's primary strategic planning document and provides the strategic context for planning and development decisions throughout the State.

Amongst a diverse range of identified priorities, the strategy seeks to encourage a more balanced population distribution across the State, with a focus on increased residential populations in regional communities. This includes planning for a regional residential population of up to 1.2 million people by 2056, to assist in easing population pressure and urban sprawl in the Perth Metropolitan Region.

In particular, the strategy recognises the role of the Pilbara Cities initiative in developing Port Hedland into a city where people choose to settle on a permanent basis. This involves pro-active planning to enhance Port Hedland's appeal as a place to raise families with access to high standards of education and healthcare, and diverse employment and career opportunities. The Stables site is a high amenity area for residential living as previously discussed. Choosing areas that can offer high amenity residential living is a key to attracting population growth and permanent residents. Whereas choosing future areas to house the population in low amenity areas will not stimulate growth and vibrancy of Port Hedland.

The proposed Amendment has been informed by an extensive and conservative approach to management of the sensitive Pretty Pool Creek environment and the level of amenity it provides for the locality community, which will also be carried through in future structure planning. This is consistent with the Strategy's focus on achieving a "*careful and managed balance of conservation and development*" to ensure the State can sustain its growth and prosperity over the long term.

5.1.2 Pilbara Planning and Infrastructure Framework

The Pilbara Planning and Infrastructure Framework was prepared by the WA Planning Commission to provide a strategic direction for the future development of the Pilbara region over a period of 25 years, and to inform the preparation of local planning strategies and local planning schemes in the region.

The framework provides a high-level blueprint for the accommodation of future population growth and housing development in the Pilbara region, as well as identifying strategies to address economic growth, environmental management, transport and infrastructure, and tourism opportunities. In doing so, the framework seeks to ensure that the ongoing development of the Pilbara region is achieved in a manner that improves people's lives and enhances the character and environment of the region.

A key part of the framework is its role in supporting the implementation of the Pilbara Cities vision, which encourages the growth of Port Hedland to support a residential population of 50,000 by 2035, as part of a broader initiative to consolidate population growth in the region's main urban centres. This includes a desire to deliver nearly 15,000 new dwellings in Port Hedland by 2035, with a focus on:

- Achieving an efficient supply of land for future urban growth;
- Providing areas of high amenity for residential living;
- Facilitating private sector involvement in urban land development;
- Accelerating land releases for the development of new housing; and
- Providing residential land in identified growth areas to meet the needs of the labour market.

The proposed Amendment is consistent with the strategic direction established under the framework, noting that the subject site is identified as a potential residential greenfield site that can positively contribute towards accommodating population growth.

5.1.3 Port Hedland Air Quality and Noise Management Plan

The Port Hedland Air Quality and Noise Management Plan was prepared by the state government in response to concerns regarding the impact of dust and noise emissions associated with industrial operations at Port Hedland's main commercial port on surrounding residential areas.

The plan recognises the key role that Port Hedland plays in the export of iron ore and other bulk materials that underpin the economy of the region, the state and the nation. However, the scale of industry at the main port in the West End of Port Hedland results in a range of potential environmental impacts that are increasingly seen to be incompatible with nearby residential development in the locality. Whilst such uses have co-existed in Port Hedland for many years, dust levels in the West End regularly exceed national environmental guidelines, which elevates the risk to vulnerable people in the community.

As a result of the aforementioned amenity and public health concerns, the plan recommends a range of measures to address this identified land use conflict, including a focus on consolidating future residential growth in the East End of Port Hedland, whilst limiting and gradually reducing residential land use in the West End. This focus has informed the subsequent development of the Town's current and draft local planning strategy, both of which identify the subject site as a potential site for future residential housing.

In accordance with the above, reclassification/rezoning the subject land for residential purposes is consistent with the implementation framework established under the plan.

5.1.4 State Planning Policy 2.0 – Environmental and Natural Resources Policy

State Planning Policy 2 – Environmental and Natural Resources Policy (SPP2.0) defines the key principles and considerations that inform good and responsible planning outcomes with respect to issues relating to the environment and natural resources. An assessment against the relevant provisions of SPP2.0 is provided below.

General Measures

Various technical environmental, geotechnical, noise and engineering studies have been undertaken to consider the suitability of the site for future residential use. These form the appendices of this report.

Collectively, these technical studies confirm that the site can be developed for residential use, in a manner that is consistent with the general measures outlined under SPP2.0. These include:

- Providing for the implementation of effective environmental management measures to ensure quality environmental outcomes for the Pretty Pool Creek system and associated mangrove habitat.
- Ensuring that the land is suitable for future residential development and does not contain any significant natural resources (i.e. mining assets).
- Providing for the protection of identified cultural heritage assets, as identified through engagement with the Traditional Owners, the Kariyarra people, including:
    - Protecting the sensitive Pretty Pool Creek environment to prevent any adverse impact, whilst maintaining public access; and
    - Providing for the ongoing protection of the four identified heritage sites within the boundary of the subject site, consistent with the recommendations of the accompanying Cultural Heritage Assessment Report.

Considering the impact of changing climatic conditions and associated coastal processes, in accordance with the adopted Port Hedland Townsite Coastal Hazard Risk Management Plan (CHRMAP), and the accompanying site specific Coastal Hazard Assessment.

Other specific matters dealt with under SPP2.0 are generally discussed below.

Water Resources

This report is accompanied by a Local Water Management Strategy (refer to appendices within Appendix 1 – Environmental Assessment Report). The LWMS demonstrates that urban stormwater will be managed in accordance with the WAPC's Better Urban Water Management Guidelines. The strategy outlines that any potential impacts can be readily managed so as not to have any significant impact on the natural water resources.

Air Quality

As discussed in detail above, the Port Hedland Air Quality and Noise Management Plan seeks to consolidate future residential development in the East End of Port Hedland, as proposed by this Scheme Amendment, in response to dust and air quality concerns in the established West End residential areas. The proposed Amendment will assist in providing a supply of suitable land for residential development in the East End, where land use conflict and associated air quality impacts are within acceptable levels, thereby enabling the limitation and gradual reduction of residential land uses in the West End.

Soil and Land Quality

The suitability of the land for future residential development has been addressed in detail through the various geotechnical, environmental and engineering servicing investigations. These assessments conclude that:

Development on the estuarine deposits poses earthworks and servicing challenges for urban development. In the context of the Town's CHRMAP and in considering the constraints of developing on the estuarine deposits, it is highly likely structure planning within the proposed urban development zone footprint will avoid residential development on tidal flat areas.

The majority of the site has a 'moderate to low' risk of acid sulphate soils occurring within 3 metres of the natural soil surface, with some small areas identified as having a 'high to moderate' risk of acid sulphate soils. This can be readily managed through the subdivision and development process, with further detailed investigations to be carried out at the structure plan stage.

The subject site does not contain any registered contaminated sites, nor has it been used in the past for any use which may have resulted in contamination, thereby ensuring its suitability for future residential use.

Biodiversity

This Amendment is accompanied by a detailed Environmental Assessment Report, which includes a Mangrove and Erosion Impact Assessment. The findings of the environmental report confirm there are no significant impacts on the environment.

In addition, it is noted that the environmental studies undertaken to date will be supported by further detailed investigations and management plans to be prepared at the structure plan stage, as provided for through the proposed amendments to Appendix 10 of TPS5. These will include:

- A Construction Management Plan.
- A Foreshore Management Plan.
- A Mangrove Management Plan.
- A Drainage and Nutrient Management Plan.
- A Marine Turtle Management Plan.
- An Acid Sulfate Soil Management Plan (if required).

This will ensure the implementation of appropriate environmental management measures as part of the future subdivision and development of the subject site.

Landscape

The ecological, aesthetic and social value of Pretty Pool Creek and the associated mangrove system is acknowledged, and the proposed Amendment seeks to facilitate development that complements and does not detract from established landscape character of the area. In this regard, it is noted that:

- The development of the subject site will not adversely affect the landscape value of Pretty Pool Creek, as views to Pretty Pool Creek from Styles Road are already obscured by the natural limestone ridge that runs parallel to Styles Road, whilst existing views from Athol Street to the north and Cooke Point Drive to the east will be unaffected;
- Due consideration has been given to retaining the biodiversity values of the surrounding area, as detailed above; and
- Public access to Pretty Pool Creek from the subject site will be maintained as part of the future structure plan, subdivision and development of the site, in recognition of the level of amenity the creek offers for the existing and proposed residential communities.

Greenhouse Gas Emissions and Energy Efficiency

Whilst the provisions of SPP2.0 relating to greenhouse gas emissions and energy efficiency are not directly relevant at the scheme amendment stage, consideration of climate responsive urban design solutions will form part of the future structure planning for the site.

5.1.5 State Planning Policy 2.6 – State Coastal Planning

State Planning Policy 2.6 – State Coastal Planning (SPP2.6) sets out a range of policy measures to ensure that development in coastal locations appropriately takes into account the potential impact of coastal hazards. This includes considerations relating to coastal hazard risk management and the sustainable use of the Western Australian coastline that are relevant in the context of this Amendment.

SPP2.6 places particular emphasis on the need for adequate coastal hazard risk management and adaptation planning, which has been addressed through the preparation of the Port Hedland Townsite Coastal Hazard Risk Management and Adaptation Plan (CHRMAP).

Essentially the adopted CHRMAP supports further development in the East End of Port Hedland, including urbanisation of the subject site. Urbanisation can be accommodated by adaptation measures, specifically filling to a minimum finished development level of 6.7m AHD. The provisions of SPP2.6 and CHRMAP considerations are further discussed in this report.

5.1.6 State Planning Policy 2.9 – Water Resources

State Planning Policy 2.9 – Water Resources provides guidance to planning decision-makers in relation to managing impacts on water resources at various stages in the planning process, including local planning scheme amendments. This includes a focus on mitigating potential adverse impacts to water resources and promoting total water cycle management, to ensure best practice for the sustainable use of urban water resources.

The LWMS demonstrates that urban stormwater will be managed in accordance with the WAPC's Better Urban Water Management Guidelines. The strategy outlines that any potential impacts can be readily managed so as not to have any significant impact on the natural water resources.

5.1.7 State Planning Policy 3.0 – Urban Growth and Settlement

State Planning Policy 3.0 – Urban Growth and Settlement (SPP3.0) is a high level policy that seeks to promote a sustainable and well planned pattern of settlement across the State, with a sufficient supply of suitable land to provide for a wide variety of housing, employment, recreation facilities and open space.

The proposed Amendment responds to the provisions of SPP3.0 by:

- Representing an important preliminary step in facilitating the supply of suitable and affordable land for residential growth in Port Hedland, in an area specifically identified for future urban growth under the established strategic planning framework at both the State and local level;
- Providing for a comprehensive future structure planning process that will promote good urban design outcomes, having due regard for the WAPC's Liveable Neighbourhoods guidelines; and
- Appropriately addressing relevant servicing infrastructure requirements as will be discussed further in this report
- The subject site has been identified in the local planning framework as a future site for urbanisation, as will be discussed further in this report.

5.1.8 State Planning Policy 3.4 – Natural Hazards and Disasters

State Planning Policy 3.4 – Natural Hazards and Disasters (SPP3.4) seeks to implement a systematic approach to the consideration of natural hazards and disasters in the planning process, including in the assessment of local planning scheme amendments.

In response to the provisions of SPP3.4 the proposed Amendment acknowledges the findings of the Town's adopted CHRMAP and makes provision for this as part of the amendments to Appendix 10 by inserting provision for a minimum finished development level of 6.7m AHD.

5.1.9 State Planning Policy 3.7 – Planning in Bushfire Prone Areas

State Planning Policy 3.7 – Planning in Bushfire Prone Areas (SPP3.7) sets out the policy measures that apply to development in identified bushfire prone areas under the Department of Fire and Emergency Services State Map of Bush Fire Prone Areas.

As the subject site is located within an identified bushfire prone area, this application is supported by a Bushfire Management Plan (BMP). The BMP demonstrates that the relevant requirements under SPP3.7 can be appropriately addressed to comply SPP3.7.

Refer to Appendix 4 – Bushfire Management Plan

5.2 Local Planning Framework

5.2.1 Pilbara's Port City Growth Plan

Pilbara's Port City Growth Plan operates as the Town's adopted local planning strategy and seeks to guide the continued growth of Port Hedland into a Port City for the Pilbara region.

The primary aim of the plan is to promote the growth of Port Hedland as "*A nationally significant, friendly city, where people want to live and proud to call home*". This includes a specific focus on housing diversity and land supply capacity, to provide an adequate supply of affordable land and housing choice to cater for a diverse and permanent residential population.

There is an intent to develop 23,043 new residential dwelling throughout Port Hedland and South Hedland. In particular, the East End of Port Hedland is to be developed as a high amenity coastal community that offers significant housing density and diversity, together with sport and recreation opportunities, and education and community facilities.

The subject site is located within 'Precinct 2 – East End Urban Village' under the plan and is identified for medium density residential development. As such, the proposed Amendment to rezone the subject site to facilitate future residential development is consistent with the strategic direction established under the plan.

Refer to Figure 8 – Pilbara's Port City Growth Plan

5.2.2 Town of Port Hedland Town Planning Scheme No. 5

The Town of Port Hedland Town Planning Scheme No. 5 (TPS5) is the primary statutory control on land use and development within the Town.

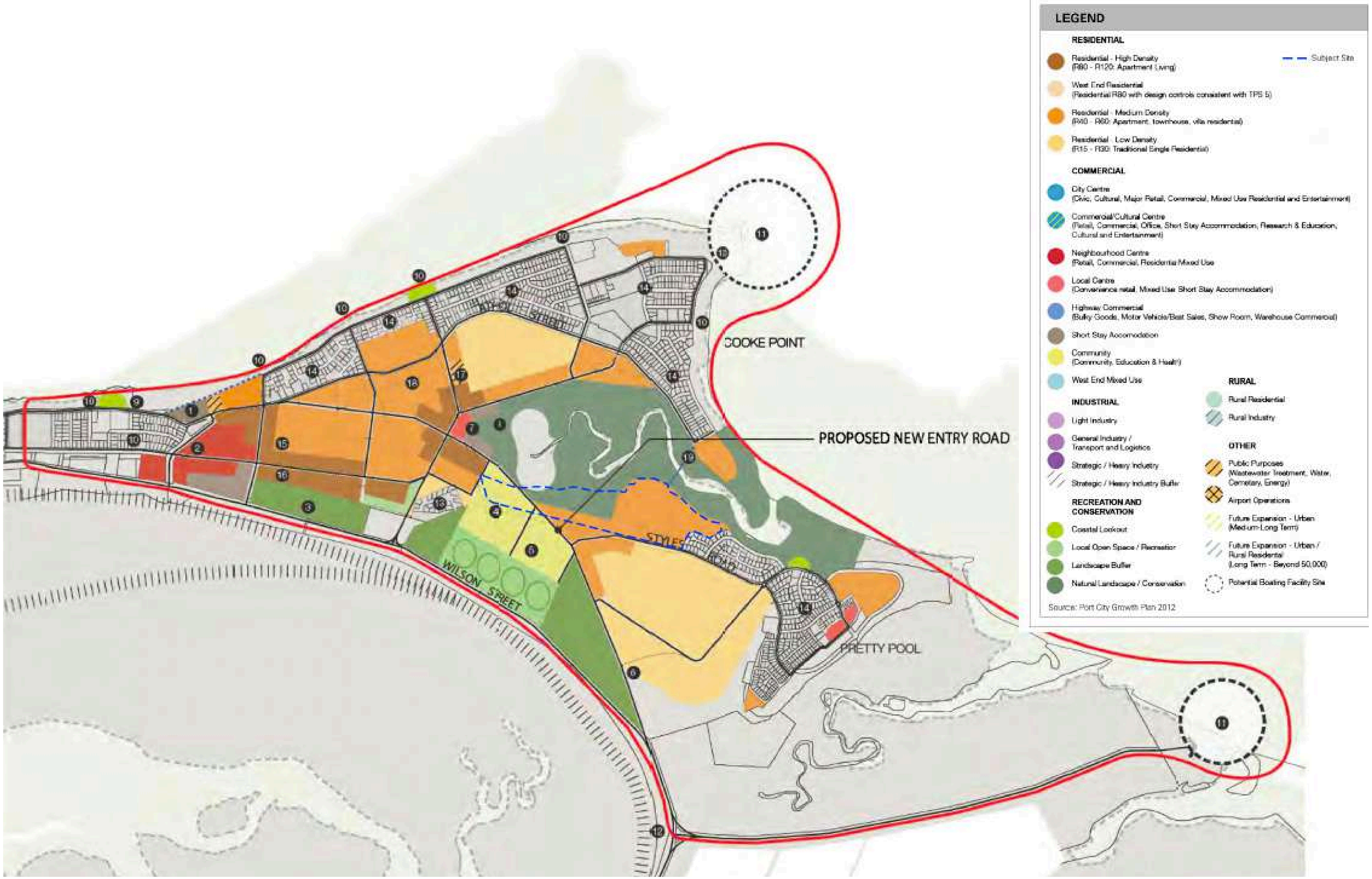
The purpose of the proposed 'Urban Development' zone under TPS5 is to identify land where further detailed planning is required prior to the subdivision and development of land, to be documented in the form of a structure plan.

As such, the proposed rezoning will provide a framework for future detailed planning to guide the delivery of future development in accordance with the objectives for the 'Pretty Pool' precinct in which the subject site is located under TPS5, which are to:

a) *reinforce the precinct as part of the entrance to Port Hedland,*
b) *ensure that any further urban development within the precinct is compatible with its environmental values,*
c) *give particular priority to the conservation and management of mangroves and tidal flats,*
d) *ensure that the facilities and the active and passive recreation activities within the Pretty Pool reserve are consistent with its district function,*
e) *permit additional tourist facilities provided these do not detract from the district recreational function and the environmental values of the precinct, and*
f) *ensure that development within the precinct is compatible with potential storm surge conditions within the precinct.*

The proposed modifications to Appendix 10 of TPS5 will also ensure that the key environmental matters relating to CHRMAP considerations, foreshore management, mangrove management, drainage and nutrient management, marine turtle habitats and acid sulphate soils are adopted as part of the future development of the subject site.

Accordingly, the proposed rezoning to 'Urban Development' under TPS5 will provide an appropriate framework for the delivery of future urban land at the subject site, consistent with the Town's adopted local planning strategy.



Source: Port City Growth Plan 2012

Figure 8. Pilbara's Port City Growth Plan

5.2.3 Port Hedland Townsite CHRMAP

The Port Hedland Townsite Coastal Hazard Risk Management and Adaptation Plan (CHRMAP), adopted in April 2019, identifies and considers coastal hazards and risks for the Port Hedland Townsite. This culminates in a recommended adaptation pathway that includes a range of actions to assist in adapting to immediate coastal inundation and erosion risks, and in undertaking appropriate planning to address increasing risks over time.

The adopted adaptation pathway accords with SPP2.6 and indicates that areas in the East End of Port Hedland are subject to a comparatively low coastal hazard risk compared with high risk areas in the West End, where a managed retreat strategy is recommended.

Accordingly, the adopted CHRMAP recognises and supports the potential for future urban expansion in the East End of Port Hedland. This will enable long-term investment into feasible protection of inundation in the East End, which is not constrained by dust and noise impacts associated with port operations, and is capable of accommodating the full suite of urban uses that could not otherwise be supported in the West End.

In accordance with the above, the proposed Amendment will provide for an urban development zone, which will enable structure planning to respond to the identified actions under the CHRMAP.

5.2.4 Draft East End Village District Structure Plan

In 2012, DevelopmentWA (then LandCorp) engaged a consultant team to prepare a district structure plan to inform the future development of Port Hedland's East End. Whilst this document has not been formally adopted by the Town or the WAPC, and therefore has no statutory weight, it does serve to further inform the broader vision for development in Port Hedland's East End.

Refer to Figure 9 – Draft District Structure Plan

Source: East End Concept Plan (RPS 2012)

Figure 9. Draft District Structure Plan

6. Planning Rationale

6.2.1 Suitability of Site for Urbanisation

The Amendment only seeks to change the zoning of the subject site at this time, consistent with the local planning framework and to allow for further investigations as part of structure planning. Both the change of zoning and approval of a structure plan would then prepare the site for future development. The timing for development of the site is dependent on further discussions with key stakeholders, in particular current lease holders.

As demonstrated in the various technical reports (i.e. environmental, geotechnical, engineering etc) the subject site can be readily developed for residential use and environmental values (i.e. turtle nesting, mangrove habitat protection) can be appropriately managed. The site has existing road access to Styles Road. Connections to reticulated power, water and sewer can be fully accommodated via extensions to existing services as outlined in the engineering servicing report.

Refer to Appendix 2 – Preliminary Engineering Servicing Report

6.2.2 Limited residential development footprint

As previously mentioned, the 'Urban Development' zone provides for a basic footprint for which structure planning is undertaken. Structure planning will identify the appropriate land uses, road layout and urban infrastructure within the urban development zone.

It is highly likely that not all of the urban development zone being proposed will be developed for residential use. A reduced residential footprint is expected as part of structure planning, which would result in a greater area provided as a foreshore setback to the Pretty Pool Creek natural area, compared with the earlier development concept plans (Figure 7).

6.2.3 Coastal processes and flooding (CHRMAP) considerations

Coastal Erosion

The Town's CHRMAP modelling and erosion investigation demonstrates that over the planning timeframe of 100 years, the Stables site is landward of the coastal erosion hazard line to the east at Pretty Pool Beach. Thus the erosion hazard criteria of SPP2.6 for the 100 year planning horizon is met.

Coastal Inundation

The Town of Port Hedland CHRMAP study has identified the subject site to be within a coastal flood inundation risk hazard area. Flooding as a result of tidal movement, storm surge, wave action and changes in sea level place as identified in the CHRMAP have the potential to impact the subject site in the long term.

The modelling undertaken in the technical investigations demonstrate that with filling of the site and provision of a bund wall of suitable rock design for stability, the SPP2.6 inundation criteria for the 100 year planning timeframe (above the 500 year ARI water level) can be satisfied.

A 6.7m AHD finished floor level of development as determined by the Cardno report, will adequately address the potential coastal flood inundation impacts identified in the Town's CHRMAP. The preliminary geotechnical and engineering investigations confirm that the site can be developed to accommodate imported fill to achieve a minimum finished floor level of 6.7m AHD. This minimum finished level is consistent with the requirements of the Port Hedland Townsite CHRMAP.

Site filling is an appropriate *adaptation measure* in response to the potential climatic impact of coastal processes and flooding (due to sea level rise) to the year 2110. Thus proposed urban development within the Amendment area can potentially comply with the provisions and expectations within SPP2.6.

Impact on Pretty Pool Creek Mangroves

Filling of the subject site has the potential to alter the natural patterns of water movement in adjacent areas. This may impact the existing Pretty Pool Creek mangrove habitat. The findings of the Cardno 2015 report, which modelled the impacts of filling of the subject site, demonstrates that the subject site (in conjunction with the development of Athol Street urban development zone) will not have a significant adverse impact on the mangrove habitat.

Notwithstanding, further investigations will be undertaken as part of structure planning to determine the cumulative impact of future development in east-end, including development of other potential urban growth sites. The results of modelling will inform structure planning and the proposed land uses within the 'Urban Development' zone.

Coastal Protection and Management

In addition to the setting of the minimum finished development level, CHRMAP work undertaken as a requirement of structure planning will include:

- Establish erosion and inundation hazard zones (i.e. calculating the allowance for physical processes). This may involve preparing a typical cross section of the development at the interface with the Pretty Pool Creek tidal flats and evaluating the potential for erosion and inundation overtime. This would be a different task than the storm surge modelling.
- Identify the assets exposed.
- Evaluate the risk of erosion and inundation.
- Develop suitable mitigation to reduce these risks (avoiding the risk being the preferred risk adaptation approach and protecting being the least preferred one), hence development which avoids the estuarine deposit geological formation would be the better approach.
- The approach needs to be acceptable to the WA Planning Commission and Town of Port Hedland, whereby the Town will be responsible for the future management of coastal protection assets.

The above considerations are requirements of SPP2.6 which needs to be adequately addressed in a structure plan. The requirements for coastal protection infrastructure and future management responsibilities and cost considerations will inform the proposed structure plan land uses and design layout for roads, public open space (including foreshore reserve) and other necessary urban infrastructure. This higher level of detail is recognised as part of the Amendment, but specific proposed measures and details of future management do not need to be determined at this scheme amendment stage.

Foreshore Management

A Foreshore Management Plan is recommended to be a consideration of structure planning and to be undertaken as a condition of subdivision. The management plan will appropriately manage access to Pretty Pool Creek, recreational areas and activities, as well as provide for the enhancement and consideration of conservation values of Pretty Pool Creek natural area.

6.2.4 Transport Noise

Transport noise emanating from BHP Billiton's Nelson Point Railway line and Wilson Street potentially impacts a portion of the subject site as outlined in the acoustic assessment accompanying this report. The acoustic assessment concludes that the impacts of transport noise can be adequately managed through noise mitigation measures (i.e. quiet house design packages) to those areas within the site affected by noise. This will be an environmental consideration that will need to be addressed as part of structure planning.

Refer to Appendix 5 – Acoustic Assesment

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7. Conclusion

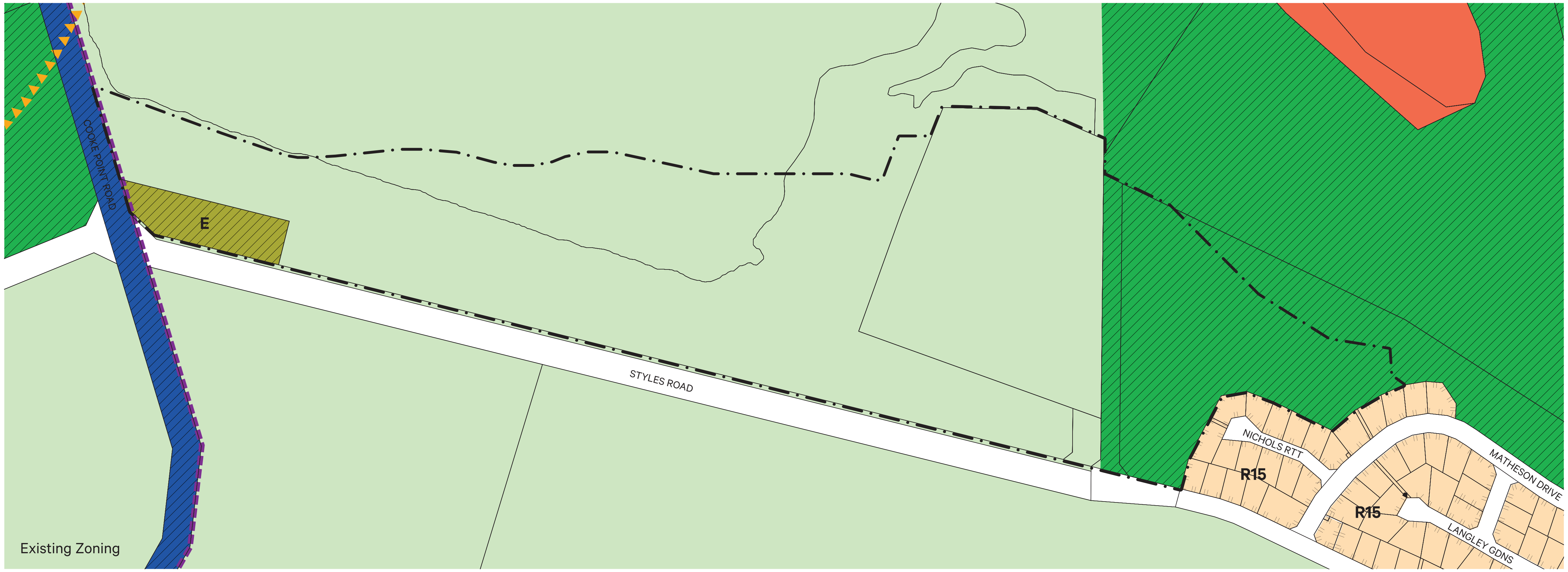
The proposed Amendment seeks to reclassify and rezone the various parcels of Crown Land that comprise the subject land from current 'Rural', 'Public Purposes: Energy' and 'Parks and Recreation' to 'Urban Development' zone. Modifications to Appendix 10 – 'Urban Development Additional Development Requirements' of TPS5 are also proposed to rationalise the Pretty Pool precinct and introduce appropriate development controls. The reclassification/rezoning to 'Urban Development' will facilitate future subdivision and development in accordance with an endorsed structure plan.

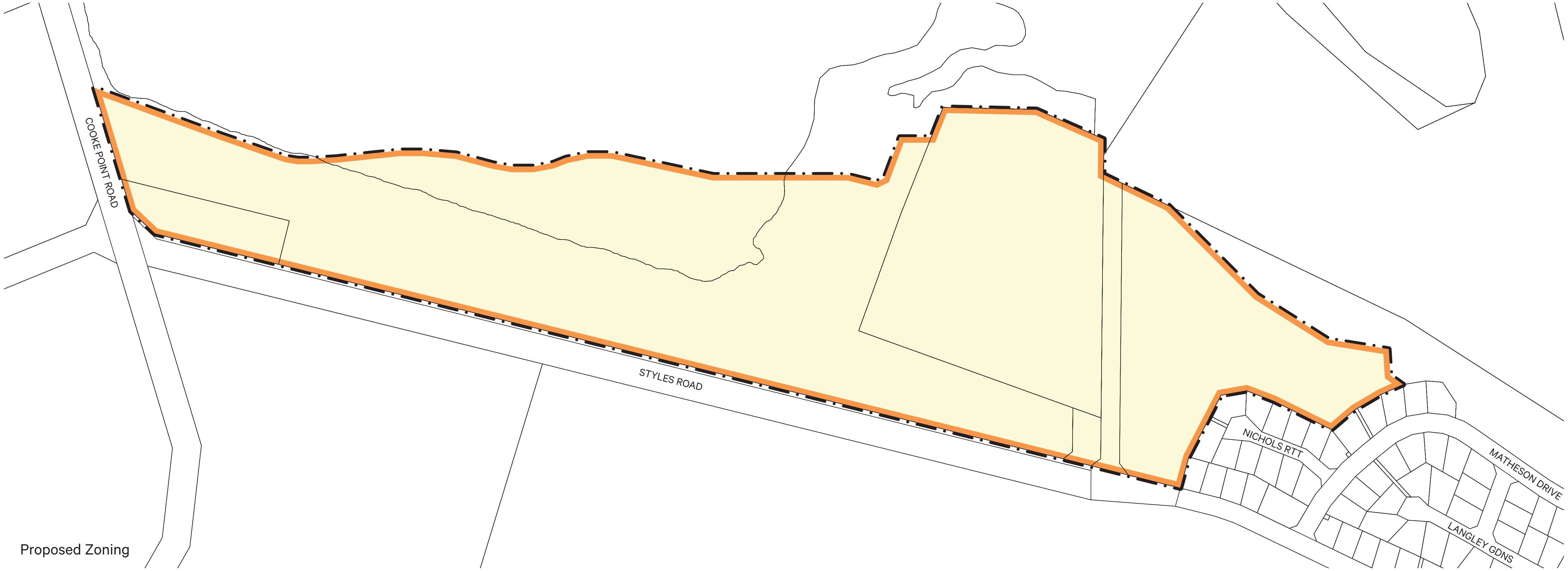
This report demonstrates the Amendment is consistent with the established planning framework. The Stables site is identified in the framework as a high amenity potential future urban development area, subject to the necessary technical investigations to determine the most appropriate design response to its site characteristics and surroundings.

The Stables site is regarded as a high amenity residential development site, forming the western extension of Pretty Pool. Although not a substantial greenfield development area, it will contribute towards providing sufficient land supply to accommodate housing for population growth in the future.

The proposal also responds to identified concerns regarding air quality and coastal hazard risk in Port Hedland's West End, which have resulted in an identified need to consolidate future growth in the East End.

It is expected that the modifications to Appendix 10 of TPS5 will ensure that the requirements for the various environment studies and management plans will be undertaken at the structure plan stage. The Amendment itself does not provide for the immediate opportunity to develop the site. Rather the Amendment will provide for further planning and investigations to be undertaken as part of the structure plan statutory approvals process.





Legend

Town of Port Hedland TPS5

Local Scheme Reserves

▨	District Road
▨	Parks and Recreation
E	Other Public Purposes: Energy
☐	Local Road

Local Scheme Zones

🟩	Rural
🟧	Residential
☐	Development Zone
🟥	Tourism

Other

— · —	Amendment Boundary
┆	R Codes
☐	Development Plan Areas
▼	Special Control Areas

Scheme Amendment Plan

Styles Road, Port Hedland

0 50 100m

Date: 12 May 2020 Scale: 1:5000@ A3 1:2500 @ A1 File: **20-213 SA-1** Staff: JP GW Checked: JP

Town of Port Hedland

Planning and Development Act 2005
RESOLUTION TO AMEND LOCAL PLANNING SCHEME

Town of Port Hedland
District Town Planning Scheme No. 5
Amendment No. 84

Resolved that the Local Government pursuant to section 75 of the *Planning and Development Act 2005*, amend the above Local Planning Scheme by:

1. Reclassifying Crown Reserve 31506 (Lot 5755) and portion of Reserve 29044 (Lot 300) Styles Road, Port Hedland and Johnson Lane (road reserve) from 'Other Public Purposes: Energy' and 'Parks and Recreation' to 'Urban Development'.

2. Rezoning Crown Reserve 30768 (Lot 5966), Crown Reserve 31462 (Lot 5770) and portion of Johnson Lane and portion of Reserve 30768 (Lot 556) and portion of Unallocated Crown Land Lot 340 Styles Road, Port Hedland from 'Rural' to 'Urban Development'.

3. Amending the Scheme Maps accordingly.

4. Amending Appendix 10 – Urban Development Additional Development Requirements as shown below:

No.	Description of Land	Conditions
Pretty Pool ~~2~~	~~Lots 1732, 1444 and Part Lot 552 Athol Street~~ Land bound by Gray Street, Wilson Street, Cooke Point Road, Athol Street and the Indian Ocean, excluding Pretty Pool Creek 1 Development Area	Subdivision and development of the land shall be in accordance with the requirements of Structure Plan(s) endorsed by the Western Australian Planning Commission, which shall address the following requirements: 1. Land identified in the Structure Plan(s) will be restricted to a built height limit that prevents light spill onto Cemetery Beach and Pretty Pool Beach and adjacent area. 2. The finished development level of all habitable use shall be a minimum of 6.7 metres Australian Height Datum. 3. Adequate coastal erosion and flood inundation protection and management measures approved by the Town of Port Hedland to comply with the Town of Port Hedland adopted Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) and provisions of the State Planning Policy No. 2.6 'State Coastal Planning Policy'. 4. Environmental Management Plans addressing the following shall be prepared, adopted and implemented to the satisfaction of the Town of Port Hedland on advice from the relevant State Government agency: a) Construction management b) Foreshore Management

		c) Mangrove Management d) Drainage and nutrient management e) Marine turtle management f) Acid Sulfate Soil management (if required) g) Other management plans as considered necessary on the advice from the relevant State Government agency.

FORM 6A

COUNCIL ADOPTION

This Standard Amendment was adopted by resolution of the Council of the Town of Port Hedland at the _______________ Meeting of the Council held on the ______ day of ____________________, 20_______.

………………………………

MAYOR/SHIRE PRESIDENT

………………………………

CHIEF EXECUTIVE OFFICER

COUNCIL RESOLUTION TO ADVERTISE

By resolution of the Council of the Town of Port Hedland at the ____________________ Meeting of the Council held on the _____________ day of ____________________, 20_______, proceed to advertise this Amendment.

………………………………

MAYOR/SHIRE PRESIDENT

………………………………

CHIEF EXECUTIVE OFFICER

COUNCIL RECOMMENDATION

This Amendment is recommended [for support/not to be supported] by resolution of the Council of the Town of Port Hedland at the ____________________ Meeting of the Council held on the _______ day of ____________________, 20_______ and the Common Seal of the Town of Port Hedland was hereunto affixed by the authority of a resolution of the Council in the presence of:

………………………………

MAYOR/SHIRE PRESIDENT

………………………………

CHIEF EXECUTIVE OFFICER

WAPC ENDORSEMENT (r.63)

…………………………………

DELEGATED UNDER S.16 OF

THE P & D ACT 2005

DATE …………………………..

APPROVAL GRANTED

………………………………...

MINISTER FOR PLANNING

DATE …………………………

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Appendix 1 – Environmental Assessment Report

ENVIRONMENTAL ASSESSMENT REPORT

The Stables development, East Port Hedland

EEL20043.002
Rev 2
12 June 2020

Document status

Version	Purpose of document	Authored by	Reviewed by	Approved by	Review date
Draft A	Draft for client review	GilGla	JohHal	NA	10/05/2015
Rev 0	Final for Issue	GilGla	JohHal	JohHal	27/05/2015
Rev 1	Final for Issue	JohHal	JohHal	JohHal	27/05/2020
Rev 2	Final for Issue	GilGla	JohHal	JohHal	11/06/2020

Approval for issue

J. Halleen 12 June 2020

This report was prepared by RPS within the terms of RPS' engagement with its client and in direct response to a scope of services. This report is supplied for the sole and specific purpose for use by RPS' client. The report does not account for any changes relating the subject matter of the report, or any legislative or regulatory changes that have occurred since the report was produced and that may affect the report. RPS does not accept any responsibility or liability for loss whatsoever to any third party caused by, related to or arising out of any use or reliance on the report.

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(compiled at rear of report)

Figures

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(compiled at rear of report)

Appendices

SUMMARY

The Town of Port Hedland (ToPH) in collaboration with DevelopmentWA proposes to develop a portion of Lot 300 on plan 53035, Lot 340 on plan 72895, Lot 556 on plan 74214, Lot 5755 Styles Road and 29 Johnson Lane in Port Hedland's East End (the site) for residential purposes. The site is known as 'the Stables development (Figure A).

The 28.6 hectares (ha) site is proposed to be rezoned to "Urban Development" under the ToPH's Town Planning Scheme (TPS) No. 5 to facilitate progressive structure planning, subdivision and development (Figure B).

TPS Amendment No. 77

Amendment No. 77 for the Stables development was previously assessed by the Environmental Protection Authority (EPA) in August 2015. The EPA assessed Amendment No. 77 as "Scheme Not Assessed: Advice Given (no appeals)" (Appendix A).

The EPA identified the following preliminary environmental factors relevant to Amendment No. 77:

- Heritage
- Terrestrial Environmental Quality
- Benthic Communities and Habitat
- Marine Fauna.

The EPA's advice and recommendations regarding the environmental factors included:

1. Heritage – The Department of Aboriginal Affairs should be consulted with respect to obligations under the *Aboriginal Heritage Act 1972*.
2. Terrestrial Environmental Quality – A Detailed Acid Sulfate Soils (ASS) Site Investigation and Management Plan should be prepared in accordance with the Department of Water and Environmental Regulation (DWER) ASS Guidelines Series and to the satisfaction of the DWER Contaminated Sites Branch.
3. Benthic Communities and Habitat – The EPA notes that the scheme amendment's northern boundary is set back from the Pretty Pool Creek mangroves and development will be separated from the mangroves by a bund and roadway. Therefore, development within the Amendment Area will not directly impact the existing mangroves. The EPA supports the proposed scheme text which requires that a Mangrove Management Plan and Construction Management Plan be prepared to the satisfaction of the ToPH on advice from the relevant state government agencies.
4. Marine fauna – Development within the scheme amendment area will be limited to single story buildings. Line of site modelling demonstrates that buildings and associated infrastructure such as streetlights within the scheme amendment area will not be visible from Pretty Pool Beach or Cemetery Beach. Therefore, providing there are adequate controls to ensure building heights do not exceed these limits, there should be no direct line of site light impacts on Pretty Pool Beach and Cemetery Beach. The EPA supports the proposed scheme text that a management plan to minimise impacts to marine turtles be prepared and implemented to the satisfaction of the ToPH on advice from the relevant state government agencies.

Coastal hazard consideration

In May 2017, the Western Australian Planning Commission (WAPC) and the Minister for Planning refused to grant approval to Amendment No. 77 for the following reasons:

1. The amendment does not address the preferential policy measure of avoiding the placement of new development within an area identified to be affected by coastal hazards.
2. Coastal hazard risk management and adaptation planning has not yet been undertaken to support the development and coastal protection works contemplated by the amendment report.

3. The amendment does not address the requirement for coastal protection works to be evaluated at a sediment cell level and to take into consideration the future protection requirements of adjoining landholdings.

In 2018, the ToPH prepared a Port Hedland Townsite Coastal Hazard Risk Management and Adaptation Plan (CHRMAP; GHD 2019) consistent with the WAPC's State Planning Policy (SPP) No. 2.6: State Coastal Planning Policy. The CHRMAP (GHD 2019) included an assessment of the Stables and Athol Street sites, both of which are located adjacent to Pretty Pool Creek. The CHRMAP (GHD 2019) was formally adopted by the ToPH and the WAPC post public consultation in 2019.

Stables development description

The Stables development provides several local and regional benefits including:

- Provision of high-quality residential land for sale within the Port Hedland's East End, noting there are approximately 900 residents living in Port Hedland's West End, the most dust, noise and hazard affected urban area in Port Hedland. In response the WAPC enacted Improvement Plan No. 50 to implement the government response to the Port Hedland Dust Management Taskforce Report and prohibit sensitive land uses and restrict population growth in the west end of Port Hedland
- Demonstration of alternative housing development in Port Hedland's East End
- Meet the planning objectives of the Pilbara's Port City Growth Plan (ToPH 2011), and Pilbara Cities goal, to build the residential population of Port Hedland to transform the regional centre into a city of 50,000 people by 2031.

Concurrently with the proposed TPS Amendment, the ToPH and DevelopmentWA are preparing a structure plan for the Stables development which reflects the outcomes of coastal hazard risk management and adaptation planning undertaken by the ToPH. The structure plan will be a variation on the 2015 three concept plan options prepared to support Amendment No. 77 (Figure C). The 2015 indicative development concept plans demonstrate that the Pretty Pool Creek mangroves will not be directly impacted by the development of the site. It is anticipated that the structure plan development footprint will be smaller in spatial extent when compared to the 2015 indicative development concept plans to account for the revised coastal hazard risk profile.

The final development area will be confirmed through the structure plan process in consultation with the ToPH and the Department of Planning, Lands and Heritage (DPLH) and in compliance with the CHRMAP (GHD 2019) and SPP 2.6: State Costal Planning Policy.

The key characteristics of the Stables development are presented in Table 1.

Table 1: Key characteristics of the Stables development

Aspect	Proposal
Project location	Portion of Lot 300 on plan 53035, Lot 556 on plan 74214, Lot 340 on plan 72895, Lot 5755 Styles Road and 29 Johnson Lane.
Project time frame	Re-zoning 2020, Structure Plan 2020/21, Subdivision approval 2025/30.
TPS amendment boundary	28.6 ha
Indicative development boundary (within TPS amendment boundary)	27.2 ha indicative development boundary will likely be reduced as part of the site's concurrent structure planning process
Potential clearing of vegetation	• Up to 11.8 ha coastal dune vegetation • Up to 10.2 ha of bare mud and samphire flats. The potential clearing area will likely be reduced as part of the site's concurrent structure planning process
Average separation distance of the TPS amendment boundary to the Pretty Pool Creek mangroves	25 metres (m)
Service infrastructure	Water supply, electricity, sewerage and telecommunications

Stakeholder engagement

To inform preliminary planning of the site, and the production of the 2015 and 2020 indicative development concept plans, DevelopmentWA has consulted extensively with the key local stakeholders and the broader Port Hedland community.

Table 2 identifies the key stakeholders consulted and provides a summary their primary concerns with the proposed development (if any were raised).

Table 2: Stakeholder engagement

Key stakeholder	Timing	Engagement method	Environmental issues raised
ToPH (executive and councillors).	26 February 2014	Presentation	Nil
Port Hedland Turf Club (Arnold Carter).	24 April 2014	On-one-one meeting	On-site geotechnical work occurring near the existing horse stables while the racehorses are being kept there.
ToPH (Pilbara Port City Working Group).	05 May 2014 and 21 July 2014	Presentation	Nil
Port Hedland Pony Club.	08 May 2014	Meeting	Nil
ToPH Mayor Kelly Howlett.	18 August 2014	On-one-one meeting	Drainage management
Port Hedland Pony Club (Camile Mathews).	10 September 2014	On-one-one meeting	Use of the site by horses during geotechnical investigation.
BHP Billiton (Corporate Affairs Manager, Chris Cottier).	06 February 2015	On-one-one meeting	Nil
Care for Hedland Environment Association (CHEA) (Program Coordinator, Bridget Poulton).	12 February 2015	On-one-one meeting	Nil
ToPH (Acting Director, Planning and Community Development, Chris Linnell and Manager of Economic Development, David Westbury).	20 February 2015	On-one-one meeting	Nil
Port Hedland Pony Club (Camile Mathews).	03 March 2015	On-one-one meeting	Nil.
Care for Hedland Environment Association (CHEA) (Program Coordinator, Bridget Poulton; ToPH Mayor Kelly Howlett; and CHEA members).	23 April 2015	Presentation	Letter received from CHEA post the presentation outlining the following issues: • Landscaping of Public Open Space with fruit trees and community gardens. • Drainage management. • Aboriginal heritage. • Direct light impacts to turtles on Pretty Pool Beach. • Need for environmental education.
ToPH TPS Amendment No. 77	24 June 2015	ToPH council decision	The ToPH supported the rezoning the land generally bound by Styles Road, Pretty Pool Creek, Cooke Point Drive and existing single residential housing in the Pretty Pool Residential area from 'Parks and Recreation', `Rural' and 'Other Public Purpose — Energy' to 'Urban Development
ToPH / DevelopmentWA engage with DPLH on the Stables project	April / May 2020	Meeting	Review of the proposed Stables amendment, the CHRMAP (GHD 2019) and Cardno modelling for the amendment

Purpose of the environmental assessment report

RPS Australia West Pty Ltd (RPS) has been commissioned to provide this Environment Assessment Report (EAR) to support the proposed TPS amendment. The TPS amendment boundary is the same amendment boundary as assessed by the EPA in 2015 for Amendment No. 77. The TPS amendment boundary and the indicative development boundary have been guided by project specific technical investigations, particularly regarding impacts to the Pretty Pool Creek mangroves (Cardno (2015), Appendix B, Cardno (2020), Appendix C), which underpin this current environmental assessment.

Specifically, the purpose of this EAR is to identify the relevant environmental factors; potential environmental impacts; outline the studies undertaken by the proponent to address these factors; and propose potential management measures.

This EAR:

- Describes the background to the proposed rezoning of the site
- Provides an overview of the proposal and describes the regional and local setting of the site
- Presents environmental factors considered relevant to site; potential environmental impacts and proposes management measures
- Supports the planning and environmental assessment of the proposed rezoning of the site.

Key studies

The following key environmental investigations identified the environmental factors and defined the TPS amendment boundary as assessed by the EPA in 2015 for Amendment No. 77:

- Review of the potential impacts to the Pretty Pool mangroves based on the hydrodynamic modelling (Cardno 2015; Appendix B)
- Review of the potential erosion impacts from coastal processes over a 100-year planning timeframe (Cardno 2015; Appendix B)
- Site survey with mangrove and mudflat vegetation mapping by RPS botanist in 2010
- Level 1 Flora and Vegetation Assessment of Lot 300 on Plan 53035 (RPS 2013a)
- Survey of waterbirds in the Pretty Pool Creek area (Bamford 2012; Appendix D)
- Preliminary Noise Impact Assessment (Herring Storer Acoustic 2011)
- Local Water Management Strategy, Stage 3 (The Stables) East Port Hedland (Cardno 2015; Appendix B)
- Review of state and Commonwealth ecological databases
- Review of key Port Hedland specific reports including:
  - Port Hedland Air Quality and Noise Management Plan: The Port Hedland Dust Management Taskforce Report (Department of State Development 2010)
  - Proposed Outer Harbour Development, Port Hedland: Public Environmental Review / Draft Environmental Impact Statement (BHP 2011)
  - Port Hedland Coastal Vulnerability Study (Cardno 2011)
- Undertaking a preliminary environmental assessment of the East Port Hedland area (RPS 2011) to identify areas of land (precincts) which are less constrained by environmental factors. RPS (2011) identified the Stables site was significantly less constrained than other areas in the East Port Hedland area.

The following additional key environmental investigations and government technical reports, which relate to coastal hazard risk management, marine turtles, terrestrial fauna, air quality, noise and bushfire, have been undertaken to provide contemporary information relevant to the proposed TPS amendment:

- Port Hedland Townsite CHRMAP (GHD 2019)

- Coastal Hydrological Review (Cardno 2020; Appendix C)
- A decade of monitoring Flatback turtles in Port Hedland, Western Australia, 2004/05 – 2013/14 (Imbricata Environmental 2016)
- Recovery Plan for Marine Turtles in Australia (Department of the Environment and Energy (Department of the Environment and Energy (DEE) 2017
- National Light Pollution Guidelines for Wildlife including marine turtles, seabirds and migratory shorebirds (DEE 2020)
- Review of state and Commonwealth ecological databases (Appendix E)
- Review of key Port Hedland specific reports including:
    a. Port Hedland Air Quality Health Risk Assessment for Particulate Matter (Department of Health (DoH) 2016)
    b. Managing Dust in Port Hedland, Industry Regulation Fact Sheet (DoH 2018)
    c. Port Hedland West End Improvement Scheme No. 1, Scheme Report (WAPC 2020)
- Noise Impact Assessment (Herring Storer Acoustic 2020; this report is included as an appendix in the Scheme Amendment report)
- Bushfire Management Plan (Bushfire Prone Planning 2020; this report is included as an appendix in the Scheme Amendment report)

The Stables development

The project specific technical investigations, in particular the mangrove and potential erosion impacts assessments (Cardno 2015, Appendix B), defined the spatial extent of the TPS amendment boundary to ensure the Pretty Pool mangrove system, and the broader Pretty Pool Creek environment, would not be directly impacted.

The TPS amendment boundary includes a tapered engineering bund / infrastructure to protect future residents of the development from storm surge and flooding. The indicative development boundary is slightly set back from the TPS amendment boundary to allow for installation of the bund / infrastructure to be installed, as close to Pretty Pool Creek as allowable, without directly impacting the mangrove community (Figure C). The development area and interface treatments with Pretty Pool Creek will be subject to further coastal processes assessment, consistent with the CHRMAP (GHD 2019), as part of the structure plan assessment and approval.

Key environmental factors

This EAR addresses the following environmental factors that need to be considered in accordance with the EPA's Statement of Environmental Principles, Factors and Objectives (EPA 2020):

- Sea factors
    - Benthic Communities and Habitats
    - Coastal Processes
    - Marine Environmental Quality
    - Marine Fauna
- Land factors
    - Flora and Vegetation
    - Terrestrial Environmental Quality
    - Terrestrial Fauna
- Water factor
    - Inland waters

- Air factor
  - Air Quality
- People factor
  - Social surroundings

Each of the environmental factors have been assessed to identify the potential impact of the proposed TPS amendment and to determine management measures to minimise these impacts.

Key environmental impacts assessed

Fatal flaw assessment based upon mangrove assessment

The potential hydrological impacts to the Pretty Pool mangroves assessment from the TPS amendment boundary, which extended to the fringe of the existing mangrove area, included an assessment of the combined potential impact of site in conjunction with the planned development of the Athol Street site (Cardno (2015), Appendix B; Cardno (2020), Appendix C). The modelling and impact matrix concluded there would be no direct losses or impacts to the existing mangroves as a result of the proposed development area (Table 6). The TPS amendment boundary allows an average separation distance of approximately 25 m from the development site to the Pretty Pool Creek mangroves.

Waterbird report

Dr Mike Bamford has undertaken waterbird surveys in the Pretty Pool area, and surrounding areas in Port Hedland, for DevelopmentWA's Pretty Pool Development from 2008 to 2011 (Bamford 2012; Appendix D).

In a regional context the numbers of most bird species using Pretty Pool area is low, but the tidal flats in Pretty Pool and Four Mile Creek Bays support moderate numbers of foraging birds. Specifically, Pretty Pool Creek recorded lower numbers of conservation significant bird species and has lower species diversity when compared to key sites around Port Hedland (Pretty Pool Bay and Cemetery / Town Beach). This comparison indicates that Pretty Pool Creek is of lower significance as habitat for conservation significant waterbird species than the other identified areas around Port Hedland.

The former Port Hedland wastewater treatment plant did seasonally attract larger numbers of waterbirds. The wastewater treatment plan was closed in 2019 with new facilities constructed in South Hedland. It is unknown if the waterbirds are using the South Hedland wastewater treatment plant or have transitioned in the surrounding local areas around Port Hedland.

Local Water Management Strategy

The Local Water Management Strategy (LWMS) for site outlines the key water servicing, drainage and environmental management considerations to be progressed in support of subsequent development design and planning approval phases (Cardno (2015), Appendix B; Cardno (2020), Appendix C).

Key water management outcomes from the LWMS include:

- First 15 millimetres (mm) of rainfall on lots to be detained within lots through soakwells or rainwater tanks
- First 15 mm of rainfall from the road reserve to be detained in a swale located on the northern boundary of the site
- All additional rainfall to be conveyed northward to Pretty Pool Creek via the road reserves and swale
- Swale to discharge any rainfall events greater than 15 mm to Pretty Pool Creek, which is consistent with the conveyance of stormwater from the surrounding residential development along Athol Street and Cooke Point
- Final finished floor level for residential development of 6.7m Australian Height Datum (m AHD) consistent with the findings of CHRMAP (GHD 2019), Cardno (2020) (Appendix C) and SPP 2.6.

Noise assessment

A 2011 preliminary noise impact assessment was undertaken for the East Port Hedland area by Herring Storer to determine the extent to which potential acoustic impacts received from vehicles on Wilson Street, passing trains and the salt harvesters could constrain development in the area. Herring Storer in June 2020 updated their noise impact assessment to support the TPS amendment and structure plan and finalise any future noise management requirements.

The Herring Storer noise impact assessment indicates the Stables site can meet the SPP 5.4: Road and Rail Transport Noise and Freight Considerations in Land Use Planning (WAPC 2019) criteria for residential development. To comply with the noise requirements of the SPP 5.4: Road and Rail Transportation Noise and Freight Consideration in Land Use Planning the following noise amelioration measures for the Stables development can be incorporated in future subdivision designs:

- Noise bund located between railway and Wilson Street
- Noise bund located at boundary of development.

Environmental management

This EAR has made specific commitments about the planning, construction, and ongoing operation of the Stables development. These management actions are summarised in Table 3 and the management framework which identifies the stage in the planning process that management actions will be implemented is displayed in Figure 1.

Since the EPA’s assessment of Amendment No. 77, the Commonwealth has released the National Light Pollution Guidelines for Wildlife (DEE 2020). In this context, the approach to the reduction of artificial light impacts from the Stables development will be consistent with the best practice lighting design principles identified in the National Light Pollution Guidelines for Wildlife (DEE 2020). The implementation of the National Light Pollution Guidelines for Wildlife (DEE 2020) best practice lighting design principles provide a contemporary framework to address the four key principles for lighting management identified in the EPA’s Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts (EPA 2010).

By applying the principles of environmental protection at the design phase, measures have been identified to minimise and avoid the direct impacts on mangroves, flatback turtles, terrestrial flora and fauna and impacts to Pretty Pool Creek ecology.

Conclusion

The ToPH in collaboration with DPLH has prepared and approved a CHRMAP (GHD 2019). Further, Cardno for the TPS amendment and the structure plan has undertaken an updated Stables site specific coastal modelling and mangrove assessment to ensure consistency with the CHRMAP (GHD 2019) and to define the development area and interface options with Pretty Pool Creek (Cardno 2020; Appendix C).

On the scientific evidence provided, particularly the outcomes of the mangrove and potential erosion impacts assessments (Cardno (2015), Appendix B; Cardno (2020), Appendix C), it is considered there are no significant environmental impacts identified by this assessment which would preclude the development of the site. Further, there has been no substantial changes to the Stables existing environment and the key environmental factors since the 2015 EPA assessment of Scheme Amendment No. 77.

Finally, it is anticipated through the concurrent structure plan design process the development area will be reduced from the TPS amendment boundary and the area previous illustrated in the 2015 indicative development concept plans (Figure C).

Table 3: Summary of the relevant environmental factors and management measures

Environmental factor	Objective	Applicable legislation and/or guidance	Potential impacts	Potential management measures
Sea				
Benthic Communities and Habitats	To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained	• Environmental Factor Guideline: Benthic Communities and Habitats (EPA 2016a) • Technical Guidance: Protection of Benthic Communities and Habitats (EPA 2016b)	• Loss of approximately 10.2 ha of intertidal mud and samphire flats • Halo effect due to either sediment scour or smothering around development boundary due to changes in the local wave conditions. • Water quality changes during construction (turbidity) or due to reduced flushing could potentially cause losses. • Indirect impacts to mangrove and samphire vegetation through reduced water quality from developmental run-off.	• Mangrove Management Plan (MMP) and Construction Management Plan (CMP) to be prepared to the satisfaction of the ToPH and the Department of Biodiversity, Conservation and Attractions (DBCA) at subdivision. The MMP will include: – Aerial photography and field surveys will be used to map the distribution and coverage of mangrove vegetation associations. – Mangrove health surveys will be undertaken in an effort to ensure that any negative impacts are detected as soon as possible. Mangrove health monitoring would consist of regular visual assessments to determine mangrove condition. – Mangrove monitoring sites will be established prior to the commencement of construction activities. • During the construction phase a CMP will be required which will address the following management and mitigation measures: – Ensuring no mangroves are cleared within the TPS amendment boundary through access restrictions – Minimising areas to be cleared within the TPS amendment boundary – Restrict access to areas outside of outside of the TPS amendment boundary – Identify and manage potential impacts to the environment surrounding the TPS amendment boundary prior to ground disturbing activities – Dust management – Noise management – Fauna management.
Coastal Processes	To maintain the geophysical processes that shape coastal morphology so that environmental values of the coast are protected	• Environmental Factor Guideline: Coastal Processes (EPA 2016c) • SPP 2.6: State Coastal Planning Policy • Port Hedland Townsite CHRMAP, Coastal Hazard Risk Management and Adaptation Plan (GHD 2019)	• Flooding and erosion of the shoreline as a result of tidal movement, storm surge, wave action, near shore currents and changes in water level. • Altering the natural patterns of sediment movement resulting from the installation of artificial structures associated with the development. • Altering the available area for potential mangrove migration or recruitment.	• Final finished floor level for residential development of 6.7 m AHD consistent with the findings of the updated Cardno coastal assessment (2020), the CHRMAP (GHD 2019) and SPP 2.6. • The proposed interface treatments with Pretty Pool Creek will be subject to further coastal modelling and processes assessment based upon the structure plan design to ensure compliance with the CHRMAP (GHD 2019) and SPP 2.6. • A Foreshore Management Plan to be undertaken at subdivision to appropriately manage access to Pretty Pool Creek, activities and conserve creek foreshore vegetation. FMP will be prepared to the satisfaction of the ToPH and the DPLH at subdivision.
Marine Environmental Quality	To maintain the quality of water, sediment and biota so that environmental values are protected	• Environmental Factor Guideline: Marine Environmental Quality (EPA 2016d) • Technical Guidance: Protecting the Quality of Western Australia's Marine Environment (EPA 2016e) • Guidance Statement for Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline (EPA 2000) • Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment Conservation Council and Agricultural and Resource Management Council of Australia and New Zealand. 2000). • Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives (Department of the Environment 2006) • Better Urban Water Management (WAPC 2008).	Altering the hydrodynamics of the creek (development fill) may interrupt and alter local water circulation within the near shore areas of the Pretty Pool Creek which may reduce water quality.	• Stormwater and drainage generated within the site will be managed in accordance with Better Urban Water Management (WAPC 2008) framework. The Local Water Management Strategy (LWMS) for site outlines the key water servicing, drainage and environmental management considerations to be progressed in support of subsequent development design and planning approval phases • Key water management outcomes from the LWMS include: – First 15 mm of rainfall on lots to be detained within lots through soak wells or rainwater tanks – First 15mm of rainfall from the road reserve to be detained in a swale located on the northern boundary of the site – All additional rainfall to be conveyed northward to Pretty Pool Creek via the road reserves and swale – Swale to discharge any rainfall events greater than 15 mm to Pretty Pool Creek, which is consistent with the conveyance of stormwater from the surrounding residential development along Athol Street and Cooke Point – Final finished floor level for residential development of 6.7 m AHD consistent with the CHRMAP (GHD 2019) and SPP 2.6. • LWMS will be updated to accord with the structure plan design • Urban Water Management Plan(s) will be finalised to the satisfaction of the ToPH and DWER at subdivision.

Environmental factor	**Objective**	**Applicable legislation and/or guidance**	**Potential impacts**	**Potential management measures**
Marine Fauna	To protect marine fauna so that biological diversity and ecological integrity are maintained	• *Environment Protection and Biodiversity Conservation Act 1999* • *Biodiversity Conservation Act 2016* • Environmental Factor Guideline: Marine Fauna (EPA 2016f) • Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts (EPA 2010) • National Light Pollution Guidelines for Wildlife including marine turtles, seabirds and migratory shorebirds (DEE 2020)	• Increased lighting from proposed development may potentially disrupt nesting and behaviour of nestling and adult turtles. • An increased residential population also has the potential to impact marine turtle nesting and hatchling behaviour, through the use of recreation vehicles, pets and interaction with nesting turtles	• At its closet point the site is located approximately 530 m from the closest turtle-nesting beach – Pretty Pool. Line of site analysis using Lidar topography illustrated TPS amendment boundary is protected from light spill by the primary dunes at Pretty Pool Beach. • The proposed development of the site will be restricted through building control provisions to single storey residences and streetlights to ensure that no artificial light sources from the development (i.e. streetlights and houses) will be directly visible to either adult females nesting or departing hatching turtles at Cemetery Beach. • To minimise the potential for the Stables development to cumulatively add to the existing skyglow levels the development's lighting will be designed to accord with the National Light Pollution Guidelines (DEE 2020), and the EPA's Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts (EPA 2010), while meeting legislative and regulatory requirements for human safety. • This will be achieved through the preparation of an Artificial Light Management Plan, inclusive of biological and artificial light monitoring and auditing requirements, which addresses the best practice lighting design principles identified in the National Light Pollution Guidelines (DEE 2020): – Start with natural darkness and only add light for specific purposes. – Use adaptive light controls to manage light timing, intensity and colour. – Light only the object or area intended – keep lights close to the ground, directed and shielded to avoid light spill. – Use the lowest intensity lighting appropriate for the task. – Use non-reflective, dark-coloured surfaces. – Use lights with reduced or filtered blue, violet and ultra-violet wavelengths • The Artificial Light Management Plan will be prepared to the satisfaction of the ToPH on advice from the DBCA at subdivision. • CMP to include provisions restricting construction to day light hours only during turtle nesting and hatching season to avoid potential artificial light impacts to marine turtles during construction and development • A Marine Turtle Management Plan will be prepared to minimise potential impacts, including through the use of recreation vehicles, pets and interaction with nesting turtles, to marine turtles from an increased residential population. The Marine Turtle Management Plan will be prepared to the satisfaction of the ToPH on advice from the DBCA at subdivision
Land				
Flora and Vegetation	To protect flora and vegetation so that biological diversity and ecological integrity are maintained	• *Environment Protection and Biodiversity Conservation Act 1999* • *Biodiversity Conservation Act 2016* • Environmental Factor Guideline: Flora and Vegetation (EPA 2016g) • Technical Guidance: Flora and Vegetation surveys for Environmental Impact Assessment (EPA 2016h)	• Loss of up to up to 11.8 ha coastal dune vegetation • Loss of up to 10 *Gomphrena pusilla* (P2) plants • Introduction and distribution of weed species. • Hydrological changes. • Vegetation disturbance/loss as a result of construction works, and increased use of off-road vehicles. • Vegetation quality degradation through increased pollution and waste.	MMP, CMP and FMP to be prepared to the satisfaction of the ToPH and the DBCA at subdivision.
Terrestrial Environmental Quality	To maintain the quality of land and soils so that the environment values are protected	**Acid Sulphate Soils**		
		• Environmental Factor Guideline: Terrestrial Environmental Quality (EPA 2016i) • Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes (Department of Environment Regulation (DER) 2015a) • Treatment and Management of Soils and Water in Acid Sulfate Soil Landscapes (DER) 2015b)	• Acidification and release of heavy metals from ASS into groundwater, surrounding marine environment. • Corrosion of concrete structures such as bridges, piles, pylons, drainage pipes.	• Undertake a preliminary ASS site investigation in accordance with the ASS guidelines. • An ASS and Dewatering Management Plan will be prepared, if required, to the satisfaction of the Department of Water and Environmental Regulation (DWER) at subdivision.
		Potential Contamination		
		• *Contaminated Sites Act 2003* • Environmental Factor Guideline: Terrestrial Environmental Quality (EPA 2016i) • Assessment and Management of Contaminated Sites (DER 2014)	Potential for risk to human health from demolition of buildings that may be constructed from asbestos containing materials.	Hazardous materials assessment will be undertaken prior to demolition of the infrastructure on 29 Johnson Lane, Port Hedland to any identify potential contaminants.

Environmental factor	Objective	Applicable legislation and/or guidance	Potential impacts	Potential management measures
Terrestrial Fauna	To protect terrestrial fauna so that biological diversity and ecological integrity are maintained	• *Environment Protection and Biodiversity Conservation Act 1999* • *Biodiversity Conservation Act 2016* • Environmental Factor Guideline: Terrestrial Fauna (EPA 2016j) • Technical Guidance: Terrestrial Fauna Surveys (EPA 2004a)	• Habitat disturbance as a result of construction, and increased use of off-road vehicles • Impact on migratory bird species through loss of habitat • As a result of disturbance during construction (noise and clearing activities), there may be an effect on the local abundance of fauna populations due to interruption to fauna behaviour, including displacement, injury or death. • Inadvertent injury and/or mortality as a result of increased vehicle strikes from increased traffic. • Impacts on significant fauna species. • Habitat destruction from increased activity from domestic pets. • Habitat and food source degradation through increased pollution and waste.	• Avoid clearing of rocky/boulder habitat that may contain micro-habitat suitable for refuge for some small terrestrial mammal species. • The Pretty Pool Creek line will be avoided. • Maintain equipment such that all noise emitting equipment is fully serviceable and working to the correct specifications. All construction movement will be scheduled to take place during the day • MMP, CMP and FMP to be prepared to the satisfaction of the ToPH and the DBCA at subdivision • FMP will also address a community education program including: – installation of signs and educational material to inform the public of the local fauna and important habitats that people should avoid – encourage the community to use dog leads and discourage people to allow dogs to roam off-leash – discourage littering and pollution through educational material and fines.
Air				
Air Quality	To maintain air quality and minimise emissions so that environmental values are protected	• Environmental Factor Guideline: Air Quality (EPA 2020b) • Port Hedland Air Quality Health Risk Assessment for Particulate Matter (Department of Health (DoH) 2016) • Managing Dust in Port Hedland, Industry Regulation Fact Sheet (DoH 2018) • Guideline for Managing the Impacts of Dust and Associated Contaminants from Land Development Sites, Contaminated Sites Remediation and Other Related Activities (Department of Environment and Conservation (DEC) 2011)	• In 2009, the EPA expressed concern that 24 hour PM10 dust concentrations regularly exceeded the air National Environmental Protection Measure (air NEPM) of 50 µg/m3 (+ 5 exceedances for natural events) and that existing planning arrangements allowed for residential development in the West End. • Air Quality could be potentially impacted, either directly or indirectly, through the generation of fugitive dust emissions through the following construction activities: – Clearing land for the development sites, public open space, roads and carpark – wind-borne dust from exposed surfaces, earth moving, transport, stockpiling or loading of materials	• Dust management at the site shall comply with Guidelines for Managing the Impacts of Dust and Associated Contaminants from Land Development Sites, Contaminated Sites Remediation and Other Related Activities (DEC 2011) through the preparation and implementation of a Dust Management Plan to prevent or avoid excessive dust generation. The Dust Management Plan will address the following wetting procedures of the development work area will be undertaken: – any dry engineering fill sand to be stockpiled will be actively wet down during active extraction – water carts will be available near the site entrance to enable pre-wetting of access roads and areas of the site where vehicle movements are anticipated will be carried out. • Dust Management Plan to be prepared to the satisfaction of the ToPH and DWER at subdivision • Prior to commencement of any construction, wind fencing will be installed on the boundaries of the site if required • Should high wind speeds be forecast, site activities will be reviewed as deemed appropriate.
People				
Social Surroundings	To protect social surroundings from significant harm	**Aboriginal culture and heritage**		
		• *Aboriginal Heritage Act 1972* • Environmental Factor Guideline: Social Surroundings (EPA 2016k) • Guidance for the Assessment of Environmental Factors: Assessment of Aboriginal Heritage (EPA 2004b).	Excavation / construction activities may unearth and/or damage artefacts or other items of cultural Aboriginal significance.	• Cultural Significance Assessment to be undertaken at subdivision • Approval to disturb the Aboriginal archaeological site under Section 18 of the *Aboriginal Heritage Act 1972* (if required) prior to ground disturbing activities • Should any Aboriginal objects be identified or unearthed during development, works will be stopped and the findings reported to the DPLH
		Amenity		
		• *Health Act 1911* • Environmental Factor Guideline: Social Surroundings (EPA 2016k) • Environmental Guidance for Planning and Development (EPA 2008)	The partial infilling of the Pretty Pool Creek flood plain may result in increased areas of standing water following rainfall and periods of higher tides which may have the potential to serve as mosquito breeding areas. Health and amenity issues could affect visitors and residents living adjacent to the water body if mosquito breeding occurs in large numbers.	• Mosquito monitoring program to be prepared to the satisfaction of the ToPH at subdivision. • If mosquito numbers are found to be excessive, a Mosquito Management Plan will be prepared in consultation with the ToPH and the Department of Health and implemented.
		Bushfire		
		• *Fire and Emergency Services Act 1998* • Environmental Factor Guideline Social Surroundings (EPA 2016k) • SPP 3.7: Planning in Bushfire Prone Areas • Guideline for Planning in Bushfire Prone Areas, Version 1.3 (DPLH and Department of Fire and Emergency Services 2017)	• Damage to people, property and infrastructure from fire • Death and/or injury due to fire	• Bushfire Management Plan has been prepared to provide the bushfire management framework proposed to be actioned as part of developing the site in accordance with the structure plan • Bushfire Attack Level contour mapping within the Bushfire Management Plan will be updated (if required) to reflect the proposed structure plan and subdivision outcomes

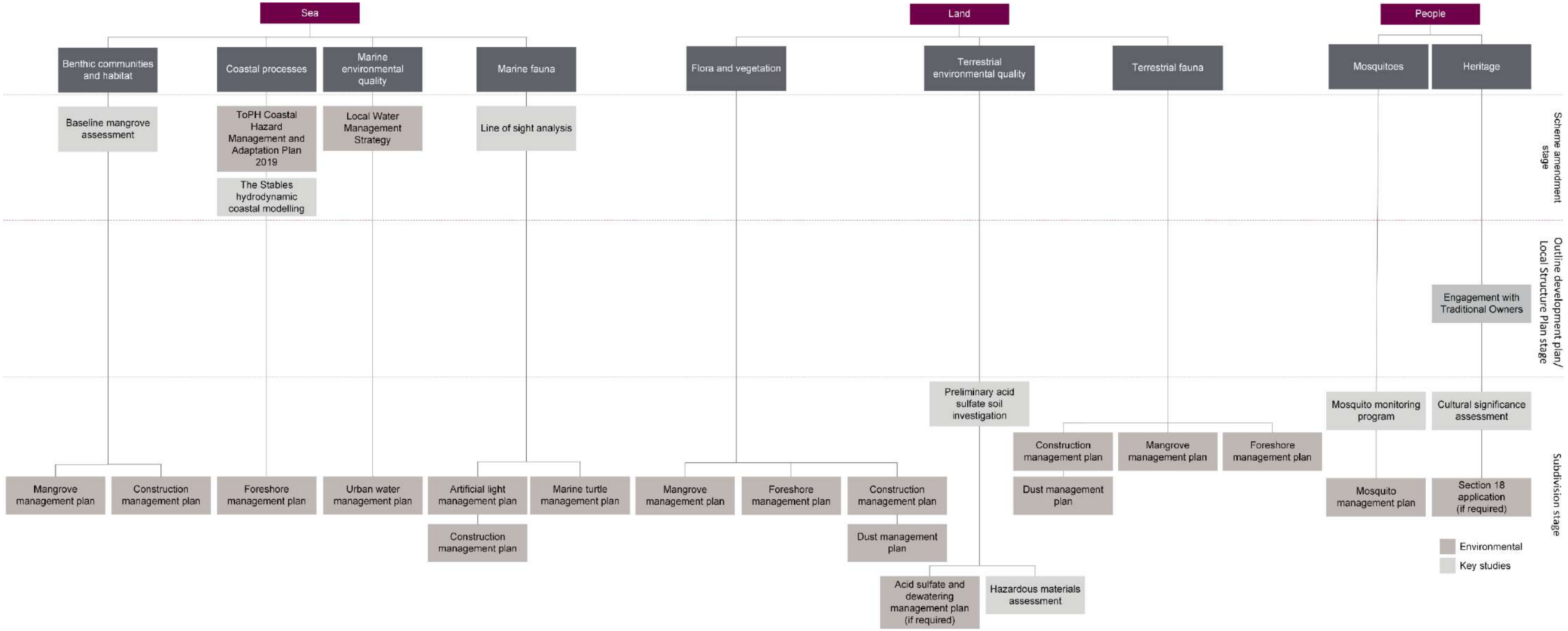

Figure 1: The Stables development TPS Amendment management framework

- Undertaking a preliminary environmental assessment of the East Port Hedland area (RPS 2011) to identify areas of land (precincts) which are less constrained by environmental factors. RPS (2011) identified the Stables site was significantly less constrained than other areas in the East Port Hedland area.

The following additional key environmental investigations and government technical reports, which relate to coastal hazard risk management, marine turtles, terrestrial fauna, air quality, noise and bushfire, have been undertaken to provide contemporary information relevant to the proposed TPS amendment:

- Port Hedland Townsite CHRMAP (GHD 2019)
- Coastal Hydrological Review (Cardno 2020; Appendix C)
- A decade of monitoring Flatback turtles in Port Hedland, Western Australia, 2004/05 – 2013/14 (Imbricata Environmental 2016)
- Recovery Plan for Marine Turtles in Australia (Department of the Environment and Energy (Department of the Environment and Energy (DEE) 2017
- National Light Pollution Guidelines for Wildlife including marine turtles, seabirds and migratory shorebirds (DEE 2020)
- Review of state and Commonwealth ecological databases (Appendix E)
- Review of key Port Hedland specific reports including:
  a. Port Hedland Air Quality Health Risk Assessment for Particulate Matter (Department of Health (DoH) 2016)
  b. Managing Dust in Port Hedland, Industry Regulation Fact Sheet (DoH 2018)
  c. Port Hedland West End Improvement Scheme No. 1, Scheme Report (WAPC 2020)
- Noise Impact Assessment (Herring Storer Acoustic 2020; this is included as an appendix in the Scheme Amendment report)
- Bushfire Management Plan (Bushfire Prone Planning 2020; this is included as an appendix in the Scheme Amendment report).

1.3 Identified key environmental factors

This EAR addresses the following environmental factors that need to be considered in accordance with the EPA's Statement of Environmental Principles, Factors and Objectives (EPA 2020):

- Sea factors
  - Benthic Communities and Habitats
  - Coastal Processes
  - Marine Environmental Quality
  - Marine Fauna
- Land factors
  - Flora and Vegetation
  - Terrestrial Environmental Quality
  - Terrestrial Fauna
- Water factor
  - Inland waters
- Air factor
  - Air Quality
- People factor
  - Social surroundings

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- Land factors
    - Flora and Vegetation
    - Terrestrial Environmental Quality
    - Terrestrial Fauna
- Water factor
    - Inland waters
- Air factor
    - Air Quality
- People factor
    - Social surroundings

Each of the environmental factors have been assessed to identify the potential impact of the proposed TPS amendment and to determine management measures to minimise these impacts.

1.4 Amendment No. 77 assessment

Amendment No. 77 for the Stables development was previously assessed by the Environmental Protection Authority (EPA) in August 2015. The EPA assessed Amendment No. 77 as “Scheme Not Assessed: Advice Given (no appeals)” (Appendix A).

The EPA identified the following preliminary environmental factors relevant to Amendment No. 77:

- Heritage
- Terrestrial Environmental Quality
- Benthic Communities and Habitat
- Marine Fauna.

The EPA’s advice and recommendations regarding the environmental factors included:

1. Heritage – The Department of Aboriginal Affairs should be consulted with respect to obligations under the *Aboriginal Heritage Act 1972*.
2. Terrestrial Environmental Quality – A Detailed Acid Sulfate Soils (ASS) Site Investigation and Management Plan should be prepared in accordance with the Department of Water and Environmental Regulation (DWER) Acid Sulfate Soils Guidelines Series and to the satisfaction of the DWER Contaminated Sites Branch.
3. Benthic Communities and Habitat – The EPA notes that the scheme amendment's northern boundary is set back from the Pretty Pool Creek mangroves and development will be separated from the mangroves by a bund and roadway. Therefore, development within the Amendment Area will not directly impact the existing mangroves. The EPA supports the proposed scheme text which requires that a Mangrove Management Plan and Construction Management Plan be prepared to the satisfaction of the ToPH on advice from the relevant state government agencies.
4. Marine fauna – Development within the scheme amendment area will be limited to single story buildings. Line of site modelling demonstrates that buildings and associated infrastructure such as streetlights within the scheme amendment area will not be visible from Pretty Pool Beach or Cemetery Beach. Therefore, providing there are adequate controls to ensure building heights do not exceed these limits, there should be no direct line of site light impacts on Pretty Pool Beach and Cemetery Beach. The EPA supports the proposed scheme text that a management plan to minimise impacts to marine turtles be prepared and implemented to the satisfaction of the ToPH on advice from the relevant state government agencies.

The TPS amendment boundary is the same amendment boundary as assessed by the EPA in 2015 for Amendment No. 77. The TPS amendment boundary and the indicative development boundary have been guided by project specific technical investigations, particularly regarding impacts to the Pretty Pool Creek mangroves (Cardno (2015), Appendix B; Cardno (2020), Appendix C), which underpin this current environmental assessment.

1.4.1 Coastal Hazard consideration

In May 2017, the Western Australian Planning Commission (WAPC) and the Minister for Planning refused to grant approval to Amendment No. 77 for the following reasons:

1. The amendment does not address the preferential policy measure of avoiding the placement of new development within an area identified to be affected by coastal hazards.
2. Coastal hazard risk management and adaptation planning has not yet been undertaken to support the development and coastal protection works contemplated by the amendment report.
3. The amendment does not address the requirement for coastal protection works to be evaluated at a sediment cell level and to take into consideration the future protection requirements of adjoining landholdings.

In 2018, the ToPH prepared a Port Hedland Townsite Coastal Hazard Risk Management and Adaptation Plan (CHRMAP; GHD 2019) consistent with the WAPC’s State Planning Policy (SPP) No. 2.6: State Coastal Planning Policy. The CHRMAP (GHD 2019) included an assessment of the Stables and Athol Street sites, both of which are located adjacent to Pretty Pool Creek. The CHRMAP (GHD 2019) was formally adopted by the ToPH and the WAPC post public consultation in 2019.

1.4.1.1.1 Structure plan context

Concurrently with the proposed TPS Amendment, the ToPH and DevelopmentWA are preparing a structure plan for the Stables development which reflects the outcomes of the CHRMAP (GHD 2019). The structure plan will be a variation on the 2015 three concept plan options prepared to support Amendment No. 77 (Figure C). The 2015 indicative development concept plans demonstrate that the Pretty Pool Creek mangroves will not be directly impacted by the development of the site. It is anticipated that the structure plan development footprint will be smaller in spatial extent when compared to the 2015 indicative development concept plans to account for the revised coastal hazard risk profile.

The final development area will be confirmed through the structure plan process in consultation with the ToPH and the Department of Planning, Lands and Heritage (DPLH) and in compliance with the CHRMAP (GHD 2019) and SPP 2.6: State Costal Planning Policy.

2 LEGISLATIVE AND POLICY FRAMEWORK

2.1 State legislation

2.1.1 *Environmental Protection Act 1986*

The *Environmental Protection Act 1986* (EP Act) is the key legislative tool for environmental protection in Western Australia. The EP Act provides for the prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment.

The EP Act is administered by the EPA and the Minister for the Environment.

2.1.2 Relevant legislation and regulations

The proposed residential development of the site will be required to comply with the requirements of other relevant of pieces of state legislation and regulations. Table 4 provides a summary of the key state legislation and regulations relevant to the residential land use of the site.

Table 4: Key state and Commonwealth legislation

State legislation	
Aboriginal Heritage Act 1972	*Contaminated Sites Act 2003*
Aboriginal Heritage Regulations 1974	*Environmental Protection Act 1986*
Biodiversity Conservation Act 2016	Environmental Protection (Clearing of Native Vegetation) Regulations 2004
Biodiversity Conservation Regulations 2018	*Fire and Emergency Services Act 1998*
Bush Fires Act 1954	*Land Administration Act 1997*
Conservation and Land Management Act 1984	*Planning and Development Act 2005*
Conservation and Land Management Regulations 2002	*Rights in Water and Irrigation Act 1914*
Commonwealth legislation	
Environment Protection and Biodiversity Conservation Act 1999	Environment Protection and Biodiversity Conservation Regulations 2000

2.1.3 Relevant guidelines and standards

Proposed residential development of the site will be subject to compliance with applicable guidance developed by the EPA, and other relevant policy documents, to assist proponents and the public to understand the minimum requirements for the protection of elements of the environment that the EPA expects to be met during the assessment process.

State Planning Policies (SPPs) are prepared under Part 3 of the *Planning and Development Act 2005* to provide planning policy control and guidance to project proponents. The development of a structure plan for the site will be required to respond to relevant SPPs.

Table 5 details the key EPA guidance, other relevant policy documents and state planning policies relevant to the residential land use of the site.

Table 5: Applicable guidelines, standards and policies

EPA factor guidelines
Environmental Factor Guideline: Benthic Communities and Habitats (EPA 2016a)
Environmental Factor Guideline: Coastal Processes (EPA 2016c)
Environmental Factor Guideline: Marine Fauna (EPA 2016f)
Environmental Factor Guideline: Flora and Vegetation (EPA 2016g)
Environmental Factor Guideline: Landforms (EPA 2016l)
Environmental Factor Guideline: Terrestrial Environmental Quality (EPA 2016i)

Environmental Factor Guideline: Terrestrial Fauna (EPA 2016j)
Environmental Factor Guideline: Air Quality (EPA 2020b)
Environmental Factor Guideline: Social Surroundings (EPA 2016k)
EPA technical guidance
Technical Guidance: Protection of Benthic Communities and Habitats (EPA 2016b)
Technical Guidance: Protecting the Quality of Western Australia's Marine Environment (EPA 2016e)
Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016h)
Technical Guidance: Terrestrial Fauna Surveys (EPA 2004a)
EPA guidance statements and assessment guidelines
Guidance Statement for Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline. Perth, Western Australia (EPA 2000)
Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts (EPA 2010)
Environmental Guidance for Planning and Development (EPA 2008)
Guidance for the Assessment of Environmental Factors: Assessment of Aboriginal Heritage (EPA 2004b).
Relevant policy documents
Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment Conservation Council and Agricultural and Resource Management Council of Australia and New Zealand. 2000).
Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives (Department of the Environment 2006)
Port Hedland Air Quality Health Risk Assessment for Particulate Matter (Department of Health (DoH) 2016)
Managing Dust in Port Hedland, Industry Regulation Fact Sheet (DoH 2018)
Guideline for Managing the Impacts of Dust and Associated Contaminants from Land Development Sites, Contaminated Sites Remediation and Other Related Activities (Department of Environment and Conservation 2011)
State Planning Policies
SPP 2.6: State Coastal Planning Policy
SPP 3.7: Planning in Bushfire Prone Areas
SPP 5.4: Road and Rail Transport Noise

2.2 Commonwealth legislation

2.2.1 *Environment Protection and Biodiversity Conservation Act 1999*

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) protects Matters of National Environmental Significance (MNES) and is administered by the Commonwealth Minister of the Environment. If an action is likely to have a significant impact on any MNES a referral to Department of Agriculture, Water and Environment (DAWE) is required. MNES: Significant impact guidelines 1.1 (Department of the Environment 2015) outlines a 'self assessment' process, including detailed criteria, to assist proponents in deciding whether or not referral may be required.

MNES that relate to the site are listed Threatened species and Migratory species protected under international agreements.

2.2.1.1 Recovery Plan for Marine Turtles

The Recovery Plan for Marine Turtles in Australia (Department of the Environment and Energy (DEE) 2017) identifies that habitat critical to the survival of a species for marine turtle stocks has been identified by consensus of a panel of experts in marine turtle biology. Specifically, regarding flatback turtles nesting and inter-nesting habitat has been identified based on the following criteria:

- Nesting habitat critical to the survival of flatback turtles includes at least 70% of nesting for the stock.
- Nesting habitat critical to survival of marine turtles is of a geographically relevant scale.

- Where relevant, nesting habitat determined to be critical to the survival of marine turtles includes areas that are: geographically dispersed; major and minor rookeries; mainland and island beaches; and winter or summer nesting.
- To ensure the validity of long-term monitoring programs for assessing trends in nesting turtle abundance, all index beaches are considered habitat critical to survival of marine turtles.
- Inter-nesting habitat critical to the survival of marine turtles is located immediately seaward of designated nesting habitat critical to the survival of marine turtles. The inter-nesting habitat critical buffer for flatback turtles is 60 km.

2.2.1.2 National Light Pollution Guidelines for Wildlife Including marine turtles, seabirds and migratory shorebirds

Light pollution was identified as a high-risk threat in the Recovery Plan for Marine Turtles in Australia (DEE 2017) because artificial light can disrupt critical behaviours such adult nesting and hatchling orientation, sea finding and dispersal, and can reduce the reproductive viability of turtle stocks. A key action identified in the Recovery Plan was the development of guidelines for the management of light pollution in areas adjacent to biologically sensitive turtle habitat.

The National Light Pollution Guidelines for Wildlife including marine turtles, seabirds and migratory shorebirds (DEE 2020) have been developed to address potential impacts to critical behaviours in wildlife from artificial light. The aim of the National Light Pollution Guidelines for Wildlife is that artificial light will be managed so wildlife is:

1. Not disrupted within, nor displaced from, important habitat[1]
2. Able to undertake critical behaviours such as reproduction and dispersal.

The National Light Pollution Guidelines for Wildlife (DEE 2020) recommend:

1. Always using best practice lighting design to reduce light pollution and minimise the effect on wildlife. Best practice lighting design principles that can be used to reduce light pollution, including:
    a. Start with natural darkness and only add light for specific purposes.
    b. Use adaptive light controls to manage light timing, intensity and colour.
    c. Light only the object or area intended – keep lights close to the ground, directed and shielded to avoid light spill.
    d. Use the lowest intensity lighting appropriate for the task.
    e. Use non-reflective, dark-coloured surfaces.
    f. Use lights with reduced or filtered blue, violet and ultra-violet wavelengths.
2. Undertaking an environmental impact assessment for effects of artificial light on wildlife for listed species for which artificial light has been demonstrated to affect behaviour, survivorship or reproduction.

2.3 Statutory planning context

2.3.1 Town of Port Hedland’s Town Planning Scheme No. 5

The site is comprised of five different parcels of land which are subject to the following reservations and zoning under the ToPH’s TPS No. 5 (Department of Planning 2001):

- Portion of Lot 300 on plan 53035 is reserved for “Parks and Recreation”.
- 29 Johnson Lane, Port Hedland; Lot 556 on plan 74214; and Lot 340 on plan 72895 are zoned “Rural”.
- Lot 5755 Styles Road, Port Hedland is zoned “Other Public Purposes – Energy”.

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[1] Important habitat for marine turtles includes all areas that have been designated as habitat critical to survival of marine turtles and biologically important areas (DEE 2019a).

This TPS amendment proposes to rezone the site to “Urban Development” to facilitate the progressive subdivision and development (Figure B). The structure plan will be a variation on the earlier 2015 indicative development concept plans. The indicative development concept plans are provided in Figure C to support the proposed TPS amendment. These indicative development concept plans were provided to support of the 2015 proposed rezoning. It is anticipated the final development footprint (which will be formalised through the structure plan) will be reduced from the 2015 indicative development concept plans.

2.4 Strategic Port Hedland planning context

The proposed TPS amendment of site is informed by the following key strategic planning documents.

2.4.1 Pilbara planning and infrastructure framework

The Pilbara Planning and Infrastructure Framework (Western Australian Planning Commission (WAPC) 2012) defines a strategic direction for the future development of the Pilbara region spanning over the next 25 years. The Pilbara Planning and Infrastructure Framework aims to address the scale and distribution of future population growth and housing development as well as identifying strategies for economic growth, environmental issues, transport, infrastructure, water resources, tourism and the emerging impacts of climate change (WAPC 2012). Additionally, the Pilbara Planning and Infrastructure Framework sets out regional planning principles, goals, objectives and actions to achieve the above set outcomes that will guide the preparation of Local Planning Strategies and Local Planning Schemes.

2.4.2 Pilbara’s Port City Growth Plan

Historically, growth in Port Hedland was supported by increasing numbers of fly in, fly out workers requiring short term accommodation. Today, the state government, through Pilbara Cities, is aiming to build the residential population of Port Hedland, instead of increasingly reliance upon fly in, fly out workers, to transform the regional centre into a city of 50,000 people by 2031.

To realise the Pilbara Cities goal the ToPH has prepared and released Pilbara’s Port City Growth Plan (ToPH 2011) which provides high level strategic guidance to facilitate that sustained growth of Port Hedland.

Pilbara’s Port City Growth Plan provides guidance on:

- Provision for significant growth, creation of local employment and investment and diversity the economy
- Reflection of cultural and landscape values through development of community and sense of place
- Location of urban and industrial growth and the forms of land use, transport and activity centres required to support the plan
- Relation to landscape, protection of the natural environmental assets and responding to climate change
- Infrastructure requirements.

Pilbara’s Port City Growth Plan documented 16 areas for future urban growth within Port Hedland area, specifically site is identified as a key growth area in Port Hedland’s East End proposed to support medium density residential land uses (Figure D). The vision for Port Hedland’s East End is as follows:

> The East End Urban Village is Port Hedland’s primary residential area. The area, encompassing established Cook Point and Pretty Pool offers significant housing density and diversity together with sport and recreation opportunities, and school and community facilities. At its heart is a retail and mixed use village that offers a range of local convenience as well as dining and entertainment choices. Strong links to the coast and mangrove environs have been established which offer residents and visitors alike a closer connection with the landscape.
>
> ToPH 2011

Pilbara’s Port City Growth Plan promotes the planned urban expansion of the existing Pretty Pool residential community into the site.

2.4.3 Port Hedland Dust Management Taskforce

Port Hedland is the world's largest volume port for bulk materials export including iron ore, salt, manganese, chrome and copper concentrates and other commodities, including cattle, fuel and chemicals are exported through the port. The port area is in the 'west end' of the town of Port Hedland, which was historically the old town centre of Port Hedland. Stockpiles containing iron ore, salt, manganese and copper are located relatively close proximity to residential areas within the west end of Port Hedland. Heavy vehicles and ships, material stockpiling and handling and a predominantly dry, windy climate contribute to dust (particulate matter or PM) dispersal over the local residential areas (DoH 2016)

In 2009, the EPA expressed concern that 24 hour PM10 dust concentrations regularly exceeded the air National Environmental Protection Measure (air NEPM) of 50 µg/m^3 (+ 5 exceedances for natural events) and that existing planning arrangements allowed for residential development in the west end of Port Hedland. The government in May 2009 established the Port Hedland Dust Management Taskforce (the Taskforce) reporting to both the Premier and the Department of State Development. The Port Hedland Dust and Noise Management Plan (DNMP) was prepared and released in March 2010.

The monitoring data collected in 2012 – 2014 at the Port Hedland and South Hedland sites concluded that with the exception of PM10 and PM2.5 all other pollutants meet the air quality standards and guidelines adopted for the health risk assessment (HRA). The risk characterisation has shown that the pollutant that is having the greatest impact on public health in both Port Hedland and South Hedland is PM10. In 2013, peak levels of PM10 reached as high as 400 µg/m^3 at the Taplin Street site and analysis of the data indicates that these exceedances were not due primarily to regional dust events but to local sources of dust in the Port Hedland area (DoH 2016).

Key recommendations from the Taskforce report specifically a land use planning includes:

- Minister for Planning request the ToPH to implement a 'Special Control' area westwards from McGregor Street (or the west end of Port Hedland) as part of its Town Planning Scheme No. 5
- This 'Special Control' area prohibits new permanent residential development and other sensitive land uses, including aged care and childcare premises in Port Hedland's west
- The zoning in the 'Special Control' area aligns with the ToPH Local Planning Strategy's Precinct 1, taking into consideration the findings of the HRA.

2.4.4 Port Hedland West End – Improvement Plan No. 50

After considering the Taskforce report on 15 October 2018 the State Government (through the WAPC planning controls) adopted the following land use planning position in relation to the management of dust in Port Hedland (WAPC 2020):

- The government supports the Taskforce recommendation that appropriate planning controls be implemented to prohibit sensitive land uses and restrict population growth in the west end of Port Hedland.
- To give effect to this, the WAPC prepared an Improvement Plan and Improvement Scheme designed to achieve the land use outcome described in the Taskforce report.

2.4.5 Noise

Similar to air quality, noise created by industrial activities has and is expected to increase with the expansion of the port's operations. With the planned expansion of industry related projects and an expected increase of residential land uses there is a need to ensure that residential land uses do not encroach or are unnecessarily impacted by industrial activities.

Noise emissions from the port and associated infrastructure can vary considerably depending on the activities being undertaken. The rail infrastructure and traffic noise associated with major arterial roads in Port Hedland also makes a considerable contribution to local noise levels during the day and into the evening.

The Taskforce report also addressed cumulative noise impacts in the context of the industrial land uses in Port Hedland's West End. The potential for noise increase associated with the port and surrounding industrial land uses was an additional factor in the Taskforce recommending preventing further residential population growth in the west end of Port Hedland.

3 DEFINING THE STABLES DEVELOPMENT

3.1 Site selection

The process to select the site as a preferred location for urban development is considered in the context of the Port Hedland's East End and involved the identification of the site in the following strategic documents and investigations:

- Preliminary Environmental Assessment Report, Port Hedland East End (RPS 2011) identifies areas of land (precincts) which are less constrained by environmental factors. RPS (2011) identified the site was significantly less constrained than other precincts in the East Port Hedland area.
- Pilbara's Port City Growth Plan (ToPH 2011) identifies the site as supporting mixed density residential development.
- Port Hedland Air Quality and Noise Management Plan (Department of State Development 2010) indicates that development of the site is consistent with the Port Hedland Dust Management Taskforce preferred outcome to "improve housing availability in desirable locations in the eastern end of Port Hedland".
- The recommendations from the Taskforce report and IP50, which prohibit sensitive land uses and restrict population growth in the west end of Port Hedland. In response, the Stables site provides an alternative land development option for landowners seeking to relocate out of the west end of Port Hedland.

3.1.1 Proposed development of the TPS amendment boundary based on hydrodynamic modelling and mangrove assessment

A key study undertaken to validate the TPS amendment boundary was the Cardno investigation of the hydrodynamic implications to Pretty Pool Creek and the mangrove system surrounding the creek (Cardno (2015), Appendix B; Cardno (2020), Appendix C). Importantly this assessment combined the potential impacts of the TPS amendment boundary with those associated with the planned development along Athol Street.

Detailed below is the methodology undertaken to determine a developable area within Pretty Pool Creek and the key outcomes of Cardno (2015) (Appendix B) and Cardno (2020) (Appendix C). This approach was previously accepted by the EPA in the approval of TPS Amendment No. 58 for Athol Street site, and the previous TPS Amendment No. 77 for the Stables development (Appendix A), where the same methodology was followed to determine the site's TPS amendment boundary whilst avoiding direct impacts to the Pretty Pool Creek mangroves.

Cardno (2015) included:

- Fatal flaw analysis of constraints to the TPS amendment boundary due to storm surge
- Assessment of any potential impacts on the mangroves due to the proposed development based on the TPS amendment boundary.

The following investigations were undertaken to define the spatial extent of the TPS amendment boundary to ensure no direct impacts on the Pretty Pool mangrove system and the broader marine environment:

1. Coastal vulnerability modelling in accordance with SPP 2.6 with the proposed development required to be above the ARI-500 storm tide inundation level for the 100-years planning period (2110). To investigate the effects of changed tidal prism characteristics on the mangroves, a Delft3D model of the Pretty Pool Creek was set up based on Cardno's previous work in the area. The tidal processes were simulated for the existing bathymetry and the TPS amendment boundary combined with the Athol Street development area which enabled differences in exchange and velocity to be investigated. Four scenarios were modelled to determine the extent of changes to exchange and velocities within Pretty Pool Creek between pre and post development conditions. The modelled scenarios include
    a. An ambient one month simulation that encompassed two spring tides with a mean high water level equal to approximately MHWS (2.8 metres Australian Height Datum [m AHD]). This is a typical tidal scenario

   b. A seven day simulation for a 2-year Average Recurrence Interval (ARI) spring tide level of approximately 3.3 m AHD
   c. An extreme 20-year ARI tropical cyclone event (T.C. Terry January 1973)
   d. An extreme 500-year ARI tropical cyclone event, incorporating 0.9 m sea level rise
2. Specifically, the following was investigated to determine any impacts on the mangroves:
   a. Decreased tidal prism as a result of the filled development area
   b. Changes to the current velocity through the mangrove area
   c. Change in mangrove inundation level and duration
   d. Change in flushing characteristics of the Pretty Pool Estuary
3. Post-modelling a matrix containing criteria critical to mangrove health and their relative tolerance levels was finalised. The matrix assessed the outcomes from the modelling study against the criteria for mangrove health
4. Assessment of development setbacks from the creek and mangroves in accordance with:
   a. SPP 2.6: State Coastal Planning Policy
   b. Technical Guidance: Protection of Benthic Communities and Habitats (EPA 2016b)

Cardno (2020) confirmed that the mangrove and potential erosion impacts study undertaken to inform Cardno (2015), identified above, remained valid in when consideration was provided to the coastal hazards identified by the CHRMAP (GHD 2019) and consistent with SPP 2.6.

3.1.2 Coastal modelling outcomes

The modelling predicted minimal changes to occur to the hydrology of the creek for the ambient tidal scenario and 2-year ARI event scenario, however a very minor reduction in overall tidal exchange was noted for these scenarios (<1%) (Cardno 2015).

Interestingly, there were minimal differences noted in the results of the extreme event scenarios (20-year and 500-year ARI for the combined Stables and Athol development boundaries). The modelling predicted a 9% and 16% reduction (post-development) in the volume of water exchanged (during the event) for the 20-year and 500-year ARI events respectively. In both extreme scenarios this reduction in water exchange translated to an increase in inundation of the mangrove areas between 5–20 centimetres (cm) (Cardno 2015).

In addition, a flood plain area adjacent to the rail loop to the west of TPS amendment boundary would likely experience some additional inundation (approximately 15 cm) during a 500-year ARI event. This would need to be considered in future planning for the region (Cardno 2015).

The model results suggest that minor changes in peak current velocities would occur in all scenarios. Peak current velocities would likely be increased in the vicinity of the TPS amendment boundary and decreased in the eastern areas of the creek. As expected, the maximum predicted change in velocities occurs in the 500-year ARI event. The predicted peak velocities for the post-construction scenario are up to 30 cm which will likely result in the redistribution of sediment during extreme events (Cardno 2015).

Cardno (2015) notes that other direct impacts (i.e. wind) would be more significant than alterations of the hydrodynamic regime during the infrequent extreme weather events as a result of the development. The increase in peak current velocities could be minimised through use of stormwater controls, and engineering technologies within the development interface area (interface treatments).

Cardno (2020) identified that an adjustment to the 2120 ‘Rare’ inundation hazard level reported in the CHRMAP (GHD 2019) was required for the Stables development. As a result of this further hydrodynamic review, the Stables development will be filled to 6.7 m AHD to comply with the ToPH’s CHRMAP (GHD 2019) and be consistent with the WAPC’s SPP 2.6.

The proposed interface treatments with Pretty Pool Creek will be subject to further coastal modelling and processes assessment by Cardno and civil engineering input based upon the final structure plan design, however consistent with the ToPH’s CHRMAP (GHD 2019) the structure plan will seek to minimise development intrusion into the creek flat areas. This detailed assessment and compliance with the CHRMAP (GHD 2019) and SPP 2.6 will be presented to the ToPH, DPLH and the WAPC as a key component of the structure plan.

3.1.3 Mangrove impact assessment

A key objective of the interrogation of TPS amendment boundary is to ensure no direct impact on the mangrove community surrounding the Pretty Pool Creek area.

The potential hydrological impacts to the Pretty Pool mangroves assessment from TPS amendment boundary included an assessment of the combined potential impact of the site in conjunction with the planned development of the Athol Street site. The modelling and impact matrix determined that there would be no direct losses or impacts to the existing mangroves as a result of the development (Table 6).

Table 6: Pretty Pool mangrove potential impacts risk matrix

Potential impact	Mechanism for positive impacts	Mechanism for negative impacts	Conclusions
Water levels	Increased water levels associated with storm events may increase flushing of hyper-saline flats and increase areas suitable for mangrove growth.	Increased water levels during extreme storm events.	Water level differences during typical conditions are patchy and of small magnitude. Therefore, water level changes are considered likely to have a minimal impact on mangroves. An increase in the severity of impacts on mangroves as a result of hydrodynamic changes during extreme events is possible; however, these are likely to be minimal and insignificant in comparison to likely wind damage at such times.
Groundwater flows	Increased flows during storm events may lead to erosion of salt-flat sediments, creation of new drainage lines, reduction in salinity and increase in area available for mangrove recruitment.	Negative impacts to mangroves near mouth of the creek are indicated during extreme storm events (cyclones).	Direct cyclonic impacts on vegetation likely to be greater than effects from altered hydrodynamics associated with the development, therefore impacts on mangroves associated with altered current flows are also considered to be minimal. As for water level increases, an increase in the severity of impacts on mangroves as a result of hydrodynamic changes during extreme events is considered to be insignificant in comparison to likely wind damage at such times.
Groundwater salinity	Increased localised freshwater flows due to hinterland effect, stormwater drainage and altered land use. Localised freshwater input is predicted to result in a decrease in groundwater salinity (and increase nutrient concentrations) in tidal flats, potentially promoting mangrove colonisation and growth, particularly on the salt flat along the development margin.	Altered hydrology and weight of development may cause hydrostatic head and alter groundwater flows such that hyper-saline groundwater under and adjacent to the development move towards mangroves.	Mangrove recruitment along the bund wall is predicted. Mangrove condition on the seaward margin of the salt flats may improve due to decreased salinity associated slight increases in inundation and current flow, conversely there is potential for delayed negative impacts on creek mangroves along salt flat margin. On balance, it is considered most likely that the development will decrease the salinity of the salt flats and promote the survival and growth of mangroves.
Nutrients	Nutrients introduced by altered land use may result in increased growth of mangroves.	Nutrients may cause increased cyanobacterial mat (algal) growth on the salt flats which may be visually apparent from the development area.	Both positive and negative impacts from increased nutrients are likely to be minimal.

Source: Cardno 2015

The assessment was undertaken to determine if changes in creek hydrology would impact the mangroves and be a resultant fatal flaw to the development. As such the assessment did not consider any secondary effects that may occur such as reduced water quality in the creek from run-off via the development. These secondary effects will be assessed and managed through the application of Better Urban Water Management principles (Cardno (2015); Appendix B). An assessment of the physical characteristics of the Pretty Pool sediments would assist in determining the likelihood of sediment erosion and redistribution during infrequent extreme weather events.

Although the development will not directly impact on the existing mangrove areas of Pretty Pool Creek it is proposed that a Mangrove Management Plan be prepared to monitor for changes in mangrove health as an early indicator of potential secondary impacts from the development, and to identify management measures for mitigating any potential impacts.

3.1.3.1 Previous mangrove monitoring for the Pretty Pool development

As part of the implementation of the monitoring and reporting commitments for the existing Pretty Pool Development, a Mangrove Management Plan was prepared, to the satisfaction of the ToPH and the (then) Department of Environment and Conservation (DEC).

The mangrove monitoring consisted of a baseline mangrove study of Four Mile Creek, which was undertaken prior to the commencement of construction in January 2009, and subsequent annual monitoring from 2010 until 2012. The monitoring result over a three year period concluded that there was no notable change in the health and the overall condition of the mangroves.

The monitoring results demonstrate that the implementation of the management measures for Pretty Pool residential stages 1, 2, 2a, 4 and 4b have been successful in mitigating potential impacts to the mangroves.

3.2 Proposed TPS amendment

Development of the site progresses the Pilbara Cities goal to build the residential population of 50,000 people by 2031 in the following ways:

- Delivery of an urban development project in Port Hedland
- Encourages greater residential density in the Port Hedland’s East End.

The investigations, in particular the mangrove and potential erosion impacts assessments (Cardno (2015),Appendix B), defined the spatial extent of the TPS amendment boundary to ensure the Pretty Pool mangrove system, and the broader Pretty Pool Creek environment, would not be directly impacted.

The TPS amendment boundary includes a tapered engineering bund / infrastructure to protect future residents of the development from storm surge and flooding. However, the boundary interface will be review with coastal engineers, ToPH and the DPLH as part of the concurrent structure plan design. However, to illustrate an modelled outcome scenario the concept plan boundary is set back from the TPS amendment boundary to allow for installation of the bund / infrastructure, as close to Pretty Pool Creek as allowable, without directly impacting the mangrove community (Figure C).

As outlined, the future structure plan is anticipated to have a reduced development footprint.

Table 7 outlines the key characteristics of the proposed TPS amendment.

Table 7: Key characteristics of TPS amendment

Aspect	Proposal
Project location	Portion of Lot 300 on plan 53035, Lot 556 on plan 74214, Lot 340 on plan 72895, Lot 5755 Styles Road and 29 Johnson Lane.
Project time frame	Rezoning 2020, Structure Plan 2020/21, Subdivision approval 2025/30.
TPS amendment boundary	28.6 ha
Indicative development boundary (within TPS amendment boundary)	27.2 ha – however, this will likely reduce through the site’s concurrent structure plan process.
Potential clearing of vegetation	• 11.8 ha coastal dune vegetation. • 10.2 ha of bare mud and samphire flats The clearing area will likely be reduced post confirmation of the final structure plan design.
Average separation distance of the TPS amendment boundary to the Pretty Pool Creek mangroves.	25 metres (m)
Service infrastructure	Water supply, electricity, sewerage and telecommunications.

4 THE STABLES DEVELOPMENT

4.1 Location

The site is located within Port Hedland, in the Pilbara region of Western Australia, about 1,600 km north of Perth, and is situated approximately 3.5 km east of the town's centre in East Port Hedland (Figure A).

The site lies adjacent to existing urban development of Pretty Pool directly to the east while to the west the site is bordered by Cooke Point Road. The southern boundary of the landholdings is bordered by Styles Road and to the north the site is loosely bordered by Water which contains the extent of Pretty Pool Creek and is zoned "Rural" under TPS No. 5 (Figure B).

4.2 Existing land uses

4.2.1 Historical land use

A review of the historic land uses within the site was undertaken using historical imagery obtained from the Landgate Map viewer dating back to the year 1995. Based on this analysis, there is no observable change to the natural environment of the site since 1995. The Port Hedland Pony Club is constructed upon 29 Johnson Lane, Port Hedland and the extents of vegetation and bare tidal flats in the adjoining landholdings remains consistent over time.

4.2.2 Existing land uses

The majority of the site is currently undeveloped and comprised primarily of native dune vegetation and intertidal mud flats (Plate 1).

Plate 1: Native dune vegetation within Lot 300 on plan 53035

Lot 300 on plan 53035 contains sand tracks that can be used to facilitate vehicular access to the Port Hedland Pony Club and Pretty Pool Creek (Plate 2).

Plate 2: Track allowing vehicle access to Pretty Pool Creek within Lot 300 on plan 53035

The Port Hedland Pony Club is located centrally within the site upon 29 Johnson Lane, Port Hedland and a large portion of Lot 300 on plan 53035 is fenced and currently in use as a horse paddock (Plate 3 and Plate 4).

Plate 3: Port Hedland Pony Club

Plate 4: Horses within Lot 300 on plan 53035

Identified from aerial photographs, the existing land uses for the remaining extent of the site (portions of Lot 556 on plan 74214 and Lot 340 on plan 72895; and Lot 5755 Styles Road, Port Hedland) appears to be for water conveyance and maintenance of the local hydrological function of Pretty Pool Creek.

5 PORT HEDLAND CLIMATE

5.1 Regional overview

Port Hedland is located within the hot, semi-arid climatic zone. Summers (October to April) are very hot with an average maximum temperature of 31.8 °C and daily maximum of up to 35.2 °C in March, the hottest month. Winter temperatures range from an average monthly minimum of 17.2 °C to an average monthly maximum of 26.8 °C (Bureau of Meteorology 2020a).

Most of the annual rainfall occurs during the summer period from scattered thunderstorms and the occasional tropical cyclone. A secondary peak in the rainfall occurs in May and June because of rainfall events caused by tropical cloud bands that intermittently affect the area. These events can also produce low maximum temperatures particularly away from the coast. Thunderstorms average 20 to 30 events per annum in the Pilbara; however, 15 to 20 events per annum are more common near the coast (Bureau of Meteorology 2020a). Thunderstorms can result in erratic and localised rainfall events that lead to tidal surges and localised flooding of Port Hedland’s low coastal plain area (Bureau of Meteorology 2020a).

The winds at Port Hedland vary in direction and strength with seasonal conditions. Generally, the windiest conditions are experienced in summer with winds generally prevailing from a north-westerly direction. Westerly winds are dominant in the morning, shifting to north-westerly in the afternoon, with an accompanying increase in speed (Bureau of Meteorology 2020a). In winter, east to south-easterly winds are dominant in the mornings and shift to north-easterlies in the afternoon before easing in the evening in response to diurnal land temperature changes (Bureau of Meteorology 2020a).

5.1.1 Cyclones

The coastline from Port Hedland to the Exmouth Gulf is the most cyclone prone area in Australia. Port Hedland has been severely impacted by 50 cyclones since 1910 (Bureau of Meteorology 2020b). Cyclones are most common in the Pilbara between February and March and sometimes result in extreme rainfall events (Bureau of Meteorology 2020b).

Cyclones can cause significant increases in the ocean level through the combined effects of low atmospheric pressure, strong onshore winds and large waves breaking near shore. This increase in the water level (storm surge) has implications for coastal development.

6 SEA FACTORS

6.1.1 Benthic primary producer habitat

6.1.1.1 Pretty Pool Creek mangroves

Port Hedland is surrounded by areas of arid zone mangroves, within the intertidal zone of creeks, where tidal inundation is sufficiently frequent. Mangroves are a potential refuge to a large variety of fauna species, including birds and bats (Paling et al. 2001).

The site is located to the south of the Pretty Pool Creek mangroves which is comprised of the following associations:

1. *Avicennia marina* (scattered) – comprising scattered individuals of the mangrove *Avicennia marina*, often with scattered samphires, but without high densities.
2. *Avicennia marina* (closed canopy, landward edge) – a forest/scrub comprising the typical zone of mangroves immediately behind the mixed association of *Avicennia marina* and *Rhizophora stylosa* (Plate 5).

Plate 5: *Avicennia marina* (closed canopy, landward edge) in Pretty Pool Creek

Although a small portion of the mapped extent of the mangroves (0.1 ha) lies within the TPS amendment boundary (Figure F), the Stables scheme amendment and future development will not result in any direct impacts or any significant indirect impacts the Pretty Pool Creek mangroves (Cardno (2015), Appendix B; Cardno (2020), Appendix C).

6.1.1.2 Intertidal mudflats

Typically, areas of intertidal mud flats are found in association with these mangrove areas. Samphire communities are known to exist in the littoral land system, which occurs along the coast of the Pilbara in level plains, slightly raised above the adjacent intertidal mudflats (Van Vreeswyk et al. 2004).

Within Pretty Pool Creek area, inclusive of the site, the samphire community is known to consist of a mixed dwarf shrubland of *Tecticornia halocnemoides, Hemichro adiandra*, *Frankenia pauciflora*, with patches of grassland of *Sporobolus virginicus*.

6.1.1.2.1 Assessment of Benthic Primary Producer Habitat Loss

Technical Guidance: Protection of Benthic Communities and Habitats (EPA 2016b) is spatially based meaning that it is based on the evaluation of areas of benthic communities and habitats which have been historically lost or are currently present and proposed to be lost or impacted within defined areas. The areas within which to calculate losses are termed Local Assessment Units (LAUs), for which that are no standard size or shape and need to be defined on a case-by case basis.

The EPA's Environmental Protection Bulletin No. 14: Guidance for the assessment of benthic primary producer habitat loss in and around Port Hedland (EPA 2011) has been superseded by the more general EPA (2016b). However, for the purpose of reviewing an area where benthic communities and habitats have been historically lost, are currently present and proposed to be lost or impacted the Inner Port Hedland Port Area LAU identified by EPA (2011) has been used to inform the potential impact of the Stables development on benthic communities and habitats at the local, regional and State-wide scales.

The Inner Port Hedland Port Area LAU encompasses near shore barrier islands, tidal creeks and adjacent intertidal areas in the vicinity of the Port Hedland Inner Port and has a total area of 15,102.5 ha (EPA 2011).

The intertidal mud flats within the site, and the Pretty Pool Creek area, are not unusual and are representative of Beard Vegetation Associations: 127 – Bare areas; mud flats recorded in the Inner Port Hedland Port Area LAU and more broadly throughout the Pilbara. Kendrick and Stanley (2001) detail that Beard Vegetation Association: 127 – Bare areas; mud flats has a low priority for reservation in the Pilbara due to the substantial amount of this community already in reservation (30,345.4 ha). The extent of Beard Vegetation Association: 127 – Bare areas; mud flats within the LAU is shown in Figure G.

Table 8 demonstrates the loss of Beard Vegetation Association: 127 in the context of the Inner Port Hedland Port Area LAU and, more holistically, in Western Australia.

Table 8: Loss of Beard Vegetation Association: 127 in the LAU

	Beard Vegetation Association:127 – Bare areas; mud flats	Percentage of Beard Vegetation Association:127 – Bare areas; mud flats in LAU	Percentage of Beard Vegetation Association:127 – Bare areas; mud flats in WA
Pre-European extent in WA (ha)	778,381	N/A	100%
Current extent in WA (ha)	778,153	N/A	99.9%
Extent in LAU (ha)	6,963.7	100%	0.89%
Original extent in Pretty Pool Creek (ha)	56.1	0.8%	0.007%
Extent in Athol Street development area (ha)	19.7	0.3%	0.003%
Extent in Stables TPS amendment area (ha)	10.2	0.1%	0.001%
Remaining extent in Pretty Pool Creek (ha) after development of the Stables and Athol Street sites	26.2	0.4%	0.003%

Sources: Shepherd et al. (2002); ENV (2011); EPA (2011)

Table 8 identifies that 10.2 ha of Beard Vegetation Association:127 – Bare areas; mud flats is within the Stables TPS Amendment area. The 10.2 ha represents approximately 0.1% of Beard Vegetation Association 127 within the Inner Port Hedland Port Area LAU and 0.001% in Western Australia. If all the Beard Vegetation Association 127 within the Stables development is permanently lost the extent remaining:

- in the LAU will be 6,953.5 ha (or 99.8% of the extent in the LAU)
- in the State will be 778,142.8 (or 99.9% of the Pre-European extent in WA)

As identified earlier in this EAR, it is anticipated the final development footprint (which will be formalised through the structure plan) will be reduced from the 2015 indicative development concept plans hence it is likely that less than 10.2 ha of Beard Vegetation Association 127 will ultimately be subject to development.

Locally within the Pretty Pool Creek area, the implementation of the Stables and Athol Street developments may result in up to 29.9 ha (or 53.3% of the extent in the Pretty Pool Creek area) of Beard Vegetation Association 127 being permanently lost. Given that the majority (99.8% in the LAU and 99.9% in the State) of Beard Vegetation Association 127 will remain and that a substantial amount of this community is already in reservation within the Pilbara (30,345.4 ha) it is considered that the biological diversity and ecological integrity of the vegetation association will not be significantly diminished.

6.2 Coastal processes

6.2.1 State Planning Policy 2.6: State Coastal Planning Policy

SPP 2.6: State Coastal Planning Policy provides guidance for decision making within the coastal zone including establishment of foreshore reserves, managing development, land use change and to protect, conserve and enhance coastal values.

SPP 2.6 applies to the coast throughout Western Australia, including:

- Sandy coasts, rocky coasts, mixed sandy and rocky shorelines, coastal lowlands, and tidal reaches of inland waters
- Near shore marine waters, state waters
- All islands within the state lying seawards of the mainland
- Land use and development within the coastal zone.

It is considered that Pretty Pool Creek is classified as a tidal reach of inland water body and therefore SPP 2.6 is applicable to the site. SPP 2.6 identifies that Port Hedland is located in Area 2. In this area, the allowance for current risk of erosion and inundation should be based on a tropical cyclone storm event. SPP 2.6 is based on a 100 year time frame when a subject proposal is being assessed. For storm surge inundation, consideration is given to ocean forces and coastal processes that have a 500 year ARI probability of being equalled or exceeded in any given year over the planning timeframe.

6.2.2 Port Hedland townsite CHRMAP

The CHRMAP (GHD 2019) identifies and considers coastal hazards and risks for the Port Hedland Townsite culminating in a recommended adaptation pathway with actions to assist in adapting to immediate coastal inundation and erosion risks and undertaking appropriate planning to address increasing risk over time. The CHRMAP (GHD 2019) considers hazards and risks in the immediate term (2010), the current planning horizon (to 2060) and the long-term (to 2120).

The CHRMAP (GHD 2019) was prepared as a strategic document for long-term planning and decision-making by the community and key stakeholders to adapt the current and future Port Hedland settlement and infrastructure to coastal erosion and inundation.

The CHRMAP (GHD 2019) assessment was inclusive of the ToPH's current Local Planning Strategy, and therefore addressed proposed new residential development area in the east end of Port Hedland.

The CHRMAP (GHD 2019) multi-criteria analysis used to assess options for the development areas (the Stables and Athol Street sites) determined "the options of accommodation and protection respond similarly to local environmental and social values, therefore financial feasibility is the key differentiator to determine the most appropriate adaptation response".

Therefore, future urban development in the East Port Hedland area needs to include feasibility investigations that compare protection through raised land levels with accommodation, with an appropriate decision made at the time of development. All urban development must be undertaken in accordance with SPP 2.6, with floor levels above the required inundation event through engineering fill or accommodation (building design).

The CHRMAP (GHD 2019) identifies in Table 2-7 the following adaption options for the east Port Hedland area (which includes the Stables):

- Unmanaged retreat and avoid new development
- Interim protection (fill) land affected by almost certain development areas and accommodate of possible and rare inundation
- Interim protection (fill) land affected by almost certain, possible, and rare events.

Consistent with the CHRMAP (GHD 2019 recommendations the specific coastal assessment of the proposed TPS amendment area will include (as part of the robust structure planning design phase) the following:

- Undertake a gap assessment to identify datasets required to inform coastal processes
- Assessment and concept option development
- Undertake the required investigations to fill any gaps in the data. This includes incorporating geotechnical investigation and numerical coastal processes modelling.
- Suitable sources of supply of sand materials is undertaken, including using the Spoilbank marina and dredged boating channel as a source of sand
- Develop a basis of design with available information
- Develop several concept designs based on the preferred approach to be optimised to confirm the most suitable design.

To be compliant with SPP 2.6, the any proposed coastal protection works for the Stables will need to demonstrate adequate funding for construction and maintenance in addition to the above design elements.

6.2.2.1 Erosion potential investigation

Cardno prepared a “fatal flaw” analysis due to mangrove and potential erosion impacts for the TPS amendment boundary (Cardno (2015), Appendix B). Cardno assessed the effects of predicted coastal erosion on the stability of the creek entrance to define a development setback in accordance with SPP 2.6. This assessment included:

- Review of the potential erosion of the shoreline due to the ongoing action of the coastal processes
- Review of the potential recession of the shoreline due to sea level rise
- Review of the potential effect of storm erosion on the shoreline
- Assessment of the potential change in form of the creek entrance.

Cardno (2015) calculated that an erosion setback of 144 metres from the horizontal shoreline datum (HSD) line at the creek entrance was applicable to 500-year storm event. Given the distance from the HSD line to the site is 230 metres the future development does not require any coastal setbacks to be incorporated into its design to comply with SPP 2.6.

Cardno (2020) confirmed that the mangrove and potential erosion impacts study undertaken to inform Cardno (2015), identified above, remained valid in when consideration was provided to the coastal hazards identified by the CHRMAP (GHD 2019) and consistent with SPP 2.6.

The proposed interface treatments with Pretty Pool Creek will be subject to further coastal modelling and processes assessment by Cardno based upon the structure plan design, however consistent with the CHRMAP (GHD 2019) the structure plan will seek to minimise development intrusion into the creek flat areas. This detailed assessment and compliance with the CHRMAP (GHD 2019) and SPP 2.6 will be presented to the ToPH, DPLH and the WAPC as a key component of the structure plan.

6.3 Marine fauna

Pretty Pool Beach is a known nesting beach for Flatback turtles. Flatback turtles are protected species under both the Western Australian *Biodiversity Conservation Act 2016* and the Commonwealth EPBC Act.

6.3.1 Flatback turtles in Port Hedland

Numerous flatback turtle studies have been undertaken in Port Hedland to support development projects including BHP Billiton's Outer Harbour Development (Pendoley Environmental (PENV) 2009, 2010, 2011a, 2011b), DevelopmentWA 's Pretty Pool Development (RPS 2009; 2010a, 2010b, 2012a, 2012b, 2013b and 2020) and more recently Port Hedland Marina (PENV (2019); RPS (2020)). The findings of CHEA's Community Volunteer Turtle Monitoring Program monitoring program at Cemetery Beach and Pretty Pool have been documented by Conservation Volunteers Australia (2013) and Imbricata Environmental (2016).

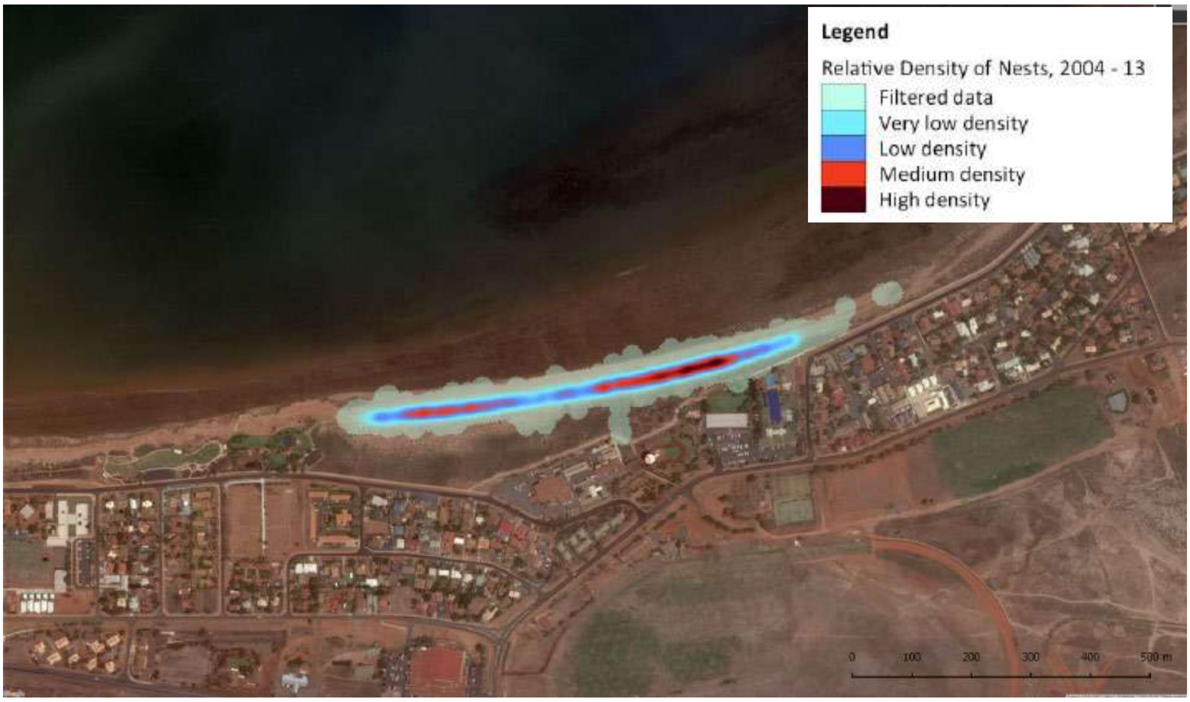
6.3.1.1 Nesting adult flatback turtles

6.3.1.1.1 Regional Significance

The nesting period for the flatback turtles occurs during the summer months, primarily between October and February (Pendoley et al 2014). Of the regionally important flatback turtle nesting areas identified by DEE (2017), Mundabullangana Station and Cemetery Beach are proximate to Port Hedland.

Mundabullangana Station is located approximately 60 km southwest of Port Hedland (DEE 2017). The primary nesting site is Cowrie Beach, a 3.3 km long, narrow, low energy beach bounded by a mangrove creek to the northeast and a rocky headland to the southwest (Pendoley et al 2014). Mundabullangana Station supports a substantial reproductive flatback turtle population with an estimated 1,861 female turtles nesting annually (Pendoley et al 2014).

Cemetery Beach is located approximately 1.4 km north-west from the Stables development. The population of nesting turtles appears to be relatively stable between 148 to 202 females/year (PENV 2019). The distribution of turtle nests at Cemetery Beach between 2004 and 2013 is presented below in Figure 2.

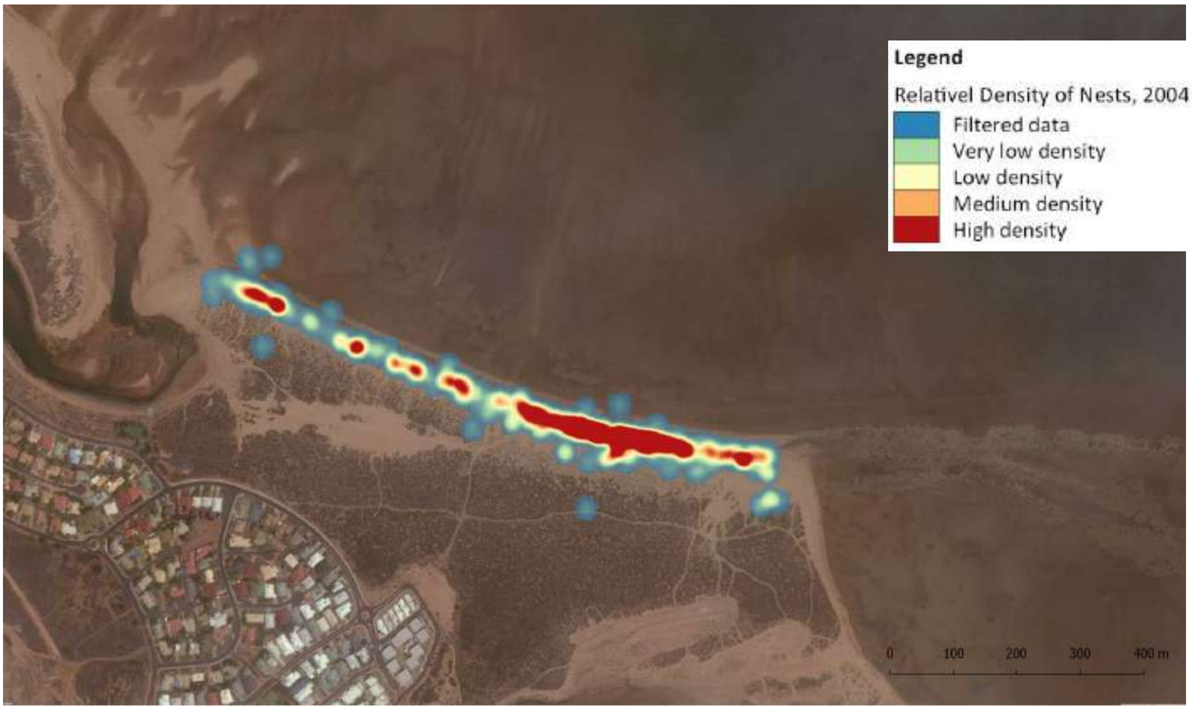


(Source: Imbricata Environmental 2016)

Figure 2: Distribution of nests at Cemetery Beach, 2004 -2013

6.3.1.1.2 Local Significance

Nesting sites within the Port Hedland townsite are Cemetery Beach and Pretty Pool Beach. Pretty Pool Beach is a north-east facing marine embayment, sheltered by Cooke Point, on the eastern side of Port Hedland. The flatback turtle nesting area is situated approximately 530 m east from the Stables development at the closest point. The population of female turtles nesting on Pretty Pool Beach ranges between 31 to 222 females/year (PENV 2019). The distribution of turtle nests at Pretty Pool Beach between 2006 and 2014 is presented below in Figure 3.



(Source: Imbricata Environmental 2016)

Figure 3: Distribution of nests at Cemetery Beach, 2004 -2013

At both Cemetery and Pretty Pool beaches, the greatest abundance of nesting was recorded on the eastern side of the beaches where the dunes are higher and less exposed to onshore artificial light sources (Imbricata Environmental 2016).

Other nesting sites proximate to Port Hedland include Reefs Island, Downes Island, Paradise Beach, Spit Point and various unnamed beaches (PENV 2009). The relative abundance of turtle tracks attained from snap-shot aerial track count surveys during the peak nesting period in December 2009 indicate that these other nesting sites support low nesting densities with approximately 6.7 tracks/km recorded at Paradise Beach and 1.4 tracks/km recorded at Downes Island (PENV 2009).

A comparison of the population size of the Port Hedland nesting sites (i.e. Cemetery and Pretty Pool beaches) to Mundabullangana Station identifies that the Port Hedland nesting sites support significantly smaller numbers of nesting turtles (Table 9).

Table 9: Size of flatback turtle nesting sites proximate to Port Hedland

Nesting site	Estimated annual population size (females/year)
Mundabullangana Station	1,861
Cemetery Beach	148 to 202
Pretty Pool Beach	31 to 222

(Sources: Pendoley et al 2014, PENV 2019)

6.3.1.2 Hatchling flatback turtles

6.3.1.2.1 Reproductive output

The average hatch success recorded for Mundabullangana Station, Cemetery Beach and Pool Beach is presented in Table 10. The average hatch success recorded for Mundabullangana Station and Cemetery Beach are very low for flatback rookeries (Pendoley et al 2014). The average hatch success at Pretty Pool Beach is comparable to other flatback turtle rookeries in the Pilbara (e.g. Barrow Island hatch success is 83.4%). The low hatch success at Mundabullangana Station and Cemetery Beach is most likely due to the elevated natural sand temperature experienced during egg incubation compared to the more southerly populations within the Pilbara (PENV 2019). Alternatively, storm surges associated with high cyclonic activity in the region affecting the embryonic development may also be a factor (DEE 2017).

Table 10: **Reproductive outputs of flatback turtle nesting sites proximate to Port Hedland**

Nesting site	Average hatch success (%)
Mundabullangana Station	68.2
Cemetery Beach	57.3
Pretty Pool Beach	73.0

(Source: Pendoley et al 2014, Imbricata Environmental 2016)

6.3.1.2.2 Nest emergence

Hatchlings start emerging from the nests at Pretty Pool Beach in early December, with a peak in early January, and continue until mid-February (Imbricata Environmental 2016).

After emerging from nests hatchlings crawl directly towards the sea, a behaviour known as sea finding. The sea finding process is directed by several cues including light wavelength, light intensity and shape and form (Lohmann et al. 1997; Tuxbury and Salmon 2005). Beach slope and sound are considered secondary cues relative to vision and are overruled by light (Lohmann et al. 1997).

6.3.1.2.3 Nearshore disbursal

The disbursal of flatback hatchlings entering the water have been shown to be primarily influenced by ocean currents under natural conditions (Wilson et al 2018). Nearshore currents in the Port Hedland region are primarily driven by astronomical tides, which causes a periodic inflow (flood tide) and outflow (ebb tide) of oceanic water to/from the Northwest shelf region (Cardno 2011). On an incoming flood tide currents generally flow in a south-southeast easterly direction, whilst on an outgoing ebb tide currents generally flow in a north-northwest direction (Cardno 2011).

6.3.2 Artificial light impacts

Artificial lighting has the potential to reduce the reproductive success of marine turtles by deterring adult females from approaching nesting beaches or nesting; and disorienting and / or misorienting hatchlings on the beach and in the nearshore environments (DEE 2020).

RPS reviewed the impacts from artificial light at Pretty Pool and Cemetery beaches. Pretty Pool Beach was used as a reference point to inform the review as it is the closest nesting beach for marine turtles to the site. Due to the greater separation distance and the higher elevation of the coastal dunes between Cemetery Beach and the site potential impacts to the marine turtles from artificial light sources directly visible to marine turtles at Pretty Pool Beach was considered to be the limiting factor to the heights of built infrastructure within the TPS amendment boundary.

6.3.2.1.1 Line of sight analysis – Pretty Pool Beach

To investigate the maximum heights at which direct light from built infrastructure within the TPS amendment boundary is visible from Pretty Pool Beach, RPS undertook a study using a specifically developed Line of Sight model (Figure J).

To inform the Line of Sight figures twenty nine house pads and streetlight masts were inserted within TPS amendment boundary in a grid and views were exported from a turtle “eye level” ground level. The results of the Line of Sight model show that single storey buildings are not visible at 9.6 m AHD (+ 3m for single storey) (Figure Ja); streetlights are not visible at 16.1 m AHD (+6.5m for streetlights) (Figure Jb); and five storey buildings are not visible at 21.6 m AHD (+ 15m for five stories) (Figure Jc) due to the presence of coastal dunes.

The coastal dunes ranging in height between 8.5 to 10 m AHD surrounding the nesting beach act as a natural barrier to protect Pretty Pool Beach from direct light spill from the landholdings. Plates A to IIII show the distance from the indicative turtle nesting location at which the coastal dunes block the turtles direct Line of Site, as displayed in Figure J, for twenty nine house pads and streetlight masts at the different elevations.

The Stables development is proposed to comprise single storey residences and streetlights. The line of sight analysis shows that Stables development can be designed so that no artificial light sources from the development (i.e. streetlights and houses) will be directly visible to either adult females nesting or departing hatching turtles at Pretty Pool Beach, which significantly reduces the pathway for potential impacts to marine turtles.

6.3.2.1.2 Line of sight analysis - Cemetery Beach

There is a significant coastal dune and existing built form that separates Cemetery Beach from the site. An analysis of the topography shows the coastal dune, and therefore existing houses, are higher in elevation than the topography which separates Pretty Pool Beach from site.

Figure Jd clearly illustrates built form scenario at +15 m AHD (5 storeys) that no direct light is visible at turtle “eye level” on Cemetery Beach from the site.

The Stables development is proposed to comprise single storey residences and streetlights. The line of sight analysis shows that Stables development can be designed so that no artificial light sources from the development (i.e. streetlights and houses) will be directly visible to either adult females nesting or departing hatching turtles at Cemetery Beach, which significantly reduces the pathway for potential impacts to marine turtles.

6.3.2.1.3 Lighting design

Skyglow will be generated from Stables development which has the potential to contribute additional light to the Port Hedland night light environment, which is already significantly impacted by the port operations. To minimise the potential for the Stables development to cumulatively add to the existing skyglow levels the development’s lighting will be designed to accord with the National Light Pollution Guidelines (DEE 2020), and the EPA’s Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts (EPA 2010), while meeting legislative and regulatory requirements for human safety.

This will be achieved through the preparation of an Artificial Light Management Plan, inclusive of biological and artificial light monitoring and auditing requirements, prepared to the satisfaction of the DBCA which addresses the best practice lighting design principles identified in the National Light Pollution Guidelines (DEE 2020):

1. Start with natural darkness and only add light for specific purposes.
2. Use adaptive light controls to manage light timing, intensity and colour.
3. Light only the object or area intended – keep lights close to the ground, directed and shielded to avoid light spill.
4. Use the lowest intensity lighting appropriate for the task.
5. Use non-reflective, dark-coloured surfaces.
6. Use lights with reduced or filtered blue, violet and ultra-violet wavelengths

7 LAND FACTORS

7.1 Flora and vegetation

7.1.1 Interim Biogeographical Regionalisation of Australia region

Port Hedland lies within the Interim Biogeographical Regionalisation of Australia region of Pilbara 4 and within the costal subregion of Roebourne (Kendrick and Stanley 2001).

The Roebourne subregion is described as:

Quaternary alluvial plains with a grass savannah of mixed bunch and hummock grasses, and dwarf Shrub Steppe of *Acacia translucens* or *A. pyrifolia* and *A. inaequilatera*. Resistant linear ranges of basalts occur across the coastal plains. These uplands are dominated by Triodia hummock grasslands. Ephemeral drainage lines support Eucalyptus woodlands. Samphire, Sporobolus grasslands and mangal occur on the marine alluvial flats and river deltas (Kendrick and Stanley 2001).

7.1.2 Pilbara vegetation mapping

Beard (1975) mapped the vegetation of the Pilbara region at a scale of 1:1,000,000. Beard Vegetation Association: 127 – Bare areas; mud flats occurs over the extent of the site (Figure E).

Shepard et al. (2002) updated the Beard (1975) vegetation boundaries to account for clearing in the intensive land use zone and divided some larger vegetation units into smaller units. Shepard et al. (2002) identifies that 99.9 % of the pre-European extent of Beard Vegetation Association: 127 – Bare areas; mud flats vegetation type remains. Kendrick and Stanley (2001) identify Beard Vegetation Association: 127 – Bare areas; mud flats has a low priority for conservation.

7.1.3 Desktop assessment

A desktop assessment was undertaken to determine the floristic values of the site using the following databases and reference materials reports:

1. DBCA's database to search for species which are considered to be "threatened" because they are under identifiable threat of extinction, rare or otherwise in need of special protection identified as occurring within a 5 km radius of the site.
2. An EPBC Act Protected Matters Report was generated using a radial buffer of 5 km from the site to determine species of conservation significance that may potentially occur within the site.
3. Port Hedland Regional Flora and Vegetation Assessment (ENV 2011), synthesised 31 technical flora and vegetation surveys / reports undertaken in Port Hedland and its surrounding hinterlands to inform its findings, was reviewed
4. Level 1 Flora and Vegetation Report, Pretty Pool Caravan Park, Port Hedland (RPS 2013a), which provides a detailed account of the flora and vegetation values of Lot 300 on plan 53035, was reviewed.

7.1.3.1 Conservation significant flora species

ENV (2011) identifies that there are no known occurrences of Threatened flora species recorded in or immediately surrounding Port Hedland. This finding is supported by DBCA's NatureMap database search results and the EPBC Act Protected Matters Report (Appendix E).

The NatureMap database results identify two priority species within the search area:

- *Gomphrena pusilla* (Priority 2)
- *Gymnanthera cunninghamii* (Priority 3).

RPS (2013a) identifies that ten *G.pusilla* (P2) plants were recorded by the survey occurring within Low open shrubland of *Acacia stellatriceps* over hummock grassland of *Triodia epactia* which is confined to a small limestone rock outcrop in the south of the Lot 300 on plan 53035. ENV (2011a) identifies that 1,030 *G. pusilla* (P2) individuals have been recorded around Port Hedland at three locations with all the recordings occurring on low sandy rises that occur in conjunction with mangroves along the coastline. Given that 1,030 *G. pusilla* (P2) individuals have been recorded around Port Hedland, it is considered likely *G pusilla* (P2) is well represented in the locality.

G. cunninghamii (P3) is known from 12 locations around Port Hedland, with a total of seven individuals being recorded by ENV (2011a) at these locations on low sandy rises near the coast and on creek banks in the north-west of the ENV's Port Hedland study area. No *G. cunninghamii* (P3) individuals were recorded by RPS (2013a).

7.1.3.2 Conservation significant vegetation communities

The EPBC Act Protected Matters Report identified that there were no known occurrences of Threatened Ecological Communities (TECs) protected under the EPBC Act identified within the site or within a surrounding five kilometre radius buffer.

Further, Kendrick and Stanley (2001) identifies that there are no TECs in the Pilbara 4 Bioregion and no Priority Ecological Communities (PECs) were identified by RPS (2013a).

7.1.3.3 Landscape-vegetation types and units

The site is underlain by primary and secondary coastal dune associations which are known to consist of the following landscape-vegetation types:

- Secondary dune comprising low shrub of *Acacia stellaticeps* over hummock grassland of *Triodia epactia*) with open herbland of *Euphorbia tannensis*
- Bare tidal salt flats comprised mixed dwarf shrubland of *Tecticornia halocnemoides, Hemichro adiandra, Frankenia pauciflora,* with patches of grassland of *Sporobolus virginicus* (Figure F).

RPS (2013a) provides a detailed account of the vegetation units present within the secondary dunes surrounding Pretty Pool Creek (Table 11).

Table 11: Vegetation units

Vegetation unit	Photograph
A. Low shrubland of *Crotalaria cunninghamii* and *Aerva javanica* over grassland of *Cenchrus ciliaris*	
B. Low shrubland of *Acacia stellatriceps* and *Aerva javanica* over mixed grassland of *Triodia epactia* and *Cenchrus ciliaris*	

Vegetation unit	Photograph
C. Low shrubland of *Acacia stellatriceps* and *Aerva javanica* over grassland of *Cenchrus ciliaris*	
D. Open grassland of *Triodia epactia* and *Cenchrus ciliaris*	
E. Low open shrubland of *Acacia stellatriceps* over hummock grassland of *Triodia epactia*	
F. Mixed dwarf shrubland of *Frankenia pauciflora, Trianthema tugidifolia* over mixed grassland of *Triodia epactia* and *Cenchrus ciliaris* over open herbland of *Swainsonia pterostylis* and *Eragrostis falcatta*	

Source: RPS (2013)

The condition of the majority of vegetation within these vegetation units was identified as ranging from "Degraded" to "Completely Degraded" (RPS 2013a). This finding was supported by ENV (2011) which identified that, of the extent of the site surveyed by the study, the condition of the vegetation was "Completely Degraded".

7.2 Landforms

7.2.1 Topography

Figure H shows that the point of highest elevation within the site is a coastal dune approximately 8 m AHD within Lot 300 on plan 53035. A narrow limestone ridgeline, ranging in height from approximately 5.5 m AHD to 7.0 m AHD, also runs parallel to Styles Road. From these points of higher elevation the site reduces in elevation sloping northwards towards Pretty Pool Creek.

7.2.2 Geology

The 1:50,000 Geology Series (Port Hedland sheet) indicates that the subsurface profile below the site comprises dune limestone, mud and silt, older dune shelly sand and mobile dunes.

A geotechnical investigation undertaken by Coffey to delineate and describe the subsurface characteristics of the site confirmed limestone, dune sand and estuarine deposits (Figure I).

7.3 Terrestrial environmental quality

7.3.1 Acid sulfate soils

The WAPC in consultation with DWER has compiled Acid Sulfate Soil (ASS) risk maps that are based on surface geology mapping and provide a broad scale indication of the risk of occurrence of ASS.

The DWER ASS risk mapping indicates the site contains small areas of "High to moderate" risk of ASS occurring within 3 metres of the natural soil surface with the majority of the land being mapped as "Moderate to low" risk of ASS occurring within 3 metres of natural soil surface (Figure I).

7.3.2 Potential contamination

A search of the DWER's Contaminated Sites Database was undertaken on in May 2020 and no matches were recorded for the Stables site.

Given that the majority of the site is comprised of primarily of native vegetation, significant contamination is unlikely to be present.

29 Johnson Lane, Port Hedland contains the Port Hedland Pony Club which has aged infrastructure associated with equestrian land uses (Plate 3). This infrastructure may have been made from materials containing asbestos and a Hazardous Materials Assessment (HAZMAT) for Contamination should be undertaken prior to the demolition of the infrastructure to any identify potential contaminants.

7.4 Terrestrial fauna

7.4.1 Fauna habitat

The key fauna habitats within the site are the tidal flats between the Pretty Pool Creek mangrove community and coastal vegetation on the secondary dune (Figure F).

7.4.2 Desktop assessment

A desktop search was undertaken using the following databases:

1. DBCAs NatureMap database search for species which are declared as “Rare or likely to become extinct”, “Birds protected under international agreement” and “Other specially protected fauna” identified as occurring within a 5 km radius of the site on 05 June 2020 (Appendix E).
2. An EPBC Act Protected Matters Report was generated using a radial buffer of 5 km from the site on 05 June 2020. Species of conservation significance that may potentially utilise the landholdings are identified by the EPBC Act Protected Matters Report (Appendix E).

Species that potentially occur within the site and that are identified as protected under the BC Act and / or under the EPBC Act are listed in Table 12.

The analysis of the likely fauna to occur within the Stables site is considered to be limited due to the sparse vegetation within TPS amendment boundary. The mangrove and Pretty Pool Creek environments, immediately adjacent to the site, provide a diverse range of fauna habitats which does support conservation significant species, for example migratory birds, as outlined in Table 12.

Table 12: Conservation significant fauna species potentially occurring within the TPS amendment boundary

Species	Conservation status (state)	Conservation status (EPBC)	Occurrence within the TPS amendment boundary
Reptiles			
Ctenotus angusticeps (Airlie Island skink)	Priority 3	N/A	The Airlie Island skink is known from approximately 12 locations in north-west WA: Airlie Island (offshore from Onslow), Thangoo Station (Roebuck Bay), Pretty Pool and Wedgefield (Port Hedland), Redbank (Port Hedland), Finucane Island (Port Hedland), Beebingarra Creek, Roebuck (Crab Creek), Cape Keraudren (Pardoo), Port Smith (Lagrange), Willie Creek (Broome), Boodarie Station and Karratha. On the mainland, the Airlie Island skink is known to inhabit the landward fringe of salt marsh communities in samphire shrubland or marine couch grassland in the intertidal zone along mangrove margins. This species is strongly associated with samphire species, *Tectornia halocnemoides* subsp. *tenuis* and *Suaeda arbusculoides*, which occur on clayey soils, and mixed herb and grass cover of *Muellerolimon salicorniaceum* and *Sporobolus virginicus*, which occur on sandy soils (DAWE 2020a). There is samphire habitat within the site available for the Airlie Island skink, however it is considered unlikely that the landholdings would contain habitat on which the Airlie Island skink is dependent upon for species survival.
Liasis olivaceus barroni (Pilbara olive python)	Schedule 3	Vulnerable	The Pilbara olive python is common and wide-spread in the Pilbara and has been identified as a species that should not be listed as threatened or declining (Kendrick and Stanley 2001). Pilbara olive pythons are most often seen at night and are generally found around rocky areas, rocky outcrops and cliffs, particularly in the vicinity of watercourses and water holes, but are also known to shelter in logs, flood debris, caves, tree hollows and thick vegetation (Burbidge 2004). Given that the site lack rocky habitats preferred by the Pilbara olive python it is not considered likely that this species would occur within the landholdings.
Birds			
Anous stolidus (common noddy)	Schedule 5	Migratory	In Australia, the common noddy occurs mainly in ocean off the Queensland coast, but the species also occurs off the north-west and central Western Australia coast. During the breeding season, the common noddy usually occurs on or near islands, on rocky islets and stacks with precipitous cliffs, or on shoals or cays of coral or sand. When not at the nest, individuals will remain close to the nest, foraging in the surrounding waters. During the non-breeding period, the species occurs in groups throughout the pelagic zone (open ocean) (DAWE 2020b). Given that the preferred breeding habitat of the common noddy does not occur within the site it is considered unlikely that this species will be significantly impacted by proposed development.
Actitis hypoleucos (common sandpiper)	Schedule 5	Migratory	Common sandpipers mainly breed in parts of Europe and Asia, and occasionally Africa. The population that migrates to Australia breeds in the Russian far east. European breeding birds rarely remain in Europe during the non-breeding period, with individuals moving to Africa and Asia. In Australia, it is found along all coastlines and in many areas inland, the common sandpiper is widespread in small numbers. The population when in Australia is concentrated in northern and western Australia with areas of national importance in Western Australia including Nutysland Nature Reserve and Roebuck Bay. The species utilises a wide range of coastal wetlands and some inland wetlands, with varying levels of salinity, and is mostly found around muddy margins or rocky shores and rarely on mudflats. The common sandpiper has been recorded in estuaries and deltas of streams, as well as on banks farther upstream, around lakes, pools, billabongs, reservoirs, dams and claypans, and occasionally piers and jetties (DAWE 2020c). There is potential habitat within the site for the common sandpiper, however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.

Species	Conservation status (state)	Conservation status (EPBC)	Occurrence within the TPS amendment boundary
Apus pacificus (fork-tailed swift)	Schedule 5	Migratory	The fork-tailed swift is almost exclusively aerial, flying from less than 1 m to at least 300 m above ground and probably much higher. In Australia, they mostly occur over inland plains but sometimes are found above foothills or in coastal areas. They mostly occur over dry or open habitats, including riparian woodland and tea-tree swamps, low scrub, heathland or saltmarsh (DAWE 2020d). Given that the aerial nature of this species it is unlikely to be significantly impacted by the proposed development.
Ardea ibis (cattle egret)	N/A	Migratory	The cattle egret is widespread in southern and eastern Asia and Australasia and is highly mobile, rendering them less susceptible to population fragmentation. In Western Australia breeding colonies nest predominantly in Melaleuca swamps in November and December although breeding is dependent to some extent on rainfall (DAWE 2020e). Given that the preferred wetland habitat of the cattle egret does not occur within the site it is considered unlikely that this species will be significantly impacted by proposed development.
Ardea modesta (eastern great egret)	N/A	Migratory	The Eastern great egret is widespread in southern and eastern Asia and Australasia and is highly mobile, rendering them less susceptible to population fragmentation. In Western Australia breeding colonies nest predominantly in Melaleuca swamps in November and December although breeding is dependent to some extent on rainfall (DAWE 2020f). Given that the preferred wetland habitat of the Eastern great egret does not occur within the site it is considered unlikely that this species will be significantly impacted by proposed development.
Arenaria interpres / Arenaria interpres subsp. Interpres (ruddy turnstone)	Schedule 5	Migratory	Ruddy turnstones are widespread within Australia during its non-breeding period of the year, including from Tasmania in the south to Darwin in the north and many coastal areas in between. It is found in most coastal regions, with occasional records of inland populations. It strongly prefers rocky shores or beaches where there are large deposits of rotting seaweed (DAWE 2020g). Given that the preferred coastal habitat of ruddy turnstones does not occur within the site it is considered unlikely that this species will be significantly impacted by proposed development.
Calidris acuminate (sharp-tailed sandpiper)	Schedule 5	Migratory	Sharp-tailed sandpiper spends the non-breeding season in Australia with small numbers occurring regularly in New Zealand. In Western Australia (WA), scattered records occur along the Nullarbor Plain and the southern areas of the Great Victoria Desert. They are widespread from Cape Arid to Carnarvon, around coastal and sub-coastal plains of Pilbara Region to south-west and east Kimberley Division. Inland records indicate the species is widespread and scattered from Newman, east to Lake Cohen, south to Boulder and west to Meekatharra. In Australasia, the Sharp-tailed sandpiper prefers muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, salt marsh or other low vegetation (DAWE 2020h). There is potential habitat within the site for the Sharp-tailed sandpiper, however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Calidris alba. (sanderling)	Schedule 5	Migratory	In Australia, the species is almost always found on the coast, mostly on open sandy beaches exposed to open sea swell, and also on exposed sandbars and spits, and shingle banks, where they forage in the wave-wash zone and amongst rotting seaweed. Sanderlings also occur on beaches that may contain wave-washed rocky outcrops Rarely, they are recorded in near-coastal wetlands, such as lagoons, hypersaline lakes, salt ponds and samphire flats (DAWE 2020i). There is potential habitat within the site for the sanderling however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.

Species	Conservation status (state)	Conservation status (EPBC)	Occurrence within the TPS amendment boundary
Calidris canutus (red knot)	Schedule 2	Endangered	The Red knot is common in all the main suitable habitats around the coast of Australia with very large numbers being regularly recorded in north-west Australia. In Australasia the red knot mainly inhabit intertidal mudflats, sand flats and sandy beaches of sheltered coasts, in estuaries, bays, inlets, lagoons and harbours; sometimes on sandy ocean beaches or shallow pools on exposed wave-cut rock platforms or coral reefs (DAWE 2020j). There is potential habitat within the site for the Red knot however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Calidris ferruginea (curlew sandpiper)	Schedule 1	Critically Endangered	In Australia, curlew sandpipers occur around the coasts and are also quite widespread inland, though in smaller numbers. Records occur in all states during the non-breeding period, and also during the breeding season when many non-breeding one year old birds remain in Australia rather than migrating north. Curlew sandpipers mainly occur on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast, and ponds in salt works and sewage farms (DAWE 2020k). There is potential habitat within the site for the curlew sandpiper however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Calidris tenuirostris (great knot)	Schedule 1	Migratory	The great knot breeds in north-east Siberia and winters along coastal areas. It feeds on bivalves, gastropods, crustaceans and other invertebrates it finds in shallow coastal waters (DAWE 2020l). There is potential habitat within the site for the great knot however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Calidris melanotos (pectoral sandpiper)	Schedule 5	Migratory	In Australasia, the Pectoral Sandpiper prefers shallow fresh to saline wetlands. The species is found at coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands (DAWE 2020m). There is potential habitat within the site for the Pectoral sandpiper however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Calidris ruficollis (red-necked stint)	Schedule 5	Migratory	In Australasia, the Red-necked stint is mostly found in coastal areas, including in sheltered inlets, bays, lagoons and estuaries with intertidal mudflats, often near spits, islets and banks and, sometimes, on protected sandy or coralline shores. Occasionally they have been recorded on exposed or ocean beaches, and sometimes on stony or rocky shores, reefs or shoals. They also occur in salt works and sewage farms; salt marsh; ephemeral or permanent shallow wetlands near the coast or inland, including lagoons, lakes, swamps, riverbanks, waterholes, bore drains, dams, soaks and pools in salt flats (DAWE 2020n). There is potential habitat within the site for the Red-necked stint however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.

Species	Conservation status (state)	Conservation status (EPBC)	Occurrence within the TPS amendment boundary
Calidris subminuta (long-toed stint)	Schedule 5	Migratory	In Western Australia, the species is found mainly along the coast, with a few scattered inland records. It is widespread around the Pilbara region and the Kimberley Division between Karratha and Wyndham-Kununurra. The Long-toed Stint occurs in a variety of terrestrial wetlands. They prefer shallow freshwater or brackish wetlands including lakes, swamps, river floodplains, streams, lagoons and sewage ponds (DAWE 2020o). Given that the preferred wetland habitat of the long-toed stint does not occur within the site it is considered unlikely that this species will be significantly impacted by proposed development.
Calonectris leucomelas (streaked shearwater)	Schedule 5	Migratory	The streaked shearwater can be found over both pelagic and inshore waters. It feeds mainly on fish and squid which it catches by surface-seizing and shallow plunges. It often associates with other seabirds and will follow fishing boats. Breeding begins in March in colonies on offshore islands, occupying burrows on forested hills. It undergoes transequatorial migration (Birdlife International 2020a) Given that the preferred breeding habitat of the streaked shearwater does not occur within the site it is considered unlikely that this species will be significantly impacted by proposed development.
Charadrius lescheaultii (greater sand plover)	Schedule 3	Vulnerable	In Australia, the greater sand plover occurs in coastal areas in all states, though the greatest numbers occur in northern Australia, especially the north-west with the species being especially widespread between North West Cape and Roebuck Bay in Western Australia. In the non-breeding grounds in Australasia, the species is almost entirely coastal, inhabiting littoral and estuarine habitats. They mainly occur on sheltered sandy, shelly or muddy beaches with large intertidal mudflats or sandbanks, as well as sandy estuarine lagoons (DAWE 2020p). There is potential habitat within the site for the greater sand plover however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Charadrius mongolus (lesser sand plover)	Schedule 1	Endangered	Internationally important sites in Western Australia and counts include Eighty Mile Beach,1575; Roebuck Bay, 1057; Broome, 745; Port Hedland Saltworks, 668. This species usually occurs in coastal littoral and estuarine environments. It inhabits large intertidal sandflats or mudflats in sheltered bays, harbours and estuaries, and occasionally sandy ocean beaches, coral reefs, wave-cut rock platforms and rocky outcrops. It also sometime occurs in short saltmarsh or among mangroves. The species also inhabits saltworks and near-coastal saltpans, brackish swamps and sandy or silt islands in river beds (DAWEq). There is potential habitat within the site for the lesser sand plover however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Charadrius veredus (oriental plover)	Schedule 5	Migratory	The oriental plover is a non-breeding visitor to Australia where it occurs in both coastal and inland areas. In coastal habitats this species is found on estuarine mudflats and sandbanks, sandy or rocky ocean beaches or nearby reefs, or in near-coastal grasslands. In inland regions the oriental plover inhabit flat, open, semi-arid or arid grasslands, where the grass is short and sparse, and interspersed with hard, bare ground, such as claypans, dry paddocks, playing fields, lawns and cattle camps (DAWE 2020r). There is potential habitat within the site for the oriental plover however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.

Species	Conservation status (state)	Conservation status (EPBC)	Occurrence within the TPS amendment boundary
Chlidonias leucopterus (white-winged tern)	Schedule 5	Migratory	In Western Australia, the species is widespread on the southern west coast, mainly from Ballingup and the estuary of Vasse River north to Mongers Lake, and also on coasts of the Pilbara region and Kimberley Division, with occasional records farther inland, mainly along major river systems, such as the Ord. The species only rarely occurs in the Gascoyne Region of the central-western coast, and is occasionally recorded along the southern coast. The species mostly inhabits fresh, brackish or saline, and coastal or subcoastal wetlands. White-winged Black Terns frequent tidal wetlands, such as harbours, bays, estuaries and lagoons, and their associated tidal sandflats and mudflats (DAWE 2020s). There is potential habitat within the site for the White-winged Tern however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Fregata ariel (lesser frigatebird)	Schedule 5	Migratory	The lesser frigatebird is almost exclusively aerial and the most common and widespread frigatebird in Australia. It is common in tropical seas breeding on remote islands, in mangroves or bushes / scrub (Birdlife International 2020b). Given that the aerial nature of this species it is unlikely to be significantly impacted by the proposed development.
Gelochelidon nilotica (gull-billed tern)	Schedule 5	Migratory	Gull-billed Terns are found in freshwater swamps, brackish and salt lakes, beaches and estuarine mudflats, floodwaters, sewage farms, irrigated croplands and grasslands. They are only rarely found over the ocean (Birdlife Australia 2020a). There is potential habitat within the site for the Gull-billed Tern however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Glareola maldivarum (oriental pratincole)	Schedule 5	Migratory	The oriental pratincole is a medium-sized shorebird that occurs in small to very large flocks of thousands to millions of individuals. It is widespread in the northern extent of Australia, particularly along the coastlines of Western Australia's Pilbara and Kimberley regions. The breeding season is spent in southern, south-eastern and eastern Asia, with the non-breeding season spent largely in Australia. During this time, the oriental pratincole preferably inhabits beaches, mudflats, islands, open plains, flood plains or short grassland, often with extensive areas of bare ground (DAWE 2020t). There is potential habitat within the site for the oriental pratincole however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Haliaeetus leucogaster (white-bellied sea eagle)	N/A	Migratory	The White-bellied sea eagle is not globally threatened, but has been subject to population decline within Australia and South East Asia. In Australia, it is distributed along the coastline, and is restricted to a narrow band of coastline in south-western Australia. The population residing within Australia is estimated at 500 mating pairs. The White-bellied sea eagle is found in coastal habitats and tends to occupy dunes, tidal flats, woodlands, forests and grasslands (generally in areas associated with large bodies of water). When not migrating, the home range of the White-bellied sea eagle can be up to 100 square km, although breeding adult birds are generally sedentary (breeding season runs from June to January). The nests of these birds are large and conspicuous, generally constructed in large trees, cliffs, rocky outcrops, mangroves, caves or on artificial structures (DAWE 2020u). It is considered likely that the White-bellied sea eagle may be observed overflying the landholding infrequently, however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.

Species	Conservation status (state)	Conservation status (EPBC)	Occurrence within the TPS amendment boundary
Hirundo rustica (barn swallow)	Schedule 5	Migratory	The barn swallow occurs in open land, such as agricultural pasture and plains, roosting or nesting in dead trees, banks, cliff cavities and rock shelves. It is a regular non-breeding summer migrant to northern Australia, where its range extends from the Kimberley region to north-eastern and south-eastern Queensland (DAWE 2020v). Given that the preferred plain habitat of the barn swallow does not occur within the site is considered unlikely that this species will be significantly impacted by proposed development.
Limicola falcinellus (broad-billed sandpiper)	Schedule 5	Migratory	In Western Australia, few records occur in the south-west, but the broad-billed sandpiper may be regular in small numbers at scattered locations, from Warden Lake Nature Reserve and Coramup Creek to Guraga Lake Nature Reserve and Hurstview Lake. They mostly occur on the coasts of the Pilbara and Kimberley between Onslow and Broome, but are also recorded north to the mouth of Lawley River, and inland at Lake Daley. The broad-billed sandpiper occurs in sheltered parts of the coast, favouring estuarine mudflats but also occasionally occur on saltmarshes, shallow freshwater lagoons, saltworks and sewage farms, and in areas with large soft intertidal mudflats, which may have shell or sandbanks nearby (DAWE 2020w). There is potential habitat within the site for the Broad-billed sandpiper however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Limnodromus semipalmatus (Asian dowitcher)	Schedule 5	Migratory	The Asian dowitcher was first recorded in Australia in 1972 and is a regular visitor to the north-west between Port Hedland and Broome. The Asian Dowitcher occurs in sheltered coastal Environments, such as embayments, coastal lagoons, estuaries and tidal creeks. They are known to frequent shallow water and exposed mudflats or sandflats (DAWE 2020x). There is potential habitat within the site for the Asian dowitcher however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Limosa lapponica (*bar-tailed godwit)/ Limosa lapponica* subsp. *Baueri (*bar-tailed godwit [western Alaskan])/ *Limosa lapponica* subsp. *Menzbieri* (bar-tailed godwit [northern Siberian]).	Schedule 5 / Schedule 3 / Schedule 1	Migratory / Vulnerable / Critically Endangered	Bar-tailed godwits have been recorded in the coastal areas of all Australian states. It is widespread in the Torres Strait and along the east and south-east coasts of Queensland, NSW and Victoria, including the offshore islands. Bar-tailed godwits are found mainly in coastal habitats such as large intertidal sand flats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays. (DAWE 2020y). There is potential habitat within the site for bar-tailed godwits however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.

Species	Conservation status (state)	Conservation status (EPBC)	Occurrence within the TPS amendment boundary
Limosa limosa (black-tailed godwit)	Schedule 5	Migratory	The black-tailed godwit breeds in eastern Siberia and moves to south-eastern Asia and Australia during the non-breeding season This is one of the most abundant migratory shorebirds visiting Australia each year. The black-tailed godwit has a primarily coastal habitat environment. The species is commonly found in sheltered bays, estuaries and lagoons with large intertidal mudflats or sandflats, or spits and banks of mud, sand or shell-grit; occasionally recorded on rocky coasts or coral islets (DAWE 2020z). There is potential habitat within the site for the Black-tailed godwit however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Macronectes giganteus (southern giant petrel)	Schedule 5	Endangered	In Australia, the southern giant petrel breeds on six subantarctic and Antarctic islands in Australian territory; Macquarie Island, Heard Island and McDonald Island in the Southern Ocean, and Giganteus Island, Hawker Island, and Frazier Island in the Australian Antarctic Territories. The southern giant petrel is marine bird that occurs in Antarctic to subtropical waters. In summer, it mainly occurs over Antarctic waters, and it is widespread south as far as the pack ice and onto the Antarctic continent (DAWE 2020aa). Given the southern giant petrel's preference for subantarctic and Antarctic habitats it is not considered likely that this species would occur within the site.
Motacilla flava (yellow wagtail)	Schedule 5	Migratory	The Yellow wagtail has an extremely large range, extending from Europe, east through Siberia to west Asia and north-western China; and south through the Arabian Peninsula to Egypt. This species occupies a range of damp or wet habitats with low vegetation, from damp meadows, marshes, waterside pastures, sewage farms and bogs to damp steppe and grassy tundra. In the north of its range it is also found in large forest clearings (Birdlife International 2020c). Given that the preferred freshwater habitats of the Yellow wagtail do not occur within the site is considered unlikely that this species will be significantly impacted by proposed development.
Numenius madagascariensis (eastern curlew)	Schedule 1	Critically Endangered	Within Australia, the eastern curlew has a primarily coastal distribution. The species is found in all states, particularly the north, east, and south-east regions including Tasmania. Eastern curlews are rarely recorded inland. They have a continuous distribution from Barrow Island and Dampier Archipelago, Western Australia, through the Kimberley Division and along Northern Territory, Queensland, and NSW coasts and the islands of Torres Strait. They are patchily distributed elsewhere. The eastern curlew is most commonly associated with sheltered coasts, especially estuaries, bays, harbors, inlets and coastal lagoons, with large intertidal mudflats or sand flats, often with beds of seagrass. Occasionally, the species occurs on ocean beaches (often near estuaries), and coral reefs, rock platforms, or rocky islets. The birds are often recorded among salt marsh and on mudflats fringed by mangroves, and sometimes use the mangroves. The birds are also found in salt works and sewage farms (DAWE 2020ab). There is potential habitat within the site for the eastern curlew however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.

Species	Conservation status (state)	Conservation status (EPBC)	Occurrence within the TPS amendment boundary
Numenius minutus (little curlew)	Schedule 3	Migratory	Little curlews generally spend the non-breeding season in northern Australia from Port Hedland in Western Australia to the Queensland coast. The little curlew is most often found feeding in short, dry grassland and sedgeland, including dry flood plains and black soil plains, which have scattered, shallow freshwater pools or areas seasonally inundated (DAWE 2020ac). There is potential habitat within the site for the little curlew however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Numenius phaeopus (whimbrel) / *Numenius phaeopus subsp. Variegatus* (whimbrel)	Schedule 5	Migratory	The whimbrel is often found on the intertidal mudflats of sheltered coasts. It is also found in harbours, lagoons, estuaries and river deltas, often those with mangroves, but also open, un-vegetated mudflats (DAWE 2020ad). There is potential habitat within the site for whimbrels however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Pezoporus occidentalis (night parrot)	Schedule 1	Endangered	The Night Parrot is a highly elusive nocturnal ground dwelling parrot found in the arid and semi-arid zones of Australia. he Night Parrot was thought to be extinct but in 2013 it was rediscovered in Queensland (Pullen Pullen Reserve). Subsequently, the Night Parrot Recovery Team confirms that there is one population recently recorded in the Diamantina National Park/Pullen Pullen Reserve area in western Queensland, and other recent records in the Wiluna district of central WA, and the Lake Gregory area of northern WA (DAWE 2020ae) It is likely that the Night Parrot is locally absent from the Port Hedland townsite.
Pandion haliaetus (osprey)	Schedule 5	Migratory	The breeding range of the Osprey extends around the northern coast of Australia (including many offshore islands) from Albany in Western Australia to Lake Macquarie in NSW; with a second isolated breeding population on the coast of South Australia. Ospreys occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. They are mostly found in coastal areas but occasionally travel inland along major rivers, particularly in northern Australia. They require extensive areas of open fresh, brackish or saline water for foraging. They frequent a variety of wetland habitats including inshore waters, reefs, bays, coastal cliffs, beaches, estuaries, mangrove swamps, broad rivers, reservoirs and large lakes and waterhole (DAWE 2020af) There is potential habitat within the site for Ospreys however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Plegadis falcinellus (glossy ibis)	Schedule 5	Migratory	Within Australia, the largest contiguous areas of prime habitat is inland and northern flood plains. The glossy ibis is commonly in largest numbers in drying Top End grass/sedge swamps and Channel Country grass/forb meadows. The species is sometimes recorded in wooded swamps, artificial wetlands (such as irrigated fields), and in mangroves for breeding (DAWE 2020ag). Given that the preferred habitat of the glossy ibis does not occur within the site it is considered unlikely that this species will be significantly impacted by proposed development.

Species	Conservation status (state)	Conservation status (EPBC)	Occurrence within the TPS amendment boundary
Pluvialis fulva (Pacific golden plover)	Schedule 5	Migratory	Within Australia, the Pacific golden plover is widespread in coastal regions, though there are also a number of inland records (in all states), sometimes far inland and usually along major river systems, especially the Murray and Darling rivers and their tributaries In non-breeding grounds in Australia this species usually inhabits coastal habitats, though it occasionally occurs around inland wetlands. Pacific golden plovers usually occur on beaches, mudflats and sand flats (sometimes in vegetation such as mangroves, low salt marsh such as Sarcocornia, or beds of seagrass) in sheltered areas including harbours, estuaries and lagoons, and also in evaporation ponds in saltworks (DAWE 2020ah). There is potential habitat within the site for the Pacific golden plover however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Pluvialis squatarola (grey plover)	Schedule 5	Migratory	The grey plover breeds around the Arctic, and winters along tropical and temperate coasts worldwide. Non-breeding birds occur around coastal Australia, with approximately 12,000 annually migrating to Australia. They inhabit intertidal mud flats, salt marshes, sand flats and beaches and feed on polyochaete worms, molluscs and crustaceans (DAWE 2020ai). There is potential habitat within the site for the grey plover however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Rostratula australis (Australian painted snipe)	Schedule 2	Endangered	Painted snipes generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. They also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains. Typical sites include those with rank emergent tussocks of grass, sedges, rushes or reeds, or samphire; often with scattered clumps of lignum Muehlenbeckia or canegrass or sometimes tea-tree (Melaleuca) (DAWE 2020aj). There is potential habitat within the site for painted snipes however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Sterna hirundo (common tern)	Schedule 3	Migratory	The species is a non-breeding migrant to Australia, where it is widespread and common on the eastern coast south to eastern Victoria, and common on parts of the northern coast, mainly east of Darwin. Common terns are marine, pelagic and coastal. In Australia, they are recorded in all marine zones, but are commonly observed in near-coastal waters, both on ocean beaches, platforms and headlands and in sheltered waters, such as bays, harbours and estuaries with muddy, sandy or rocky shores (DAWE 2020ak). There is potential habitat within the site for the common tern however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Sternula albifrons (little tern)	Schedule 5	Migratory	Little Terns inhabit sheltered coastal environments, including lagoons, estuaries, river mouths and deltas, lakes, bays, harbours and inlets, especially those with exposed sandbanks or sand-spits, and also on exposed ocean beaches (DAWE 2020al). There is potential habitat within the site for the little tern however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.

Species	Conservation status (state)	Conservation status (EPBC)	Occurrence within the TPS amendment boundary
Thalasseus bergii (crested tern)	Schedule 5	Migratory	The Crested Tern is widely distributed throughout most of the Australian coastline. They breed in colonies on small offshore islands where their nests are so densely packed together that adjacent owners can touch each other's bills. Though the Crested Tern is usually a strictly coastal species, there are occasional records in the arid interior of Australia, where birds were possibly blown by passing tropical cyclones (Birdlife Australia 2020b). Given that the preferred coastal habitat of the crested tern does not occur within the site it is considered unlikely that this species will be significantly impacted by proposed development.
Tringa brevipes (grey-tailed tattler)	Priority 4, Schedule 5	Migratory	Within Australia, the grey-tailed tattler has a primarily northern coastal distribution and is found in most coastal regions. The grey-tailed tattler is often found on sheltered coasts with reefs and rock platforms or with intertidal mudflats. It can also be found at intertidal rocky, coral or stony reefs as well as platforms and islets that are exposed at low tide (DAWE 2020m). There is potential habitat within the site for the grey-tailed tattler however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Tringa glareola (wood sandpiper)	Schedule 5	Migratory	The wood sandpiper uses well-vegetated, shallow, freshwater wetlands, such as swamps, billabongs, lakes, pools and waterholes. They are typically associated with emergent, aquatic plants or grass, and dominated by taller fringing vegetation, such as dense stands of rushes or reeds, shrubs, or dead or live trees, especially Melaleuca and river red gums *Eucalyptus camaldulensis* and often with fallen timber(DAWE 2020an). Given that the preferred habitat of the wood sandpiper does not occur within the site it is considered unlikely that this species will be significantly impacted by proposed development.
Tringa nebularia (common greenshank)	Schedule 5	Migratory	The common greenshank does not breed in Australia, however, the species occurs in all types of wetlands and has the widest distribution of any shorebird in Australia. The Common Greenshank is found in a wide variety of inland wetlands and sheltered coastal habitats of varying salinity. It occurs in sheltered coastal habitats, typically with large mudflats and saltmarsh, mangroves or seagrass. Habitats include embayments, harbours, river estuaries, deltas and lagoons and are recorded less often in round tidal pools, rock-flats and rock platforms. The species uses both permanent and ephemeral terrestrial wetlands, including swamps, lakes, dams, rivers, creeks, billabongs, waterholes and inundated floodplains, claypans and saltflats (DAWE 2020ao). There is potential habitat within the site for the common greenshank however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.
Tringa stagnatilis (marsh sandpiper)	Schedule 5	Migratory	The marsh sandpiper is found on coastal and inland wetlands throughout Australia. The marsh sandpiper lives in permanent or ephemeral wetlands of varying salinity, including swamps, lagoons, billabongs, salt pans, salt marshes, estuaries, pools on inundated flood plains, and intertidal mudflats and also regularly at sewage farms and salt works (DAWE 2020ap). There is potential habitat within the site for the marsh sandpiper however given the substantial extent of potential habitat available for this species in Port Hedland, and the broader Pilbara region, the risk of significant impact occurring to this species as a result of developing the landholdings for residential purposes is considered to be low.

Species	Conservation status (state)	Conservation status (EPBC)	Occurrence within the TPS amendment boundary
Mammals			
Dasyurus hallucatus (northern quoll)	Schedule 1	Endangered	In the Pilbara, the Great Sandy Desert, Gibson Desert and Little Sandy Deserts define the distributional boundaries of northern quoll in the north, east and south. Records from the Pilbara bioregion are scattered across the four subregions; namely the Hamersley, Fortescue Plains, Chichester and Roebourne Plains subregions with records extending as far west as the Little Sandy Desert and as far south as Karinjini National Park (DAWE 2020aq). Habitat critical to the survival of the species includes rocky habitats, such as ranges, escarpments, mesas, ranges, gorges, breakaways, boulder fields, major drainage lines or treed creeklines; structurally diverse woodland or forest areas containing large diameter trees, termite mounds or hollow logs; and offshore islands where the Northern quoll is known to exist (Commonwealth of Australia 2011). As part of the Regional Fauna Assessment of the Port Hedland area, completed by ENV for BHP Billiton, targeted searches were undertaken in all rocky habitats within the Port Hedland area for northern quoll focusing on locations where the species had been previously recorded (ENV 2011b). No northern quolls were recorded in the locality of Pretty Pool by ENV (2011b) with all the searches and recent recordings of this species being in Pippingarra, approximately 20 km south of Pretty Pool (ENV 2011b). Given the lack of detection of this species by ENV (2011b), it is not considered likely that the northern quoll would occur within the site or adjacent areas in Pretty Pool.
Macrotis lagotis (greater bilby)	Schedule 2	Vulnerable	The greater bilby is restricted to drier desert areas in the Northern Territory, Western Australia and a small portion of south-western Queensland. Greater bilbys live in sandy desert areas in spinifex grasslands. They dig large burrows up to 2 metres deep in sandplain country. They also seem to prefer freshly burnt country where there are more plentiful supplies of preferred foods. The greater bilby has not been recorded within the general area of East Port Hedland (DAWE 2020ar). Given the greater bilby's preference for sandplain habitats it is not considered likely that this species would occur within the site.
Macroderma gigas (ghost bat)	Schedule 3	Vulnerable	Ghost bats currently occupy habitats ranging from the arid Pilbara to tropical savanna woodlands and rainforests. During the daytime they roost in caves, rock crevices and old mines (Commonwealth of Australia 2016). Given the lack of suitable roosting habitat in the site, it is considered unlikely that the development of the landholdings would significantly impact the Ghost bat.

7.4.2.1 Migratory birds

Dr Mike Bamford has undertaken waterbird surveys in the Pretty Pool area, and surrounding areas in Port Hedland, for DevelopmentWA's Pretty Pool development from 2008 to 2011. Spring surveys were favoured to coincide with peak southward migration of migratory waterbirds through Port Hedland.

The findings of Dr Mike Bamford's final report were reviewed to inform the assessment of migratory waterbirds for the site. A copy of the report; Surveys of Migratory Waterbirds at the Pretty Pool Development, Port Hedland (Spring 2008 to Spring 2011) (Bamford 2012) is provided in Appendix D for Pretty Pool Creek context.

Bamford (2012) identifies that in a regional context the numbers of most bird species using Pretty Pool area is low, but the tidal flats in Pretty Pool and Four Mile creek bays support moderate numbers of foraging birds. Specifically, Pretty Pool Creek recorded lower numbers of conservation significant bird species and has lower species diversity when compared to key sites around Port Hedland (Pretty Pool Bay and Cemetery / Town Beach). This comparison indicates that Pretty Pool Creek is of lower significance as habitat for conservation significant water bird species than the other identified areas around Port Hedland.

The former Port Hedland wastewater treatment plant did seasonally attract larger numbers of waterbirds. The wastewater treatment plan was closed in 2019 with new facilities constructed in South Hedland. It is unknown if the waterbirds are using the South Hedland wastewater treatment plant or have transitioned in the surrounding local areas around Port Hedland.

Bamford (2012) notes the Pretty Pool Creek mangroves community supports a range of terrestrial bird species, some of which are mangrove dependent. The mangroves will not be significantly impacted by the proposed development (Cardno (2015), Appendix B, Cardno (2020), Appendix C) and therefore the ecosystem service of habitat provision for the terrestrial bird species will not be diminished.

8 WATER FACTOR

8.1 Inland waters

8.1.1 Surface drainage

Pretty Pool Creek, directly to the north of site, is predominantly a marine based tidal system with occasional freshwater inflows from the surrounding catchments. The surface drainage within Pretty Pool Creek generally runs towards the mangroves and south-west towards the southern intertidal flats.

Although average rainfall is low, the Port Hedland region is characterised by periodic cyclonic events yielding high volume storm flows. During extreme cyclonic events, stormwater from the west flows towards Pretty Pool Creek and contributes to flooding in low-lying areas.

Stormwater from the surrounding residential developments of Cooke Point, in the north, and Pretty Pool, in the east, is currently conveyed towards Pretty Pool Creek following rainfall events.

8.1.2 Groundwater

The key groundwater resources for the Pilbara coast are the alluvial aquifers. Three aquifer units have been identified within the alluvial deposits (SKM 2007):

- Upper aquifer – an unconfined aquifer within alluvium, calcarenite and/or paleosol stratigraphic units
- Middle aquifer – located within red beds of clays and sands of low permeability
- Lower aquifer – an aquifer of low permeability conglomerate with highly permeable gravel lenses.

Groundwater data from the coastal plain aquifers from the surrounding Pretty Pool area indicate the groundwater is generally highly saline to brackish. As the Stables development is located adjacent to the Indian Ocean interface it is anticipated groundwater flow will generally be towards the ocean.

9 AIR FACTOR

9.1 Air Quality

Port Hedland, a regional town in Western Australia, is home to the world's largest iron ore export port. Air quality, and specifically dust, has been recognised as a significant environmental issue by the EPA in 2009. Dust in Port Hedland can be generated from natural sources (such as the dry dusty land of the Pilbara region) and anthropogenic sources (such as the handling and stockpiling of bulk commodities such as iron ore). Specifically, in 2009 the EPA expressed concern that 24 hour PM10 dust concentrations regularly exceeded the air National Environmental Protection Measure (air NEPM) of 50 µg/m3 (+ 5 exceedances for natural events) and that existing planning arrangements allowed for residential development in the West End. In response, the Port Hedland Dust Management Taskforce reporting to the Premier was convened by the Department of State Development in May 2009. The Port Hedland Dust and Noise Management Plan (DNMP) was prepared and released in March 2010.

Concurrently, the Port Hedland Industries Council (PHIC) was founded in 2009 to provide an integrated and coordinated approach to establishing and operating an ambient air quality monitoring network in Port Hedland.

The Port Hedland Air Quality and Noise Management Plan (DSD, 2010) identified the need to establish an 'independent, comprehensive air quality monitoring regime' in Port Hedland. The Taskforce intended that the monitoring regime would provide a basis to measure the performance of industry against relevant targets, and the data would inform and guide future industry and community planning. In 2009 PHIC established an ambient air quality monitoring network in Port Hedland.

The PHIC ambient air quality monitoring network consists of eight (8) stations distributed across the Port Hedland region. The stations measure a combination of PM10, PM2.5, meteorological conditions (wind speed, wind direction and temperature) and oxides of nitrogen (reported as NO2). Data from each station is uploaded to a public website for viewing in real-time (www.phicmonitoring.com.au).

The monitoring data collected in 2012-2014 at the Port Hedland and South Hedland sites show that with the exception of PM10 and PM2.5 all other pollutants meet the air quality standards and guidelines adopted for the Health Risk Assessment (HRA). The risk characterisation has shown that the pollutant that is having the greatest impact on public health in both Port Hedland and South Hedland is PM10

In 2013, peak levels of PM10 reached as high as 400 µg/m^3 at the Taplin Street site and analysis of the data indicates that these exceedances were not due primarily to regional dust events but to local sources of dust in the Port Hedland area. The sandy environment of the Spoilbank land formation was identified as most likely to have contributed to exceedances at both the Taplin Street and Kingsmill Street monitors (DoH, 2016).

RPS notes that the Taskforce's recommendation for a current interim guideline of 24-hour PM10 of 70 µg/m^3 continues to apply to residential areas of Port Hedland and that measures should be introduced to cap (and if possible, reduce) the number of permanent residents in dust affected areas of Port Hedland.

This recommendation to reduce permanent residents in dust-affected areas of Port Hedland (i.e. the west end of Port Hedland) was a significant driver to strategically identify land areas in Port Hedland's east end outside of the dust affected areas to provide alternative housing locations. This advice from the Taskforce was the catalyst for identifying the Stables site and the Athol Street development in the ToPH's 2011 Pilbara's Port City Growth Plan and the WAPC in 2018 endorsed an Improvement Plan and Improvement Scheme designed to achieve the land use outcomes described in the Taskforce report and reduce permanent residents in dust affected west end of Port Hedland.

10 PEOPLE FACTOR

10.1 Social surroundings

10.1.1 Aboriginal heritage and culture

A search of the DPLH's Aboriginal Heritage Inquiry System (AHIS) identified that a small part of Other Heritage Place (Site ID: 28249; Name: Pretty Pool) intersects the site boundary (Figure K; Appendix G).

Anthropos Australis undertook an Aboriginal heritage survey of East Port Hedland in 2011, which also identified Aboriginal archaeological Shell Midden and Engraving sites within the site (Figure K).

10.1.2 Natural and historical heritage

A search of the Heritage Council's inHerit database and the ToPH's Heritage Inventory undertaken on 05 June 2020 did not identify any State-listed heritage sites or places of considerable cultural significance on the ToPH's Heritage List within the site.

10.1.3 Amenity

10.1.3.1 Noise

A Preliminary Noise Impact Assessment was undertaken for the East Port Hedland area by Herring Storer Acoustics to determine the extent to which potential acoustic impacts received from vehicles on Wilson Street, passing trains and the salt harvesters would constrain development opportunities in the area.

Herring Storer Acoustics determined that noise received from passing trains during the night period is the critical noise source and period for compliance.

Under SPP 5.4: Road and Rail Transport Noise and Freight Considerations in Land Use Planning (WAPC 2009) noise received by the passing trains needs to comply with the following target acoustic criteria:

- External
- LAeq(Day)of 60dB(A)
- LAeq(Night) of 55dB(A).

Herring Storer identified to comply with the noise requirements of the State Planning Policy 5.4 Road and Rail Transportation Noise and Freight Consideration in Land Use Planning (SPP 5.4) the following noise amelioration measures for the Stables development can be incorporated in future subdivision designs:

- Noise bund located between railway and Wilson Street.
- Noise bund located at boundary of development.

The Herring Storer noise impact assessment report was updated in 2020 to support the scheme amendment and structure plan and define future noise management requirements. The Preliminary Noise Impact Assessment is an appendix of the Scheme Amendment report.

10.1.3.2 Mosquitoes

Mosquito borne viruses can occur anywhere where conditions are warm and wet. In the Pilbara the mosquito-borne diseases of most concern are:

- Ross River virus
- Barmah Forest virus
- Murray Valley encephalitis.

The critical factor in determining whether mosquitoes and midges are likely to be a nuisance or a health risk is the presence of water, as mosquitoes and midges require standing water to breed during their larval stage (Russell 1999). To determine the likely risk of mosquitoes and midges breeding within or proximate to the site it is necessary to identify any potential breeding areas.

Any areas within the site (including during and post-construction) where pooling of water may occur could act as a potential breeding site, the following examples are provided:

- Stormwater drainage systems
- Low-lying areas temporarily flooded by rainfall
- Temporary areas created during construction works such as bunded areas or trenches
- Pretty Pool Creek may provide mosquito breeding habitat.

Mosquito studies have been carried out in the Pretty Pool Creek area by the Arbovirus Surveillance and Research Laboratory at the University of Western Australia and the ToPH. The studies indicated that most of mosquito species include *Aedes vigilax* which are associated with mangrove and intertidal habitats and *Culex annulirostris* which are associated with fresh and polluted water in domestic areas.

10.1.4 Bushfire

A search of Department of Fire and Emergency Services’ Map of Bushfire Prone Areas identified that the site is mapped as a Bushfire Prone Area (Figure N).

The WAPC released SPP 3.7: Planning in Bushfire Prone Areas to reduce the risk of bushfire to people, property and infrastructure. SPP 3.7 defines a bushfire-prone area as an area that has been designated by the Fire and Emergency Services Commissioner under Section 18 of the *Fire and Emergency Services Act 1998* (as amended) as an area that is subject, or likely to be subject, to bushfires.

11 ASSESSMENT OF THE TPS AMENDMENT

11.1 TPS amendment boundary

The TPS amendment will not cause any net loss of mangrove vegetation within the Pretty Pool Creek either through direct removal of mangroves or changes in the hydrology of the creek (Cardno (2015), Appendix B, Cardno (2020), Appendix C).

The TPS amendment boundary includes approximately 10.2 ha of intertidal mudflats, which are sparsely populated with samphire vegetation, and are considered to be Benthic Communities and Habitat. The samphire vegetation is not unusual and is representative of the broad vegetation associations recorded throughout Port Hedland and the wider Pilbara region. Further to this, the samphire vegetation in this region typically occurs in the mid to upper intertidal zone and is not subject to daily tidal inundation, and as a result experiences greater fluctuations and higher salinities (Adam 1995).

The Pretty Pool Creek mangroves fall within the Inner Port Hedland Port Area LAU in accordance with Environmental Protection Bulletin No. 14: Guidance for the assessment of benthic primary producer habitat loss in and around Port Hedland (EPA 2011). Recent estimate of cumulative losses that have occurred within this LAU since 1963 have estimated losses of around 11–13%.

BHP Billiton undertook detailed investigations into the current distribution of mangroves in the Inner Port Hedland Port Area LAU as a component of the environmental assessment of their outer harbour development proposal. The investigation aimed to accurately define estimates of cumulative losses of mangrove vegetation in this LAU by incorporating areas of mangrove regrowth (SKM 2011). The investigation determined that the significant losses that have occurred in some areas have been significantly offset by considerable gains in other areas, and that the estimated net loss between 1963 and 2008 is approximately 2.2% (59 ha) (SKM 2011). The investigation then considers losses from recent proposals for industrial developments within the LAU, inclusive of the outer harbour project (29 ha) and has calculated a net loss (worst case) of 5.9% (160.1 ha) within the LAU.

The EPA has considered the results of the mangrove research undertaken by BHP Billiton and suggests that the cumulative losses of mangroves are between 5.7% and 14%.

The TPS amendment is not expected to cause any irreversible loss of, or serious damage to the existing Pretty Pool mangroves, and as such will not further contribute to the current cumulative losses or present a risk to the ecological integrity of the Inner Port Hedland Port Area LAU.

Furthermore, hydrodynamic modelling determined that the TPS amendment would cause only minor changes to the flushing characteristics and water levels in the creek during ambient conditions and regular rainfall events (i.e. 2-year ARI events). The largest change in tidal exchange and depth of inundation, (being 16% less tidal exchange and 20 cm deeper inundation) occurred in the 500-year ARI event scenario (includes 0.9 m sea level rise), indicating that the proposed development of the site would not likely impact on current or future mangrove distribution within the Pretty Pool Creek area. Additionally, TPS amendment boundary allows an average separation distance of approximately 25m to the Pretty Pool Creek mangroves.

Guidance Statement for Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline (EPA 2000) requires that any loss or disturbance of mangroves be minimised or mitigated, and that a management program be developed to monitor to detect any changes in mangrove biodiversity, coverage and productivity. As such it is proposed that a Mangrove Management Plan be prepared and implemented.

11.2 Indicative development boundary

Indicative development concept plans of the proposed residential development have been provided in Figures C in support of the proposed rezoning.

The TPS amendment boundary includes a tapered engineering bund / infrastructure to protect future residents of the development from storm surge and flooding. The indicative development boundary is slightly set back from the TPS amendment boundary to allow for installation of the bund / infrastructure to be installed, as close to Pretty Pool Creek as allowable, without directly impacting the mangrove community (Figure C). The final development area, which will be reduced from the TPS boundary, will be determined through the structure plan assessment and approval in liaison with DPLH and in the context of the Cardno coastal processes modelling and the CHRMAP (GHD 2019).

12 KEY ENVIRONMENTAL FACTORS IDENTIFIED

12.1 Benthic communities and habitat

12.1.1 Environmental objective

To protect benthic communities and habitats so that biological diversity and ecological integrity are maintained

12.1.2 Potential impacts

Aspects of this proposal that may affect the mangrove community of Pretty Pool includes:

- Loss of up to 10.2 ha of intertidal mud and samphire flats.
- Halo effect due to either sediment scour or smothering around the development boundary due to changes in the local wave conditions
- Water quality changes during construction (turbidity) or due to reduced flushing could potentially cause indirect losses
- Indirect impacts to mangrove and samphire vegetation through reduced water quality from developmental run-off

12.1.3 Management response

Cardno (2015) mangrove assessment concluded that any modifications to the creek hydrodynamics from the TPS amendment boundary would be minor and would not have a significant impact on the mangrove community. The assessment was undertaken to determine if changes in creek hydrology would impact the mangroves and be a resultant fatal flaw to the development. Cardno (2020) confirmed that the mangrove and potential erosion impacts study undertaken as part of Cardno (2015) remained valid in when consideration was provided to the coastal hazards identified by the CHRMAP (GHD 2019) and consistent with SPP 2.6.

Figure L shows the separation distances from TPS amendment boundary to the outer extent of the Pretty Pool Creek mangroves. The separation distances have been measured at 100 m intervals. The average separation distance for the majority of the outer extent of the Pretty Pool Creek mangroves from TPS amendment boundary is approximately 25 m.

The following measures ensure the Pretty Pool Creek mangroves will not be directly impacted as a result of the proposed development of site:

- The level of separation between the Pretty Pool Creek mangroves to the indicative development boundary.
- The spatial extent of the TPS amendment boundary being defined by the detailed hydrodynamic modelling undertaken by Cardno (2015)
- Preparation and implementation of MMP and CMP to the satisfaction of the ToPH and the DBCA at subdivision.

The MMP will include:

- Aerial photography and field surveys will be used to map the distribution and coverage of mangrove vegetation associations.
- Mangrove health surveys will be undertaken in an effort to ensure that any negative impacts are detected as soon as possible. Mangrove health monitoring would consist of regular visual assessments to determine mangrove condition
- Mangrove monitoring sites will be established prior to the commencement of construction activities.

All site works required as part of the future development of the site are proposed to be undertaken within the TPS amendment boundary. No site works, for example the installation of walling or earth bund / infrastructure, is proposed outside of the TPS amendment boundary.

During the construction phase a CMP will be required which will address the following management and mitigation measures:

- Ensuring no mangroves are cleared within the TPS amendment boundary
- Minimising areas to be cleared within the TPS amendment boundary
- Restrict access to areas outside of outside of the TPS amendment boundary
- Identify and manage potential impacts to the environment surrounding the TPS amendment boundary prior to ground disturbing activities
- Restrict construction to day light hours only during turtle nesting and hatching season
- Dust management
- Noise management
- Fauna management.

The implementation of the CMP will ensure site works are only undertaken within the TPS amendment boundary and that site works do not impact the Pretty Pool Creek mangroves. The CMP will also ensure any potential impacts to the environment surrounding the TPS amendment boundary are identified and appropriately managed prior to ground disturbing activities.

12.2 Coastal processes

12.2.1 Environmental objective

To maintain the geophysical processes that shape coastal morphology so that environmental values of the coast are protected.

12.2.2 Potential impacts

- Flooding and erosion of the shoreline as a result of tidal movement, storm surge, wave action, near shore currents and changes in water level.
- Altering the natural patterns of sediment movement resulting from the installation of artificial structures associated with the development.
- Altering the available area for potential mangrove migration or recruitment.

12.2.3 Management response

- Final finished floor level for residential development of 6.7 m AHD consistent with the findings of the CHRMAP (GHD 2019) and SPP 2.6.
- The proposed interface treatments with Pretty Pool Creek will be subject to further coastal modelling and processes assessment based upon the structure plan design to ensure compliance with the CHRMAP (GHD 2019) and SPP 2.6.
- A Foreshore Management Plan (FMP) to be undertaken at subdivision to appropriately manage access to Pretty Pool Creek, activities and conserve creek foreshore vegetation to the satisfaction of the ToPH and the DBCA at subdivision

12.3 Marine Environmental Quality

12.3.1 Environmental objective

To maintain the quality of water, sediment and biota so that environmental values are protected.

12.3.2 Potential impacts

Altering the hydrodynamics of the creek (development fill) may interrupt and alter local water circulation within the near shore areas of the Pretty Pool Creek which may reduce water quality.

12.3.3 Management response

- The Local Water Management Strategy (LWMS) for site outlines the key water servicing, drainage and environmental management considerations to be progressed in support of subsequent development design and planning approval phases (Cardno (2015), Appendix B; Cardno (2020), Appendix C).
- Key water management outcomes from the LWMS include:
  - First 15 millimetres (mm) of rainfall on lots to be detained within lots through soakwells or rainwater tanks
  - First 15 mm of rainfall from the road reserve to be detained in a swale located on the northern boundary of the site
  - All additional rainfall to be conveyed northward to Pretty Pool Creek via the road reserves and swale
  - Swale to discharge any rainfall events greater than 15mm to Pretty Pool Creek, which is consistent with the conveyance of stormwater from the surrounding residential development along Athol Street and Cooke Point
  - Final finished floor level for residential development of 6.7 m AHD consistent with the CHRMAP (GHD 2019) and SPP 2.6.
- LWMS will be updated to accord with the structure plan design.
- Urban Water Management Plan(s) will be finalised to the satisfaction of the ToPH and the DWER at subdivision.

12.4 Marine fauna

12.4.1 Environmental objective

To protect marine fauna so that biological diversity and ecological integrity are maintained.

12.4.2 Potential impacts

- Increased lighting from proposed development may potentially disrupt nesting and behaviour of nestling and adult turtles.
- An increased residential population also has the potential to impact marine turtle nesting and hatchling behaviour, through the use of recreation vehicles, pets and interaction with nesting turtles.

12.4.3 Management response

12.4.3.1 Siting

The proposed development of the site will be restricted through building control provisions to single storey residences and streetlights to ensure that no artificial light sources from the development (i.e. streetlights and houses) will be directly visible to either adult females nesting or departing hatching turtles at Cemetery Beach.

12.4.3.2 Lighting design

To minimise the potential for the Stables development to cumulatively add to the existing skyglow levels the development's lighting will be designed to accord with the National Light Pollution Guidelines (DEE 2020), and the EPA's Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts (EPA 2010), while meeting legislative and regulatory requirements for human safety.

This will be achieved through the preparation of an Artificial Light Management Plan, inclusive of biological and artificial light monitoring and auditing requirements, which addresses the best practice lighting design principles identified in the National Light Pollution Guidelines (DEE 2020):

a. Start with natural darkness and only add light for specific purposes.
b. Use adaptive light controls to manage light timing, intensity and colour.
c. Light only the object or area intended – keep lights close to the ground, directed and shielded to avoid light spill.
d. Use the lowest intensity lighting appropriate for the task.
e. Use non-reflective, dark-coloured surfaces.
f. Use lights with reduced or filtered blue, violet and ultra-violet wavelengths

The Artificial Light Management Plan will be prepared to the satisfaction of the ToPH on advice from the DBCA at subdivision.

12.4.3.3 Construction management

CMP (Section 12.1.3) to include provisions restricting construction to day light hours only during turtle nesting and hatching season to avoid potential artificial light impacts to marine turtles during construction and development

12.4.3.4 Marine turtle management plan

A Marine Turtle Management Plan will be prepared to minimise potential impacts, including through the use of recreation vehicles, pets and interaction with nesting turtles, to marine turtles from an increased residential population. The Marine Turtle Management Plan will be prepared to the satisfaction of the ToPH on advice from the DBCA at subdivision.

12.5 Flora and vegetation

12.5.1 Environmental objective

To protect flora and vegetation so that biological diversity and ecological integrity are maintained

12.5.2 Potential impacts

- Loss of up to up to 11.8 ha coastal dune vegetation
- Loss of up to 10 *Gomphrena pusilla* (P2) plants
- Introduction and distribution of weed species
- Hydrological changes
- Vegetation disturbance/loss as a result of construction works
- Vegetation quality degradation through increased pollution and waste.

12.5.3 Management response

MMP (Section 12.1.3), CMP (Section 12.1.3) and FMP (Section 11.1.1.3) to be prepared to the satisfaction of the ToPH and the DBCA at subdivision.

12.6 Terrestrial environmental quality

12.6.1.1 Environmental objective

To maintain the quality of land and soils so that the environment values are protected.

12.6.2 Acid sulfate soils

12.6.2.1 Potential impacts

ASS soils are stable when left undisturbed, but when they are exposed to air, during excavation or dewatering, this can set off a reaction resulting in acidity (sulfuric acid) being produced.

The potential impacts include:

- Acidification and release of heavy metals from ASS into groundwater, Pretty Pool Creek, and surrounding marine environment
- Corrosion of concrete structures such as bridges, piles, pylons and drainage pipes.

12.6.2.2 Management response

- A preliminary ASS investigation will need to be conducted to confirm the presence or absence of ASS prior to any site earth works.
- If ASS occurs, an ASS and Dewatering Management Plan (ASSDMP) will be prepared to the satisfaction of the DWER at subdivision.

12.6.3 Potential contamination

12.6.3.1 Potential impacts

Potential for risk to human health from demolition of buildings that may be constructed from asbestos containing materials.

12.6.3.2 Management response

HAZMAT assessment should be undertaken prior to demolition of the infrastructure on 29 Johnson Lane, Port Hedland to any identify potential contaminants.

12.7 Terrestrial fauna

12.7.1 Environmental objective

To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.

12.7.2 Potential impacts

Activities that impact on vegetation and flora typically extend to fauna that rely on this habitat for nesting, foraging and/or shelter. The potential impacts to terrestrial fauna may include:

- Habitat disturbance as a result of construction, and increased use of off-road vehicles
- Impact on migratory bird species through loss of habitat
- As a result of disturbance during construction (noise and clearing activities), there may be an effect on the local abundance of fauna populations due to interruption to fauna behaviour, including displacement, injury or death
- Inadvertent injury and/or mortality as a result of increased vehicle strikes from increased traffic

- Impacts on significant fauna species
- Habitat destruction from increased activity from domestic pets
- Habitat and food source degradation through increased pollution and waste.

The proposed development is likely to result in disturbance to waterbirds which inhabit the Pretty Pool Creek shoreline and mud flats. The impacts to these waterbirds are likely to include a permanent loss of foraging habitats and noise impacts resulting from the use of heavy machinery during the construction phase.

12.7.3 Management response

- Avoid clearing of rocky/boulder habitat that may contain micro-habitat suitable for refuge for some small terrestrial mammal species.
- The Pretty Pool Creek line will be avoided.
- Maintain equipment such that all noise emitting equipment is fully serviceable and working to the correct specifications. All construction movement will be scheduled to take place during the day.
- MMP (Section 12.1.3), CMP (Section 12.1.3) and FMP (Section 11.1.1.3) to be prepared to the satisfaction of the ToPH and the DBCA at subdivision.
- FMP will also address a community education program including:
  - installation of signs and educational material to inform the public of the local fauna and important habitats that people should avoid
  - encourage the community to use dog leads and discourage people to allow dogs to roam off-leash
  - discourage littering and pollution through educational material and fines.

12.8 Air Quality

12.8.1 Environmental objective

To maintain air quality and minimise emissions so that environmental values are protected.

12.8.2 Potential impacts

In 2009, the EPA expressed concern that 24 hour PM10 dust concentrations regularly exceeded the air National Environmental Protection Measure (air NEPM) of 50 µg/m3 (+ 5 exceedances for natural events) and that existing planning arrangements allowed for residential development in Port Hedland's West End.

Air Quality could be potentially impacted, either directly or indirectly, through the generation of fugitive dust emissions through the following construction activities:

- Clearing land for the development sites, public open space, roads and carpark
- wind-borne dust from exposed surfaces, earth moving, transport, stockpiling or loading of materials

12.8.3 Management response

- Dust management at the site shall comply with Guidelines for Managing the Impacts of Dust and Associated Contaminants from Land Development Sites, Contaminated Sites Remediation and Other Related Activities (Department of Environment and Conservation 2011) through the preparation and implementation of a Dust Management Plan to prevent or avoid excessive dust generation. The Dust Management Plan will address the following wetting procedures of the development work area will be undertaken:
  - Any dry engineering fill sand to be stockpiled will be actively wet down during active extraction
  - Water carts will be available near the site entrance to enable pre-wetting of access roads and areas of the site where vehicle movements are anticipated will be carried out.

- Dust Management Plan to be prepared to the satisfaction of the ToPH and DWER at subdivision
- Prior to commencement of any construction, wind fencing will be installed on the boundaries of the site if required
- Should high wind speeds be forecast, site activities will be reviewed as deemed appropriate.

12.9 Social Surroundings

12.9.1 Aboriginal heritage and culture

12.9.1.1 Environmental objective

To protect social surroundings from significant harm.

12.9.1.2 Potential impacts

The potential impacts of the proposed development on Aboriginal Heritage sites are related primarily to direct disturbance of sites and include:

- Excavation / construction activities may unearth and/or damage artefacts or other items of cultural Aboriginal significance.

12.9.1.3 Management response

- Cultural Significance Assessment to be undertaken at subdivision
- Approval to disturb the Aboriginal archaeological site under Section 18 of the *Aboriginal Heritage Act 1972* (if required) prior to ground disturbing activities
- Should any Aboriginal objects be identified or unearthed during development, works will be stopped and the findings reported to the DPLH

12.9.2 Amenity - Mosquitos

12.9.2.1 Environmental objective

To protect social surroundings from significant harm.

12.9.2.2 Potential impacts

The partial infilling of the Pretty Pool Creek flood plain may result in increased areas of standing water following rainfall and periods of higher tides which may have the potential to serve as mosquito breeding areas. Health and amenity issues could affect visitors and residents living adjacent to the water body if mosquito breeding occurs in large numbers.

12.9.2.3 Management response

- Mosquito monitoring program to be prepared to the satisfaction of the ToPH at subdivision.
- If mosquito numbers are found to be excessive, a Mosquito Management Plan will be prepared in consultation with the ToPH and the Department of Health and implemented.

12.9.3 Bushfire

12.9.3.1 Environmental objective

To protect social surroundings from significant harm.

12.9.3.2 Potential impacts

- Damage to people, property and infrastructure from fire.
- Death and/or injury due to fire.

12.9.3.3 Management response

- Bushfire Management Plan has been prepared to provide the bushfire management framework proposed to be actioned as part of developing the site in accordance with the structure plan.
- Bushfire Attack Level contour mapping within the Bushfire Management Plan will be updated (if required) to reflect the proposed structure plan and subdivision outcomes.

13 FRAMEWORK FOR MANAGEMENT PLAN IMPLEMENTATION

The planning instrument that will be used to ensure the proposed management plans are implemented for the Stables development is the *Planning and Development Act 2005*.

Specifically, to regulate the production, delivery and approval of the management plans, subdivision conditions, which identify the requirement for the management plans to be provided, will be contained in the WAPC's subdivision approval.

In the absence of appropriate Model Subdivision Conditions, Non-standard Subdivision Conditions will be placed upon the subdivision application(s) for the Stables development. The Non-standard Subdivision Conditions will be placed upon the subdivision application(s) by the ToPH, with advice provided by the DBCA (where appropriate).

The Non-standard Subdivision Conditions will detail the requirements for the management plans and the appropriate regulatory authority(s) responsible for the approval of the management plans / clearance of the specific subdivision condition.

Regulation of the management plans through subdivision conditions provides certainty that the management plans will be approved prior to the development of the Stables development commencing. It will also allow for development to proceed in accordance with the management plans to ensure potential impacts are appropriately managed / mitigated.

14 CONCLUSIONS

In considering the proposed TPS amendment for the Stables development it is necessary to do so in the greater context of community issues currently facing Port Hedland, including:

- Critical land supply constraints and house affordability
- Resources workforce of which a significant proportion is fly in, fly out and on current projections that this proportion is going to increase significantly
- Lack of township amenity
- Land use conflict between the expansion of the port facilities and adjacent residential land uses in the west end of Port Hedland.

The proposed development of the Stables development can deliver the Pilbara's Port City Growth Plan aims and the Pilbara Cities state government initiative.

The Stables project creates a new residential area in Port Hedland's East End where people can choose to live permanently because of the high quality lifestyle proposed. The proposed development would facilitate (and maximise) high amenity residential development within the Port Hedland's East End.

A key conclusion of this EAR of the Stables development is that the proposed development footprint does not present as being a "fatal flaw" to the mangroves or the hydrological functioning of Pretty Pool Creek. The hydrodynamic modelling and subsequent mangrove risk matrix determined that the development would not cause any direct loss or damage to the mangroves.

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PLATES

PLATES

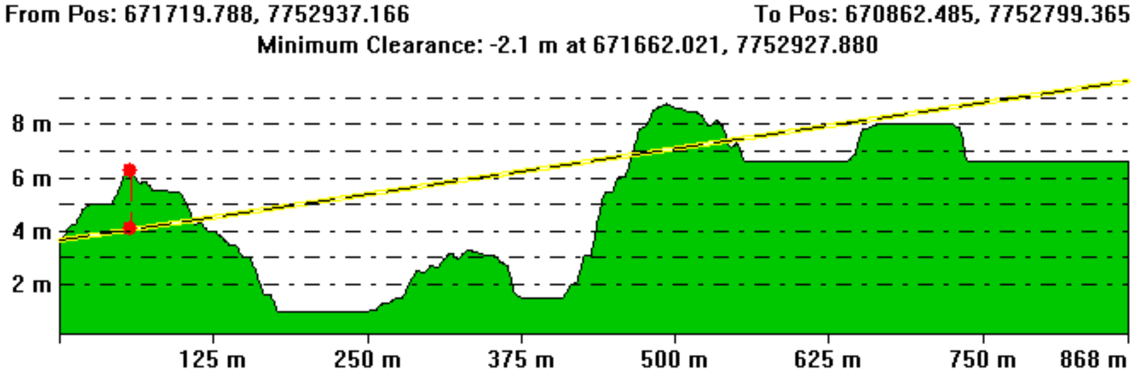


Plate A: Line of Site from ground level at Pretty Pool Beach to House 1 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

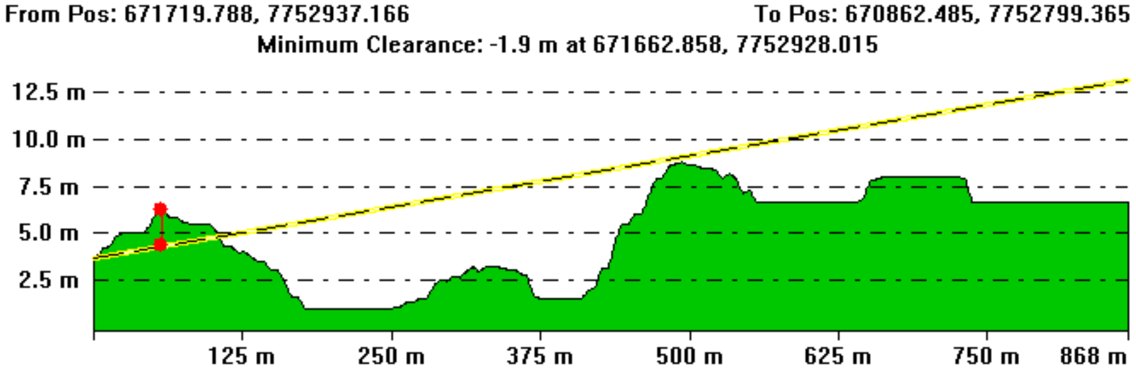


Plate B: Line of Site from ground level at Pretty Pool Beach to House 1 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

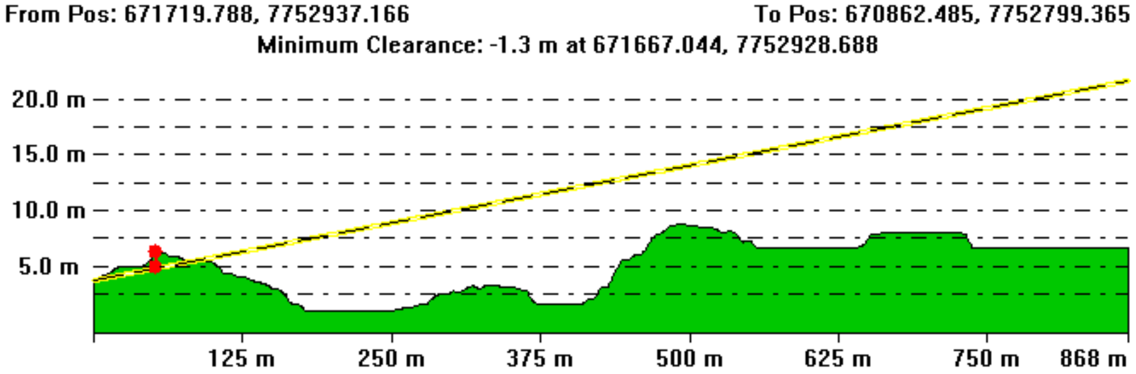


Plate C: Line of Site from ground level at Pretty Pool Beach to House 1 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

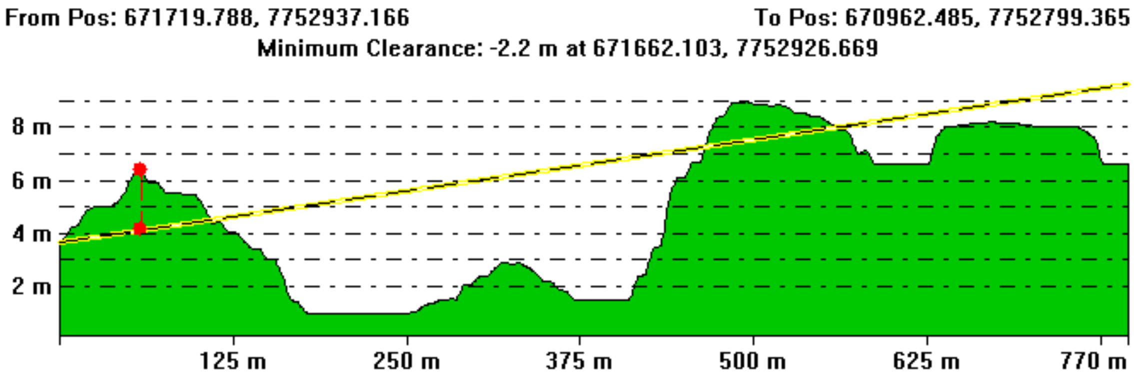


Plate D: Line of Site from ground level at Pretty Pool Beach to House 2 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

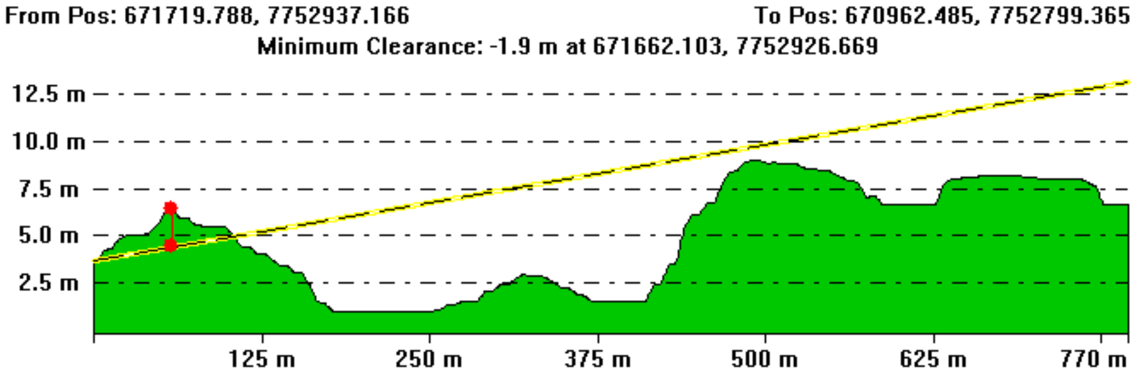


Plate E: Line of Site from ground level at Pretty Pool Beach to House 2 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

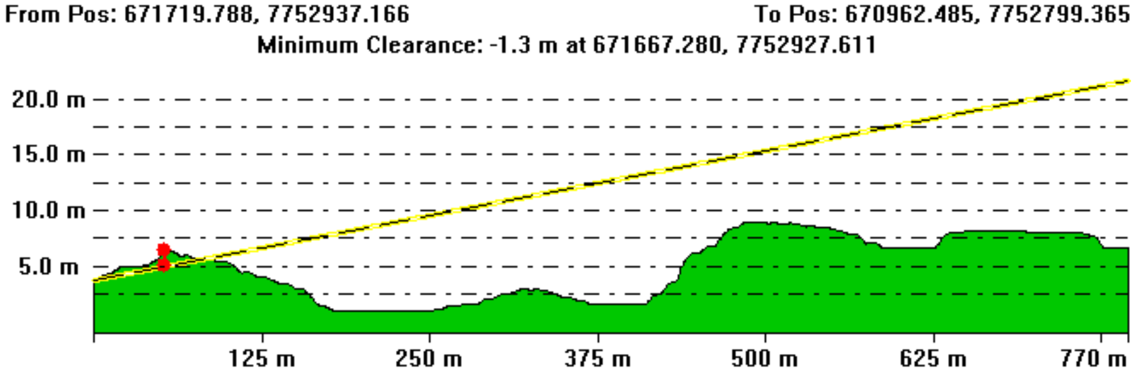


Plate F: Line of Site from ground level at Pretty Pool Beach to House 2 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

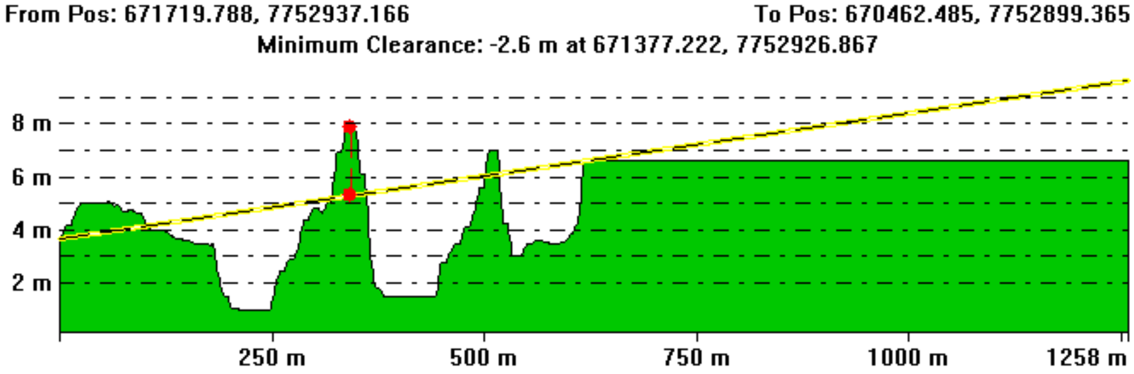


Plate G: Line of Site from ground level at Pretty Pool Beach to House 3 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

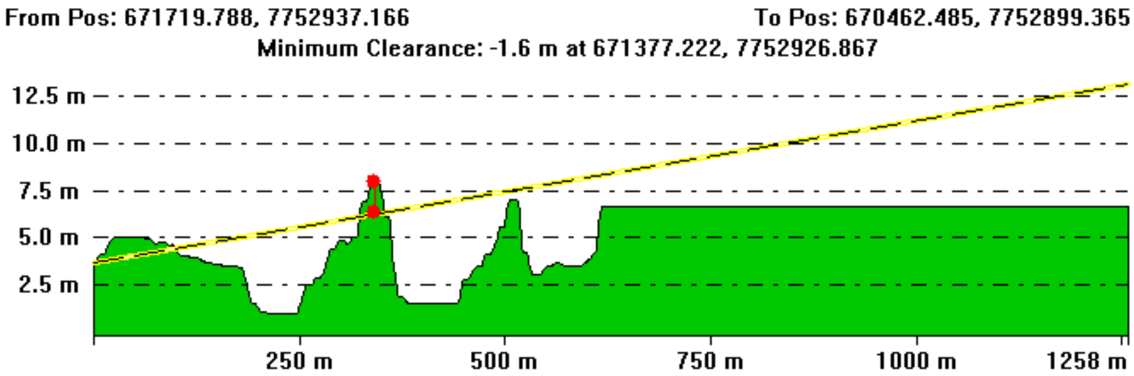


Plate H: Line of Site from ground level at Pretty Pool Beach to House 3 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

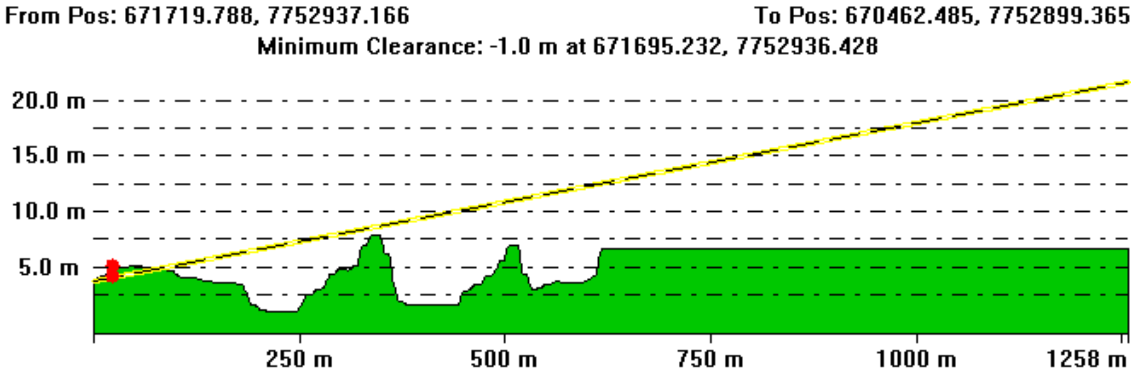


Plate I: Line of Site from ground level at Pretty Pool Beach to House 3 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

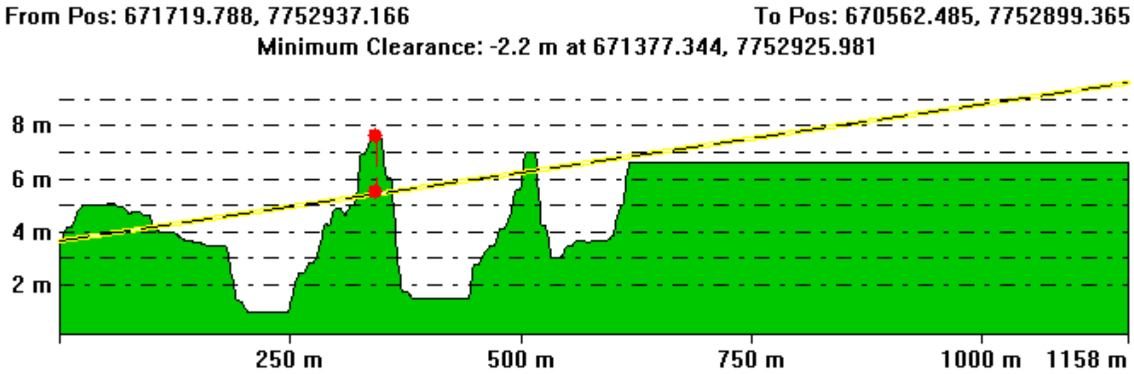


Plate J: Line of Site from ground level at Pretty Pool Beach to House 4 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

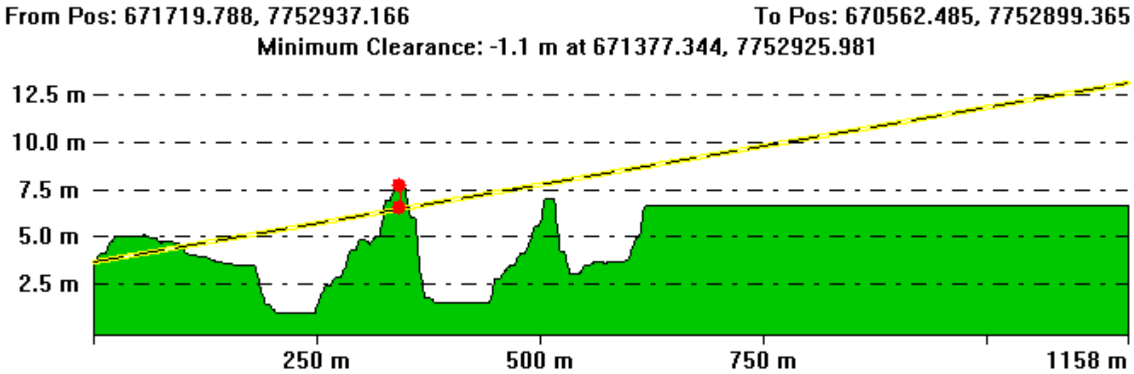


Plate K: Line of Site from ground level at Pretty Pool Beach to House 4 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

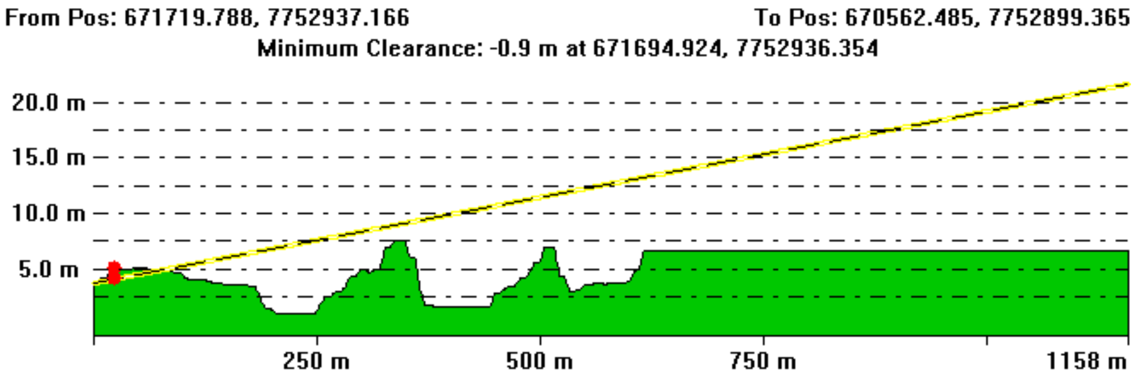


Plate L: Line of Site from ground level at Pretty Pool Beach to House 4 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

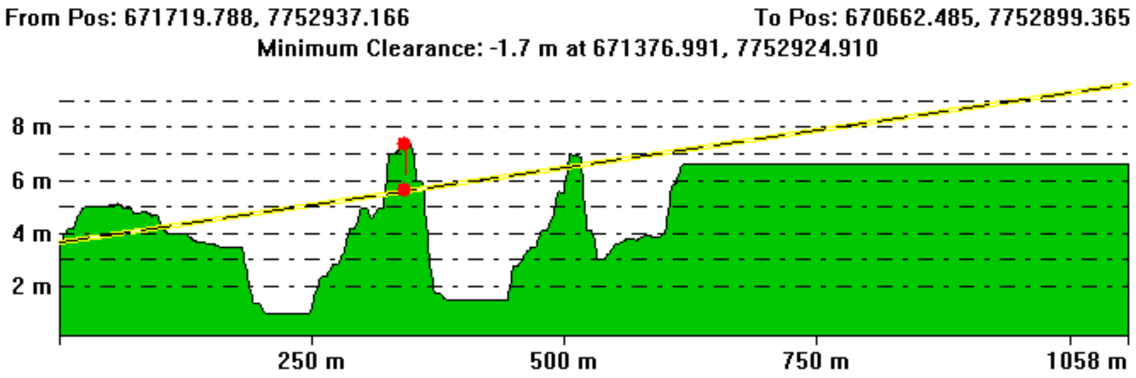


Plate M: Line of Site from ground level at Pretty Pool Beach to House 5 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

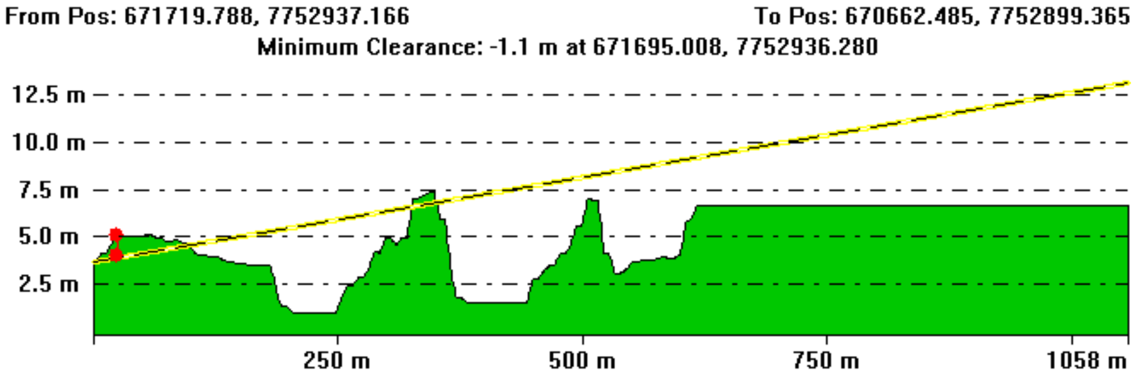


Plate N: Line of Site from ground level at Pretty Pool Beach to House 5 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

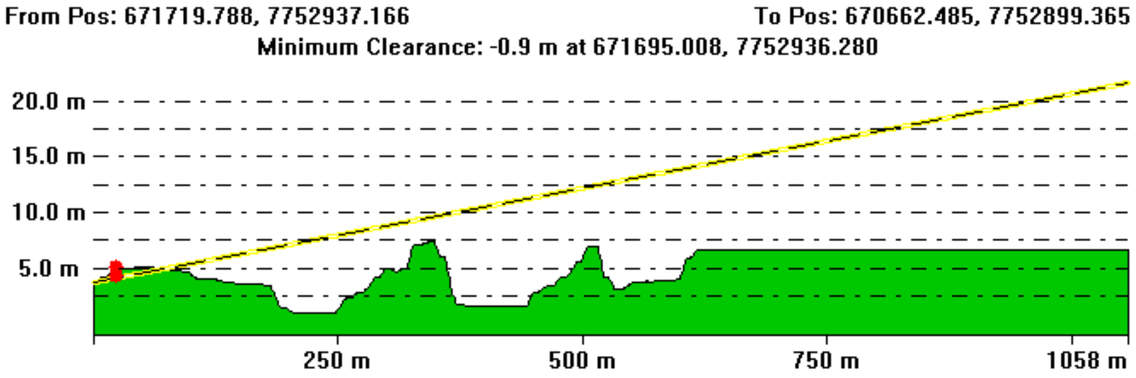


Plate O: Line of Site from ground level at Pretty Pool Beach to House 5 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

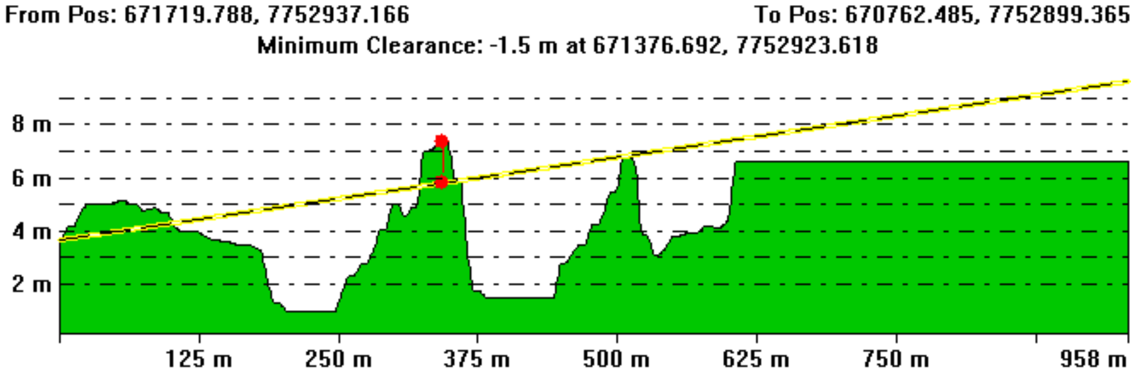


Plate P: Line of Site from ground level at Pretty Pool Beach to House 6 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

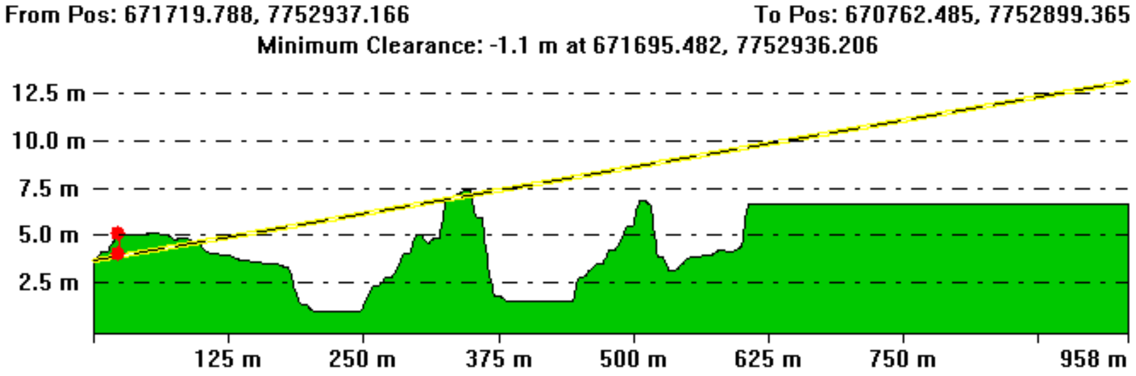


Plate Q: Line of Site from ground level at Pretty Pool Beach to House 6 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

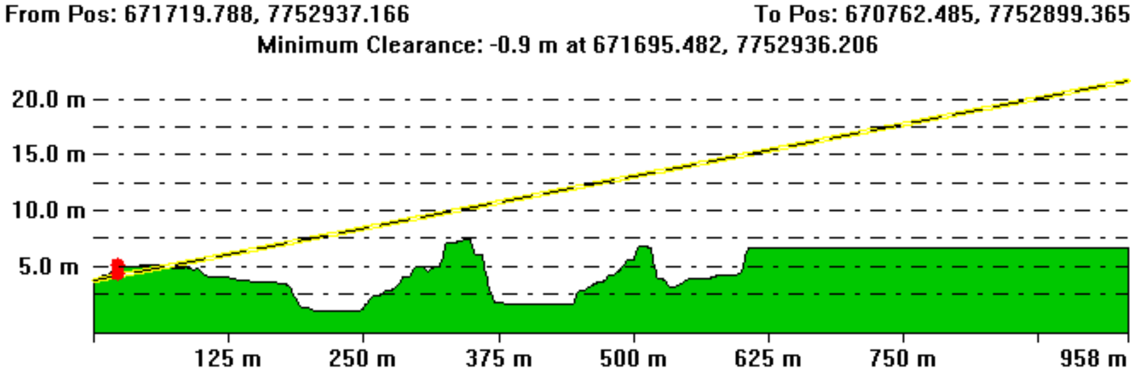


Plate R: Line of Site from ground level at Pretty Pool Beach to House 6 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

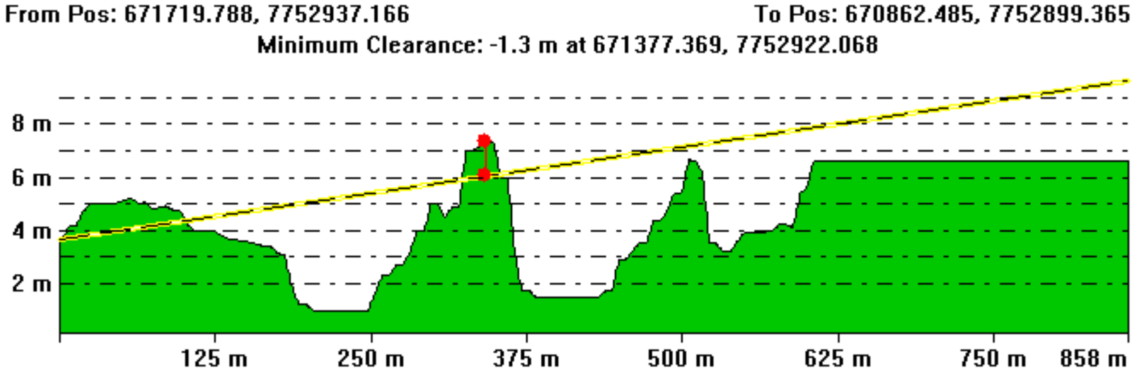


Plate S: Line of Site from ground level at Pretty Pool Beach to House 7 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

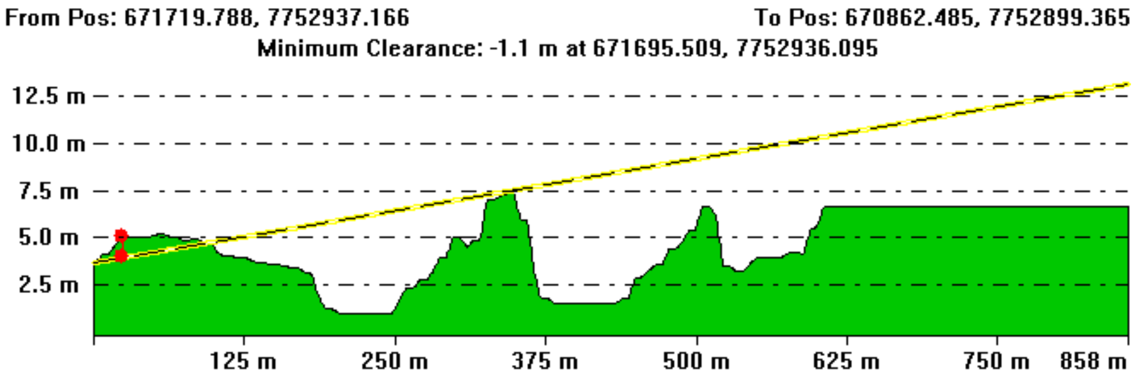


Plate T: Line of Site from ground level at Pretty Pool Beach to House 7 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

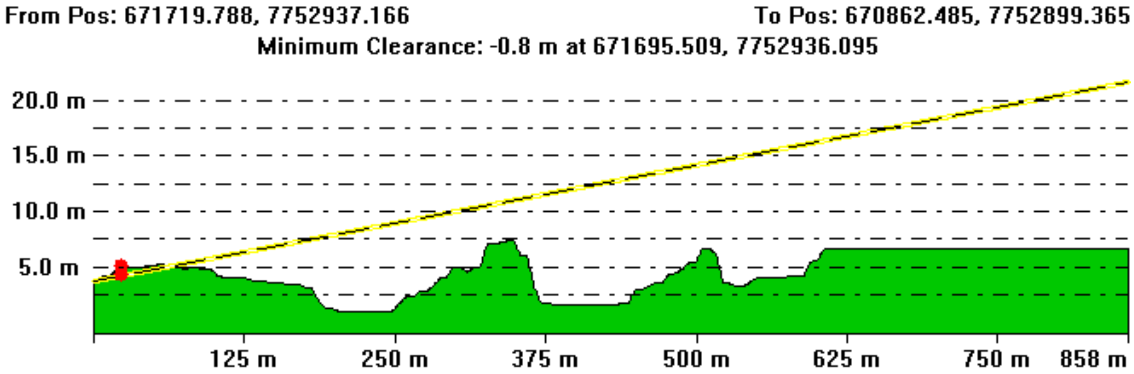


Plate U: Line of Site from ground level at Pretty Pool Beach to House 7 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

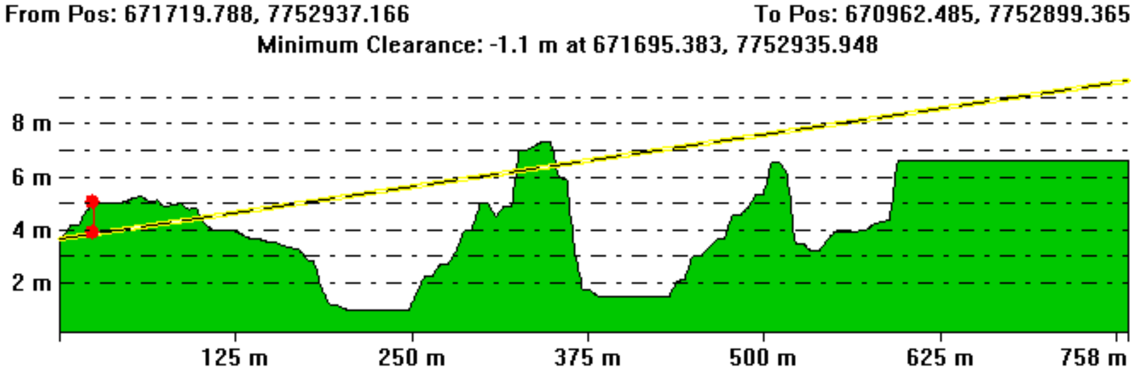


Plate V: Line of Site from ground level at Pretty Pool Beach to House 8 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

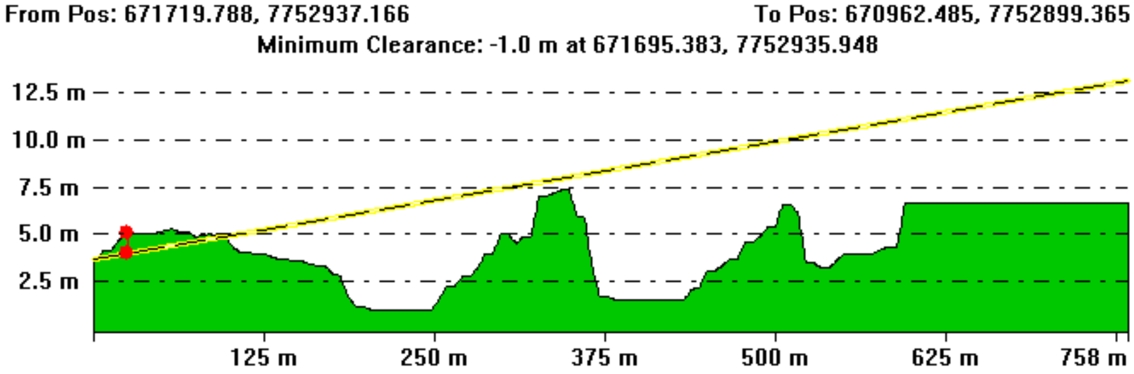


Plate W: Line of Site from ground level at Pretty Pool Beach to House 8 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

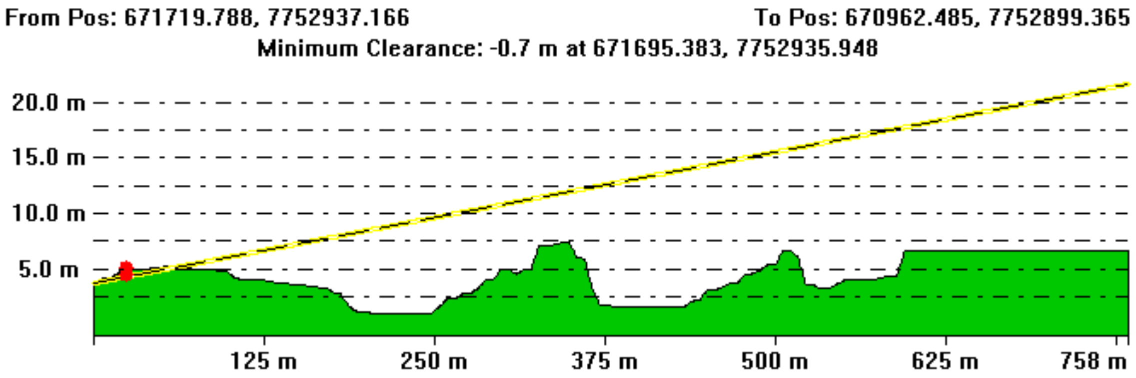


Plate X: Line of Site from ground level at Pretty Pool Beach to House 8 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

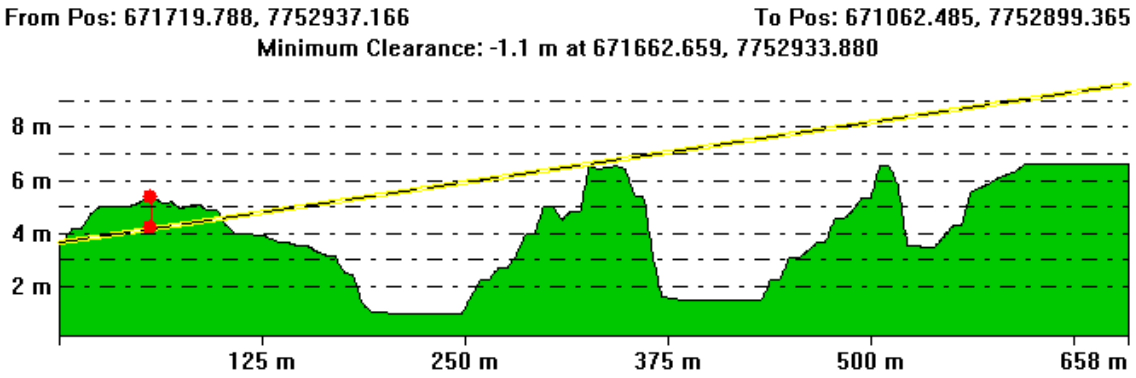


Plate Y: Line of Site from ground level at Pretty Pool Beach to House 9 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

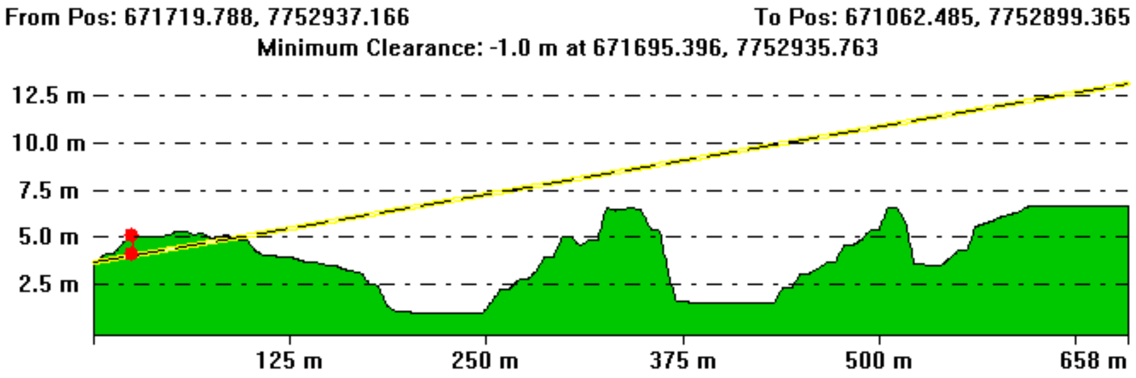


Plate Z: Line of Site from ground level at Pretty Pool Beach to House 9 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

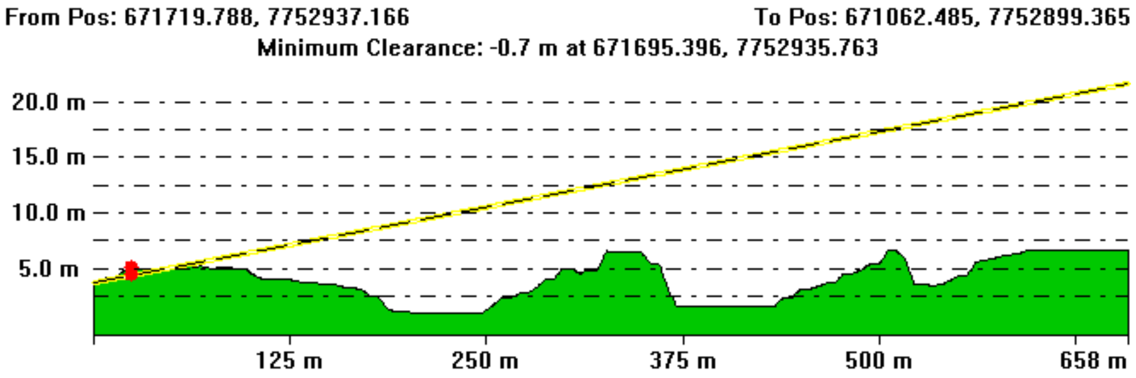


Plate AA: Line of Site from ground level at Pretty Pool Beach to House 9 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

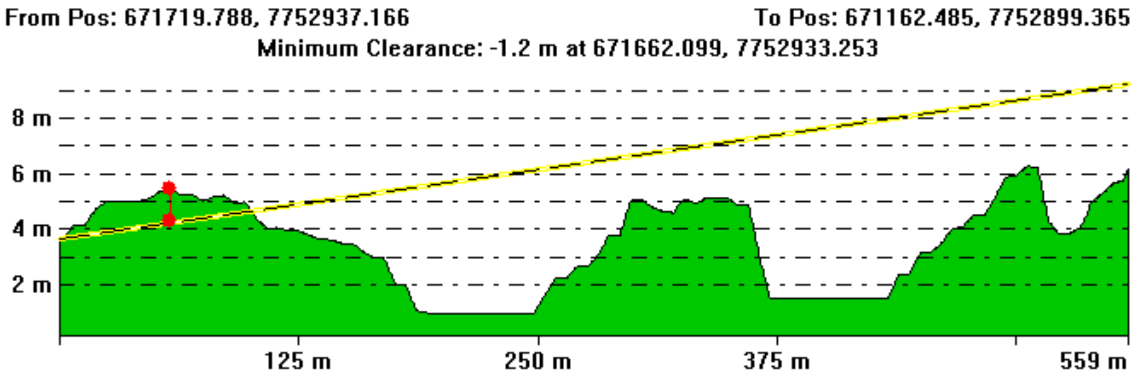


Plate BB: Line of Site from ground level at Pretty Pool Beach to House 10 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

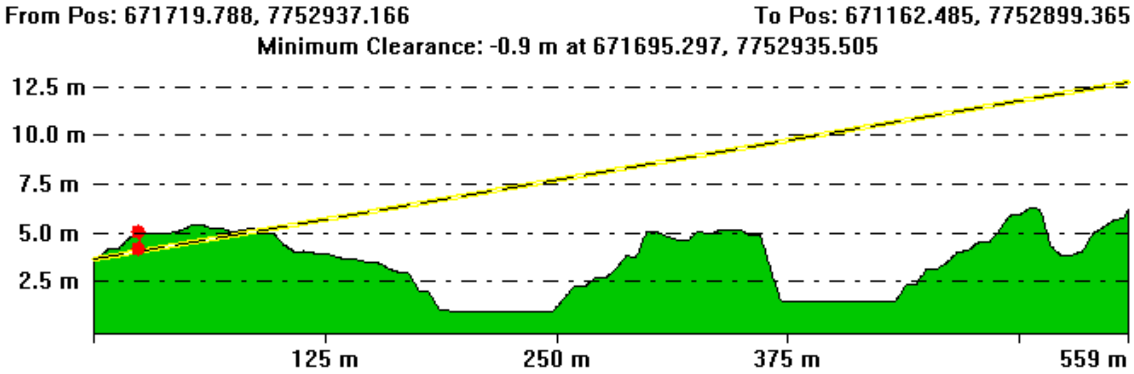


Plate CC: Line of Site from ground level at Pretty Pool Beach to House 10 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

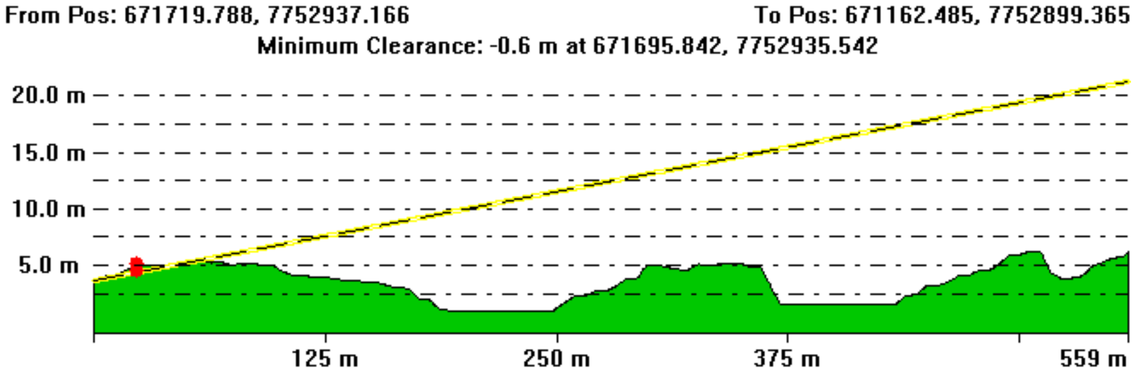


Plate DD: Line of Site from ground level at Pretty Pool Beach to House 10 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

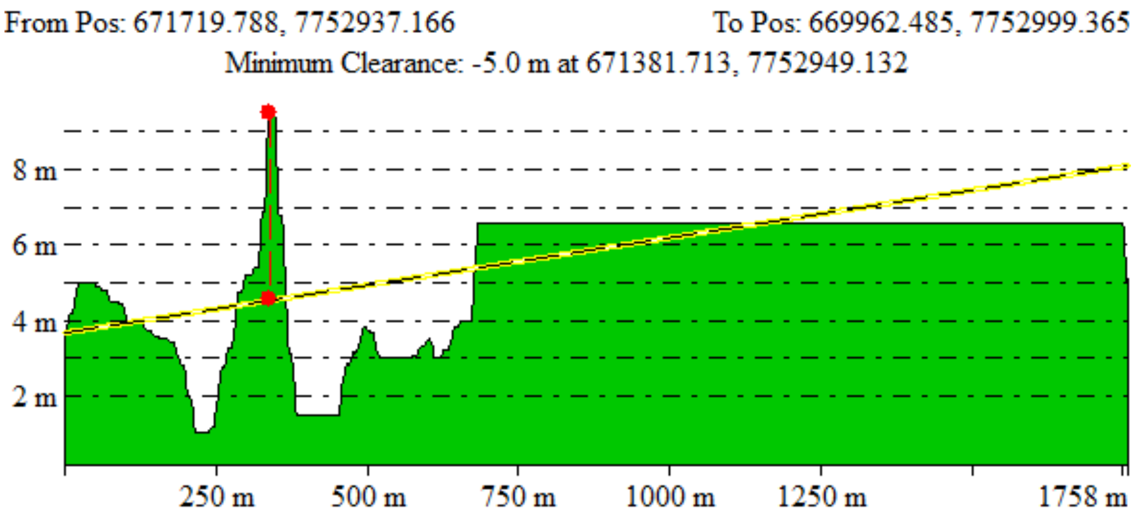


Plate EE: Line of Site from ground level at Pretty Pool Beach to House 11 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

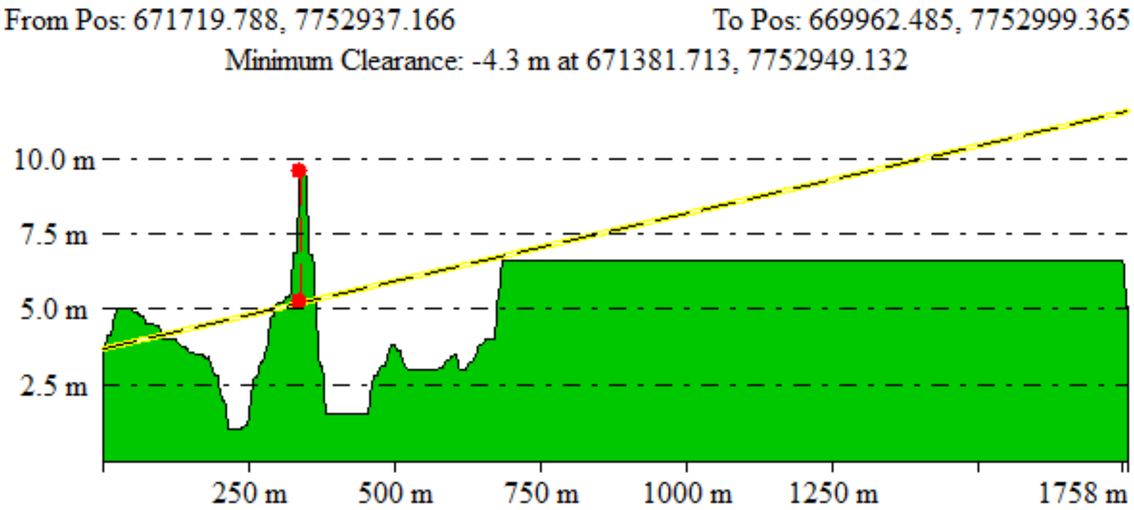


Plate FF: Line of Site from ground level at Pretty Pool Beach to House 11 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

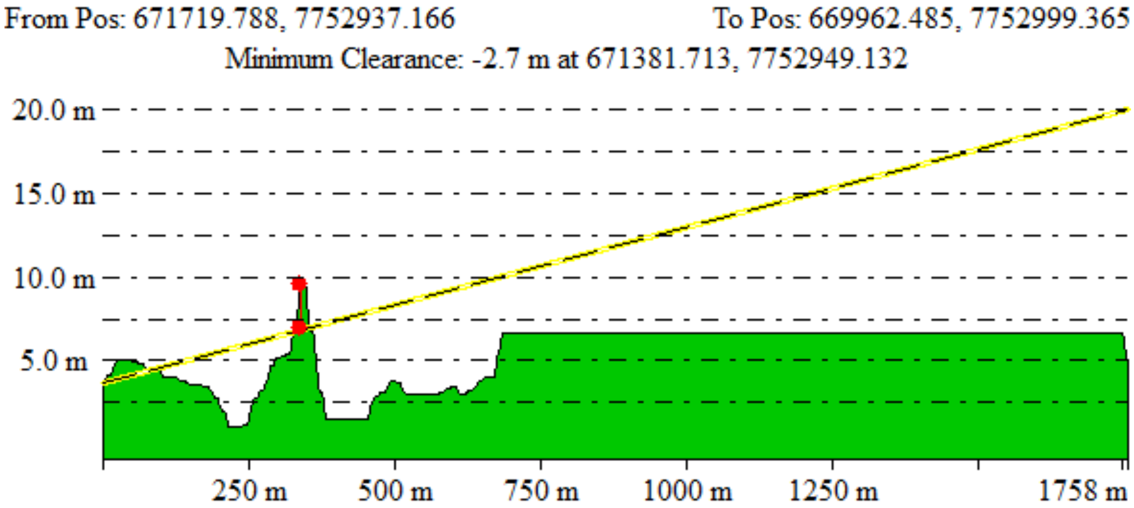


Plate GG: Line of Site from ground level at Pretty Pool Beach to House 11 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

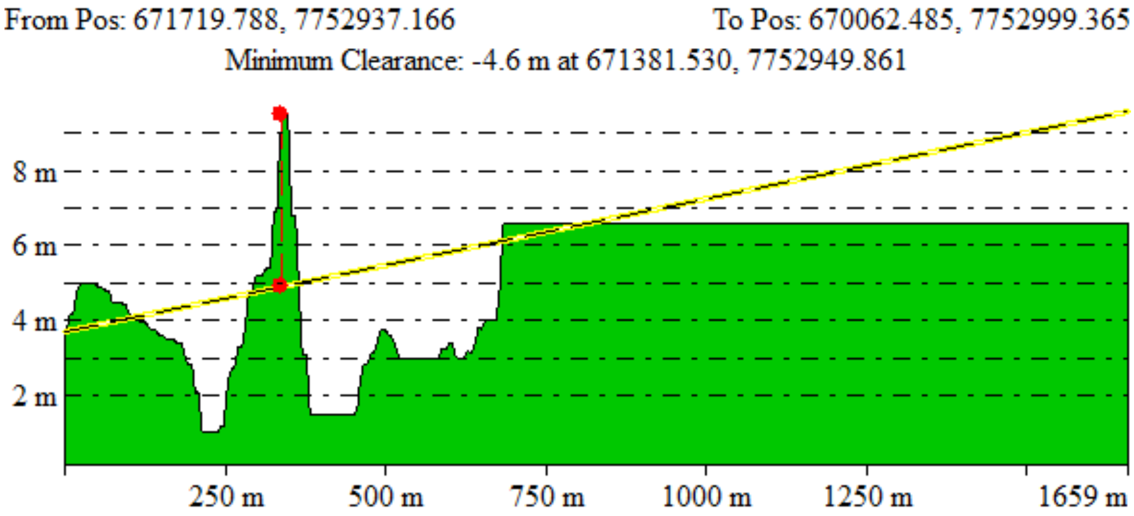


Plate HH: Line of Site from ground level at Pretty Pool Beach to House 12 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

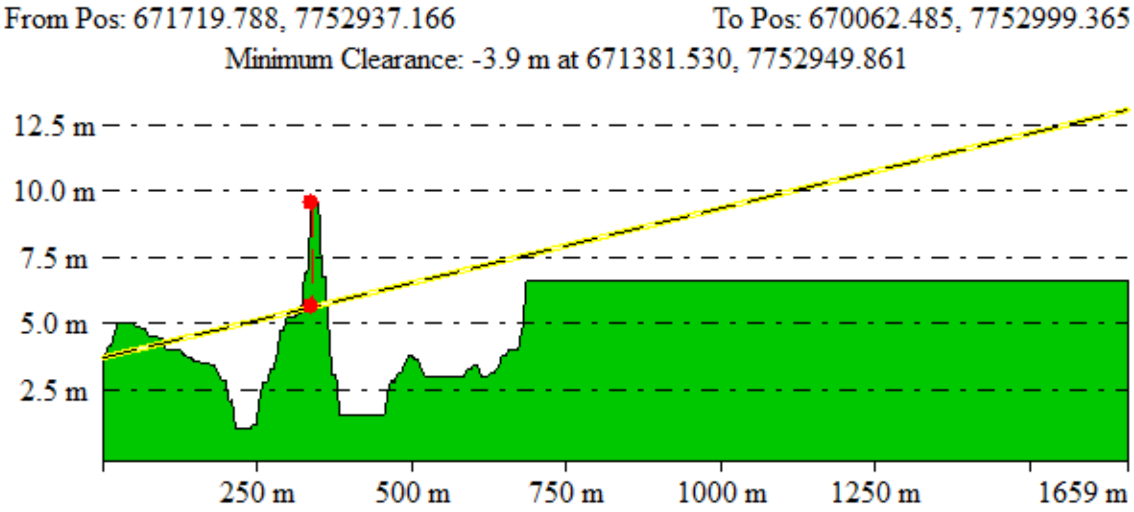


Plate II: Line of Site from ground level at Pretty Pool Beach to House 12 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

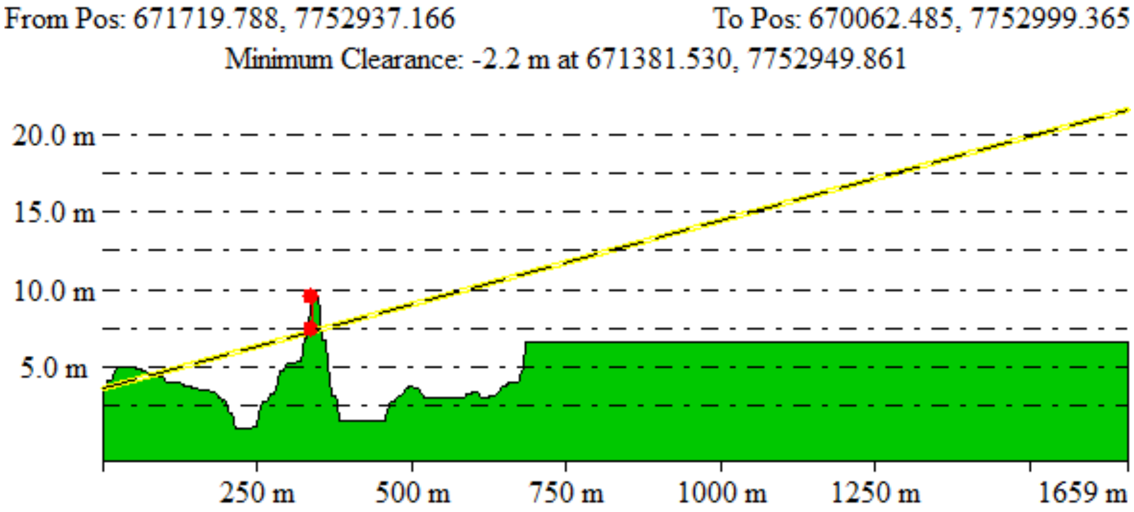


Plate JJ: Line of Site from ground level at Pretty Pool Beach to House 12 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

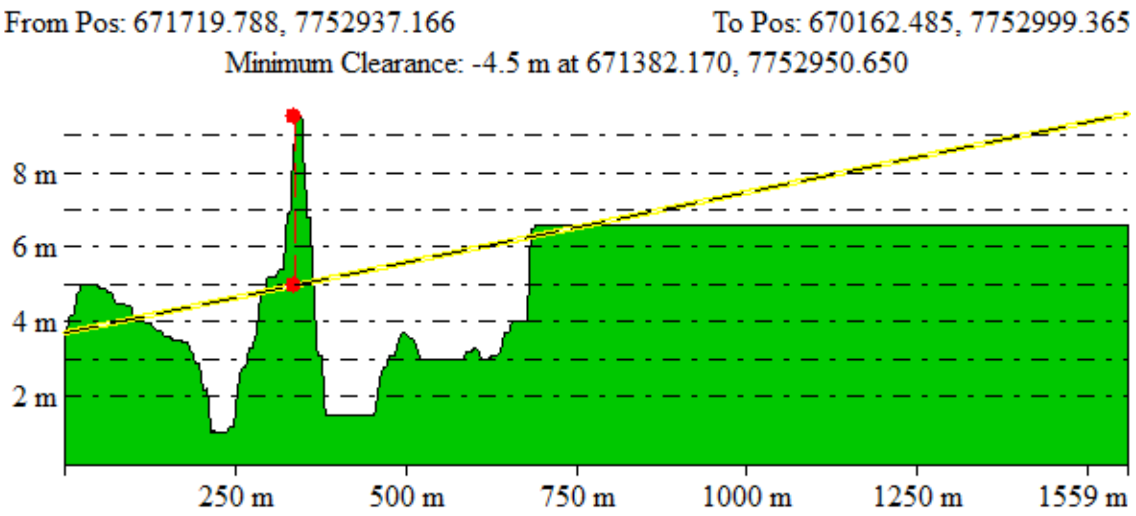


Plate KK: Line of Site from ground level at Pretty Pool Beach to House 13 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

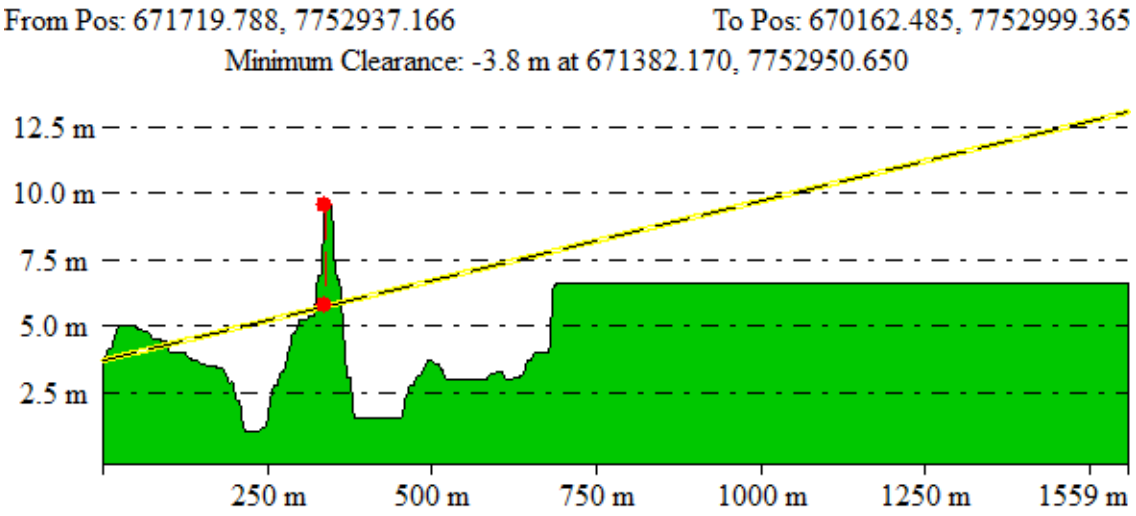


Plate LL: Line of Site from ground level at Pretty Pool Beach to House 13 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

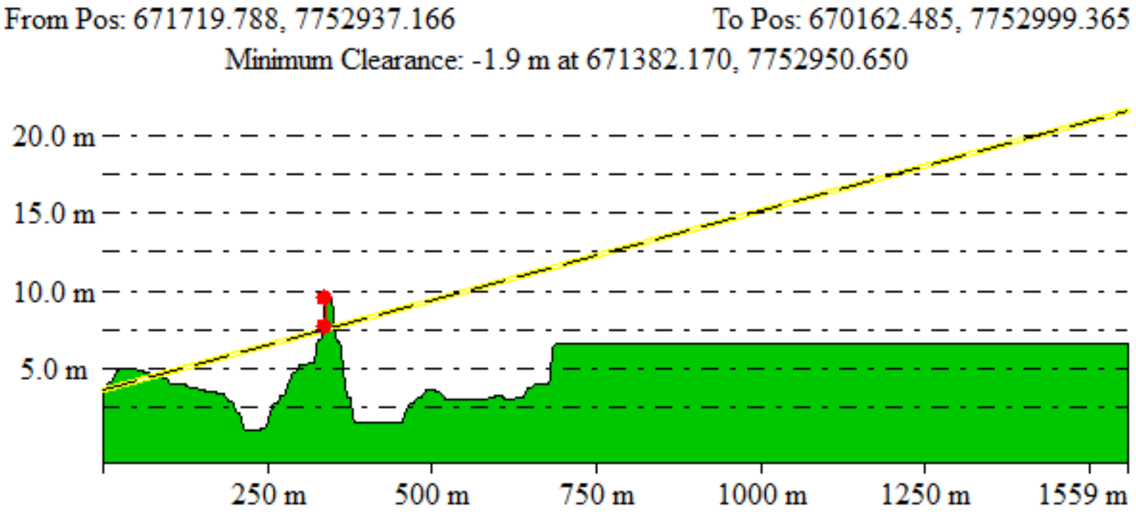


Plate MM: Line of Site from ground level at Pretty Pool Beach to House 13 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

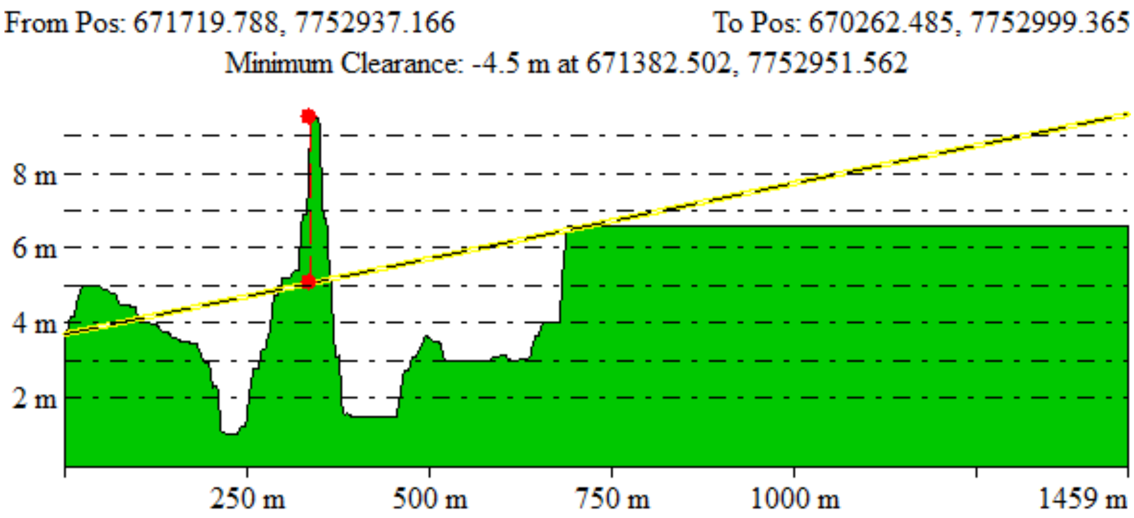


Plate NN: Line of Site from ground level at Pretty Pool Beach to House 14 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

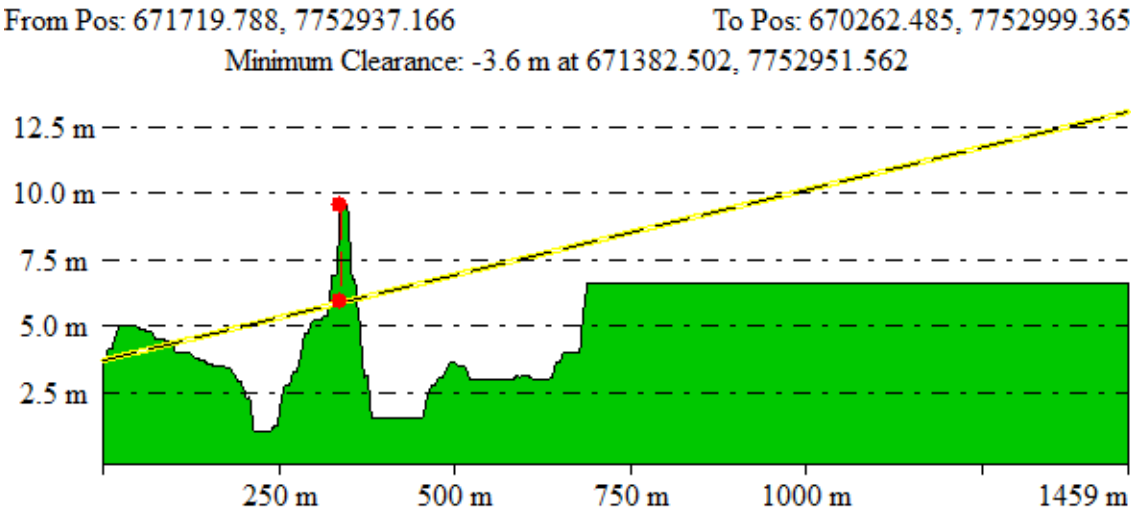


Plate OO: Line of Site from ground level at Pretty Pool Beach to House 14 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

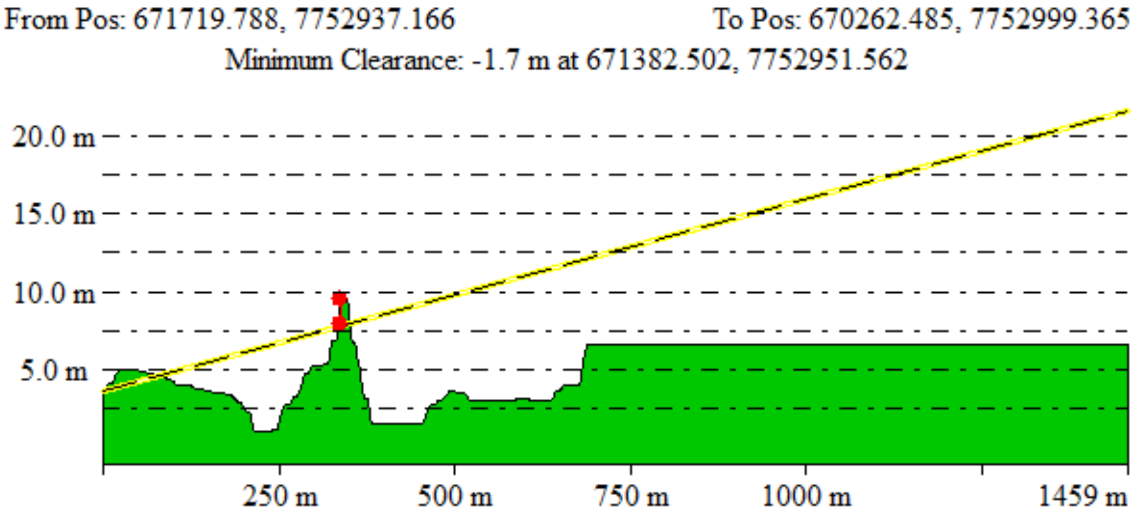


Plate PP: Line of Site from ground level at Pretty Pool Beach to House 14 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

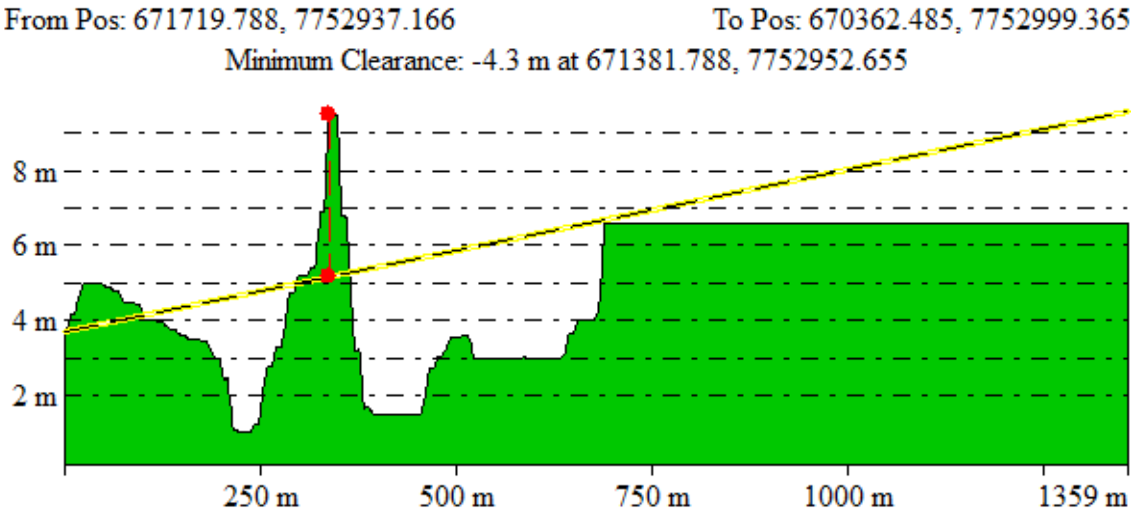


Plate QQ: Line of Site from ground level at Pretty Pool Beach to House 15 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

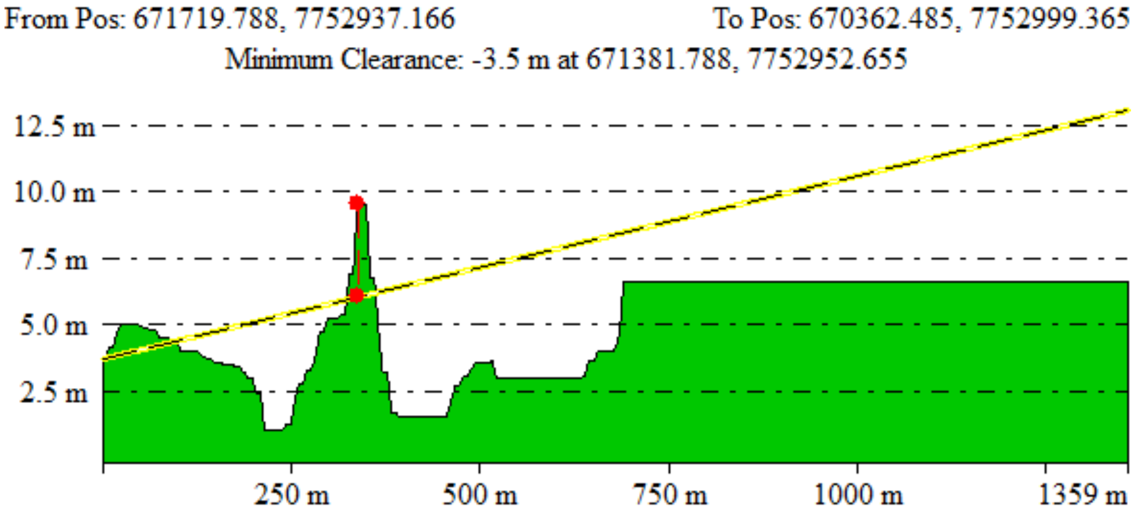


Plate RR: Line of Site from ground level at Pretty Pool Beach to House 15 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

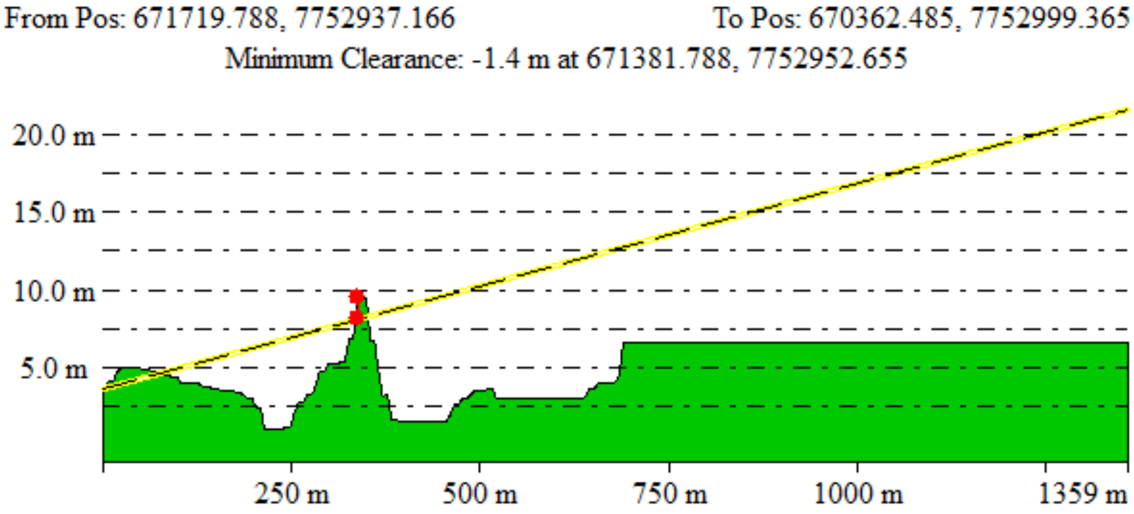


Plate SS: Line of Site from ground level at Pretty Pool Beach to House 15 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

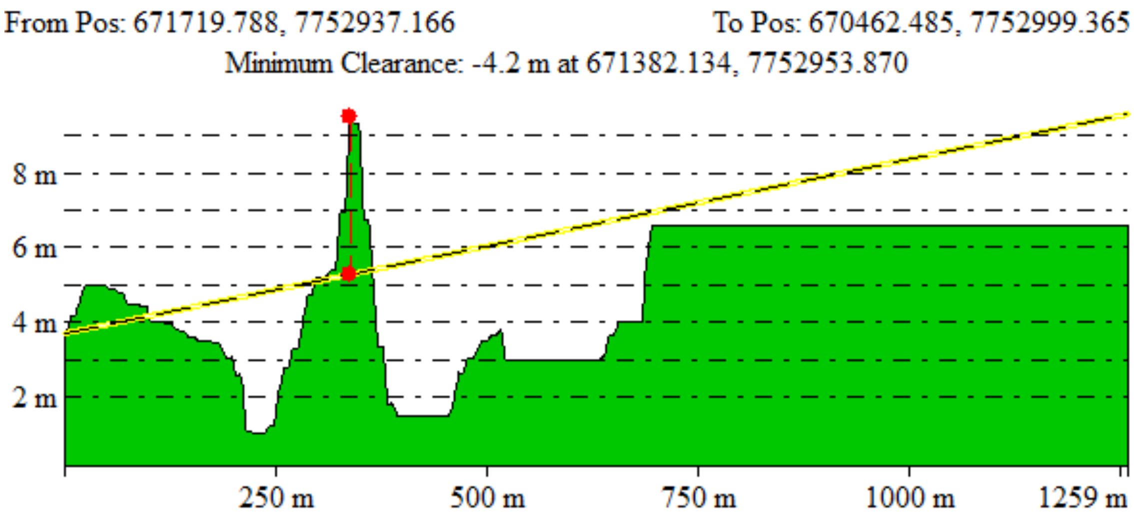


Plate TT: Line of Site from ground level at Pretty Pool Beach to House 16 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

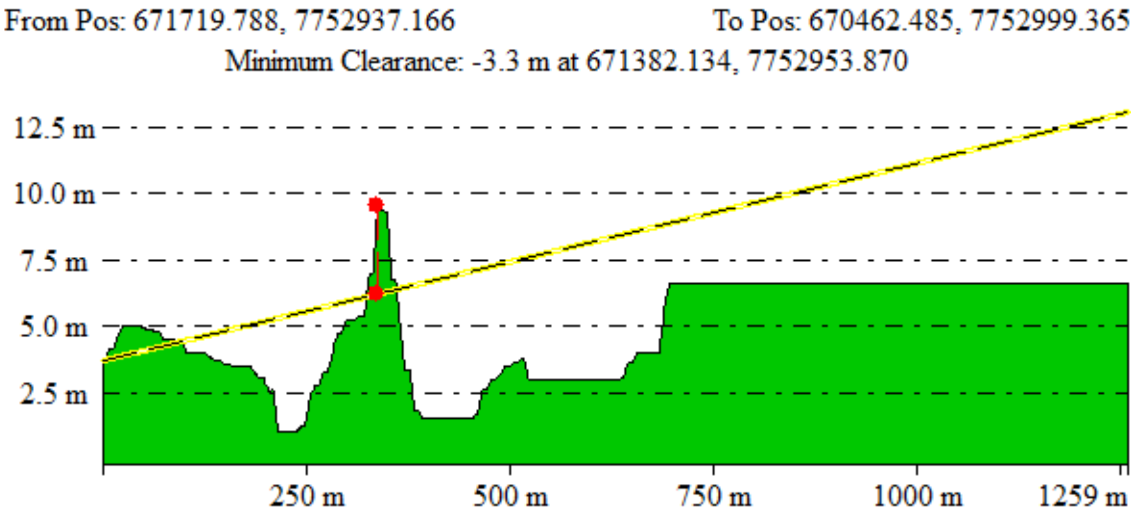


Plate UU: Line of Site from ground level at Pretty Pool Beach to House 16 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

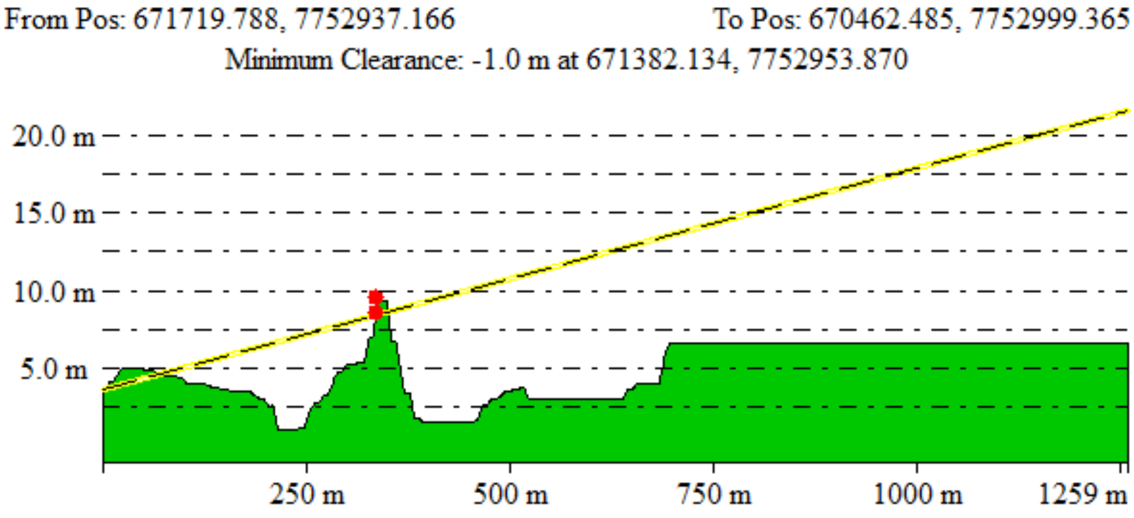


Plate VV: Line of Site from ground level at Pretty Pool Beach to House 16 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

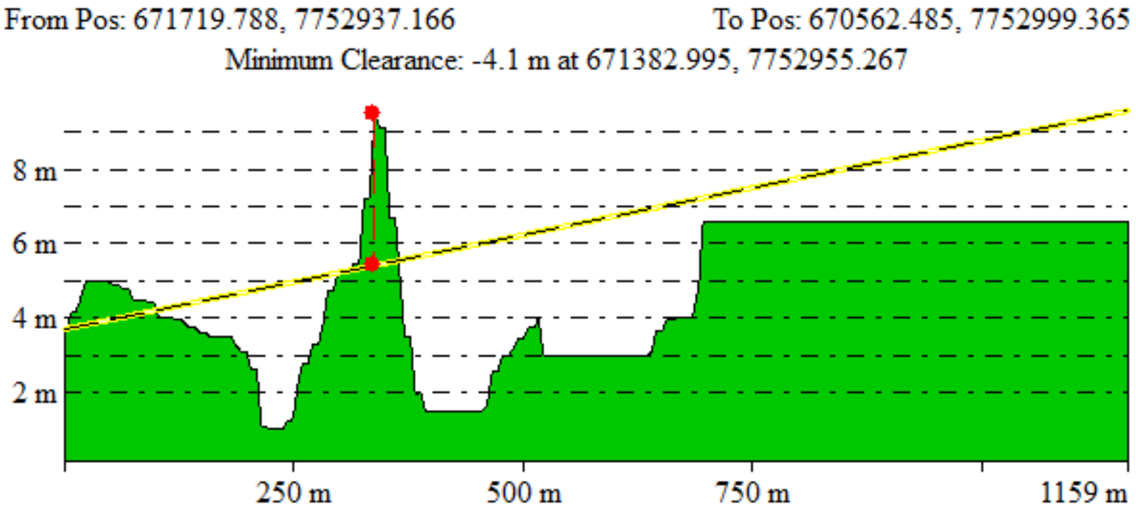


Plate WW: Line of Site from ground level at Pretty Pool Beach to House 17 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

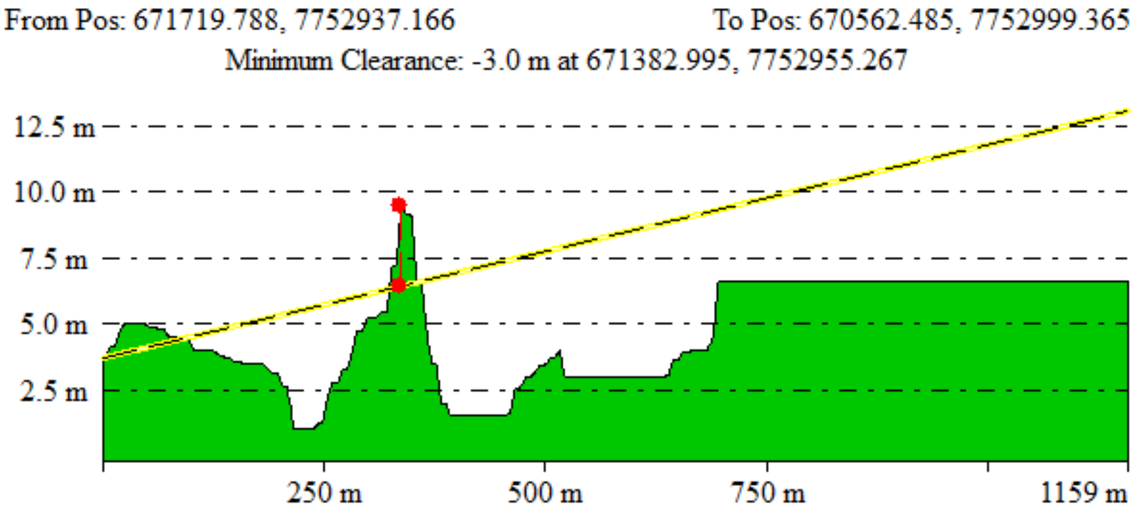


Plate XX: Line of Site from ground level at Pretty Pool Beach to House 17 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

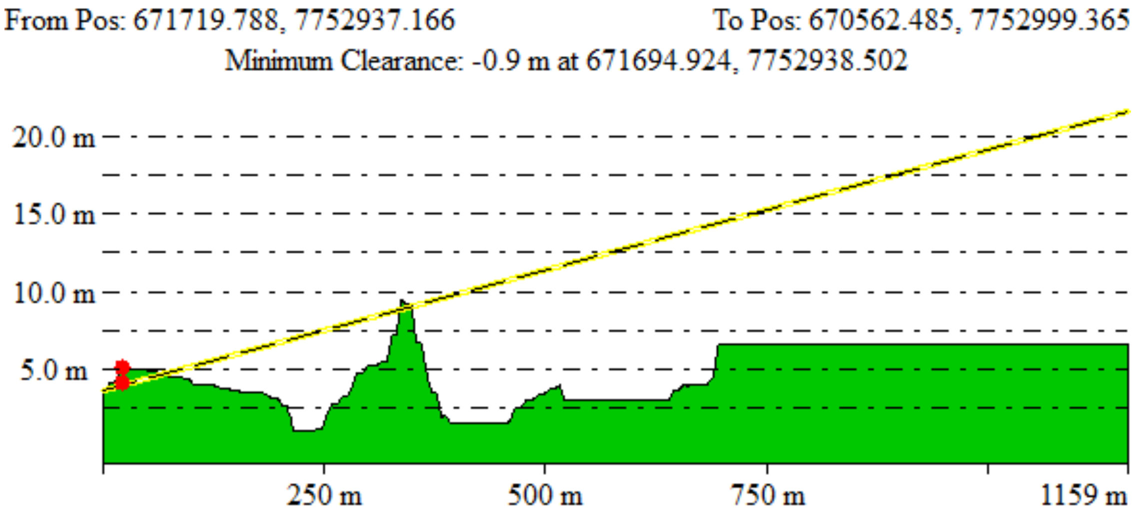


Plate YY: Line of Site from ground level at Pretty Pool Beach to House 17 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

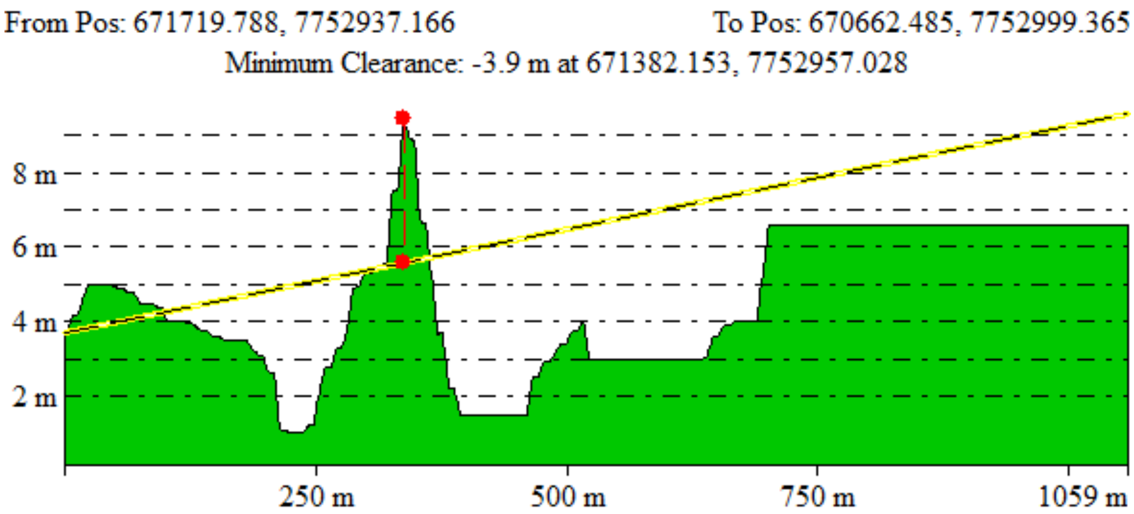


Plate ZZ: Line of Site from ground level at Pretty Pool Beach to House 18 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

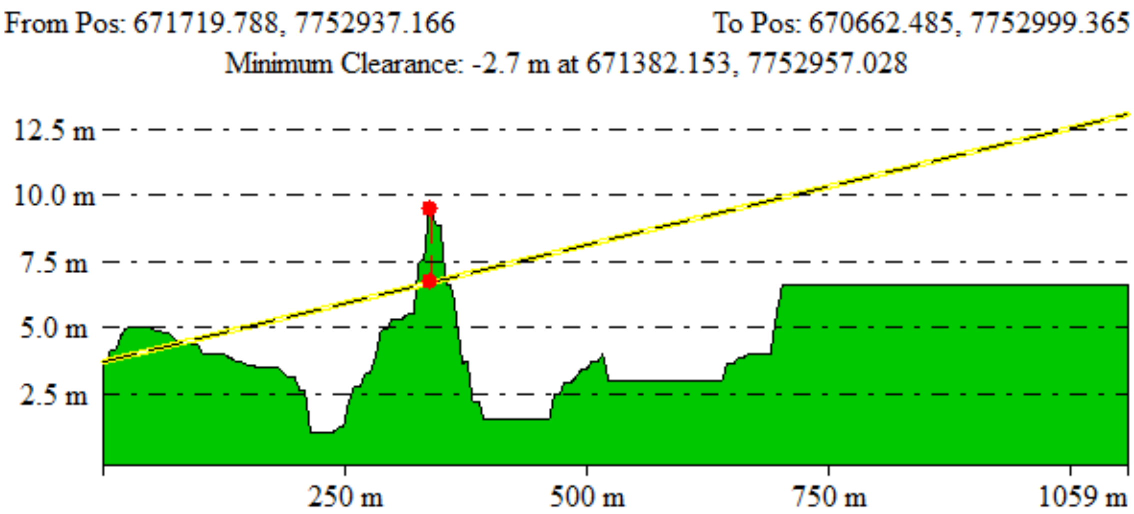


Plate AAA: Line of Site from ground level at Pretty Pool Beach to House 18 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

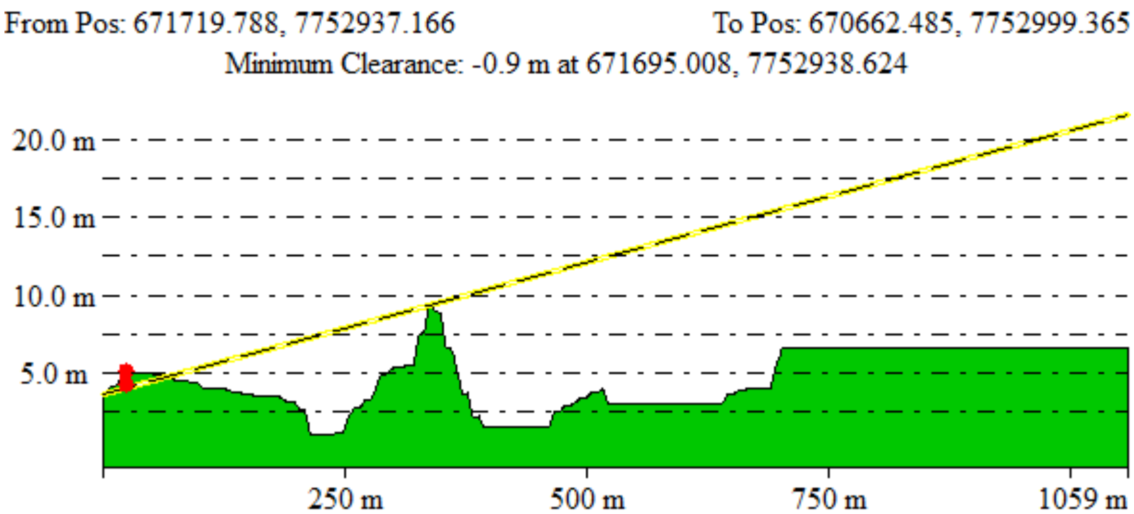


Plate BBB: Line of Site from ground level at Pretty Pool Beach to House 18 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

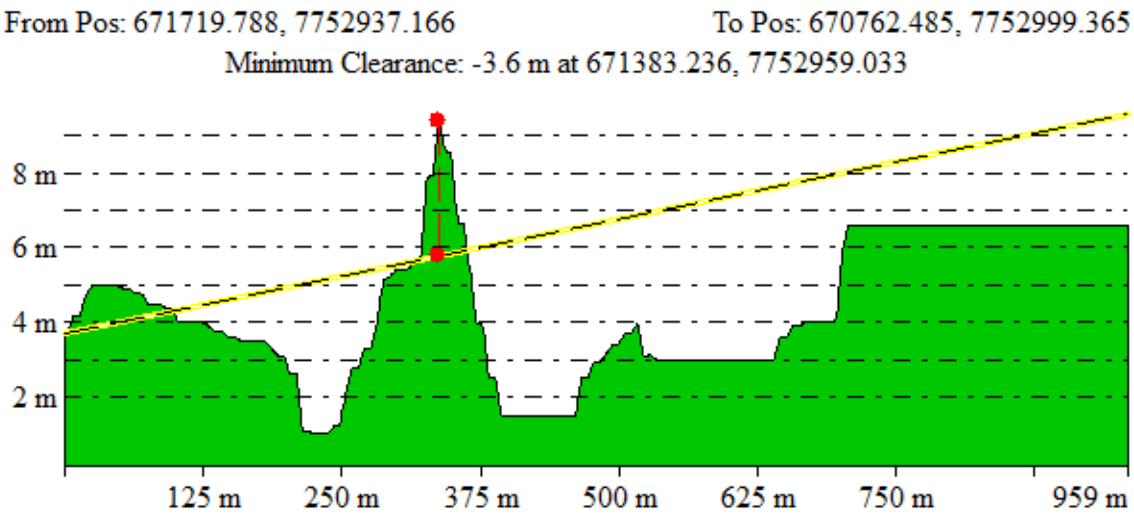


Plate CCC: Line of Site from ground level at Pretty Pool Beach to House 19 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

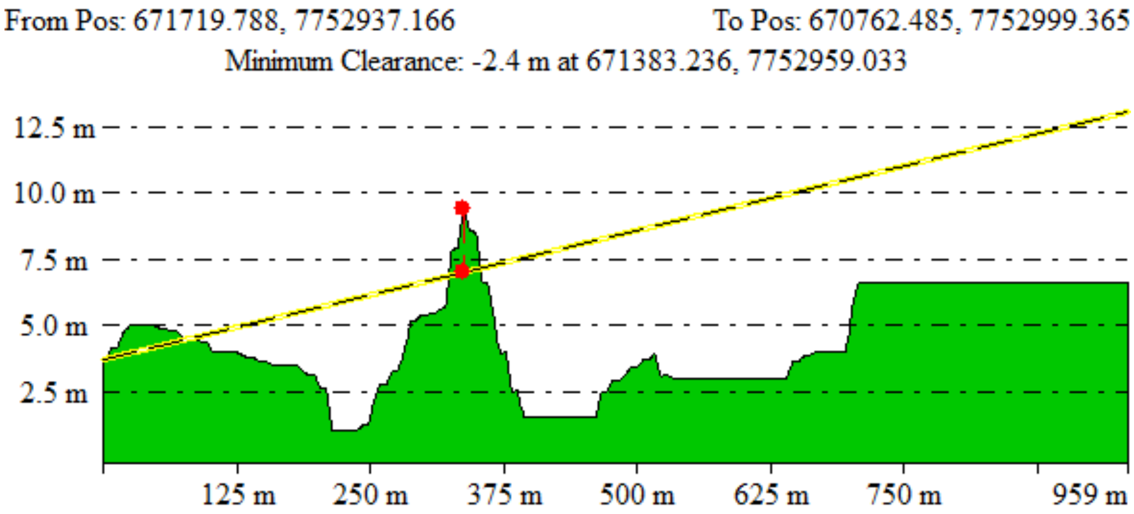


Plate DDD: Line of Site from ground level at Pretty Pool Beach to House 19 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

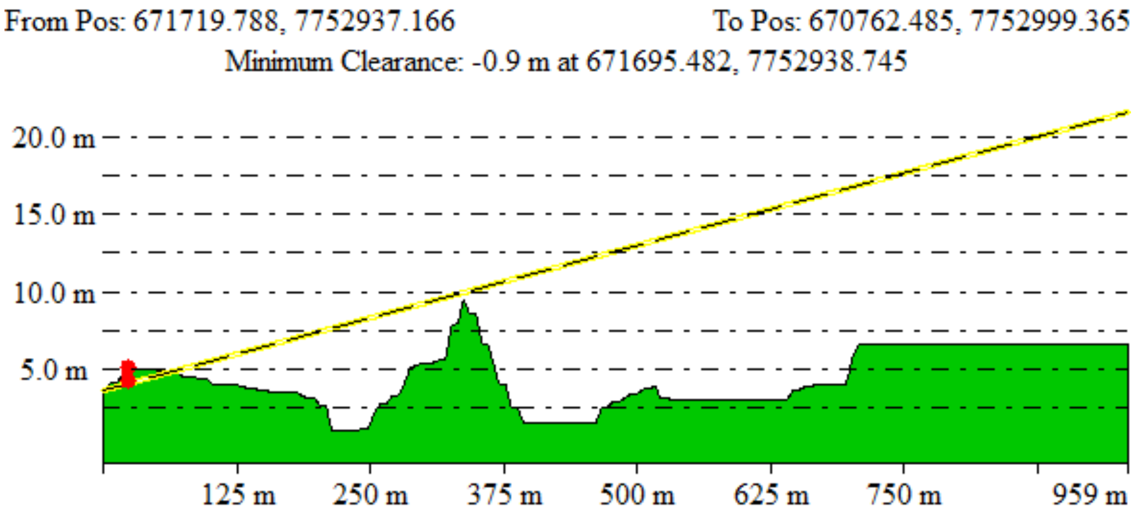


Plate EEE: Line of Site from ground level at Pretty Pool Beach to House 19 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

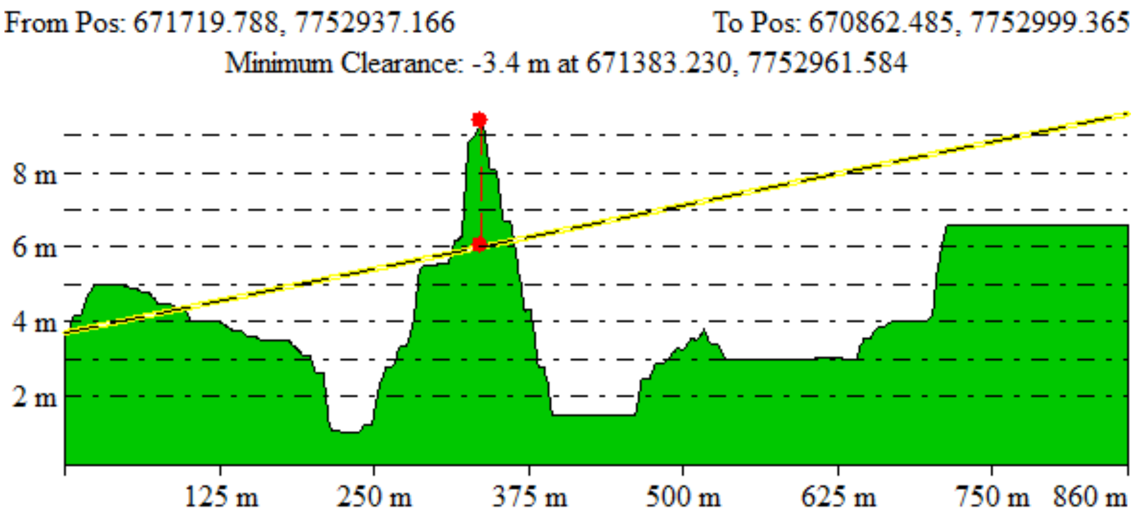


Plate FFF: **Line of Site from ground level at Pretty Pool Beach to House 20 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)**

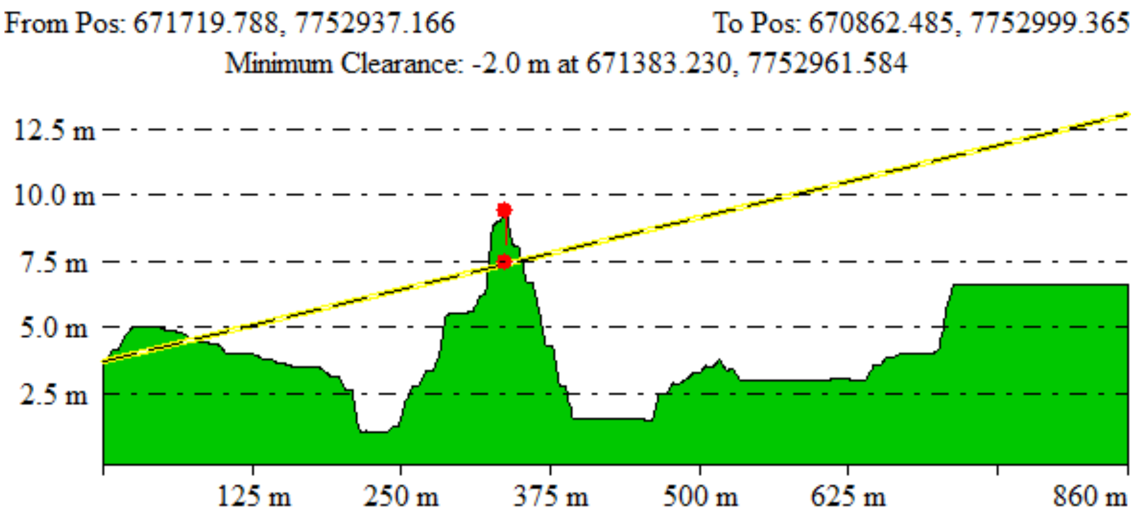


Plate GGG: **Line of Site from ground level at Pretty Pool Beach to House 20 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)**

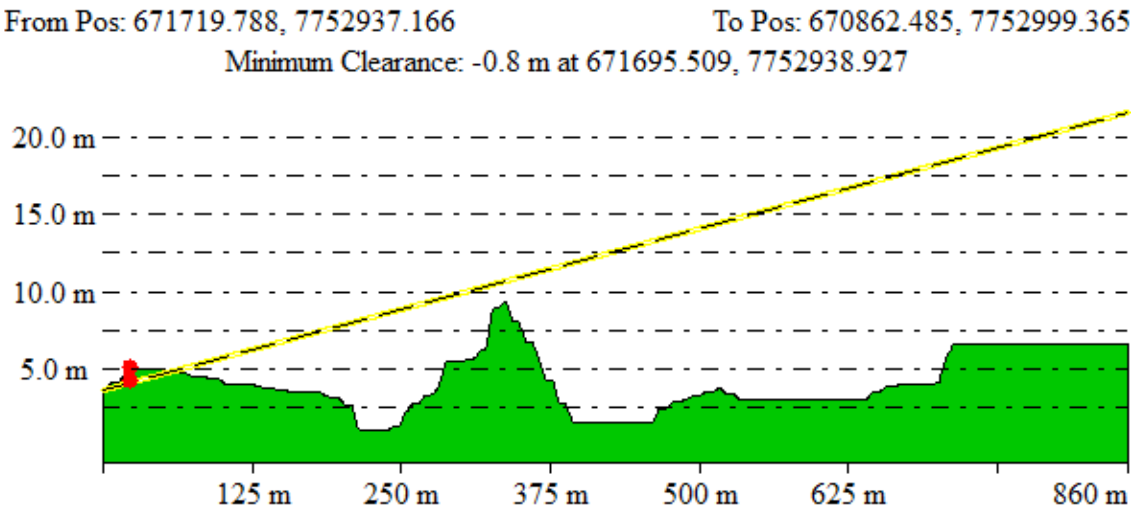


Plate HHH: **Line of Site from ground level at Pretty Pool Beach to House 20 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)**

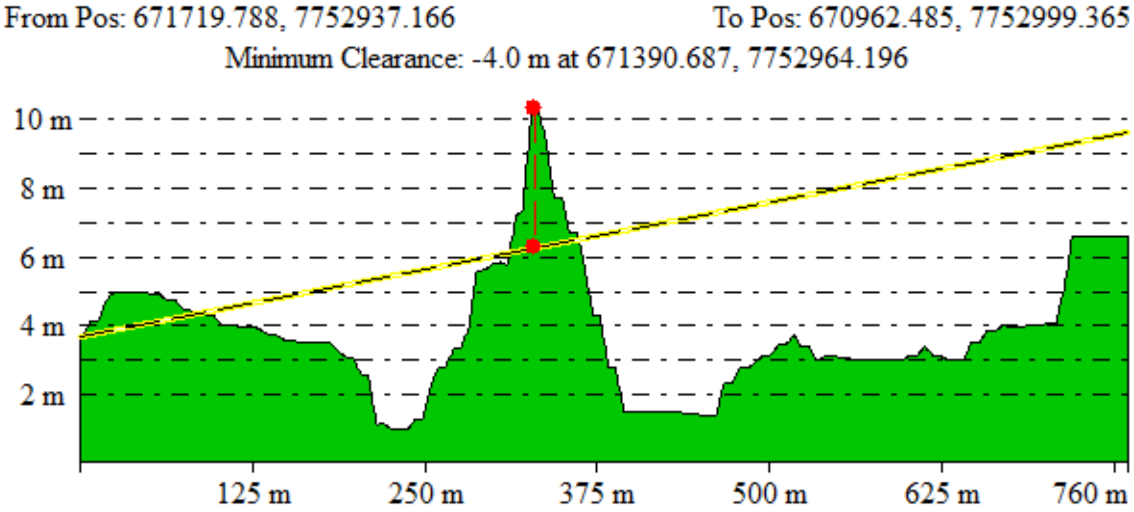


Plate III: Line of Site from ground level at Pretty Pool Beach to House 21 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

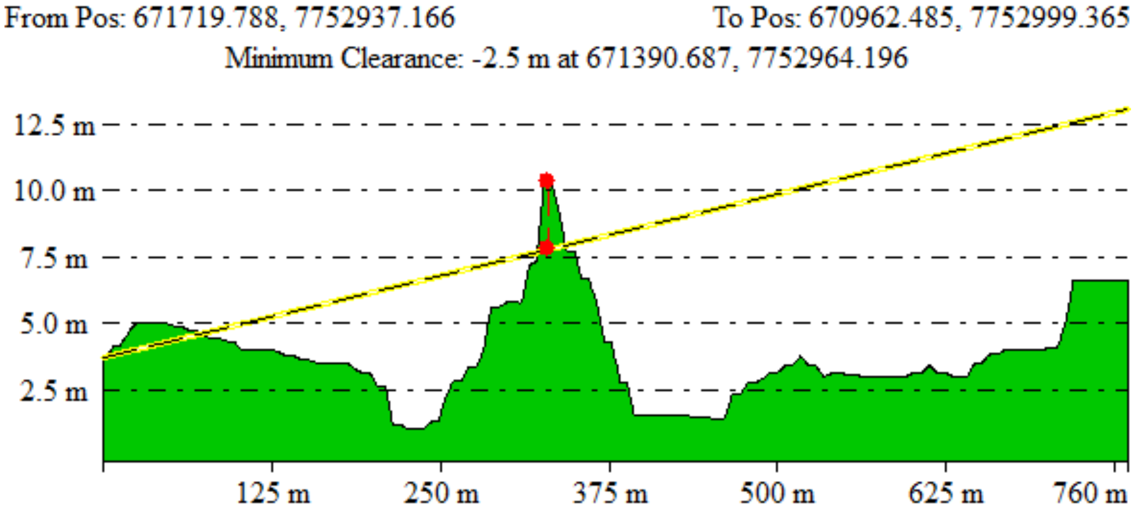


Plate JJJ: Line of Site from ground level at Pretty Pool Beach to House 21 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

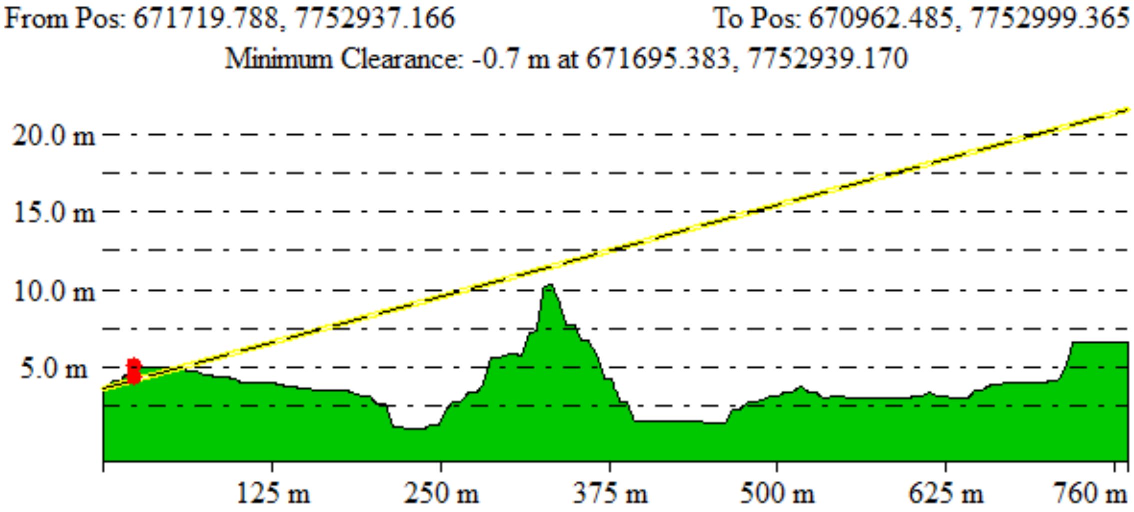


Plate KKK: Line of Site from ground level at Pretty Pool Beach to House 21 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

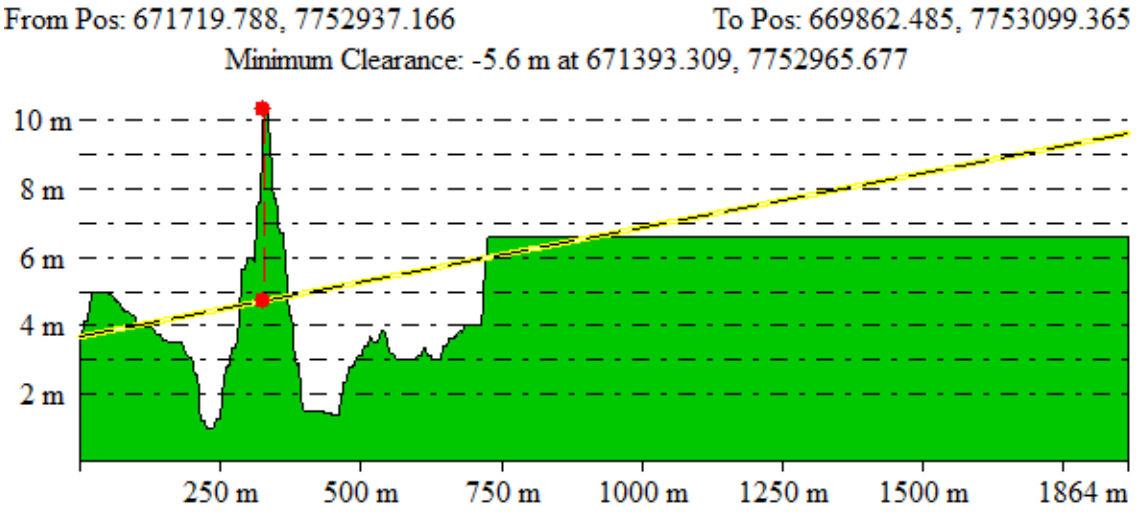


Plate LLL: Line of Site from ground level at Pretty Pool Beach to House 22 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

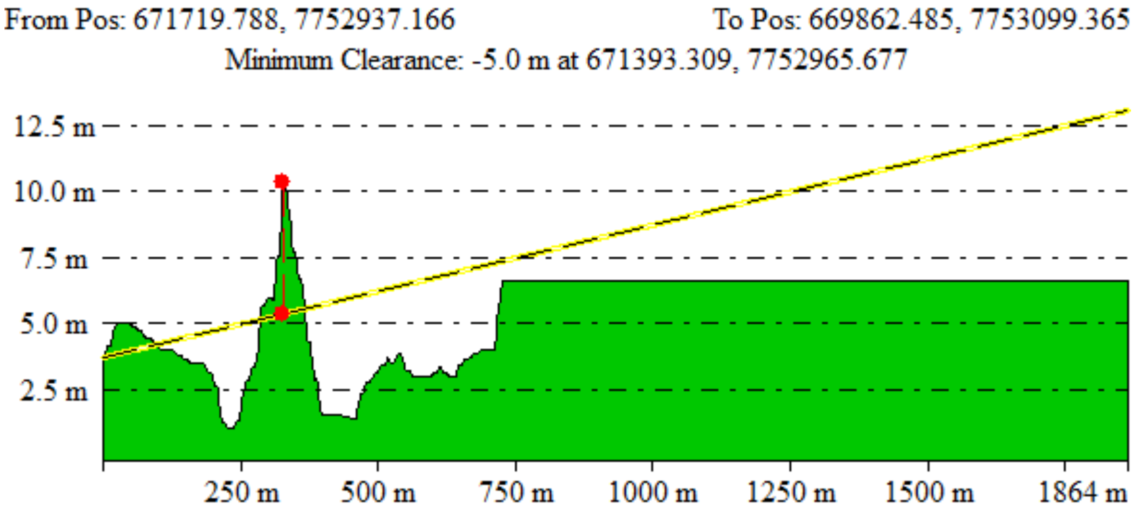


Plate MMM: Line of Site from ground level at Pretty Pool Beach to House 22 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

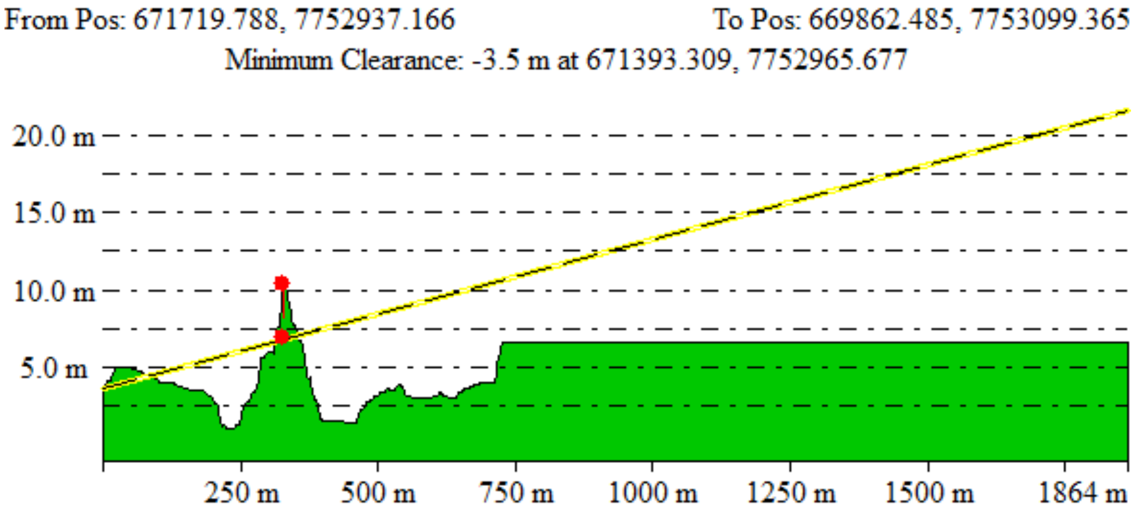


Plate NNN: Line of Site from ground level at Pretty Pool Beach to House 22 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

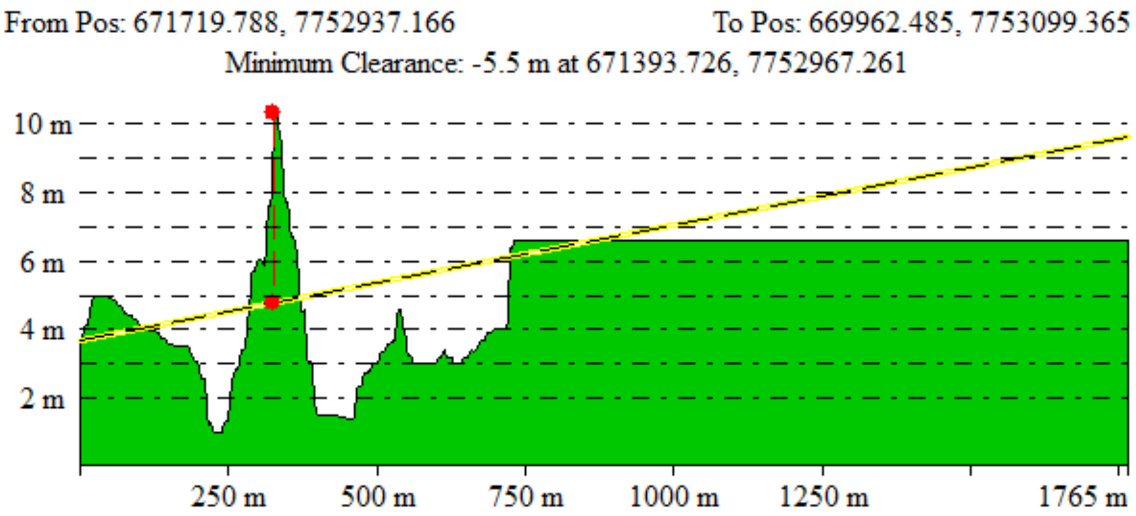


Plate OOO: Line of Site from ground level at Pretty Pool Beach to House 23 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

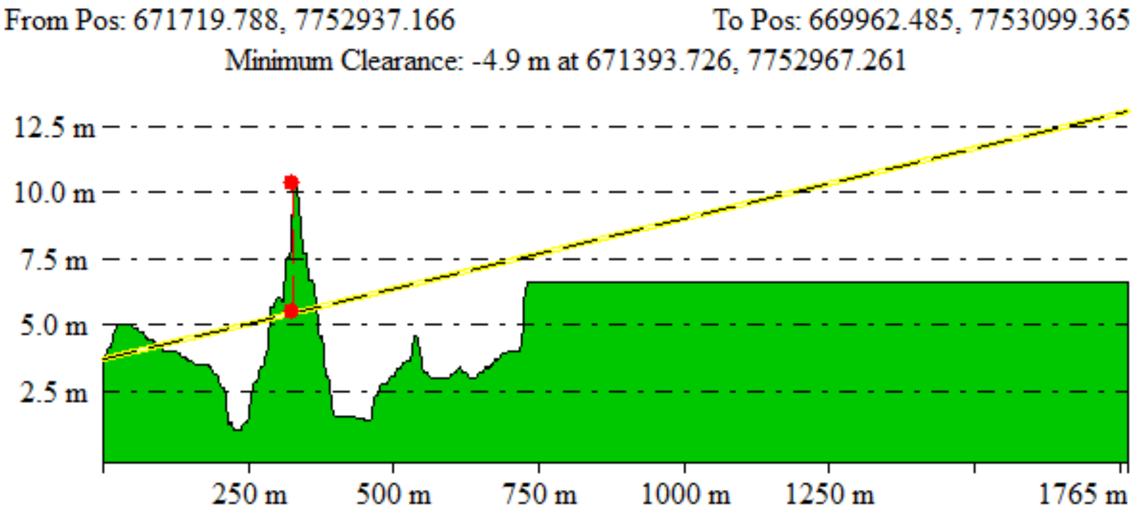


Plate PPP: Line of Site from ground level at Pretty Pool Beach to House 23 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

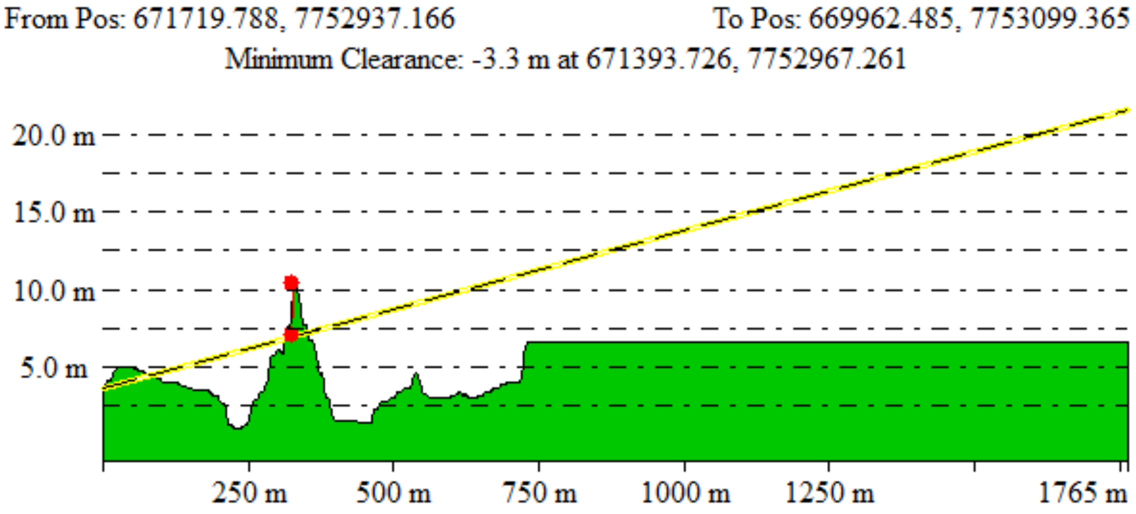
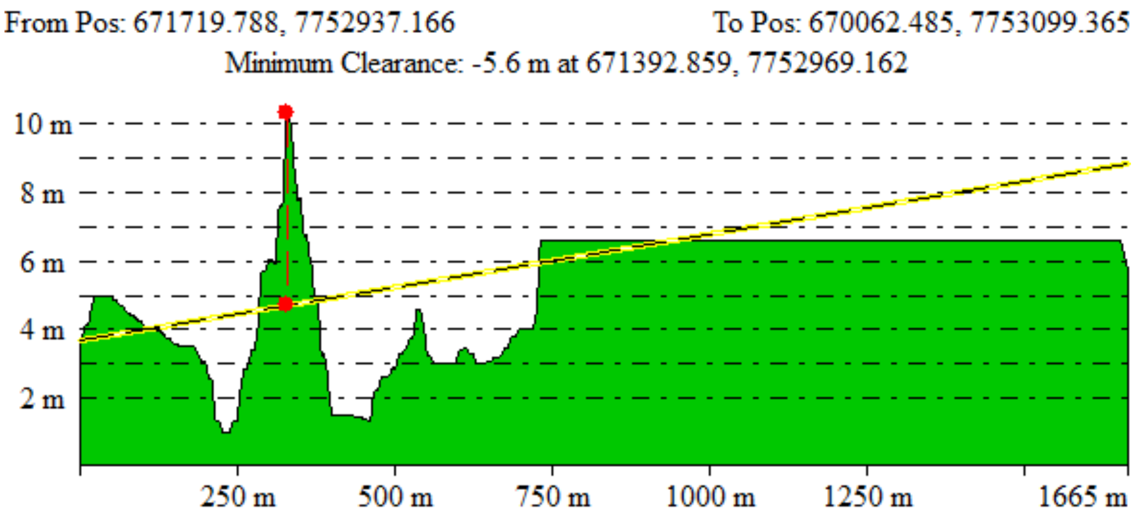


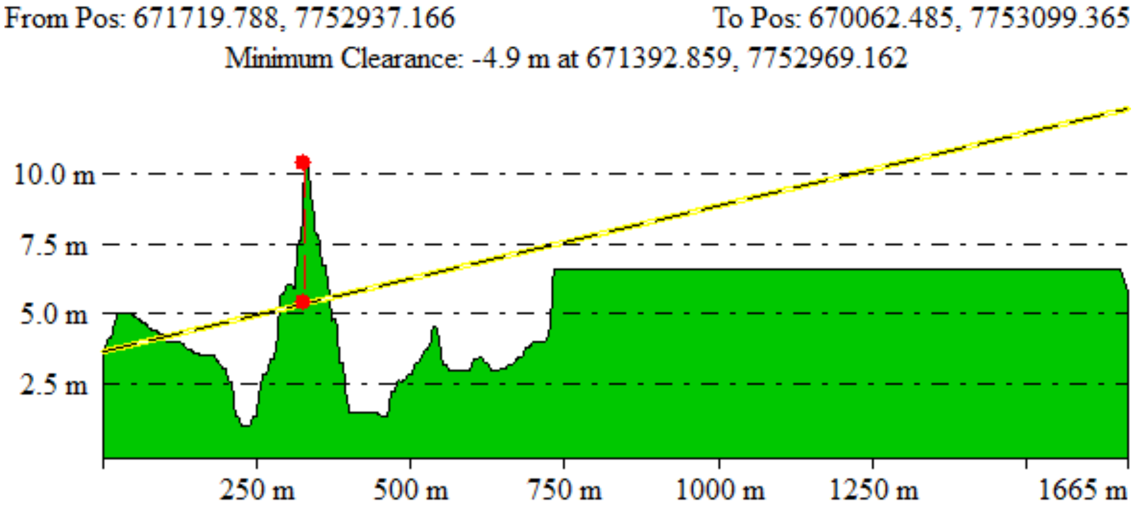
Plate QQQ: Line of Site from ground level at Pretty Pool Beach to House 23 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)



From Pos: 671719.788, 7752937.166 To Pos: 670062.485, 7753099.365

Minimum Clearance: -5.6 m at 671392.859, 7752969.162

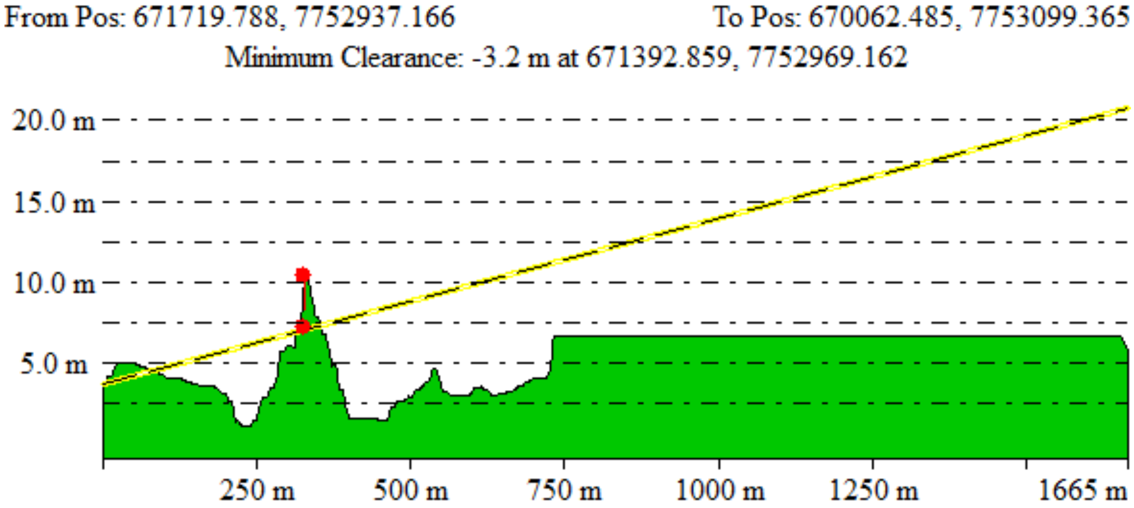
Plate RRR: **Line of Site from ground level at Pretty Pool Beach to House 24 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)**



From Pos: 671719.788, 7752937.166 To Pos: 670062.485, 7753099.365

Minimum Clearance: -4.9 m at 671392.859, 7752969.162

Plate SSS: **Line of Site from ground level at Pretty Pool Beach to House 24 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)**



From Pos: 671719.788, 7752937.166 To Pos: 670062.485, 7753099.365

Minimum Clearance: -3.2 m at 671392.859, 7752969.162

Plate TTT: **Line of Site from ground level at Pretty Pool Beach to House 24 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)**

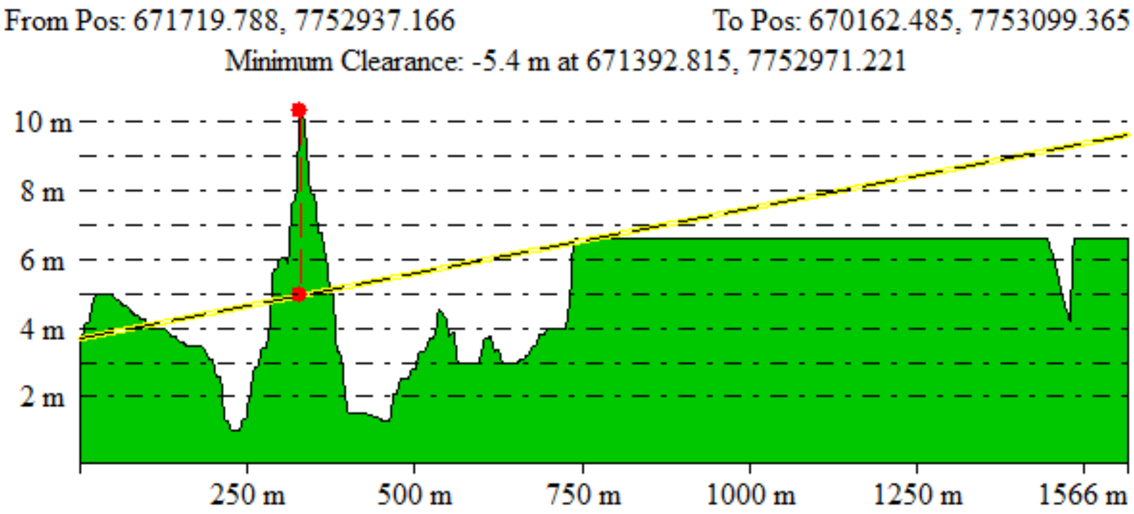


Plate UUU: Line of Site from ground level at Pretty Pool Beach to House 25 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

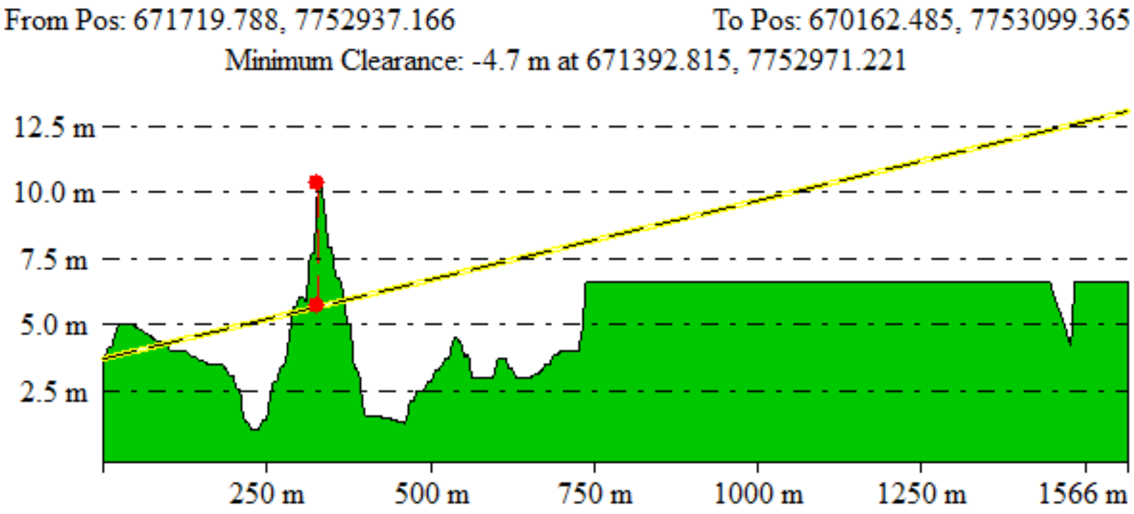


Plate VVV: Line of Site from ground level at Pretty Pool Beach to House 25 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

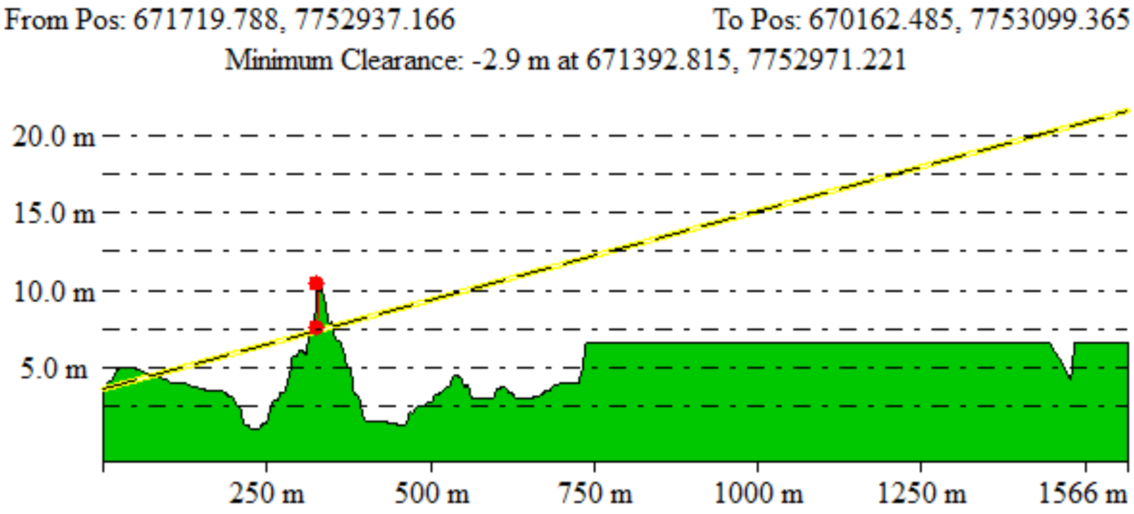


Plate WWW: Line of Site from ground level at Pretty Pool Beach to House 25 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

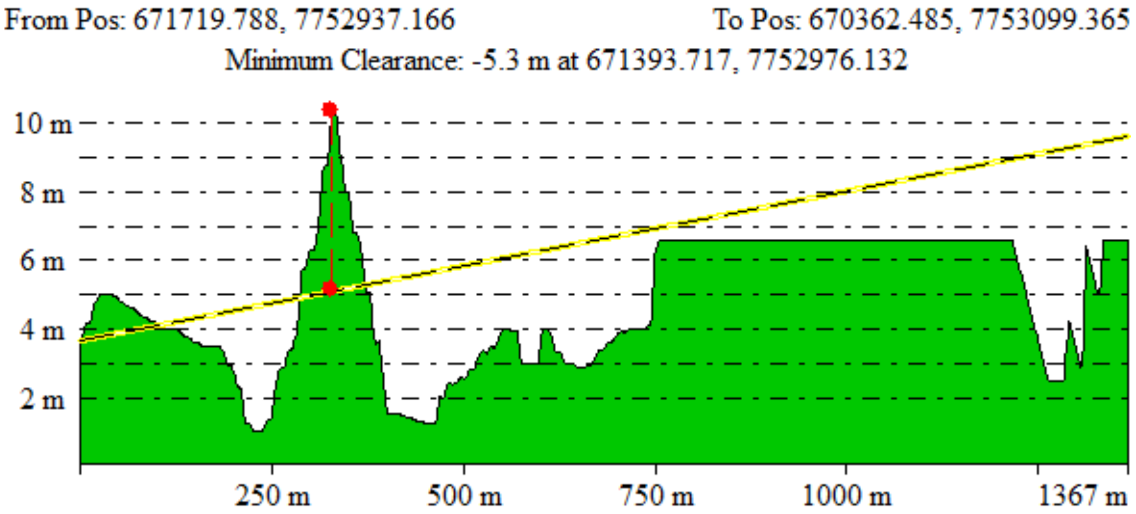


Plate XXX: Line of Site from ground level at Pretty Pool Beach to House 26 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)

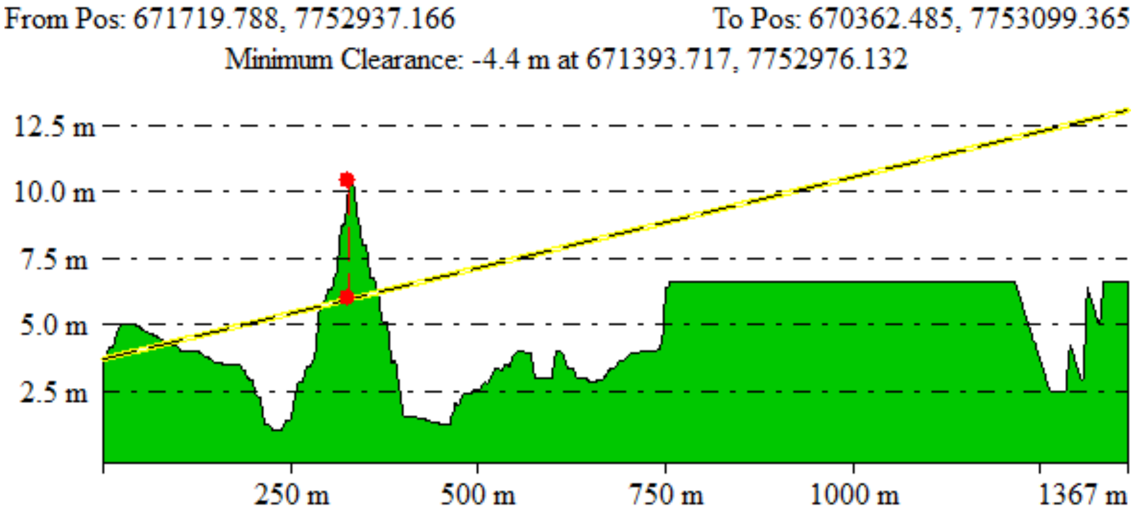


Plate YYY: Line of Site from ground level at Pretty Pool Beach to House 26 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)

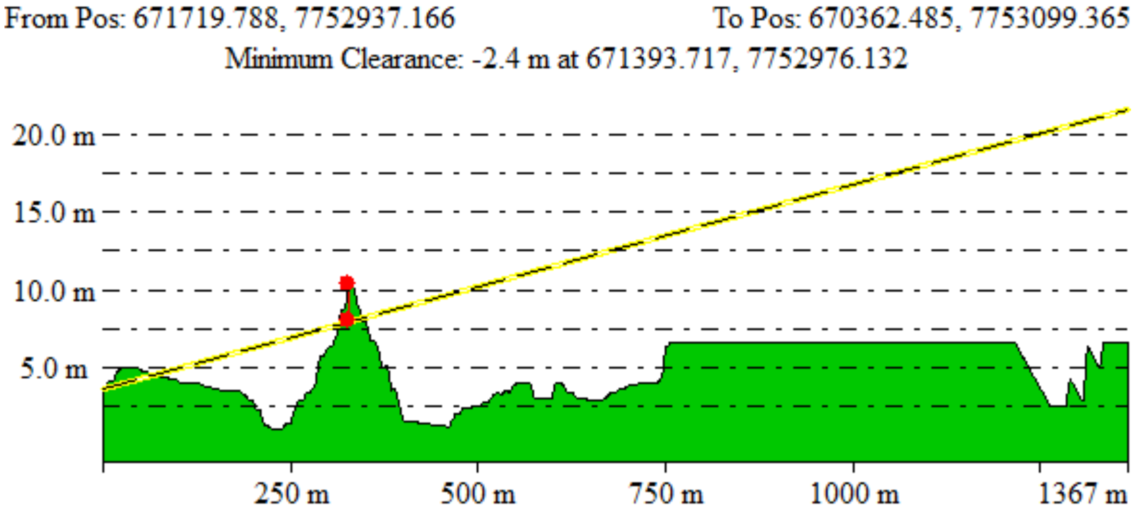
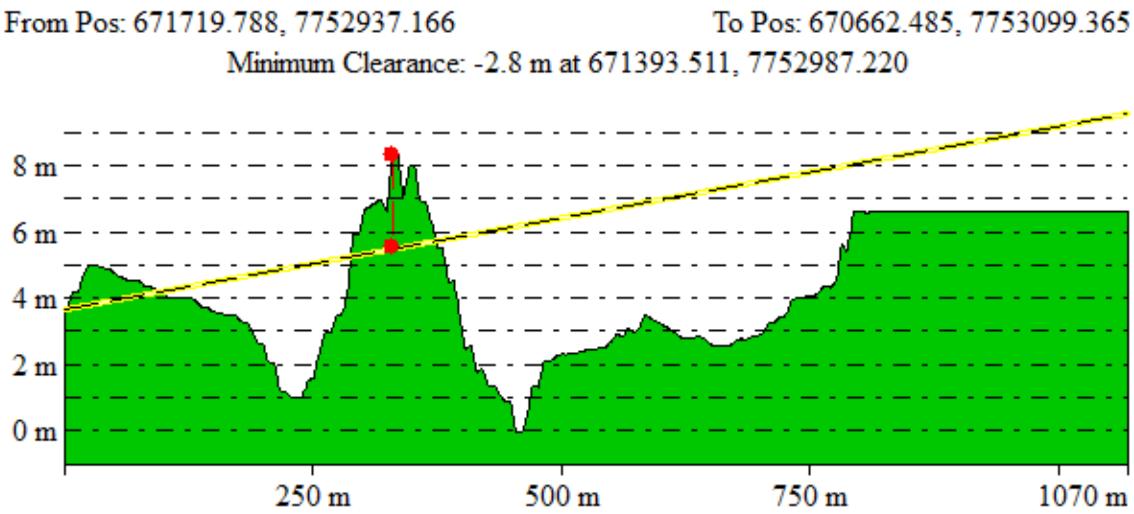


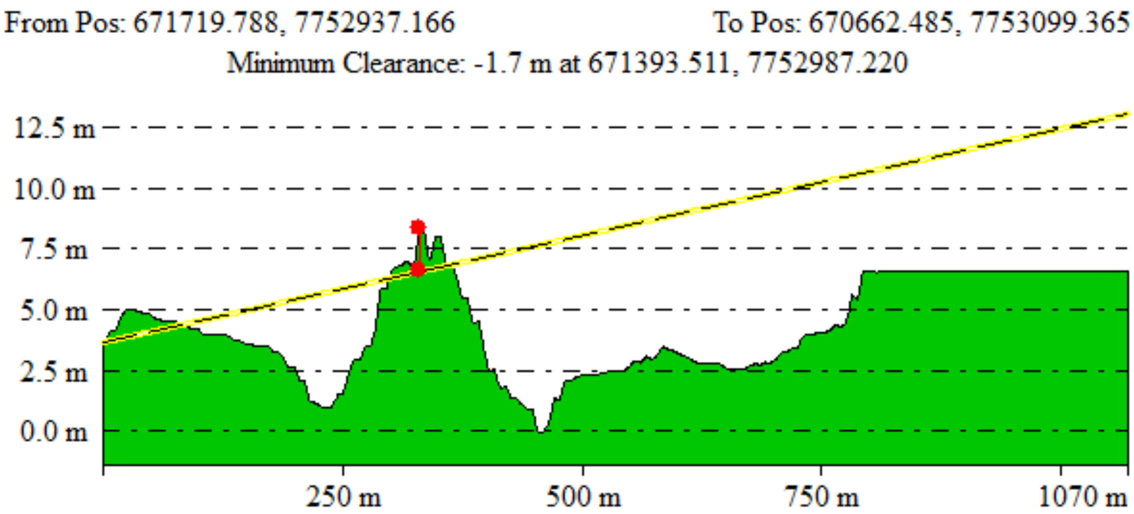
Plate ZZZ: Line of Site from ground level at Pretty Pool Beach to House 26 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)



From Pos: 671719.788, 7752937.166 To Pos: 670662.485, 7753099.365

Minimum Clearance: -2.8 m at 671393.511, 7752987.220

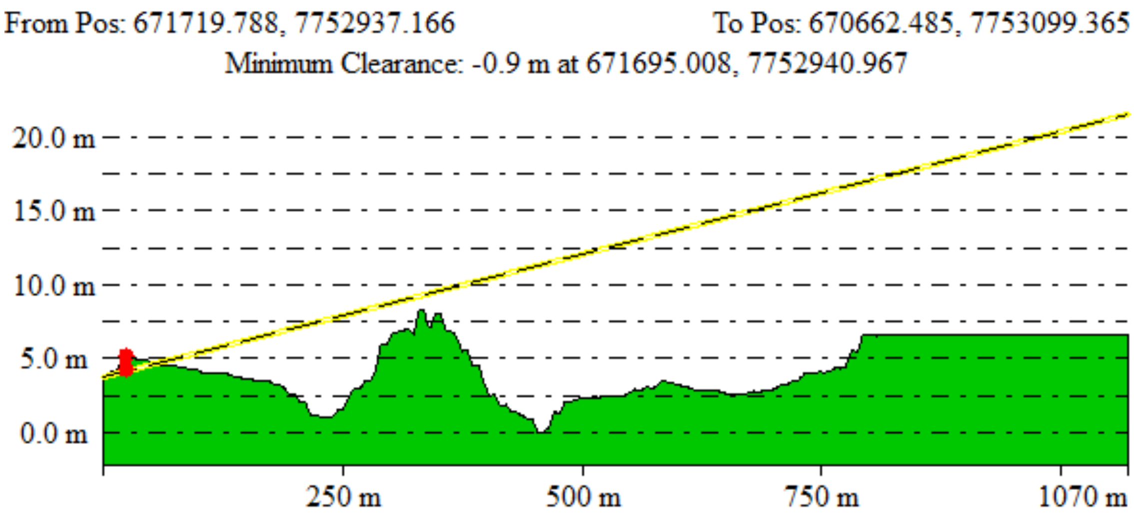
Plate AAAA: Line of Site from ground level at Pretty Pool Beach to House 27 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)



From Pos: 671719.788, 7752937.166 To Pos: 670662.485, 7753099.365

Minimum Clearance: -1.7 m at 671393.511, 7752987.220

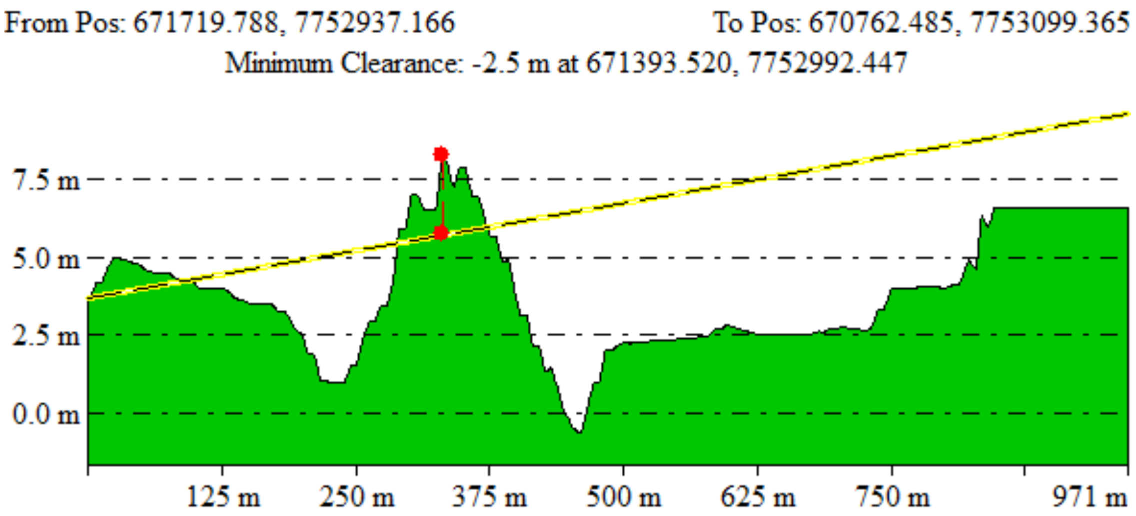
Plate BBBB: Line of Site from ground level at Pretty Pool Beach to House 27 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)



From Pos: 671719.788, 7752937.166 To Pos: 670662.485, 7753099.365

Minimum Clearance: -0.9 m at 671695.008, 7752940.967

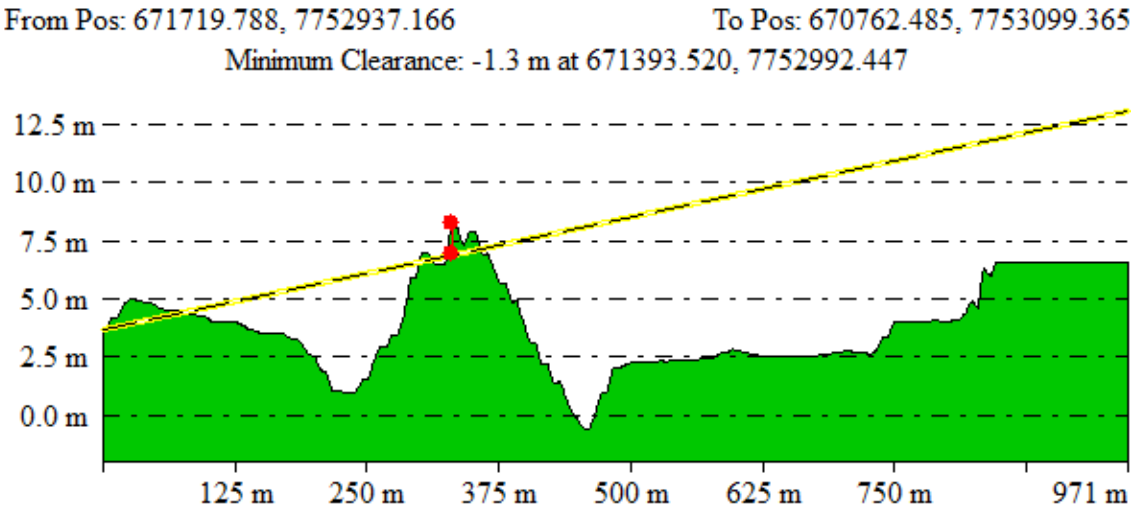
Plate CCCC: Line of Site from ground level at Pretty Pool Beach to House 27 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)



From Pos: 671719.788, 7752937.166 To Pos: 670762.485, 7753099.365

Minimum Clearance: -2.5 m at 671393.520, 7752992.447

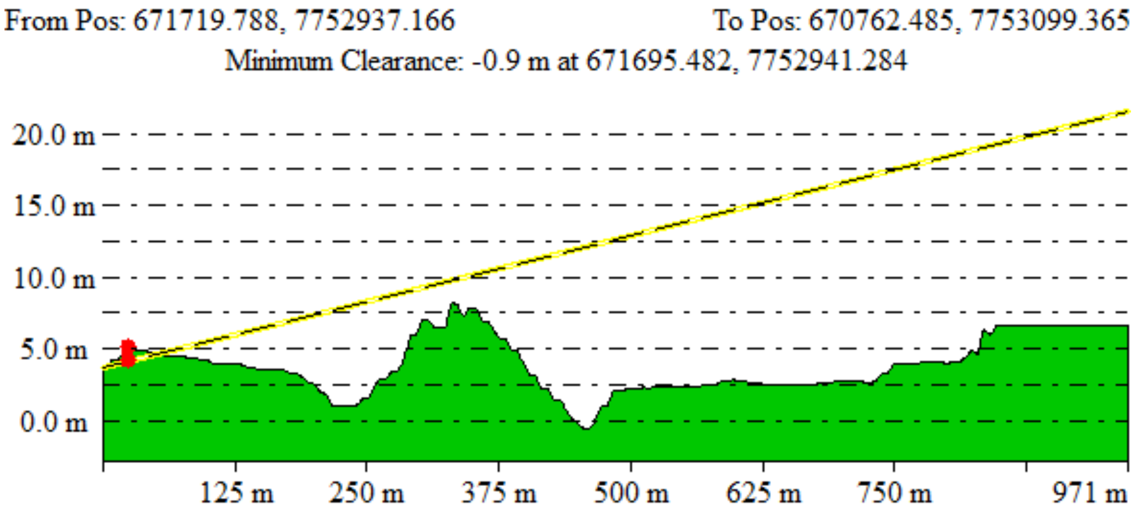
Plate DDDD: Line of Site from ground level at Pretty Pool Beach to House 28 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)



From Pos: 671719.788, 7752937.166 To Pos: 670762.485, 7753099.365

Minimum Clearance: -1.3 m at 671393.520, 7752992.447

Plate EEEE: Line of Site from ground level at Pretty Pool Beach to House 28 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)



From Pos: 671719.788, 7752937.166 To Pos: 670762.485, 7753099.365

Minimum Clearance: -0.9 m at 671695.482, 7752941.284

Plate FFFF: Line of Site from ground level at Pretty Pool Beach to House 28 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)

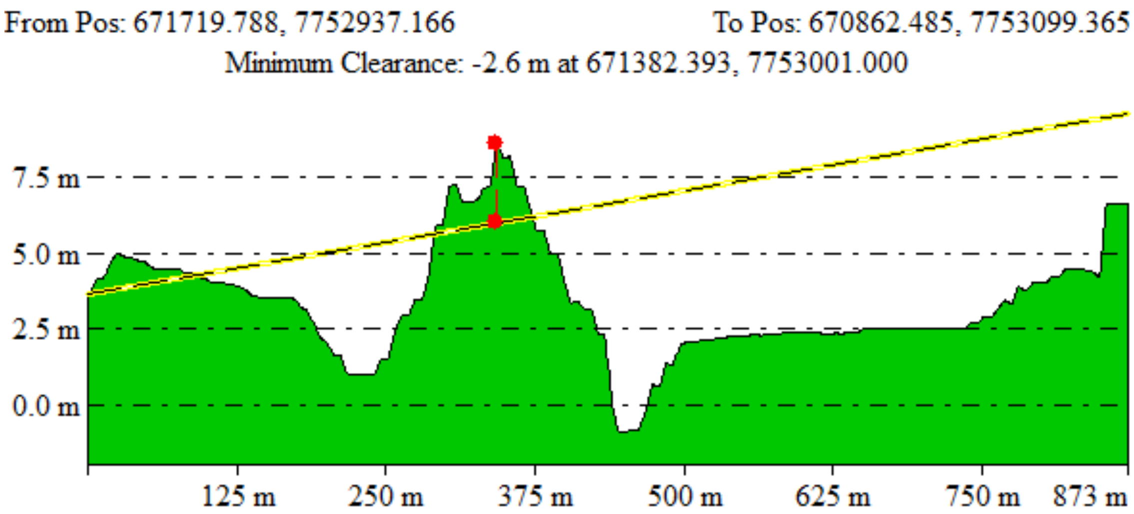


Plate GGGG: **Line of Site from ground level at Pretty Pool Beach to House 29 at 9.6 m AHD (+ 3 m from the finished floor level (6.7 m AHD) to simulate a one storey residence)**

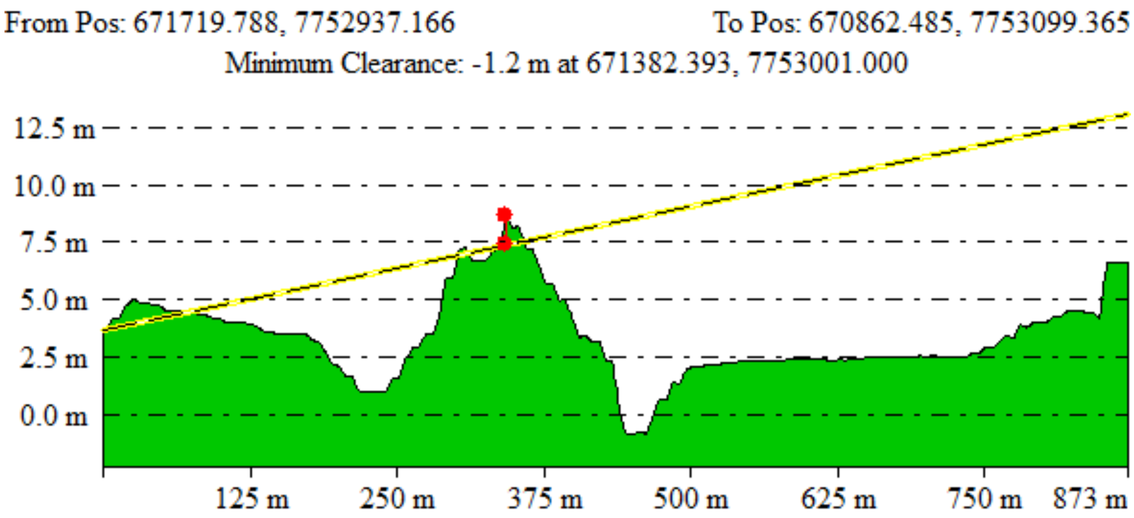


Plate HHHH: **Line of Site from ground level at Pretty Pool Beach to House 29 at 16.1 m AHD (+ 6.5 m from the finished floor level (6.7 m AHD) to simulate a street light pole)**

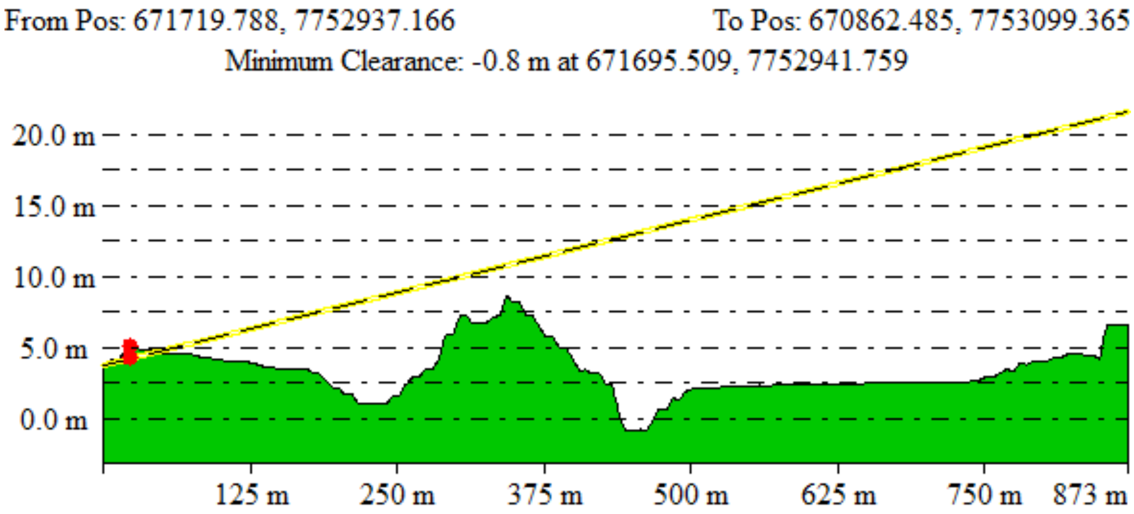


Plate IIII: **Line of Site from ground level at Pretty Pool Beach to House 29 at 21.1 m AHD (+ 15 m from the finished floor level (6.7 m AHD) to simulate a five storey residence)**

FIGURES

Figure A

Site location

GCS GDA 1994

0 125 250 500 m

Job Number: L20043-002
Doc Number: 001
Date: 26.05.20
Scale: 1:10,000 @ A3
Created by: MA
Source: Orthophoto - Landgate, 2020

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Document Path: G:\Jobs\L_Jobs\L20043 - DevWA Athol_Stables\Figures L20043-002\L20043-002_G_001_FigA Site Location_200526.mxd

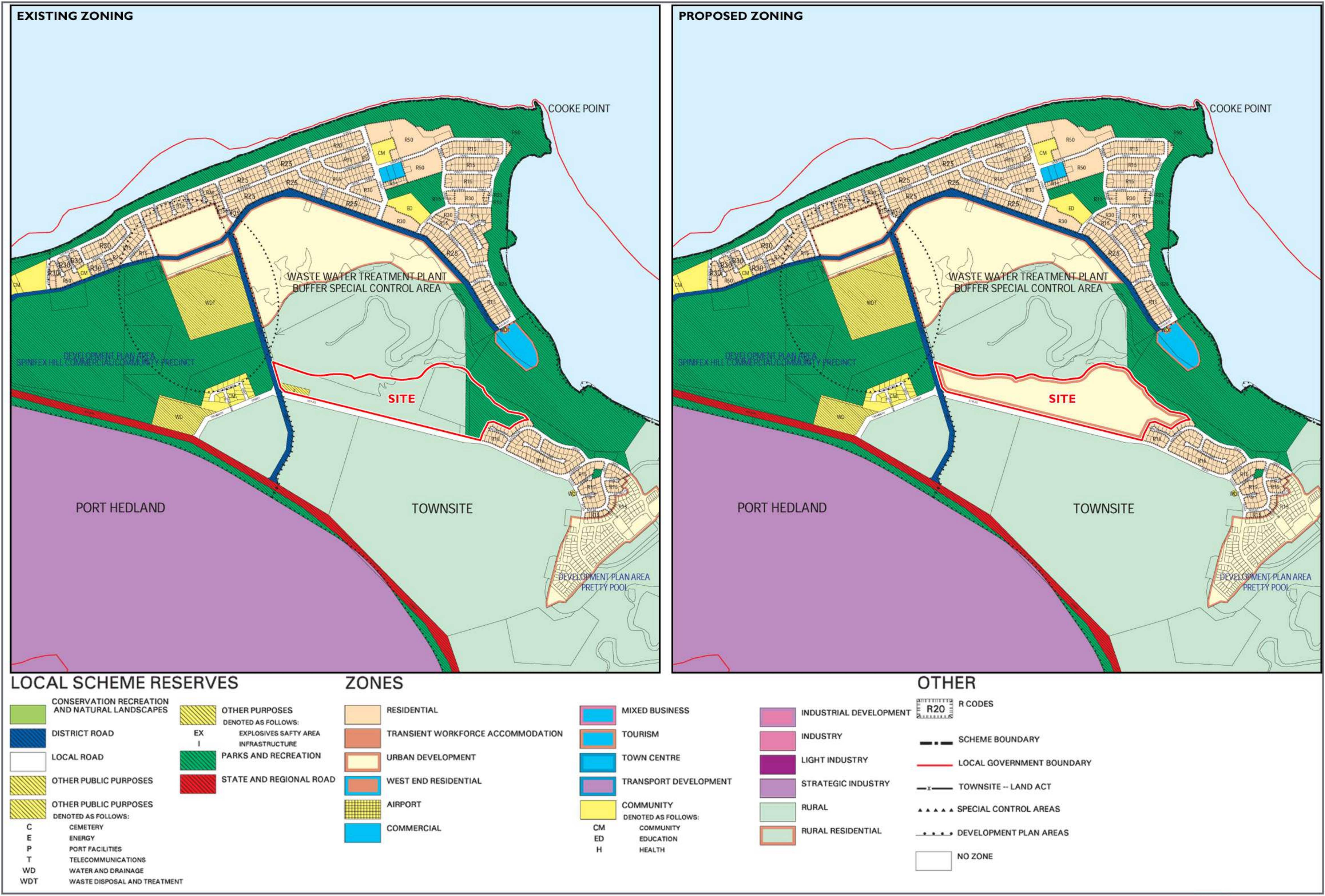

Figure B

Existing and proposed zoning under Town of Port Hedland's Town Planning Scheme No. 5

GDA 1994 MGA Zone 50
0 250 500 750 1000 m

Job Number: L20043-002
Doc Number: 002
Date: 26.05.20
Scale: NTS @ A3
Created by: MA
Source: Department of Planning - 14.01.14

LEGEND

- 🟨 LOW DENSITY RESIDENTIAL (R20)
- 🟫 MEDIUM DENSITY RESIDENTIAL (R40)
- 🟩 PUBLIC OPEN SPACE
- ▭ 30 METRE BUFFER TO HORSE STABLES SUBJECT TO FURTHER INVESTIGATION
- ● ABORIGINAL HERITAGE SITES
- - - - INDICATIVE DEVELOPMENT BOUNDARY
- MANGROVES
- DUAL USE PATH
- - - - GEOLOGICAL AREAS
- A DUNE SAND
- B ESTUARINE DEPOSIT
- C LIMESTONE

LAND USE / LOT YIELD ANALYSIS

GROSS DEVELOPABLE AREA	27.16HA
CARAVAN PARK	4.3HA
GROSS RESIDENTIAL AREA	22.86HA
PUBLIC OPEN SPACE	2.36HA (10%)
LOW DENSITY R20	9.66HA
MEDIUM DENSITY R40	4.12HA
ROADS	6.72HA
R20 138 LOTS @ 700SQM	
R40 137 LOTS @ 300SQM	
TOTAL LOT YIELD	**275**

Figure C-1

Concept plan - Option 1

Job Number: CL20043-002
Doc Number: 003a
Date: 26.05.20
Scale: 1:4,000 @ A3
Created by: MA
Source: Element, 20-213 SA-1, 26.05.2020

Figure C-2

Concept plan - Option 2

Job Number: CL20043-002
Doc Number: 003b
Date: 26.05.20
Scale: 1: 4,000 @ A3
Created by: MA
Source: Element, 20-213 SA-2, 26.05.2020

Figure C-3

Concept plan - Option 3

Job Number: CL20043-002
Doc Number: 003c
Date: 26.05.20
Scale: 1: 4,000 @ A3
Created by: MA
Source: Element, 20-213 SA-3, 26.05.2020

Precinct Highlights

1. Mixed use/short stay iconic development site.
2. Neighbourhood centre providing primary Port Hedland mixed use/retail opportunities.
3. Setback to rail corridor subject to detail investigation, incorporating district recreation.
4. High School.
5. Primary School.
6. New entry road with direct connection to coastal drive.
7. Local convenience shopping/cafe/restaurant with 'mangrove experience'.
8. Short-stay accommodation next to mangrove environs.
9. Coastal drive (slow speed environment).
10. Coastal park/lookout.
11. East end coastal access opportunities.
12. Upgraded access to/from Wilson Street.
13. Existing community retained in open space environs.
14. Opportunities for density increases.
15. Development to recognise historic past through links to racecourse and former airfield.

RESIDENTIAL

- 🟤 Residential - High Density (R80 - R120: Apartment Living)
- ● West End Residential (Residential R80 with design controls consistent with TPS 5 Amendment 22)
- 🟠 Residential - Medium Density (R40 - R60: Apartment, townhouse, villa residential)
- 🟡 Residential - Low Density (R15 - R30: Traditional Single Residential)

COMMERCIAL

- 🔵 City Centre (Civic, Cultural, Major Retail, Commercial, Mixed Use Residential and Entertainment)
- ▨ Commercial/Cultural Centre (Retail, Commercial, Office, Short Stay Accommodation, Research & Education, Cultural and Entertainment)
- 🔴 Neighbourhood Centre (Retail, Commercial, Residential Mixed Use)
- ● Local Centre (Convenience retail, Mixed Use, Short Stay Accommodation)
- 🔵 Highway Commercial (Bulky Goods, Motor Vehicle/Boat Sales, Show Room, Warehouse Commercial)
- 🟤 Short Stay Accomodation
- 🟡 Community (Community, Education & Health)
- ● West End Mixed Use

INDUSTRIAL

- 🟣 Light Industry
- 🟣 General Industry/Transport and Logistics
- 🟣 Strategic/Heavy Industry
- ▨ Strategic/Heavy Industry Buffer

RURAL

- ● Rural Residential
- ▨ Rural Industry

RECREATION AND CONSERVATION

- 🟢 Local/Passive Open Space
- 🟢 Landscape Buffer
- 🟢 Natural Landscape/Conservation

OTHER

- ▨ Public Purposes (Wastewater Treatment, Water, Cemetary, Energy)
- ▨ Airport Operations
- ▨ Future Expansion - Urban (Medium-Long Term)
- ▨ Future Expansion - Urban/Rural Residental (Long Term - Beyond 50,000)

Figure D

East End Urban Village

Job Number: L20043-002
Doc Number: 004
Date: 26.05.20
Scale: NTS @ A3
Created by: MA
Source: Department of Planning - 14.01.14

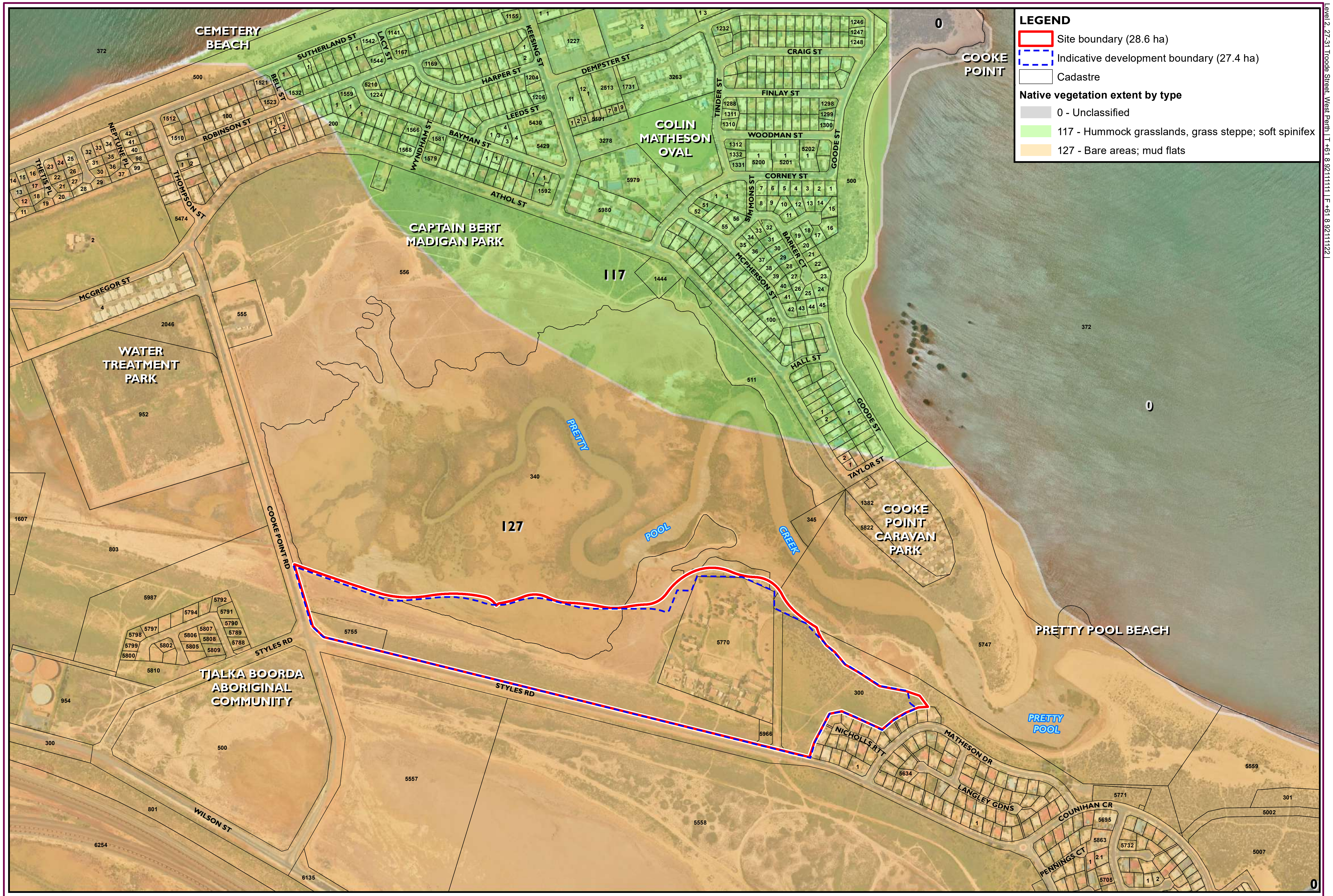

Figure E

Beard vegetation association

GDA 1994 MGA Zone 50

0 95 190 380 m

Job Number: L20043-002
Doc Number: 005
Date: 26.05.20
Scale: 1:7,500 @ A3
Created by: MA
Source: Orthophoto - Landgate, 2020

Document Path: G:\Jobs\L_Jobs\L20043 - DevWA Athol_Stables\Figures L20043-002\L20043-002_G_005_FigE Beard Vegetation Association_200526.mxd

Level 2, 27-31 Troode Street, West Perth | T +61 8 9211 1111 | F +61 8 9211 1122 |

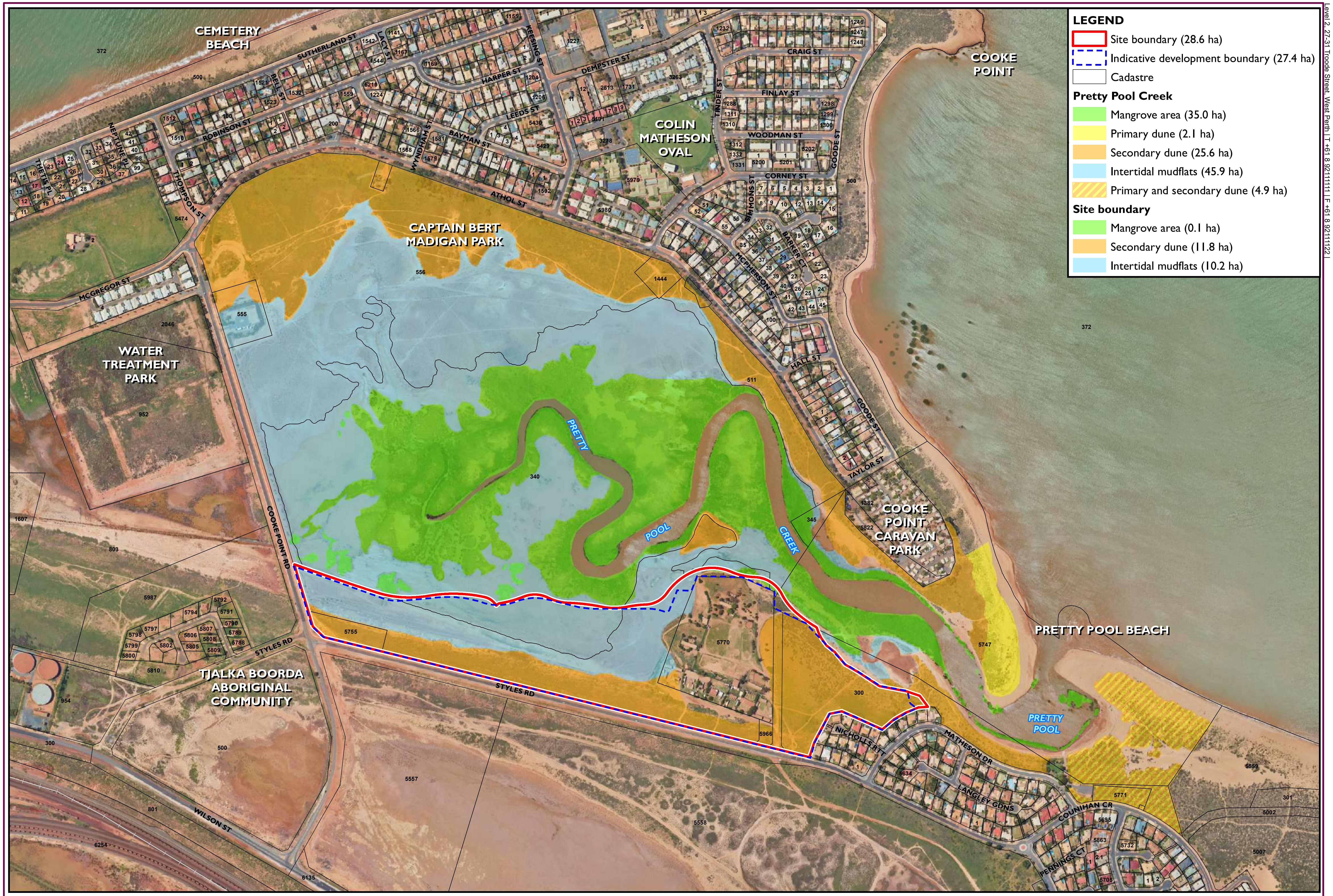

Figure F

Landscape - Vegetation types and units

Job Number: L20043-002
Doc Number: 006
Date: 26.05.20
Scale: 1:7,500 @ A3
Created by: MA
Source: Orthophoto - Landgate, 2020

Document Path: G:\Jobs\L_Jobs\L20043 - DevWA Athol_Stables\Figures L20043-002\L20043-002_G_006_FigF Landscape-Vegetation Types and Units_200526.mxd

Level 2, 27-31 Troode Street, West Perth | T +61 8 92111111 | F +61 8 92111122 |

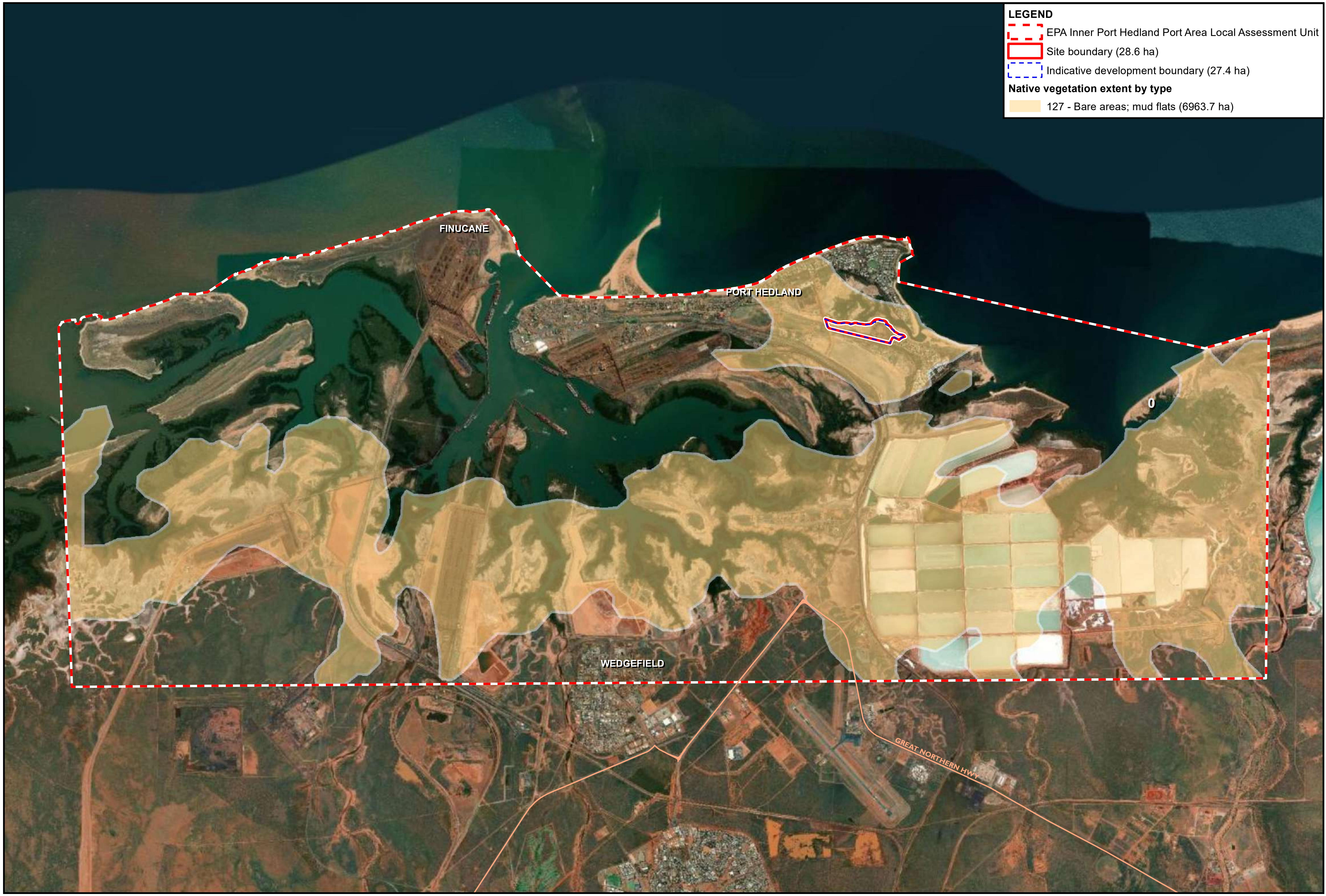

Figure G
Extent of Beard Vegetation Association: 127 Bare areas; mud flats within EPA Inner Port Hedland Port Area Local Assessment Unit

GDA 1994 MGA Zone 50

0 750 1,500 3,000 m

Job Number: L20043-002
Doc Number: 007
Date: 26.05.20
Scale: 1:60,000 @ A3
Created by: MA
Source: Orthophoto - Esri World Imagery

Level 2, 27-31 Troode Street, West Perth | T +61 8 9211 1111 | F +61 8 9211 1122 |

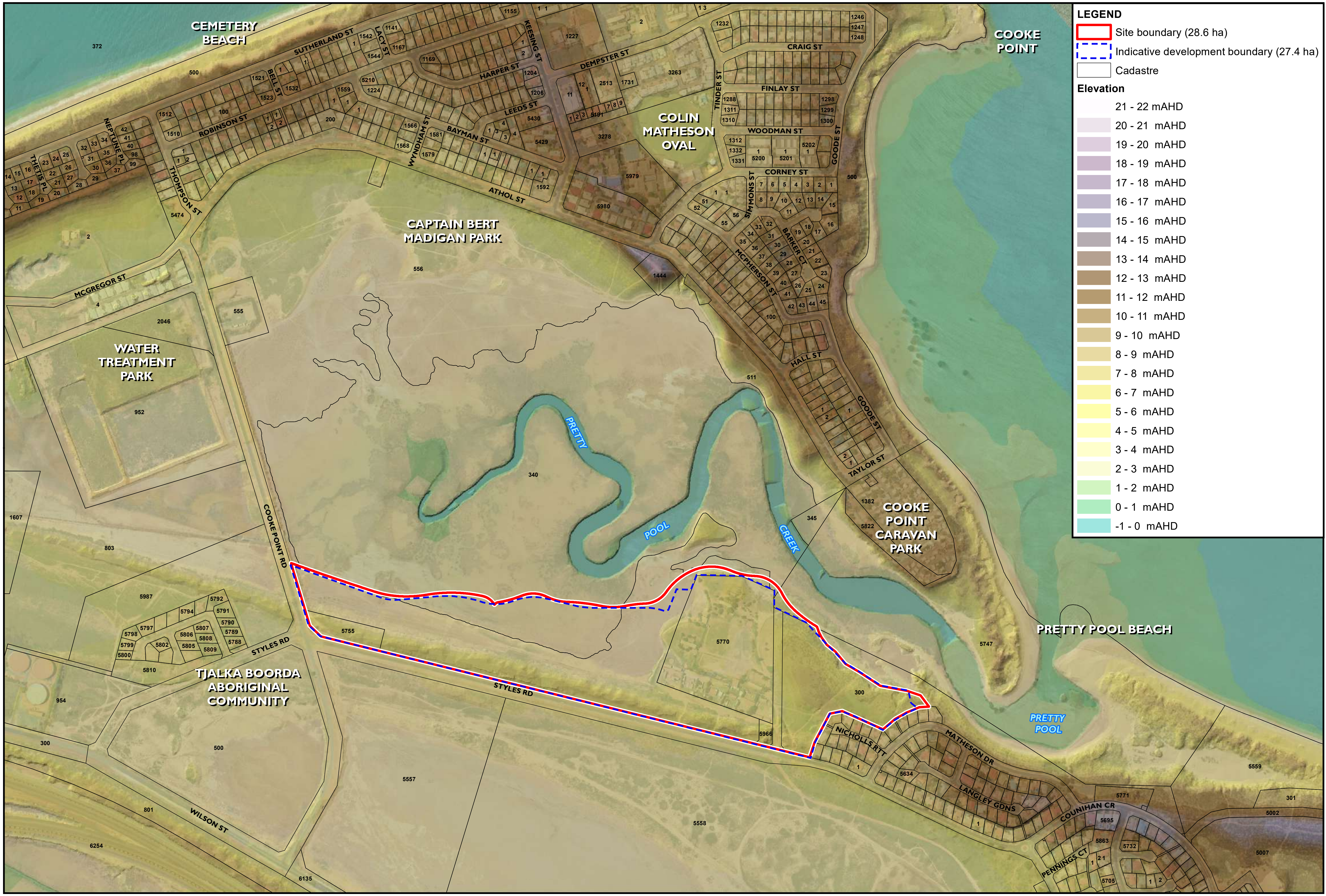

Figure H

Topography

GDA 1994 MGA Zone 50

0 95 190 380 m

Job Number: L20043-002
Doc Number: 008
Date: 26.05.20
Scale: 1:7,500 @ A3
Created by: MA
Source: Orthophoto - Landgate, 2020

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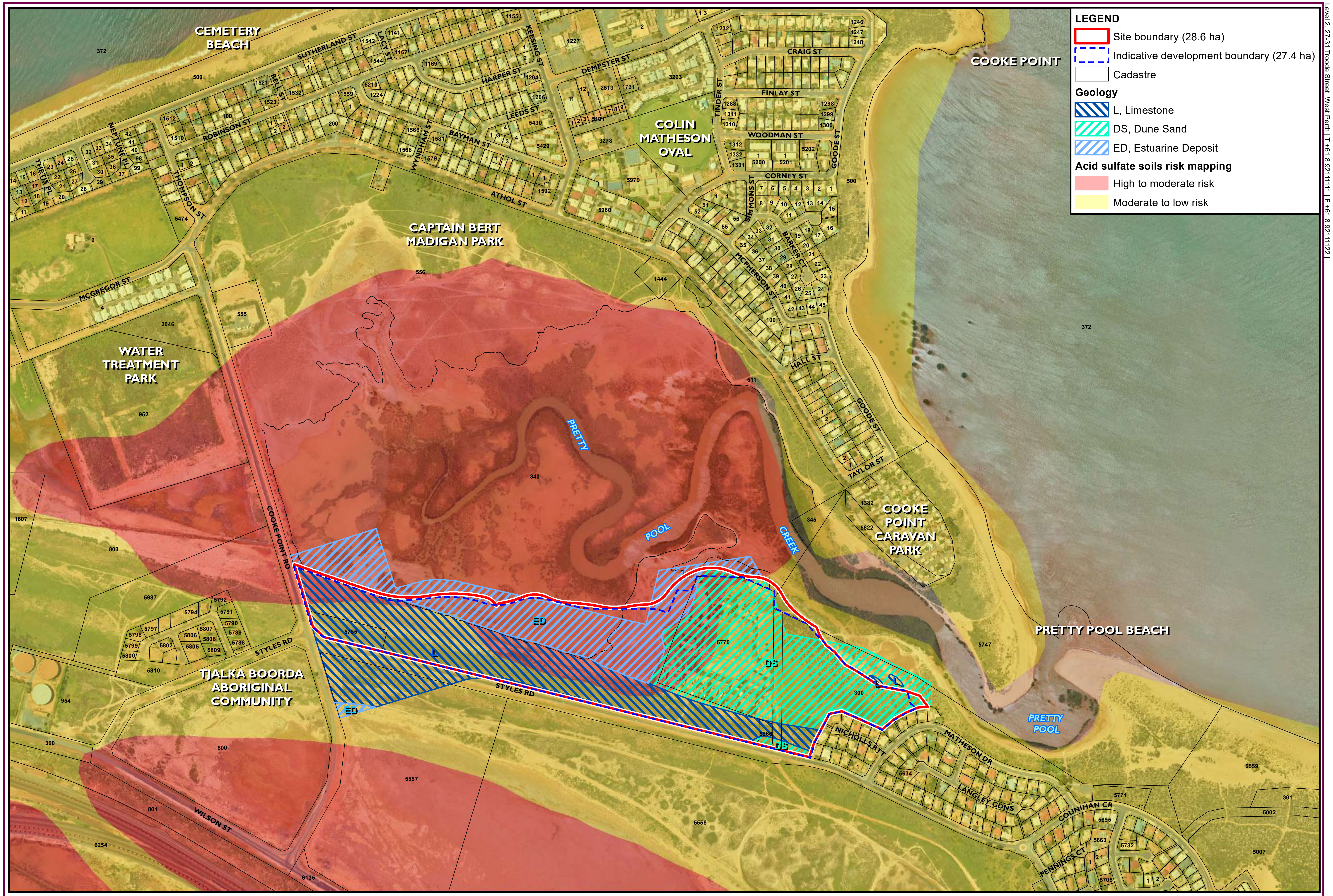
Document Path: G:\Jobs\L_Jobs\L20043 - DevWA Athol_Stables\Figures L20043-002\L20043-002_G_008_FigH Topography_200526.mxd



Level 2, 27-31 Troode Street, West Perth | T +61 8 9211 1111 | F +61 8 9211 1122

Figure I

Geology and acid sulfate soils risk mapping

GDA 1994 MGA Zone 50

0 95 190 380 m

Job Number: L20043-002
Doc Number: 009
Date: 26.05.20
Scale: 1:7,500 @ A3
Created by: MA
Source: Orthophoto - Landgate, 2020

Document Path: G:\Jobs\L_Jobs\L20043 - DevWA Athol_Stables\Figures L20043-002\L20043-002_G_009_FigI Geology and ASS_200526.mxd

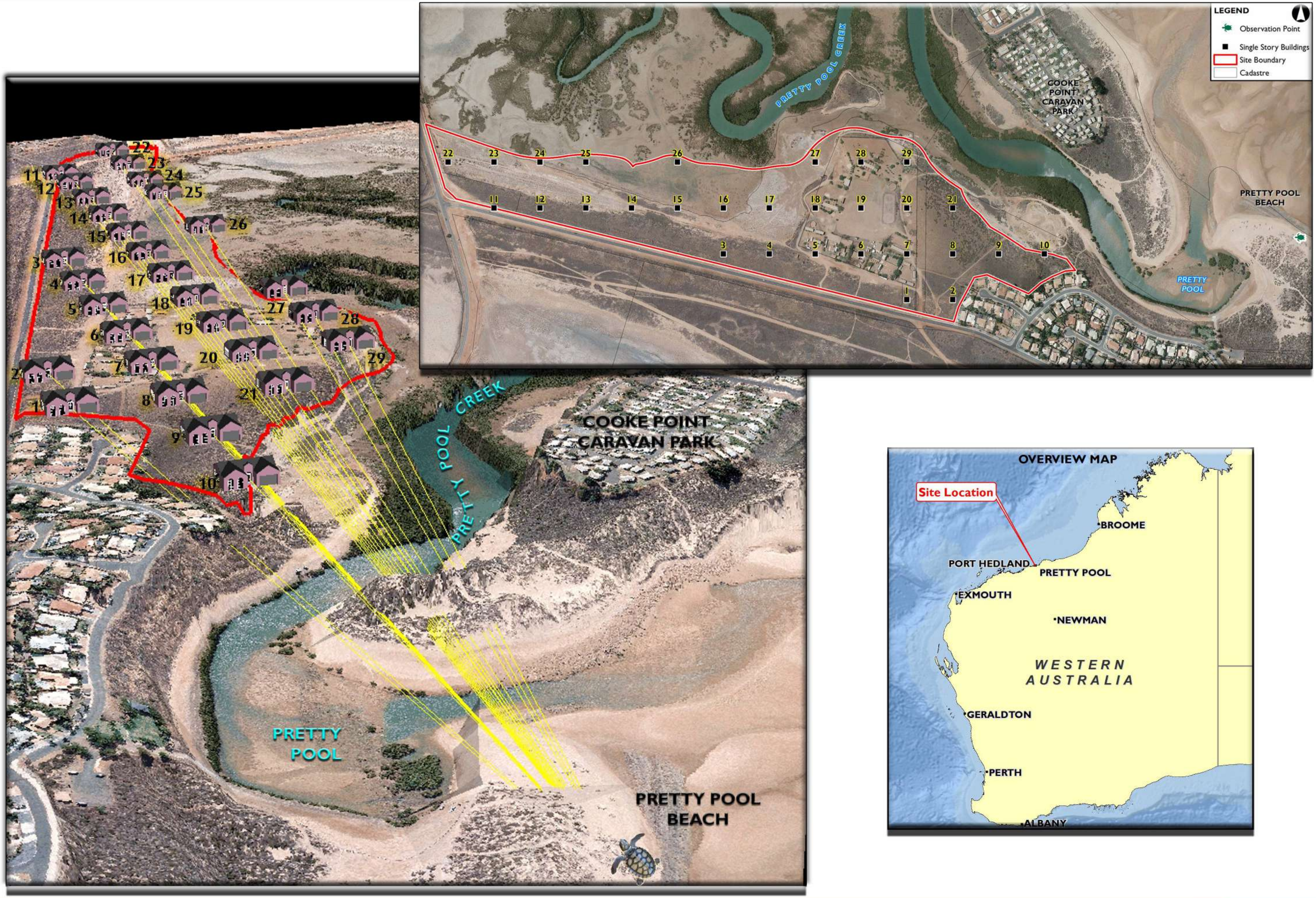


Figure J-A

Line of sight from Pretty Pool Beach – Single storey

Job Number: L20043-002
Doc Number: 010a
Date: 26.05.20
Scale: NTS @ A3
Created by: MA
Source: Department of Planning - 14.01.14

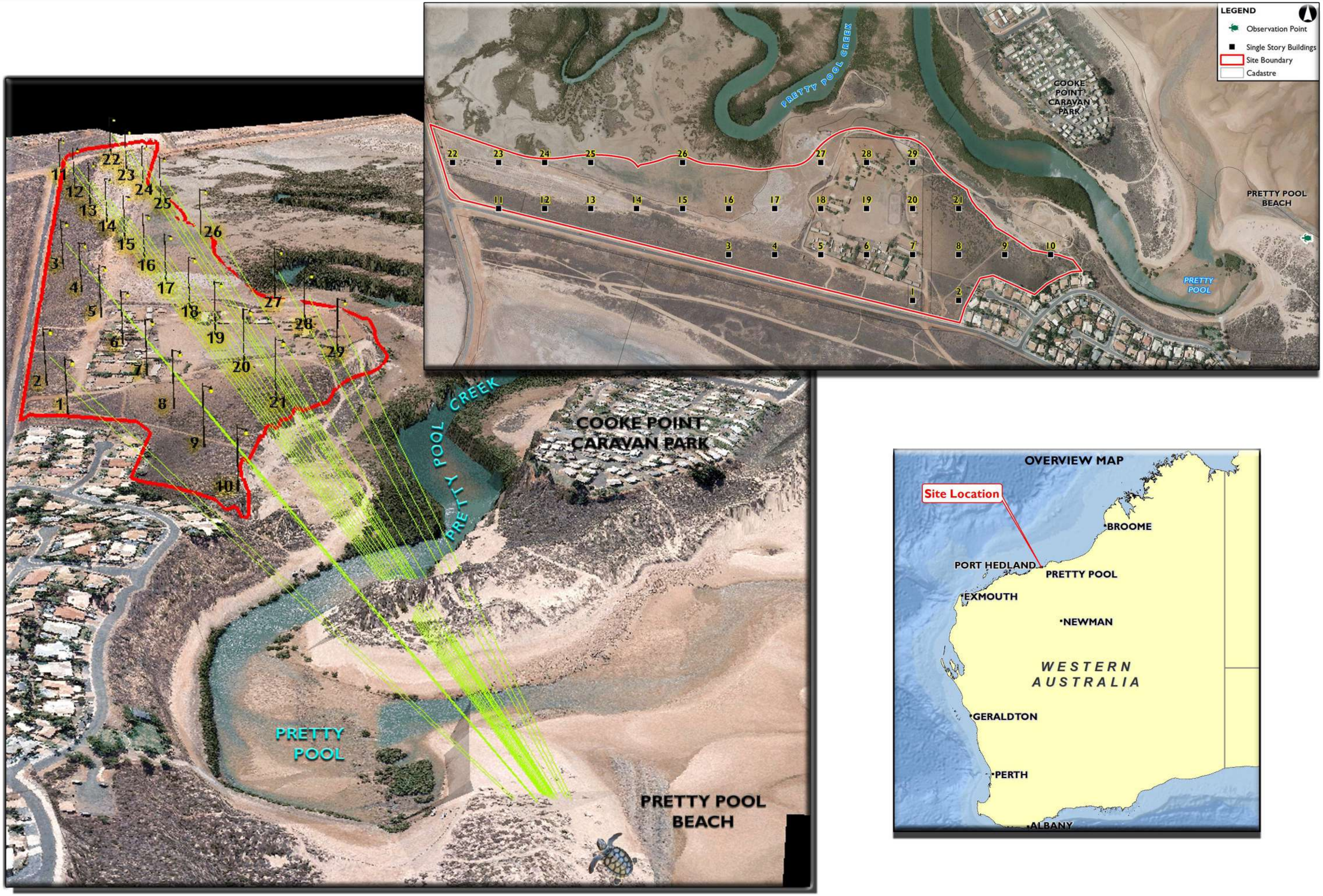


Figure J-B

Line of sight from Pretty Pool Beach – Street light

Job Number: CL20043-002
Doc Number: 010b
Date: 26.05.20
Scale: NTS @ A3
Created by: MA
Source: Department of Planning - 14.01.14

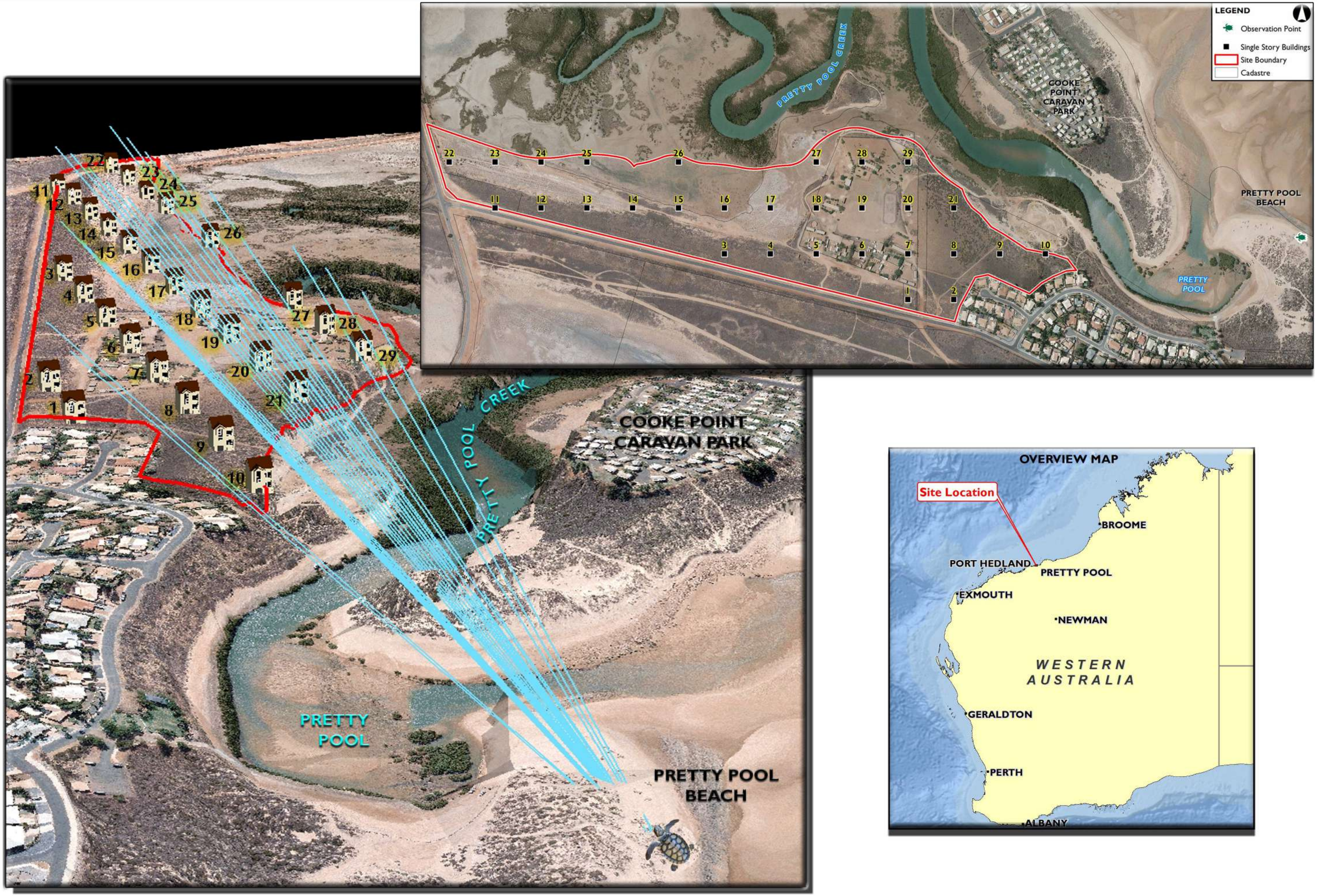


Figure J-C

Line of sight from Pretty Pool Beach – Multiple storey

Job Number: L20043-002
Doc Number: 010c
Date: 26.05.20
Scale: NTS @ A3
Created by: MA
Source: Department of Planning - 14.01.14

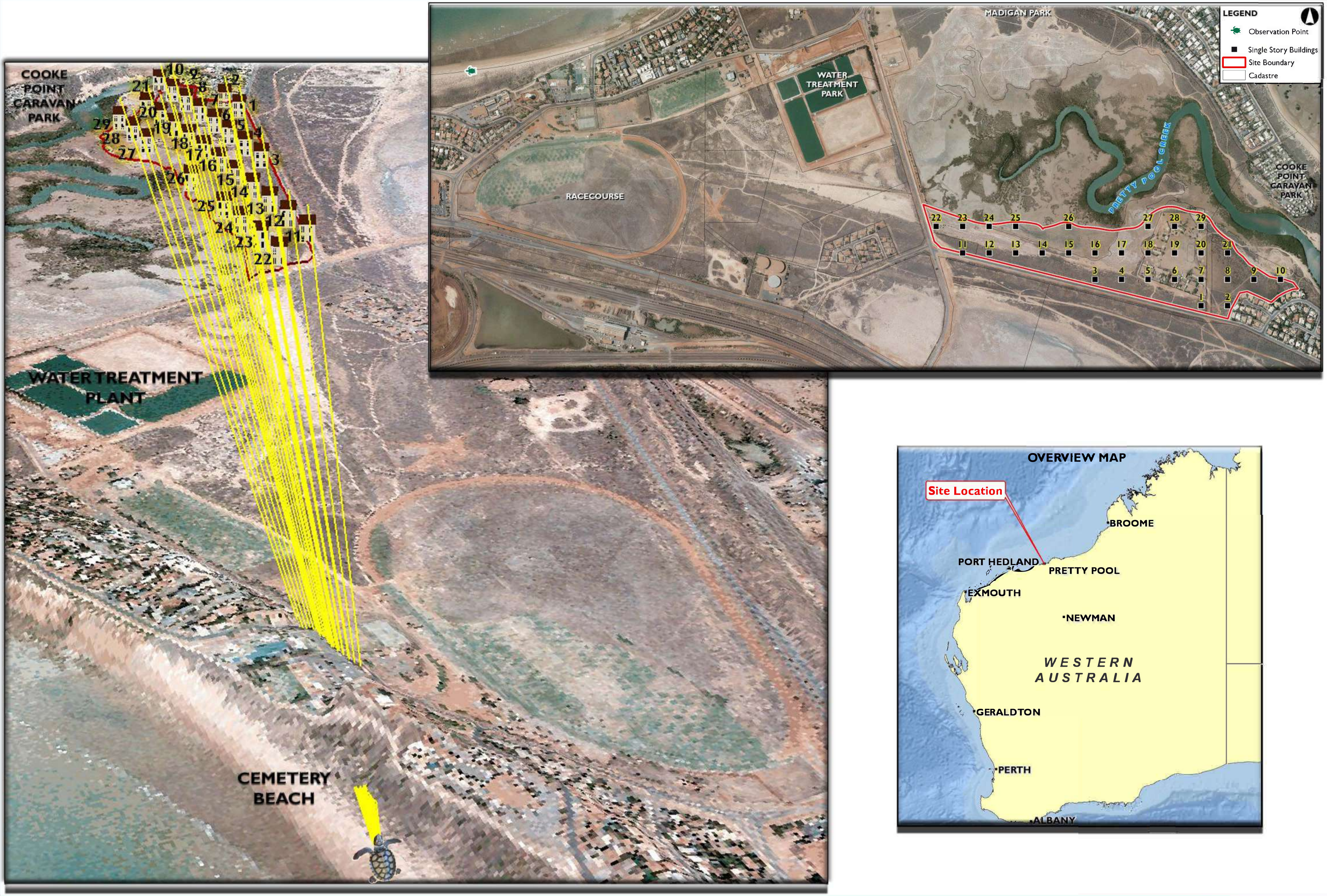


Figure J-D

Line of sight from Cemetery Beach – Multiple storey

Job Number: C20043-002
Doc Number: 010d
Date: 26.05.20
Scale: NTS @ A3
Created by: MA
Source: Department of Planning - 14.01.14

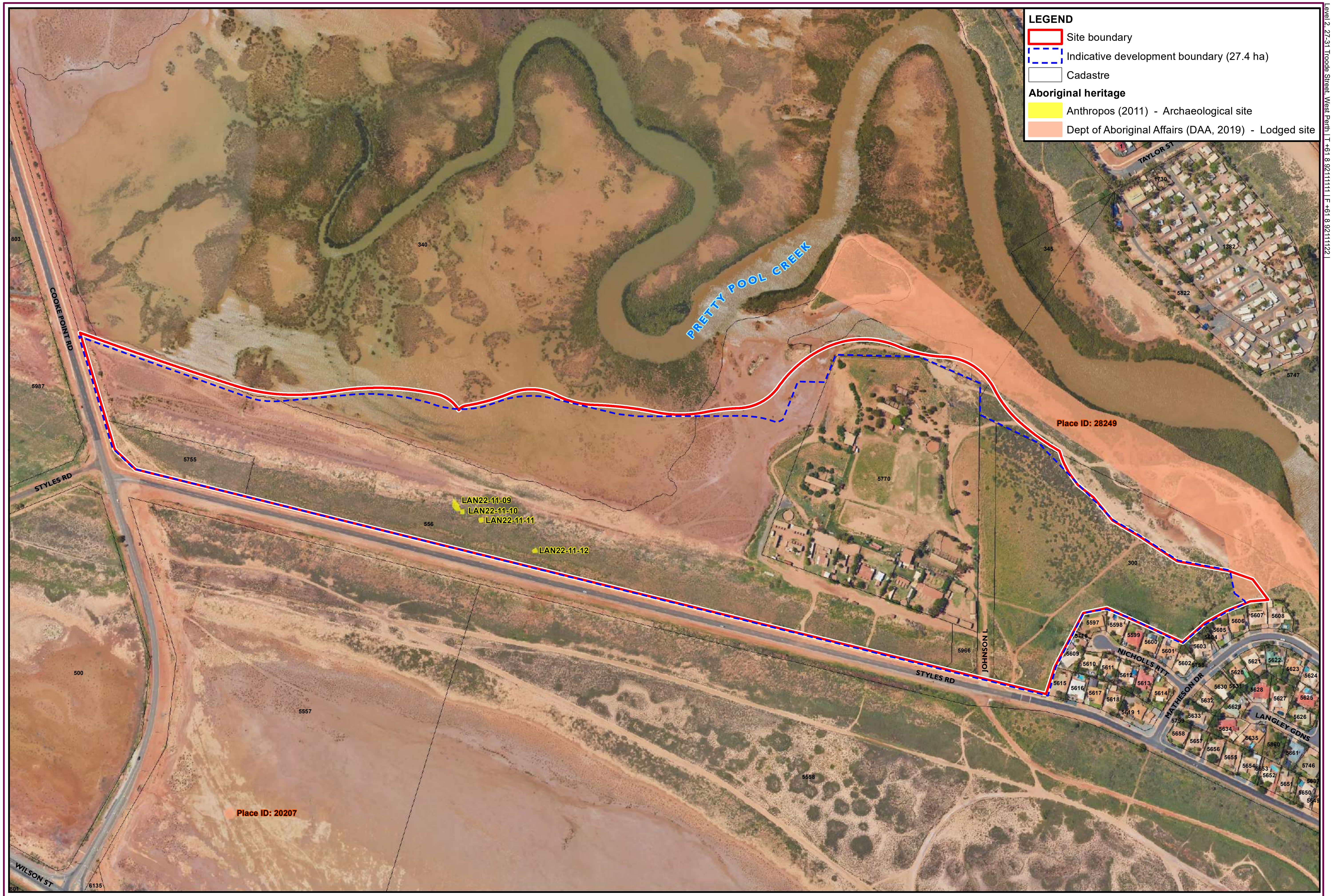


Figure K

Aboriginal heritage

Job Number: L20043-002
Doc Number: 011
Date: 26.05.20
Scale: 1:4,000 @ A3
Created by: MA
Source: Orthophoto - Landgate, 2020

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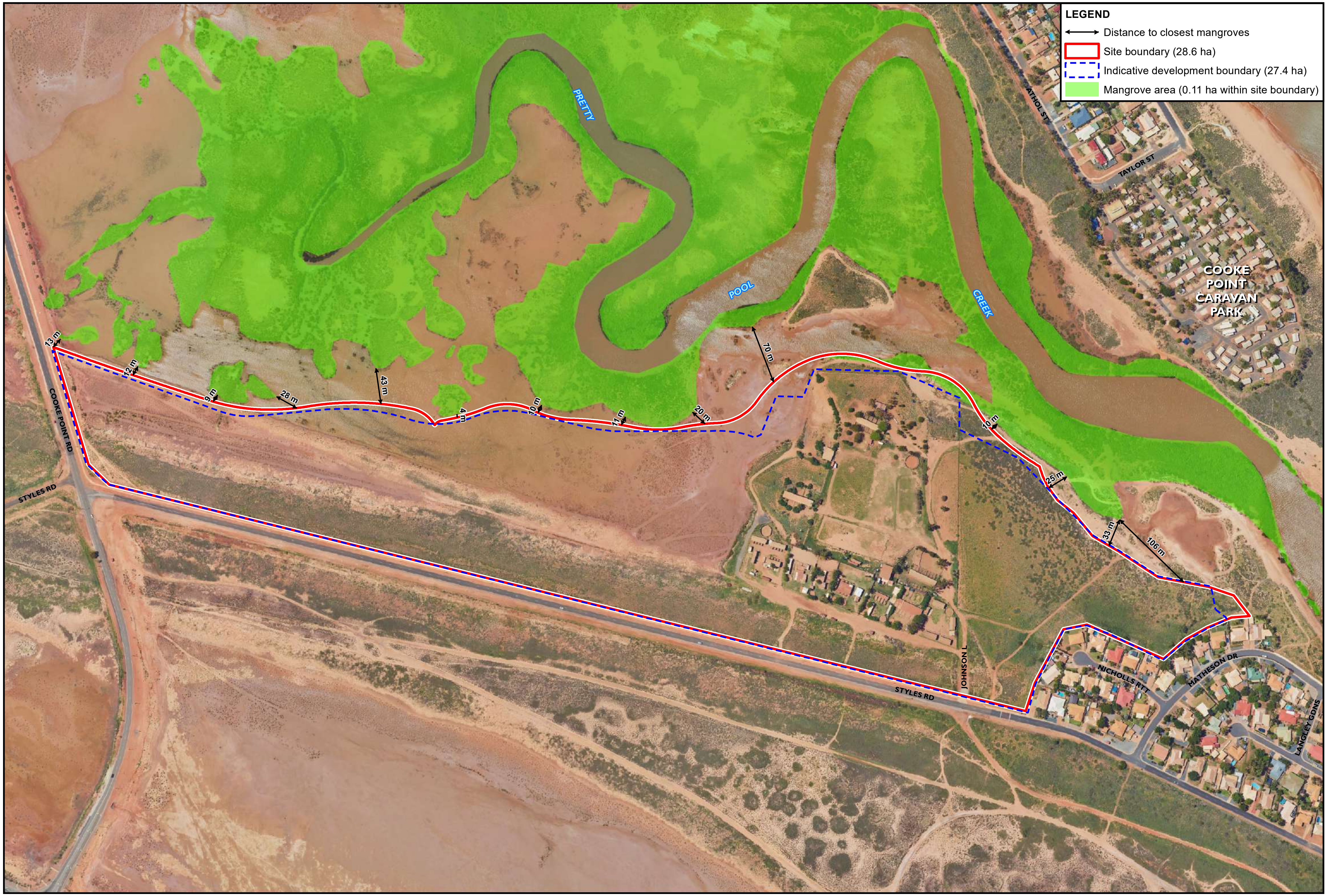
Document Path: G:\Jobs\L_Jobs\L20043 - DevWA Athol_Stables\Figures L20043-002\L20043-002_G_011_FigK Aboriginal Heritage_200526.mxd



LEGEND

↔ Distance to closest mangroves

🟥 Site boundary (28.6 ha)

▭ Indicative development boundary (27.4 ha)

🟩 Mangrove area (0.11 ha within site boundary)

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Figure L

Distance to the Pretty Pool Creek mangroves

GDA 1994 MGA Zone 50

0 50 100 200 m

Job Number: L20043-002
Doc Number: 012
Date: 26.05.20
Scale: 1:4,000 @ A3
Created by: MA
Source: Orthophoto - Landgate, 2020

Document Path: G:\Jobs\L_Jobs\L20043 - DevWA Athol_Stables\Figures L20043-002\L20043-002_G_012_FigL Distance to Pretty Pool Creek Mangroves_200526.mxd

Appendix A
EPA decision and advice

GOVERNMENT OF
WESTERN AUSTRALIA

Environmental Protection Authority

Chief Executive Officer
Town of Port Hedland
PO Box 41
PORT HEDLAND WA 6721

Your Ref:
Our Ref: *CMS15200*
Enquiries: *Anthony Sheehan, 6145 0800*
Email: *Anthony.Sheehan@epa.wa.gov.au*

Dear Sir/Madam

DECISION UNDER SECTION 48A(1)(a)
Environmental Protection Act 1986

SCHEME:	**Town of Port Hedland - Town Planning Scheme 5 - Amendment 77**
LOCATION:	**Various Lots Styles Road**
RESPONSIBLE AUTHORITY:	**Town of Port Hedland**
DECISION:	**Scheme Not Assessed: Advice Given (no appeals)**

Thank you for referring the above proposed scheme to the Environmental Protection Authority (EPA).

After consideration of the information provided by you, the EPA considers that the proposed scheme should not be assessed under Part IV Division 3 of the *Environmental Protection Act 1986* (EP Act) but nevertheless provides the attached advice and recommendations.

Please note the following:

- For the purposes of Part IV of the EP Act, the scheme is defined as an assessed scheme. In relation to the implementation of the scheme, please note the requirements of Part IV Division 4 of the EP Act.
- There is no appeal right in respect of the EPA's decision to not assess the scheme.

A copy of this letter and the attached advice and recommendations will be made available to the public via the EPA website.

Yours sincerely

Darren Foster
Director
Strategic Policy and Planning Division

Delegate of the Chairman of the Environmental Protection Authority
Under Notice of Delegation No. 33 published 17 December 2013

17 August 2015

Encl. Scheme Advice and Recommendations

ADVICE UNDER SECTION 48A(1)(a)
ENVIRONMENTAL PROTECTION ACT 1986

Town of Port Hedland Scheme 5 Amendment 77

Location: Town of Port Hedland

Determination: Scheme Not Assessed – Advice Given (no appeals)

Determination Published: ***17 August 2015***

Summary

The Town of Port Hedland proposes to rezone land generally bound by Styles Road (south), Pretty Pool Creek (north), Cooke Point Drive (west) and existing single residential housing in the Pretty Pool residential area (east) from "Rural", "Parks and Recreation" and "Other Public Purpose – Energy" to "Urban Development".

The Environmental Protection Authority (EPA) has considered the scheme amendment in accordance with the requirements of the *Environmental Protection Act 1986* (EP Act). In making its decision on whether to assess the scheme amendment, the EPA has applied its 'Significance Framework' which relates to the extent to which the scheme amendment meets the EPA's environmental objectives for the environmental factors.

The EPA considers that the scheme amendment is unlikely to have a significant effect on the environment and does not warrant formal assessment under Part IV of the EP Act. The potential impacts from the scheme amendment can be adequately managed to meet the EPA's objectives through the implementation of the responsible authority's scheme provisions, management plans and regulated through other statutory processes.

1. Environmental Factors

The EPA has identified the following preliminary environmental factors relevant to this scheme amendment:

a) Heritage;
b) Terrestrial Environmental Quality;
c) Benthic Communities and Habitat; and
d) Marine Fauna

2. Advice and Recommendations regarding Environmental Factors

a. Heritage

The EPA understands from the Environmental Assessment Report supporting the scheme amendment that newly identified Aboriginal Shell Midden and Engraving archaeological sites may be located within the amendment area. The Department of Indigenous Affairs should be consulted with respect to obligations under the *Aboriginal Heritage Act 1972*.

b. Terrestrial Environmental Quality

Desktop investigations based on broad-scale mapping indicate that the northern portion of the scheme amendment area is rated as High to Moderate Acid Sulfate Soils (ASS) Disturbance Risk and the southern portion of the area is rated as Moderate to Low ASS Disturbance Risk. The extent and severity of the risk should be determined in accordance with the Western Australian Planning Commission's *Acid Sulfate Soils Planning Guidelines.* A Detailed Site Investigation and Management Plan should be prepared in accordance with the Department of Environment Regulation (DER) *Acid Sulfate Soils Guidelines Series* and to the satisfaction of the DER Contaminated Sites Branch.

c. Benthic Communities and Habitat

Benthic primary producer habitats (BPPH) are important for the maintenance of healthy marine ecosystems. In recognition of the importance of BPPH, the EPA published *Environmental Assessment Guideline No. 3: Protection of Benthic Primary Producer Habitats in Western Australia's Marine Environment.* Areas called Local Assessment Units (LAUs) are used as the spatial basis for cumulative loss assessments.

Development at Port Hedland has resulted in the incremental loss of BPPH, including mangrove and other intertidal and sub tidal habitats. Consequently, the EPA published *Environmental Protection Bulletin No. 14: Guidance for the Assessment of Benthic Primary Producer Habitat Loss in and around Port Hedland.* The Bulletin established a Port Hedland LAU. The Pretty Pool Creek mangroves are within the Port Hedland LAU.

The EPA notes that the scheme amendment's northern boundary is set back from the Pretty Pool Creek mangroves and development will be separated from the mangroves by a bund and roadway. Therefore, development within the Amendment Area will not directly impact the existing mangroves.

Modelling prepared for the scheme amendment indicates that changes to the hydrodynamics of the creek from development within the scheme amendment area will be minor. Therefore, significant indirect impacts to the Pretty Pool Creek mangroves are not considered to be likely, providing runoff during construction is adequately managed.

The EPA supports the proposed scheme text which requires that a Mangrove Management Plan and Construction Management Plan be prepared to the satisfaction of the Town of Port Hedland on advice from the relevant State Government Agencies.

d. Marine Fauna

Pretty Pool Beach and Cemetery Beach are known Flatback turtle nesting beaches. Flatback turtles are listed as "Threatened" under the *Wildlife Conservation Act 1950* and "Vulnerable" under the *Environmental Protection and Biodiversity Conservation Act 1999.* Flatback turtle nesting and hatchling behaviour can be affected by light spill on to nesting beaches and the adjacent sea and light glow.

Development within the scheme amendment area will be limited to single story buildings. Line of site modelling demonstrates that buildings and associated infrastructure such as street lights within the scheme amendment area will not be visible from Pretty Pool Beach or Cemetery Beach. Therefore, providing there are adequate controls to ensure building heights do not exceed these limits, there should be no direct line of site light impacts on Pretty Pool Beach and Cemetery Beach.

Turtle nesting and hatchling behaviour can also be affected by light glow. The EPA recommends that *Environmental Assessment Guideline No. 5 Protecting Marine Turtles from Light Impacts* inform urban design and building within the scheme amendment area. Ideally, the application of these guidelines should be a condition of the scheme text. For example, the Guideline recommends the following approach to lighting:

- Keep it OFF (keep lights off when not needed)
- Keep it LOW (mount lights low down with lowest intensity for the job)
- Keep it SHIELDED (stop all light escaping upwards and outwards) and
- Keep it LONG (use long wavelength lights).

In addition to potential light spill impacts, an increased residential population also has the potential to impact marine turtle nesting and hatchling behaviour, through the use of recreation vehicles, pets and interaction with nesting turtles. The EPA supports the proposed scheme text that a management plan to minimise impacts to marine turtles be prepared and implemented to the satisfaction of the Town of Port Hedland on advice from the relevant State Government Agencies.

Appendix B

Local Water Management Strategy

Our Ref: CW1122600:FSC
Contact: Frederic Saint-Cast

Wednesday, 27 May 2020

Element
Level 18, 1991 St Georges Tce

Perth WA 6000

Attention: Justin Page

Cardno (WA) Pty Ltd
ABN 77 009 119 000

11 Harvest Terrace
West Perth WA 6005
Australia

Phone +61 8 9273 3888
Fax +61 8 9486 8664

www.cardno.com

Dear Justin,

SCHEME AMENDMENT - THE STABLES - COASTAL AND HYDROLOGICAL REVIEW

This letter was prepared by Cardno to support the submission of the new scheme amendment proposal for the Stables ("the Development") with respect to coastal and hydrology matters considering existing documentation, including the following references:

[1] Cardno (2011) **Port Hedland Coastal Vulnerability Study.** *Prepared by Cardno for LandCorp. File Ref: Job Number: LJ15014 - Report Number: Rep1022p - 10 August 2011. Version: 2 Final - 10 August 2011.*

[2] Cardno (2015a) **Mangrove & Potential Erosion Impacts Assessments - Stage 3 (The Stables) East Port Hedland.** *Prepared by Cardno for LandCorp. File Ref: V14018_005_R001_RevB_MangroveAssessment - 5 February 2015. Version: Rev B - 5 February 2015.*

[3] Cardno (2015b) **Local Water Management Strategy – Stage 3 (The Stables) East Port Hedland.** *Prepared by Cardno for LandCorp. File Ref: V14018-WA-R002-D-LWMS – April 2015. Version: D – 13/08/2015.*

[4] GHD (2019) **Port Hedland Townsite CHRMAP - Coastal Hazard Risk Management and Adaptation Plan.** *Prepared by GHD for the Town of Port Hedland. File Ref: 6136239 - April 2019. Version: Rev 0 - 29/03/2019.*

In consideration of the findings provided in the references above, Cardno has structured this letter as follows:

- Part 1 addresses the review of the Coastal Hazard Risk Management and Adaptation Plan (CHRMAP, GHD 2019) recently completed by the Town of Port Hedland ("the Town"). It briefly summaries the implications of the CHRMAP for future development of The Stables ("the Site"). It also includes an adjustment to the Rare inundation level which was missed reported in GHD (2019) report. This adjustment corresponds to an upward revision of +0.1m of the Rare inundation level for the 500ARI event to 2120. This revised level, equivalent to 6.7mAHD, is adopted as the minimum development level at the Site, in compliance with SPP2.6 to effectively mitigate the future risk of coastal inundation at the Site.
- Part 2 addresses the review of the Mangrove & Potential Erosion Impacts (Cardno, 2015a) completed by LandCorp in 2015, prior to the release of the Town CHRMAP. It acknowledges the validity of the study and its findings in the context of the CHRMAP and outlines minor addendums to the Cardno (2015a) technical report.
- Part 3 addresses the review of the Local Water Management Strategy (Cardno, 2015b) completed by LandCorp in 2015, prior to the release of the Town CHRMAP. It acknowledges the validity of the study and its findings in the

context of the Town CHRMAP and outlines minor addendums to the Cardno (2015b) technical report.

Part 1 – Review of the Town Coastal Hazard Risk Management and Adaptation Plan

Cardno reviewed of the Town CHRMAP (GHD, 2019) with a focus on its implication for the Site.

The Town CHRMAP provides clear recommendations for future development at the Site. It recognises that future coastal inundation hazard may be posing a threat to certain land use in the area, and that it would constitute an unacceptable risk for residential development at the Site without further mitigation measure put in place. In accordance with SPP2.6, the Town CHRMAP recommends that any future development at the Site will be required to be above the Rare inundation level defined as the 500-year Average Recurrence Interval (ARI) storm tide inundation level for the 100-years planning period (2120).

The 2120 intolerable risk of inundation extent for the Almost certain, Possible and Rare uncertainty level is shown in the Town CHRMAP (GHD, 2019, p.54 *Figure 4-10 East Townsite inundation hazard and recommended adaptation*). The inundation likelihood levels are provided in the Town CHRMAP (GHD, 2019, *Table 2-10 Inundation likelihood levels*). In the case of the 2120 planning horizon, if the elevation of the asset is below the Rare inundation level of 6.6mAHD the asset is defined as impacted by inundation. Conversely, if the asset is defined as not impacted by inundation if the minimum elevation of the asset is above the rare inundation level of 6.6mAHD.

Upon further inspection of the source of water level information cross-referenced in the Town CHRMAP (GHD, 2019, p22. *Table 5-3 Inundation water levels Area 1. Blue values are taken from Cardno 2011*), it was noted that the water level reported in the Port Hedland Coastal Vulnerability Study (Cardno, 2011) were provided for 2110 and not for 2120 as reported in GHD (2019). The sea level rise allowance increases by 0.1m between 2110 and 2120. So, the 500year ARI design water level for 2120 should have been 6.7mAHD and not 6.6mAHD.

In consideration of the above, Cardno recommends an adjustment to the 2120 Rare inundation hazard level reported in the Town CHRMAP for the Site. This adjustment corresponds to an upward revision of +0.1m of the original Rare inundation level for the 500ARI event to 2120, equivalent to 6.7mAHD. This revision was subsequently raised in pre-lodgement consultations with the Town and supported at officer level. As a result, the Development will be filled to 6.7mAHD to comply with the revised CHRMAP guidance and comply with SPP2.6 to effectively mitigate the future risk of coastal inundation at the Site.

Part 2 - Review of the Mangrove & Potential Erosion Impacts

Cardno reviewed the Mangrove & Potential Erosion Impacts (Cardno, 2015a) with a focus on the implication of the Town CHRMAP review findings (Part 1) on its validity.

The only departures from the original assumptions made in the Mangrove & Potential Erosion Impacts (Cardno, 2015b) is related to a minor revision of the inundation level for the 500ARI event incorporating sea level rise, which would affect the modeling study as follows:

i. The horizontal footprint of the development in the model remains unchanged and the vertical level of the development in the model would be raised by +0.1m, from 6.6mAHD to 6.7mAHD.

ii. The allowance for sea level rise in Scenario 4 (500ARI event incorporating sea level rise) would increase by +0.1m, from 0.9m to 1.0m, in line with the time horizon revision from 2110 to 2120.

These minor revisions are not expected to change the findings of the study with respect to Mangrove & Potential Erosion Impacts for the following reasons:

1. The revised development level does not affect the modelling results for the original scenarios which covers the vast majority of the scope of the investigation.
   a. The original Scenarios 1, 2 and 3 remain unchanged and are still applicable.
   b. The original Scenario 4 remain unchanged and are still applicable to 2110.
2. The original Scenario 4 to 2110 can be seen has a hazard with a probability of occurrence of 16.5% over the time horizon considered, while an extended Scenario 4 to 2120 would be seen as a hazard with a probability of occurrence of 18.1% over the time horizon considered. These two hazard likelihoods are not meaningfully different.

3. At the Site, with a tidal range in the order of 6.5m, a surge height in the order of 2m and sea level rise projection in the order of 1m to 2120, a nominal water level variation in the order of 0.1m is within the general accuracy of the storm surge model and within the general vertical tolerance of bathymetric and topographic survey for a model of this scale.
4. The mangrove & potential erosion impacts are assessed by comparing the hydrodynamic model results before and after development. This assessment show that the consequences of the development are not deemed significant with respect to mangrove & potential erosion impacts. So, a minor alteration of the water level is not expected to result in any significant deviation from the original modelled mangrove & potential erosion impacts findings.

In consideration of the Part 1 and the above review, Cardno confirm that the Mangrove & Potential Erosion Impacts study (Cardno, 2015a) is still applicable with no changes to 2110. The subsequent minor changes in design level reflecting the extension of time horizon to 2120 are not expected to significantly change the Mangrove & Potential Erosion Impacts risk profile original assessed. As a result, Cardno confirm that the Mangrove & Potential Erosion Impacts is still applicable to 2120 with respect to mangrove & potential erosion impacts subject to the following minor addendums to the Mangrove & Potential Erosion Impacts technical report (Cardno, 2015a):

1 Introduction

References to “To comply with SPP2.6, any future development in this region of Port Hedland will be required to be above the 500-year Average Recurrence Interval (ARI) storm tide inundation level for the 100-years planning period (~~2110~~). From the recommendations in the Port Hedland Coastal Vulnerability Study (Cardno 2011), the site would be required to be filled to a minimum level of ~~+6.6 m AHD~~.” should be read as “To comply with SPP2.6, any future development in this region of Port Hedland will be required to be above the 500-year Average Recurrence Interval (ARI) storm tide inundation level for the 100-years planning period (2120). From the recommendations in the Port Hedland Coastal Vulnerability Study (Cardno 2011), the site would be required to be filled to a minimum level of +6.7 m AHD.”

2.4.1 Development Cases

References to “design fill level of ~~+6.6 m AHD~~” should be read as “design fill level of +6.7 m AHD”.

6.1 Implications for Development

References to “the full footprint will be filled to a level of ~~+6.6 m AHD~~” should be read as “the full footprint will be filled to a level of +6.7 m AHD”.

Part 3 - Review of the Local Water Management Strategy

Cardno reviewed the Local Water Management Strategy (Cardno, 2015b) with a focus on the implication of the Town CHRMAP review findings (Part 1) and the Mangrove & Potential Erosion Impacts review findings (Part 2) on its validity.

The Local Water Management Strategy (Cardno, 2015a) was *Approved by Department of Water and Environmental Regulation (then Department of Water) 25 August 2015.*

In consideration of the Part 1 and Part 2 above, Cardno confirm that the Local Water Management Strategy is still applicable subject to the following minor addendums to the Local Water Management Strategy (Cardno, 2015b):

Section 2.5.2 Flooding

Revised 6.7m AHD finished level to be applied to the site for long term accommodation (i.e. residential) in accordance with the CHRMAP.

Section 2.5.2.1 Mangrove and Erosion Impact Assessment

Third dot point to be updated to read the site will need to be filled to 6.7mAHD.

Appendix A: Mangrove and Erosion Impacts Assessment

Appendix A, Mangrove and Erosion Impacts Assessment (Cardno, 2015b) to be consistent with the addendum noted in part 2 above.

Yours sincerely,

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Local Water Management Strategy

Stage 3 (The Stables)
East Port Hedland

Prepared for LandCorp
March 2015

Document Information

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Document Control

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A	25/02/2015	Stephen Clarke	SLC	Justine Jones	JMMJ
B	17/03/2015	Stephen Clarke	SLC	Justine Jones	JMMJ

Executive Summary

This Local Water Management Strategy (LWMS) has been prepared by Cardno (WA) Pty Ltd (Cardno) to support LandCorp's initiative to undertake concept planning and initiate a Scheme Amendment to allow development of Stage 3 (The Stables) East Port Hedland (the Site). The Site is situated in the Town of Port Hedland (ToPH) approximately 5 kilometres east of the town centre and is proposed to consist of a residential subdivision comprised of low and medium density lots (R20 and R40, respectively).

Two indicative development concept options were evaluated for the Site (option 1 and option 2). These options consisted of similar arrangements of residential development, with a primary difference between the two being the location of a caravan park and small differences in R20 and R40 lot area totals.

The development of a LWMS is the appropriate mechanism to establish broad level designs and management measures for flood mitigation and effective stormwater management at the structure planning stage. A LWMS is intended to provide overall guidance to the general stormwater management principles for the area and to guide future Urban Water Management Plans (UWMP) that will support subdivision approval.

This LWMS has been developed to:

> Provide a broad level stormwater management framework to support future urban development;
> Incorporate appropriate Best Management Practices (BMP) into the drainage systems that address the environmental and stormwater management issues identified;
> Minimise development construction costs and ongoing operation and maintenance costs for the land owners and ToPH; and
> Gain support from the Department of Water (DoW) and ToPH for the proposed method to manage stormwater within the development area and potential impacts on downstream areas.

A number of broad level studies that include the Site provide a regional environmental context for the LWMS. These have been reviewed in order to provide suitable background information and provide an indication of the issues requiring further investigation. In summary, the investigations conducted to date indicate that:

> The Site has historically been undeveloped and is used for equine purposes associated with the Port Hedland Pony Club;

> The Site falls south and north from a high ridge line (7.5 to 8.0 mAHD) located approximately 50 m north of Styles Road to 2.5 mAHD in the north and 3.0 mAHD in the south;

> Ground conditions are primarily sandy clay/clay estuarine deposits across the western half of the northern half of site and dune sand on the eastern portion of the site with a limestone ridge spanning the entire southern half of the Site;

> Infiltration has been calculated onsite in two locations to be 5 m/day;

> The estuarine deposits of the western half of the northern portion of the Site are considered to be of High to Moderate Risk of Acid Sulfate Soils (ASS);

> Runoff volumes flowing north towards Pretty Pool Creek that are associated with the six minute 5 year average recurrence interval (ARI) , 10 year ARI and 100 year ARI rainfall events have been modelled as 1,200 m^3, 6,050 m^3, and 11,300 m^3, respectively.

> No surface water was identified in or in the vicinity of the Site;

> Groundwater is present within 3 m of surface;

> Regional groundwater is typically neutral with an average pH of 7.27 and an average TDS of 3,510 mg/L;

> No wetlands or ESA were identified in the vicinity of the Site; and

> No TEC or TPFL are likely to be found within the Site; and

> While no records of species of threatened fauna have been recorded within the Site, three species of threatened fauna have been recorded within 1 km of the Site's boundaries.

The LWMS has determined appropriate water conservation, stormwater management and groundwater management design criteria based on overarching documents, the requirements of the ToPH, DoW and from similar developments.

The overall aim of total water cycle management includes the sustainable consumption of potable water and consideration of all water sources. Therefore the use of water within the development will be minimised wherever possible. This will be achieved through considered landscaping of the Public Open Space (POS) to minimise areas requiring irrigation. In addition, POS areas will be irrigated with fit-for-purpose water where possible. Water efficient appliances and water efficient gardens will be promoted at the lot scale. This will encourage the development to meet the target use of water within household's target of 100 m^3/person/year (Government of Western Australia 2007).

The stormwater management objectives for the Site are to retain (and treat) the first 15 mm of any rainfall event as close to source as possible using soakwells and/or rainwater tanks where appropriate. It is proposed based on the current masterplanning that runoff from the road reserve will be conveyed to a swale on the northern development boundary via the surface flow on the roads.

The POS areas on the northern boundary will contain the large vegetated swale in order to retain and infiltrate the first 15 mm of a rainfall event from the road reserve. Other strategies to minimise erosion and mitigate sediment transport have also been identified within the LWMS, such as the installation of sediment control devices during construction and the need for an Erosion and Sediment Control Program to be referred to within future UWMP. Specific emphasis has also been placed on the minimisation of erosion and scour associated with fill materials, due to the potential impact of elevated fines deposited in the tidal mangroves of Pretty Pool Creek.

The Site model discharges runoff into the swale at multiple locations to more accurately model peak flows associated with rainfall events and ensure that flows are retained and infiltrated. All discharge mechanisms will divert flows away from the identified Aboriginal Heritage sites, and no flow structures are to be built in the vicinity of these sites.

The overall objective for groundwater management is to minimise any changes to the underlying groundwater level and quality as a result of development. It is recommended that prior to commencement of the next stage of the planning process groundwater monitoring is undertaken to characterise annual groundwater fluctuations.

It is proposed that the overall condition of POS areas be monitored on a bi-annual basis following completion of the civil and landscaping works. POS and groundwater salinity monitoring will ensure that the high amenity value of the development is maintained prior to handover of the POS areas to the ToPH.

This LWMS provides a framework that the proponent can utilise to assist in implementing stormwater management methods that:

- have been based on site-specific investigations;
- are consistent with relevant State policies; and
- have been endorsed by the ToPH.

The responsibility for working within the framework established within the LWMS rests with the proponent and their contractors, although it is anticipated the future management actions beyond the proposed management timeframes will be the responsibility of the ToPH.

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1 Introduction

Cardno (WA) Pty Ltd (Cardno) has been commissioned by LandCorp to prepare a Local Water Management Strategy (LWMS) to support concept planning and initiate a Scheme Amendment to allow development of Stage 3 (The Stables) East Port Hedland (the Site). The Site is approximately 35 hectares in area and located in East Port Hedland 9 km north of Port Hedland Airport. The Site is bound by Pretty Pool Creek in the north, a residential development to the east, Styles Road in the south and Cooke Point Drive to the west. The Site location plan is presented in Figure **1**.

It is important that stormwater runoff from developments is managed and clearly documented early in the planning process. This provides a framework for actions and measures to achieve the desired stormwater management at the subdivision stage. The development of a LWMS is considered to be the appropriate mechanism to establish the concept design and management measures for flood mitigation and effective stormwater management.

The Site is currently zoned ‘Rural’ and ‘Parks and Recreation’. Historical land use has been predominantly undeveloped land along with recreational and equine purposes. Changing land use can have implications for quality and quantity of stormwater generated which can affect the local and downstream environments. In addition, the development of the Site will require the sustainable use of water resources across the wider area and within the Site itself. The overall aim of the LWMS is to ensure that any potential impacts from land use change, and subsequent development, are minimised.

1.1 Policy Framework

There are a number of State Government documents that relate to the Site. These documents include:

- State Water Plan (Government of WA 2007);
- Acid Sulfate Risk Mapping (DER 2006);
- Guidance Statement 33: Environmental Guidance for Planning and Development (EPA 2006);
- State Planning Policy No 3: Urban Growth and Settlement (WAPC 2006); and
- Liveable Neighbourhoods (WAPC 2007).

In addition to the above documents, there are a number of published guidelines and standards available that provide direction regarding the objectives which stormwater management should aim to achieve. These are key inputs and include:

- Decision Process for Stormwater Management in Western Australia (DoW 2009);
- National Water Quality Management Strategy (ANZECC 2000);
- Stormwater Management Manual of Western Australia (DoW 2007); and
- Better Urban Water Management (WAPC 2008).

These guidance documents, together with information from the Town of Port Hedland (ToPH) and Department of Water (DoW), were reviewed to determine the likely data requirements for the Site.

1.2 Sources of Information

A number of broad level information sources that describe the Site have provided a regional context to the LWMS. These were reviewed in order to gather suitable background information for the Site, and also to provide an indication of the issues requiring further and more detailed investigation. The background information was sourced from a variety of references, including:

- DoW's Water Information (WIR) Database Search;
- WA Atlas Database Search;
- Department of Environment and Conservation (DEC) - Contaminated Site Database;

- East Port Hedland Geotechnical Reconnaisance (GHD, 2011);
- Preliminary Environmental Assessment Report (RPS 2011);
- East Port Hedland Concept Plan Report (RPS 2012); and
- Summary of Fatal Flaws for Proposed Development of East Port Hedland Based on Hydrodynamic Modelling.

1.3 Objectives

The LWMS for the Site has been developed to meet the following major objectives:

- Develop a stormwater management strategy for flood protection of the Site and downstream environments;
- Incorporate appropriate Best Management Practices (BMP) into the drainage system to address erosion and sediment transport within the development;
- Develop a water conservation strategy; and
- Gain support from the DoW and ToPH for the proposed method to manage stormwater within the Site and potential impacts on the Site and downstream environments.

2 Pre-development Environment

2.1 Land Use

The Site is approximately 31ha in size and consists of tidal flats and stabilised dunes currently zoned as 'Rural' and 'Parks and Recreation'. The Site has historically been undeveloped, with a small portion used for horse stabling purposes associated with the Port Hedland Pony Club (the Pony Club), which currently occupies approximately 6ha in the middle of the Site.

2.1.1 Indigenous Heritage

Three sites of indigenous heritage significance were identified within the Site during the development of the East Port Hedland Concept Plan. These areas are located along the southern boundary extent and have been identified during consultation with local indigenous communities (Anthropos Australis, 2011). The location of these indigenous heritage sites is outlined in Figure 2.

2.1.2 Non-Indigenous Heritage

Based on examination of the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) Heritage Database and the Government of Western Australia State Heritage Inventory no Non-Indigenous Heritage sites have been identified.

2.2 Topography

The Site falls south and north from a high ridge line between 7.5 and 8.0 mAHD located approximately 50 m north of Styles Road. The Site falls to 2.5 mAHD just inside the northern border. From here it slopes into the mangroves and Pretty Pool Creek. A topographic map of the Site and its immediate surrounds can be found in Figure 3.

2.3 Climate

Long term climatic averages indicate that the Site is located in an area of low to moderate rainfall, receiving 332 mm per annum on average (BoM, 2014), with the majority of rainfall received between January and March. The region experiences rainfall on average 33 days a year.

Chart 1 summarises the past 10 years of climate data sourced from the Port Hedland Airport (WA) Bureau of Meteorology station (BoM, 2014), approximately 7.7km from the Site. Temperatures are constant throughout the year and range between approximately 20°C in winter and 45°C in summer. The oscillating trend illustrated in Chart 1 is reasonably constant. This implies that no major changes in temperature have occurred in the last 10 years.

Precipitation trends for the Port Hedland Airport have also remained relatively constant through the previous 10 years. The average precipitation for this period (356 mm) has been relatively constant except for 2013 where there was a significant rise (713 mm). This significant increase in rainfall is attributable to the fact that three of the ten greatest rainfall volumes over the past 30 years occurred in 2013 (BoM, 2014).

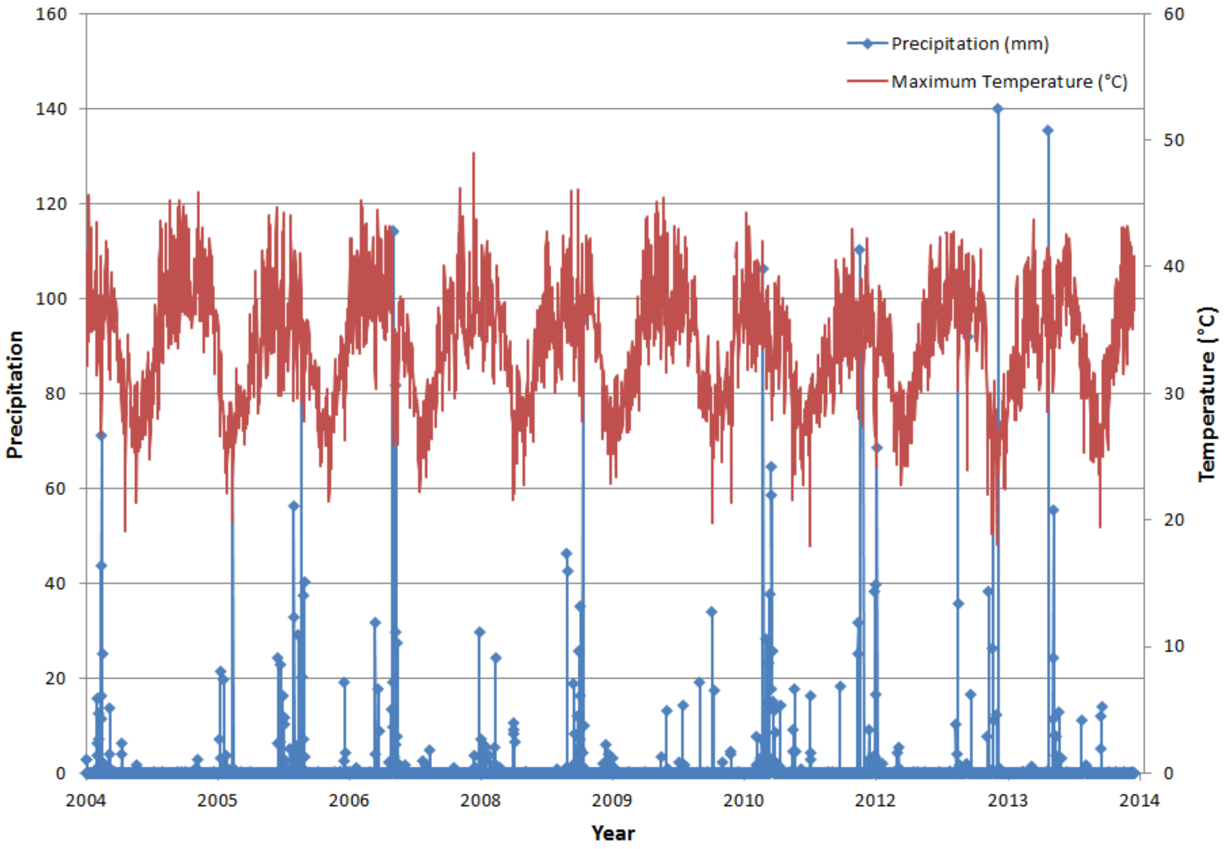

Chart 1 **Climate Data for the Port Hedland Airport from 2004 - 2014**

2.4 Geotechnical conditions

A geotechnical investigation (Coffey, 2014) of the Site was conducted in order to:

- assess ground conditions;
- characterise the site geotechnically;
- obtain Acid Sulfate Soils (ASS) samples for testing;
- conduct permeability tests; and
- to determine depth to groundwater.

Based on two falling head tests and historic data from the Port Hedland area, an infiltration rate of 5 m/day was recommended for use in the design of soakwells (Coffey, 2014).

2.4.1 Ground Conditions

Ground conditions have been generalised into three areas for subsurface profiles. These subsurface profiles consist of:

- Dune sand – fine to coarse grained sand of loose to medium density located on the eastern half of the northern half of the Site;
- Estuarine deposits – low to high plasticity sandy clay/clay that is typically very soft located on the western half of the northern half of the Site; and
- Limestone – well cemented calcarnite and calcisilite of low to high strength spanning the southern half of the Site.

Figure 4 provides an outline of the soil types based on previous geotechnical investigations (GHD, 2011; Coffey, 2014).

2.4.2 Acid Sulfate Soils

ASS are naturally occurring soils that contain iron sulphide (iron pyrite) minerals. If disturbed by dewatering, drainage or soil excavation, the pyrites can oxidise thereby releasing iron compounds and sulphuric acid. These soils can result in environmental harm and damage to infrastructure. ASS that have been oxidised and resulted in the creation of acidic conditions are termed Actual ASS, and those that have acid generating potential but remain in naturally anaerobic conditions are termed Potential ASS.

ASS are predominantly found in WA's coastal regions in low-lying wetlands and tidal flats and have also been identified inland within WA's South West Region. The potential for ASS to occur within the Site may be assessed by examining the type of soil present and the depth to groundwater. These soils may occur in a variety of waterlogged soils such as dark organic rich soils and muds, peaty wetland soils, some pale grey sands, "coffee rock" (cemented iron and/or organic rich sands) found below the watertable and pyritic soils (Department of Environment and Conservation (DEC), n.d.)

Potential ASS are those which have:

- a pH close to neutral (6.5-7.5);
- contain un-oxidised iron sulphides;
- are usually soft, sticky and saturated with water; and
- are usually gel-like muds but can include wet sands and gravels which have the potential to produce acid if exposed to oxygen.

Actual ASS are characterised by soils that:

- have a pH of less than 4;
- contain oxidised iron sulphides;
- vary in texture; and
- often contain jarosite (a yellow mottle produced as a by-product of the oxidation process).

The DEC provides broad-scale risk maps for several coastal regions of WA where a high or moderate probability of ASS occurrence has been identified. A search of this database has indicated that the low lying estuarine deposits located in the west and northwest regions of the site are classified as having a high to moderate risk of ASS, and the remainder of the site is classified as being of moderate to low risk. Figure 5 demonstrates the ASS mapping for the surrounding area of the site, confirming that the site is within areas of pronounced risk of ASS.

Results of ASS sampling and testing from the site have confirmed that there is a high risk of encountering acid generating soils in the estuarine deposits of the Site, and that the remainder of the Development will be located on subsurface profiles that are possess a moderate to low risk of encountering acid generating soils (Coffey, 2014a).

2.5 Hydrology

A desktop review of available hydrological and topographic information was undertaken to assess the existing hydrological environment. The objectives of this review were to:

- Develop an understanding of how stormwater is currently accommodated onsite;
- Identify impacts of flooding on potential development on current ground elevations;
- Determine if the site acts as a drainage sump to surrounding land; and
- Ensure if the site is acting as a sump to surrounding land that sufficient space is set aside for stormwater in the final plan.

Drainage of the Site currently entails no pipe or pit network, but instead involves overland flow northward to the tidal flats associated with Pretty Pool Creek. The tidal nature of Pretty Pool Creek provides strong tidal influences for drainage and storm surge inundation of the Site.

2.5.1 Storm Surge Inundation

Cyclonic activity impacts the study area during the wet season (between November and May). Due to the proximity of the site to the Pretty Pool Estuary, it is susceptible to ocean inundation resulting from extreme storm surge events. In the future the effects of climate change are likely to cause sea levels to rise. Information provided by Western Australia Planning Commission (WAPC) show sea levels will have risen by 0.9m in 2110, therefore also increasing the likelihood of inundation at the study area.

The WAPC State Coastal Planning Policy 2.6 (WAPC 2003) provides the following recommendation for development in cyclone prone areas: Development should be set back from any areas that would potentially be inundated by the ocean during the passage of a Category 5 cyclone tracking to maximise its associated storm surge.

- (WAPC SPP2.6 Section F.4)

2.5.2 Flooding

As indicated previously, Cardno undertook a flood vulnerability study in 2011 where the 100 year and 500 year average recurrence interval (ARI) flood levels of 5.9 mAHD and 6.6 mAHD were found, respectively. Any development of the site will need the finished floor levels to be above the 100 year ARI flood level by a recommended minimum of 0.5 m. This will require fill over most of the site. No flooding from Pretty Pool Creek was considered in the hydrological model as all modelling was based on pluvial flooding.

Further work undertaken as part of the Mangrove and Erosion Impacts Assessment clarified the proposed finished floor levels for the types of land use proposed within the development as follows:

> Long term accommodation (i.e. residential), assuming a 100 year ARI design life: +6.6 m AHD.

> Short term lease (i.e. caravan park site), assuming a 50 year ARI design life: +5.3 m AHD.

Additional details of the calculations used to determine this level can be found in Appendix A.

2.5.2.1 Mangrove and Erosion Impacts Assessment

Cardno (2015) has undertaken an assessment of impacts to the mangrove community located in Pretty Pool Creek and erosion potential with respect to development of both the Site and the Athol Street development to the north. The result of this assessment has indicated that the development of both sites:

> is likely to have minimal influence on the hydrodynamic regime of the mangrove community under typical tidal conditions;

> could potentially provide favourable colonising conditions for mangrove expansion due to the replacement of high salinity salt marsh with development fill;

> will increase current speeds during extreme events, resulting in the potential for increased erosion potential; and

> the Site will need to be filled to 6.6 mAHD and protected by a rock bund wall for appropriate stability.

The Mangrove and Erosion Impacts Assessment can be found in Appendix A.

2.5.3 Cooke Point Drive Culvert

An existing culvert is located 50 m north of the northwest corner of the Site. The culvert connects an existing drain on the west of Cooke Point Drive to the Pretty Pool Estuary. The drain conveys runoff from a large catchment west of Cooke Point Drive. The Cooke Point Drive culverts consist of two 0.825 mm circular culverts with one way flood gates on the downstream end (Plate 1). Once surface water passes through the culverts, its natural route is northeast towards Pretty Pool Estuary. Flooding from this culvert should not affect the site but will need to be reassessed once planning has been completed (Cardno, 2011a).

Plate 1 Culverts under Cooke Point Drive

2.5.4 Surface Water Quantity

As part of the desktop review, the Site was split into 14 catchments including one external catchment. Catchments 1, 3, 5, 6, 7, 8, 11, 12 and 13 drain north to Pretty Pool Creek. Catchments 2, 4, 9 and 10 drain south from the ridge point towards Styles Road. Catchment 14 is an external catchment located in the residential area to the south east of the Site. The catchment breakup is presented in Figure 6.

The modelling found that currently stormwater flows from the high ridgeline in the south of the Site north towards Pretty Pool Creek. There is also a small amount of runoff which flows south towards Styles Road. In significant storm events there will be sheet runoff across the Site from south to north into the Pretty Pool Creek. Under the current site conditions no runoff is detained onsite. Although runoff from the residential land (Catchment 14) to the south east does flow onto the Site, it flows through Catchment 12 north into Pretty Pool Creek. Flow paths associated with the Site are presented in Figure 6.

The volume of runoff associated with the 6 minute 5 year ARI storm (15 mm) is presented in Table 1. The 5 year ARI storm has served as the design storm for drainage networks in the ToPH, as outlined in Information Sheet 5 – Stormwater Drainage (ToPH, Date Unknown). The 10 year and 100 year ARI event for critical storm duration which the site generates are also presented in Table 1.

Table 1 Runoff Volumes Associated with each ARI event

Flow Direction	6 minute 5 yr ARI (m³)	10 yr ARI (m³)	100 yr ARI (m³)
North to Pretty Pool Creek	1,200	6,050	11,300
South to Styles Road	250	1,050	1,950

The modelling volumes presented in Table 1 give an indication of the amount of water the Site generates in each storm event. With insufficient measures taken during development, these volumes would increase due to the introduction of more impermeable surfaces. It is anticipated that post development runoff generated during these events will decrease due to the requirement of detaining and infiltrating the first 15 mm of any rainfall event. The anticipated volumes provided in Table 1 do not account for the 5 m/day infiltration rate provided by the geotechnical investigation mentioned in Section 2.4.

2.5.5 Surface Water Quality

No surface water was found to be present within the Site.

2.6 Groundwater

2.6.1 Groundwater Levels

As a component of the Site's geotechnical investigation 16 test pits were dug to evaluate near surface ground conditions (Coffey, 2014). Only eight of the 16 pits encountered groundwater, with an average watertable elevation of 1.6 mAHD and an average depth to water of 1.2 m. Surface elevations of the test pits were between 2.4 mAHD and 3.9 mAHD, with one pit located at 6.2 mAHD. Minimal correlation can be inferred between surface elevation and watertable elevation, suggesting that the Site's groundwater is controlled by conditions other than surface elevation.

Greater detail of test pitting conducted can be found in Appendix B.

2.6.2 Groundwater Quality

A query with the DoW's WIR database found 69 boreholes with appropriate water quality indicators within a 20 km radius of the Site. Results received from this query were limited to total dissolved solids (TDS) and pH. The mean, maximum and minimum of these two criteria are tabulated below in Table 2.

Table 2 Groundwater Quality Data within a 20 km radius of the Site

	TDS (mg/L)	pH
Average	3,510	7.27
Maximum	12,932	8.50
Minimum	115	6.74

2.7 Environmental Assets

2.7.1 Flora

A search undertaken of the DER's Threatened Ecological Communities (TEC) and Threatened Priority and Flora (TPFL) database indicated that there are no TECs or TPFLs located within close proximity to the Site.

Currently, no vegetation surveys have been undertaken for the Site. A preliminary environmental assessment report (RPS, 2011) completed for East Port Hedland has determined that it will be necessary to undertake a Level 2 Terrestrial Flora and Vegetation survey in the future to identify if any significant flora and vegetation communities will be impacted by development of the Site.

2.7.2 Fauna

Any native fauna identified to be under threat of extinction, rare, or in need of special protection is provided protection under the Wildlife Conservation Act 1950. Native fauna protected under the Wildlife Conservation Act 1950 is classified as "threatened". The DER maintains a database to help protect and conserve these species and communities which lists taxa that are threatened with extinction as well as taxa that are rare and threatened.

The results of the DER search indicated that there were no records of Threatened and Priority Fauna within the Site, however, Table 3 shows three threatened species of Fauna and 14 species of protected Fauna may be found within 1 km of the Site.

Table 3 Threatened and Protected Fauna

Fauna Name	Latin Name	Conservation Status
Common Sandpiper	*Actitis hypoleucos*	Protected Under International Agreement
Eastern Great Egret	*Ardea modesta*	Protected Under International Agreement
Ruddy Turnstone	*Arenaria interpres*	Protected Under International Agreement
Sharp-tailed Sandpiper	*Calidris acuminata*	Protected Under International Agreement
Sanderling	*Calidris alba*	Protected Under International Agreement
Red-necked Stint	*Calidris ruficollis*	Protected Under International Agreement
Great Knot	*Calidris tenuirostris*	Threatened

Fauna Name	Latin Name	Conservation Status
Greater Sand Plover	*Charadrius leschenaultii*	Protected Under International Agreement
Lesser Sand Plover	*Charadrius mongolus*	Threatened
Airlie Island Skink	*Ctenotus angusticeps*	Threatened
Bar-tailed Godwit	*Limosa lapponica*	Protected Under International Agreement
Rainbow Bee-eater	*Merops ornatus*	Protected Under International Agreement
Whimbrel	*Numenius phaeopus*	Protected Under International Agreement
Grey Plover	*Pluvialis squatarola*	Protected Under International Agreement
Common Tern	*Sterna hirundo*	Protected Under International Agreement
Grey-tailed Tattler	*Tringa brevipes*	Protected Under International Agreement
Common Greenshank	*Tringa nebularia*	Protected Under International Agreement

The search of the DER database is only an indicative assessment of potential communities. A Level 1 Fauna Survey will need to be undertaken to determine if any fauna of significance, or appropriate habitat, will be affected by development of the Site.

In particular, emphasis with respect to the presence of species of turtles should be placed on any fauna surveys of the Site.

2.7.3 Wetland and Sensitive Environment

A review of the DER Wetland Base and the Landgate WA Atlas indicated that there were no geomorphic wetlands of any classification on or in the immediate vicinity of the Site.

According to the DER Native Vegetation Map Viewer no Environmentally Sensitive Areas (ESA) are recorded in the Site.

2.8 Summary of Existing Environment

The pre-development environment of the Site can be summarised as follows:

> The Site has historically been undeveloped and is used for equine purposes associated with the Pony Club;

> The Site falls south and north from a high ridge line (7.5 to 8.0 mAHD) located approximately 50 m north of Styles Road to 2.5 mAHD in the north and 3.0 mAHD in the south;

> Ground conditions are primarily sandy clay/clay estuarine deposits across the western half of the northern half of site and dune sand on the eastern portion of the site with a limestone ridge spanning the entire southern half of the Site;

> Infiltration is expected to occur at a rate of 5 m/day;

> The estuarine deposits of the western half of the northern portion of the Site are considered to be of High to Moderate Risk of ASS;

> Runoff volumes flowing north towards Pretty Pool Creek that are associated with the six minute 5 year ARI, 10 year ARI and 100 year ARI rainfall events have been modelled as 1,200 m^3, 6,050 m^3, and 11,300 m^3, respectively.

> No surface water was identified in or in the vicinity of the Site;

> Groundwater is present within 3 m of surface;

> Regional groundwater is typically neutral with an average pH of 7.27 and an average TDS of 3,510 mg/L;

> No wetlands or ESA were identified in the vicinity of the Site;

> No TEC or TPFL are likely to be found within the Site; and

- While no records of species of threatened fauna have been recorded within the Site, three species of threatened fauna have been recorded within 1 km of the Site’s boundaries.

3 Proposed Development

3.1 Development Details

The Site is proposed to be developed into a subdivision containing a combination of low and medium density residential areas (R20 and R40, respectively) in line with the Stage 3 of the East Port Hedland Concept Plan.

Two indicative development concept options (option 1 and option 2) were evaluated in the execution of this LWMS. Anticipated lot provisions for each development scenario are provided in Table 4.

Table 4 Breakdown of Anticipated Lots by Indicative Development Concept Option

Option	R20 (ha)	R40 (ha)	Caravan Park (ha)	Public Open Space (ha)	Road Reserve (ha)	Undeveloped (ha)
Option 1	9.99	4.42	4.14	5.20	7.16	0.54
Option 2	10.30	4.10	4.40	5.20	6.94	0.62

Corresponding site plans for each option's indicative development concept are provided in Appendix C.

3.1.1 Access to Site

Site access for both options will be via Styles Road to the south, with the potential for inclusion of access via Cooke Point Drive.

3.1.2 Location of Public Open Space

Both options outline the same areas for POS, with 5.20 ha of POS broken into six areas as follows:

- Four park areas located on the northern development boundary – 3.05 ha;
- One large park area containing the three identified areas of indigenous heritage – 1.27 ha; and
- The Pony Club – 0.90 ha.

3.1.3 Port Hedland Pony Club

The Pony Club currently occupies approximately 6 ha of land in the center of the Site. Under both options 1 and 2, the Pony Club will be reduced in size to occupy only 0.90 ha on a centrally located plot near the centre of the Site.

3.2 Indicative Development Concept Option 1

The proposed development of option 1 involves the positioning of a large caravan park on the eastern edge of the Site, with a mixture of R20 and R40 interspersed with POS across the remainder of the development.

3.2.1 Caravan Park

The caravan park for option 1 is located in the northeastern corner of the development occupying 4.14 ha of area, and is located on dune sand, as identified in Section 2.4.1.

3.3 Indicative Development Concept Option 2

The proposed development of option 2 involves the delineation of the Site as having the caravan park located on the western edge, with a mixture of R20 and R40 interspersed with POS across the remainder of the site.

3.3.1 Caravan Park

The caravan park for option 2 is located adjacent to the western site boundary. The northern half of the caravan park will be located on estuarine deposits underlying fill, while the southern half will be located on limestone.

4 Design Criteria and Objectives

4.1 Total Water Cycle Management

Total water cycle management recognises the finite limit to a region's water resources, and the inter-relationships between the uses of water and its role in the natural environment. The State Water Plan (DoW 2007) endorses the promotion of total water cycle management and application of Water Sensitive Urban Design (WSUD) principles to provide improvement in the management of stormwater and to increase the efficient use of existing water supplies. Total water cycle management addresses not only physical and environmental aspects of water resource use and planning, but also integrates other social and economic concerns. Stormwater management design objectives should therefore seek to deliver better outcomes in terms of:

- non-potable and potable water consumption;
- stormwater quality management; and
- flood mitigation.

The overall objective for preparing a total water cycle management plan for the proposed development is to mitigate flooding, minimise sediment transport and maintain an appropriate water balance. This objective is central to the LWMS.

4.2 Water Conservation

The overall aim of total water cycle management includes the sustainable consumption of potable water and consideration of all water sources. Therefore the use of water within the development will be minimised wherever possible. The design criteria for water conservation are detailed below:

- Minimise household water usage to meet the target of 100 kL/person/year (Government of Western Australia, 2007);
- Minimise water requirements for the establishment of any vegetated areas;
- Minimise water requirements for the maintenance of POS; and
- Minimise water requirements for swale maintenance.

4.3 Stormwater Management

The overall guiding document for the development of stormwater management strategies is the Stormwater Management Manual of Western Australia (DoW, 2007). The Decision Process for Stormwater Management in Western Australia (DoW, 2009) provides guidance on how urban development can achieve compliance with the objectives, principles and delivery approach outlined in the Stormwater Management Manual of Western Australia.

4.3.1 Stormwater Quality

Water treatment systems and WSUD structures must be designed in accordance with the Stormwater Management Manual of Western Australia (DoW, 2007) and Australian Runoff Quality (Engineers Australia, 2006). Better Urban Water Management (WAPC, 2008) advocates a water quality management principle where existing surface and groundwater quality be maintained as a minimum, and preferably improved prior to discharge from the Site. Through consideration of these guidelines, the primary objective for the Site is to avoid further deterioration of water quality within receiving waterbodies.

The key design criteria which will be adopted to maintain stormwater quality are:

- Treat runoff prior to discharge by detaining the first 15 mm of rainfall onsite as close to source as possible.
- Apply appropriate structural and non-structural measures to minimise the transportation of sediments offsite and reduce applied nutrient loads.

4.3.2 Stormwater Quantity

Stormwater retention and detention structures must be designed in accordance with the Stormwater Management Manual of Western Australia (DoW, 2007) and Australian Rainfall and Runoff (AR&R) (Engineers Australia, 1987). Better Urban Water Management (WAPC, 2008) advocates a water quantity management principle where pre-development peak flows are maintained in the post development environment.

Key design criteria that will be adopted to manage stormwater quantity are detailed below:

- Detaining the first 15mm of rainfall onsite as close to source as practicably possible as per Information Sheet 5 – Stormwater Drainage (ToPH, Date Unknown).
- Ensuring the 100 year ARI event can be contained within the road reserve with a minimum 300mm freeboard to adjacent properties finished floor level.
- No water ponding after 96 hrs to stop mosquito breeding.

4.4 Groundwater Management

The overall objectives for groundwater management are to minimise changes to the underlying groundwater level and quality as a result of development. The design criteria for groundwater management that will be adopted for this LWMS are:

- Minimise changes to underlying groundwater levels as a result of development.
- Ensure that groundwater quality leaving the Site is at least the same, or better, than the water entering the Site.

5 Water Conservation Strategy

The total water consumption associated with the development of the Site can be reduced through the implementation of water conservation measures discussed in the following sections. The conservation strategy has been designed to meet the objectives and criteria stated in Section 4.2.

5.1 Development Water Sources

It is anticipated that development on the Site will access potable water supplies associated with the East Pilbara Water Supply Scheme in line with the recent expansion of the capacity of the Yule and De Grey borefields. Access to scheme water will be via existing Water Corporation assets/infrastructure located along Styles Road.

5.2 Development Scale Water Conservation Measures

5.2.1 Landscaping

There are a number of landscaping design and POS management measures that will be implemented to achieve the design criteria stated in Section 4.2:

- Retention of existing vegetation in newly recreated POS areas to reduce demand for irrigation;
- Retention of native vegetation within POS areas (where possible) to reduce demand for water during establishment;
- Minimal turf will be employed for POS to reduce irrigation demands;
- Turf used in POS will be of a species that requires minimal water and fertiliser; and
- Drainage swales and verge will be vegetated with local planting or minimal lawn where appropriate.

5.2.2 Irrigation

There are a number of irrigation management measures that will be implemented to achieve the design criteria stated in Section 4.2:

- Irrigation systems will be designed and installed according to best water efficient practices;
- Irrigation of revegetated areas within the POS can be established on a two year sacrificial irrigation drip system, to be decommissioned following the establishment of planting; and
- Management of irrigation practices to minimise losses to evaporation.

Conservation of potable water will be encouraged through fit-for-purpose use in order to minimise any water waste. Through fit-for-purpose use the irrigation of POS and landscaped areas can be undertaken using groundwater, treated wastewater and/or greywater.

A search of the DoW's Water Register has indicated that there is sufficient groundwater allocation available for the site to use in irrigation, however, sufficient sampling and testing of the groundwater source to be used will be necessary to ensure its suitability for use due to the coastal nature of the Site.

5.2.3 Community Awareness and Education

Landowners shall be provided with reputable reference material at the point of sale from sources such as the Water Corporation's Waterwise Program (2011), and the Your Home initiative (Commonwealth of Australia 2011). This information will cover a number of topics including:

- Grey Water Recycling;
- Sustainable landscaping and water efficient gardening;
- Water conservation in the home; and

> Sediment control and erosion mitigation on Lots.

5.3 Lot Scale Water Conservation Measures

5.3.1 Potable Water Supply

Scheme water for the area will be sourced from the water pipe network via the existing mains on Styles Road. Water Corporation manages both the distribution and reticulation pipe network infrastructure within the ToPH.

It is proposed that POS areas source any required irrigation from fit-for-purpose sources, and, as such, potable water will only be supplied to the development for usage within the lots.

5.3.2 Alternative Water Supply

Potable scheme water supplied by Water Corporation can be conserved by utilising low quality water, such as greywater, for uses that do not require water of a higher quality. While greywater recycling systems will not be mandated within this LWMS, landowners will be made aware of the benefits of these systems at the point of sale.

5.3.3 Water Efficient Appliances

Significant reductions in water uses can be achieved with the use of water efficient appliances. Table 5 gives an example of the water uses of typical appliances versus water efficient appliances (Australian Government 2009 and Melbourne Water 2003). These water use rates have been used in the water balance investigation.

Table 5 Water Efficient Appliances

Appliance	Water Consumption (kL/year)	
	Standard Device	Water Efficient Device
Toilet	12 L/flush	4 L/flush
Washing Machine	130 L/wash	40 L/wash
Shower Head	15 - 25L/minute	6 - 7L/minute
Taps	15 - 18L/minute	5 - 6L/minute

The water conservation strategy proposes all lots use water efficient appliances. Water efficient shower heads and tap fittings are already mandated as part of the Building Code of Australia (ABCB 2011), however, although not mandated, the uptake of other devices will be encouraged through education from the developers at point of sale.

5.3.4 Water Balance

A potable water balance based on general assumptions (Appendix D) was conducted to determine the effectiveness of the water conservation strategy for both conceptual development scenarios outlined in Section 3.1.

Due to the conceptual nature of the proposed development at this stage, the water balance has been based on the rates and calculation methodology presented in the Water Corporation Spreadsheet for H_2Options, provided in Appendix D. The exception to this methodology was that the household types were changed from “Traditional” and “Terrace” to R20 and R40, with

The resulting water consumptions for each development option are provided below in

Table 6.

Table 6 Water Consumption Requirements by Conceptual Development Option

Option	Drinking Water (ML/year)	Non-drinking Water (Ml/year)	Development Total (ML/year)	Per Person (m^3/year)
Conceptual Development Option 1	45.6	48.7	94.2	100
Conceptual Development Option 2	45.9	55.7	101.6	109

5.4 Wastewater Management

The wastewater management strategy for the Site is to pipe wastewater from lots to the existing ToPH sewerage system which is treated at the South Hedland Wastewater Treatment Plant.

Further investigation and design of the wastewater system for the Site should be explored during the UWMP phase.

6 Stormwater Management Strategy

6.1 Proposed Stormwater Management Plan

Surface water runoff will be managed both on a development scale and a lot scale. The principles behind the stormwater management strategy are:

- to detain the first 15 mm of rainfall on lots at the lots in soakwells or rainwater tanks, as best suits the ground conditions of the eventual design;
- to detain the first 15 mm of rainfall from the road reserve in a swale located on the northern boundary of the Site; and
- to convey all additional rainfall northward to Pretty Pool Creek via the road reserves and swale.

Other strategies to minimise sediment transport are discussed in the following sections. The drainage system has been designed to achieve the objectives and criteria stated in Section 4.3 and has been applied against the two indicative development concept options described in Sections 3.2 and 3.3.

6.1.1 Aboriginal Heritage Sites

Three sites of recognised aboriginal heritage are located within the indicative development boundary. The proposed stormwater management strategy will facilitate the drainage of excess stormwater away from these areas in order to protect them from any damage from inundation and erosion. At present, the stormwater management plan does not utilise any drainage structures on, or in the immediate vicinity of, the aboriginal heritage sites.

It should be noted that detailed design of the development stormwater drainage system will be undertaken at the UWMP stage. At this time, the proposed strategy may change, however, the need to protect these sites should be maintained.

6.2 Stormwater Management Strategy

The stormwater strategy for the Site is to detain the first 15mm of rainfall onsite within lots through soakwells.

All other flows will be conveyed across the catchments using the roadways to a swale situated along the northern site boundary. The swale will discharge any rainfall events greater than 15mm north into Pretty Pool Creek. Discharge from the swale will occur via overtopping along the entire length of the swale as a means to reducing scour. Design of this swale was undertaken on a catchment scale in order to ensure that individual regions of the swale adequately detained catchment specific peaks. It is noted that the swale may need to have a low flow discharge outlet depending on ground conditions, which will be based on the final masterplan design.

6.3 Post Development Stormwater Modelling

Modelling of the post development environment for both development options outlined in Section 3.1 has been undertaken using XPSWMM in order to demonstrate the performance of the proposed drainage strategy. These models were built to characterise the hydrological behaviour of the post development environment for each option. Each option involved the division of the Site into 11 catchments as demonstrated in Figure 7 and Figure 8. Modelling parameters and assumptions are provided in Appendix E.

6.3.1 Post Development Catchments

The post development was modelled as 11 subcatchments for both indicative development concepts (see Appendix C).

For both scenarios modelled, an additional catchment external to the development boundary has been included. This catchment (Catchment K) is located to the southeast of the indicative development boundary and contains the area of the existing developed lots east of the Site that will drain northward through the Site's eastern extent via the swale.

Catchment D in both scenarios contains approximately 5.20 ha of POS which contains three sites of aboriginal heritage. Catchment H in both scenarios contains approximately 0.89 ha of POS which it is understood may be allocated to the Pony Club.

For option 1, Catchment I contains 4.2 ha of area delineated as the preferred location for the proposed caravan park. For option 2, Catchment A includes a slightly larger caravan park area at 4.3 ha.

The remainder of the catchments, and the remaining areas of both catchments H and D, are developed lots with mixtures of both low density (R20) and medium density (R40) residential lots. Regardless of development scenario, drainage from each catchment will be northward to Pretty Pool Creek.

6.3.2 15mm Rainfall Event

6.3.2.1 Lots

Runoff generated from the first 15mm of a rainfall event on lots has been modelled to be detained onsite through soakwells or rainwater tanks, whichever is most applicable to the final design. The modelled volume of each soakwell has been standardised for both conceptual development options. Soakwells for development option 1 have been standardised to approximately 1.13 m^3 per 100 m^2 of impermeable lot area and soakwells for development option 2 have been standardised to approximately 1.27 m^3 per 100 m^2 of impermeable lot area.

Soakwells have been designed based on the assumption of drainage from all sides of the soakwell and an infiltration rate of 5.0 m/day[1], based on the recommendations of the geotechnical investigation (Coffey, 2014). It is acknowledged that it may not be possible to use soakwells at all locations across the site. As such, should infiltration not be possible, rainwater tanks, or a similar device, could be implemented. The volumes required within this type of system would be subject to change.

Design parameters for the soakwells of options 1 and 2 are outlined in Table 7 and Table 8, respectively. These comply with the strategy outlined in Section 4.3.

Table 7 15mm Required Soakwell Detention for Option 1

Catchments	Soakwell Volume (m^3)	Volume of Rainfall (m^3)	Number of Lots	Infiltration rate (m/day)
A	2.5	118	40	5.0
B	2.5	164	68	5.0
D	2.5	177	66	5.0
E	2.5	226	69	5.0
G	2.5	48	26	5.0
H	2.5	345	122	5.0

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[1] This is based on permeability testing undertaken by Coffey 2014 on site at two locations. It is noted that fill imported to the site or existing ground conditions across the site may have a different permeability and as such it is recommended that soakwell calculations are revisited when the *in-situ* permeability of each location has been determined.

Table 8 15mm Required Soakwell Detention for Option 2

Catchments	Soakwell Volume (m^3)	Volume of Rainfall (m^3)	Number of Lots	Infiltration rate (m/day)
B	3.0	68	18	5.0
D	3.0	220	90	5.0
E	3.0	227	69	5.0
G	3.0	48	26	5.0
H	3.0	313	113	5.0
I	3.0	188	63	5.0

For lots with insufficient drainage to facilitate the installation of soakwells, rainwater tanks will be employed to retain the first 15 mm of rainfall on the lot. For both options 1 and 2, rainwater tank sizing will be dependent on lot size. R20 lots will require rainwater tanks with an average volume of approximately 3.75 m^3, and R40 lots will require rainwater tanks with an average volume of approximately 1.80 m^3. These sizes comply with the strategy outlined in Section 4.3

6.3.2.2 Roads and Caravan Park

Flows from the roads and the proposed caravan park will be conveyed to the swale for treatment. The proposed swale will have a side slope of less than 1:3 (as per Chapter 9 DoW, 2007) and on average will be 0.3 m deep. Preliminary modelling has shown the swale to be sufficient to contain the first 15 mm of rainfall, with a maximum drainage time for both options 1 and 2 of approximately 3 hours, based on an infiltration rate of 5.0 m/day. This assumes a permeability of approximately 5 m/day. At the detailed design stage it is strongly recommended that *in-situ* permeability testing is undertaken to confirm the permeability rate prior to design of the final retention feature.

6.3.3 Rainfall Events Greater than 15 mm

Stormwater runoff from lots will be directed towards the road network which drains towards the swale system. When capacity of the swale is reached (i.e. after the first 15 mm of rainfall), it is anticipated that the presence of the pathway will serve as a spillway crest for the swale allowing for drainage to occur across the majority of the swale's crest towards Pretty Pool Creek.

At the UWMP stage more extensive modelling should be undertaken to evaluate the operation of the swale system proposed.

6.4 Stormwater Quality Management

Management of erosion and sediment transport within the Site must occur at all levels of planning from pre-construction until handover to the ToPH. Strategies that could be adopted to minimise erosion and control sediment transport prior to and during construction include:

- Retention of vegetation along the road verge;
- Incremental clearing of the development in stages to minimise erosion opportunities;
- Ground disturbance activities avoided during the wet season;
- Temporary offline sedimentation basins utilised, if required, to collect fine sediments in the event that drainage from the stage being developed cannot follow the drainage strategy described in Section 4.3.2;
- Revegetation to occur as soon as possible; and
- An Erosion and Sediment Control Program documented for the development.

Long term stormwater quality management within the Site will occur within the swale areas. This can be achieved through the swale design including erosion and sediment control features such as vegetation and rock armour.

7 Groundwater Management Strategy

7.1 Groundwater Level Management

The objectives for groundwater management are to maintain the groundwater level and quality in the post development environment.

Indicative groundwater levels for the site have indicated that groundwater is located, on average, at approximately 1.6 mAHD (Coffey, 2014). An average of 3.0 m of fill is required onsite to raise the development out of the floodplain to 6.4 m as required by the Coastal Vulnerability Study (Cardno, 2011). This fill, combined with a maximum indicative groundwater elevation of 2.7 mAHD, indicates that there is likely to be a minimum of approximately 3.7 m between the new ground surface and the groundwater level. It is recommended that a groundwater investigation and subsequent monitoring plan be undertaken for the site to determine typical groundwater ranges and how the development may be impacted prior to detailed design.

7.2 Groundwater Quality Management.

As stated in Section 4.4 the overall aim for groundwater is to ensure that the quality leaving the Site is at least the same, or better, than the water entering the Site. This will be achieved by the use of swales throughout the Site to treat the first 15mm of rainfall runoff from the roads and on lot detention. The use of swales will ensure groundwater is protected from pollutant transport such as hydrocarbons. Any pollutants or contaminants the new development may produce are not likely to infiltrate to the groundwater. It is recommended that concurrently with the groundwater level monitoring that site specific groundwater quality monitoring is also undertaken.

8 Management and Maintenance

The design and construction of the stormwater system has been undertaken in a manner that promotes the long-term health of the WSUD. Additionally, these areas often require active ongoing management, particularly in the first years after construction to ensure that the features continue to provide the designed functions.

An effective Management and Maintenance Plan (MMP) will also incorporate an effective monitoring regime to provide guidance to the required level of intensity of management actions. A MMP can provide guidance of the actions required to ensure that the overall objective is met. The overall objective of the MMP is to:

> *Maintain amenity and stormwater functions of the vegetated basins and swales whilst minimising potential environmental impacts and disturbance to surrounding residents in the longer term, and to ensure that the system is in an appropriate and sustainable condition at the point of management handover.*

The overall objective will be achieved through the implementation of a number of management actions that will be carried out at regular intervals for a period of two years from practical completion of the swale. The key areas that will be addressed through the implementation of this management plan are:

- nutrients and water quality;
- gross pollutants and sediments; and
- vegetation.

8.1 Nutrients and Water Quality

8.1.1 Structural Measures

Structural measures proposed within this LWMS maximise the removal of nutrients from stormwater flows. The designed stormwater system provides detention and treatment of the first flush rainfall through the use of vegetated swales. The combination of these components provides primary and secondary treatment to the stormwater discharging from the Site.

The actions to be implemented are detailed in Table 9.

8.2 Gross Pollutants and Sediments

8.2.1 Structural Measures

Gross Pollutants (GP) can potentially introduce health risks and reduce the overall visual amenity of an area. Sediments can carry nutrients to downstream waterbodies and clog up stormwater structural measures, in particular during the construction stage, preventing the system from working efficiently. Straw bale barriers can be used on the downslope side of lots and road reserves to prevent sediment being transported onto the road reserves and flushed towards the stormwater drainage system and the mangroves of Pretty Pool Creek. Vegetation in the swales can be used to trap GPs and sediment which can be removed manually as part of the management plan.

8.2.2 Non-Structural Measures

While the swales and basins will trap the collected GPs, ongoing management and maintenance of GPs will include:

- Periodic visual inspection of the swales.
- Removal of GPs to an offsite disposal facility in response to observations.
- Provide street sweeping to remove sediment-bound nutrients prior to runoff into swales.

The actions to be implemented are detailed in Table 9.

8.3 Vegetation

8.3.1 Weeds

Heavy growth of aquatic and terrestrial weeds can impair the aesthetic value and hydrological functioning of the swales. The primary means of monitoring and detecting weed growth will be regular visual inspections by maintenance contractors. Management of weeds will therefore include:

- Visual monitoring of the swale for presence of weeds. The information gained will then be used to direct the need for any remedial actions such as:
  - Manual removal of weeds as deemed necessary.
  - Application of approved herbicides (Round-up, Fusilade or similar) to terrestrial weeds.

The actions to be implemented are detailed in Table 9.

8.3.2 Infill Planting

Experience with managing other developments has shown that some plants are subject to theft and vandalism. Additionally, there is the potential for plants to perish prior to establishing deeper root systems. To manage this potential issue, infill planting will be conducted to maintain the required plant densities as per future landscape plans. Management of infill planting will include:

- Visual inspections of the swales for infill planting requirements. The information gained during inspections will be used to guide the need for infill planting.
- Conduct infill planting.

The actions to be implemented are detailed in Table 9.

Table 9 Maintenance Schedule and Responsibility for Management Actions

Action	Timing	Location	Responsibility
Harvest of nutrient removing vegetation	As required	Swales	Maintenance Contractor
Install straw bale barriers	During construction of the stormwater drainage network	Downward slope of all lots and road reserve	Civil contractor
Construct swales	During construction of the stormwater drainage network Minimum three-monthly	Swales	Civil contractor Landscape contractor
Inspect for GPs and sediments		Swales	Maintenance contractor
Remove GPs and sediments	In response to observations	Swales Offsite disposal facility	Maintenance Contractor/ ToPH
Dispose of waste to an approved facility	Following removal of GPs		
Provide street sweeping	Monthly – Especially during the building phase	For entire development site	
Visually monitor for terrestrial weeds	Three-monthly basis	Swales	
Manually remove weeds	In response to visual inspections	Swales	Maintenance Contractor/ Proponent
Apply herbicide to weeds at manufacturer's recommended rates	In response to visual inspections Three-monthly basis		
Visually monitor for infill planting requirements			
Conduct infill planting	In response to visual inspections		
Provide information to residents	At point of sale		

9 Monitoring

9.1 Groundwater Monitoring

Pre-development monitoring of groundwater levels and quality across the Site will need to be undertaken over two wet seasons in order to establish baseline conditions and trigger levels.

As a requirement of Better Urban Water Management (WAPC, 2008), and due to the proximity of the Site to the potentially sensitive habitat of the mangroves located in Pretty Pool Creek, post development monitoring of groundwater level and quality should be undertaken. The specifics of the post development groundwater monitoring regime should be proposed during the UWMP stage once pre-development monitoring has been completed and groundwater levels are better understood.

9.2 Maintenance of Fill and Swale System

The tidal nature of Pretty Pool Creek will require monitoring of fill materials used on site to ensure no significant erosion is being undertaken due to tidal influence and that erosion prevention measures are functioning as intended.

Post development maintenance of the drainage swales surrounding the Site will be required to ensure the erosion and scouring measures are functioning as intended. The proponent will be responsible for maintenance and erosion control of the surrounding drainage network for a period of two years following completion of the development.

A visual assessment will be undertaken on a bi-annual basis to monitor the condition of swales to ascertain that the maintenance activities specified within Section 8 achieve the objectives of the MMP. If the results from the annual monitoring report indicate that action is required to address an issue, a number of contingency measures can be employed (see Table 10).

Table 10 Visual Assessment and Contingency Actions Plan

Aspect to Monitor	Trigger for Action	Contingency Action
Debris in drainage system	Visual assessment finds the condition of an aspect poor as compared to the initial visual assessment undertaken at completion of construction.	Remove debris
GP litter		Remove litter
Storm damage		Repair drainage system to original condition
Silt		Remove silt build up and restore to original condition
Weed infestation		Removal of weeds
Condition of paving		Restore paving to original condition.
Indicators of theft/vandalism		Restore to original condition by taking appropriate action on a case-by-case basis.
Litter		Remove litter.

10 Requirement for an Urban Water Management Plan

The requirement to undertake preparation of more detailed water management plans is generally imposed as a condition of subdivision. The development of the UWMP should follow the guidance provided in the Urban Water Management Plans: Guidelines for Preparing Plans and for Complying with Subdivision Conditions (DoW 2008).

While strategies have been provided within this LWMS that address planning for water management within the Site, it is a logical progression that future subdivision designs and the supportive UWMP will clarify details not provided within the LWMS. The main areas that will require further are detailed in the following sections and include:

- Modelling of the local drainage network.
- *In-situ* permeability testing.
- Configuration of treatment and detention swales.
- Implementation of water conservation strategies.
- Non-structural water quality improvement measures.
- Management and maintenance requirements.
- Construction period management strategies.
- Monitoring and evaluation program.

In addition, all infiltration systems should be shown to empty within the designated times as detailed in Water Sensitive Urban Design: Basic Procedures for ‘Source Control’ of Stormwater (University of South Australia, 2008).

10.1 Modelling of Local Drainage Network

It is acknowledged that the drainage strategies documented in this LWMS are based on broad assumptions and data. These assumptions are considered adequate for development of the proposed swale sizes and of an appropriate level of detail. However, verification of proposed subdivision drainage designs should be undertaken by modelling the detailed drainage design. These detailed drainage designs should include road designs that show longitudinal grades to ensure sufficient capacity to contain stormwater without causing a flood risk to the development. In addition, the drain time of all WSUD features proposed should meet the 96 hr design requirement. Such modelling will allow verification that development undertaken is consistent with the design criteria given in Section 4**.**

10.2 *In-situ* Permeability Testing

Prior to any detailed design, Cardno strongly recommends that *in-situ* permeability testing is undertaken across the site and particular within the areas proposed for retention storage. This will provide site specific, location specific results for final design modelling to ensure sufficient capacity for storage has been provided.

10.3 Configuration of Treatment and Detention Swales

While the drainage catchments have been defined based on the current plans and available information, it is possible that these could undergo some change to accommodate stakeholder feedback prior to final subdivision design.

The exact location and shape of drainage features will be specified and presented within the future UWMPs. In order to review the final configurations, the hydraulic model that has been developed to support this LWMS may need to be refined. It is expected that the vegetated swales will be designed to a level that provides detailed cross-sections, sizes of detention and storage areas, detained volumes, culvert sizes, longitudinal grade, inverts etc. Onsite permeability testing will be carried out to aid stormwater modelling. The ultimate aim of revising the model will be to confirm that the final detailed drainage design meets the design criteria and drainage strategy presented in this LWMS.

10.4 Water Conservation Strategies

A number of potential measures to conserve water have been presented in this LWMS. Landscape design measures that will be incorporated into the water conservation strategy should be further detailed within future UWMPs. The manner in which the developer intends to promote water conservation measures discussed in this LWMS to future lot owners should also be discussed within future UWMPs.

10.5 Non-structural Measures

Guidance for the development and implementation of non-structural water quality improvement measures is provided within the Stormwater Management Manual for Western Australia (DoW 2007). Some measures will be more appropriately implemented at a local government level, such as street sweeping, however many can be implemented relatively easily within the design and maintenance of subdivisions and the swales. These measures are expected to be detailed within future UWMPs.

10.6 Management and Maintenance

The management measures to be implemented address surface water quality, such as the use of vegetation in swales, will require ongoing maintenance. It is therefore expected that the future UWMPs will provide detailed MMPs that will set out maintenance actions (e.g. weeding), timing (i.e. how often it will occur), locations (i.e. exactly where it will occur) and responsibilities (i.e. who will be responsible for carrying out the actions) based on the proposed landscape plans. Given that approval from the ToPH and DoW will be sought for the proposed measures, it is anticipated that consultation with these agencies will be undertaken and referral to guiding policies and documents will be made.

10.7 Construction Period Management Strategy

It is anticipated that the construction stage will require some management of various aspects (e.g. sediment, dust, surface runoff, noise, traffic etc). In particular, sediment transport and dust generation must be minimised during construction works.

Measures to control dust generation during construction may include:

- Not undertaking earthworks during dry, windy conditions.
- Water down cleared areas will occur as necessary during dry dusty periods.
- Covering materials during construction to reduce dust emissions.

Measures to prevent erosion and minimise sediment transport during construction must be documented within an Erosion and Sediment Control Program and can include a number of measures as stated in Section 8**.**

10.8 Monitoring

It will be necessary to confirm the management measures that are implemented are able to fulfil the intended management purpose, and are in a satisfactory condition at handover to the ToPH. A monitoring program should be developed to provide this information, and it should include details of objectives of the monitoring program, relevant issues and information, proposed methodology, monitoring frequency and reporting obligations. The monitoring identified in Section 9 will be further detailed at the UWMP stage.

A summary of the objectives a UWMP would need to comply with is detailed below in Table 11.

Table 11 UWMP Objectives

Objective	Requirement
Modelling of Local Drainage Network	Confirmation that 15 mm event is contained within the swale system
	Confirmation that 100 yr ARI event is contained within the road reserve
	No water ponding after 96 hrs
Configuration of Detention Areas	Detailed design of drainage features including: cross-sections, sizes of detention swales, detained volumes, culvert sizes, longitudinal grades, inverts etc.
Water Conservation Strategies	Landscape design measures to enable water conservation and method of promoting water conservation to future lot owners
	Detailed design of landscaping for vegetation water requirements and to enable better scoping of water sourcing
Non-structural Measures	Update of volumes required for irrigation from any potential changes to the Draft Structure Plan
Management and Maintenance	Management and Maintenance Plans to include: maintenance actions, timing, locations and responsibilities
Construction Period Management Strategy	Erosion and Sediment Control Program to include measures to prevent erosion and minimise sediment transport during construction.
Monitoring	Monitoring Program to provide details of the relevant issues and information, proposed methodology, monitoring frequency and reporting obligations

11 Implementation

11.1 Roles and Responsibility

This LWMS provides a framework that the ToPH can utilise to assist in implementing stormwater management methods that have been based on site specific investigations, are consistent with relevant State policies and have been endorsed by the ToPH. The responsibility for working within the framework established within the LWMS rests with the proponent and contractors, although it is anticipated future management actions beyond the proposed management timeframes will be the responsibility of the ToPH.

11.2 Assessment and Review

Reporting to the ToPH will occur annually, detailing the monitoring performed to date. This encompasses the visual/qualitative assessment of the overall condition of the development. At the end of the two year monitoring and reporting period, the overall condition of the swale will be assessed and the condition reported to the ToPH within the final monitoring report.

The overall criteria for successful completion and establishment of the area will be to fulfil the intended purpose of providing a stormwater attenuation function and increasing the overall visual amenity of the Site in general. If the swale fulfils the stated objectives, the Site will be considered to be complete and in a suitable condition for management handover to the ToPH.

If, at the end of the two year monitoring and reporting period, the drainage features are not considered to fulfil the management objectives, the proponent will work with the ToPH to select appropriate contingency actions that will aim to achieve a mutually satisfactory outcome.

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13 Abbreviations

A	
AHD	Australian Height Datum
ARI	Average Recurrence Interval
ASS	Acid Sulfate Soil
ATU	Anaerobic Treatment Unit
B	
BMP	Best Management Practices
D	
DEC	Department of Environment and Conservation
DoW	Department of Water
F	
FSA	Flood Storage Basin
G	
GP	Gross Pollutants
H	
Ha	Hectares
L	
LWMS	Local Water Management Strategy
LSP	Local Structure Plan
M	
mAHD	metre Australian Height Datum
MGL	Maximum Groundwater Level
MMP	Management and Maintenance Plan
P	
PASS	Potential Acid Sulfate Soils
POS	Public Open Space
T	
TEC	Threatened Ecological Communities
TPFL	Threatened Priority and Flora
ToPH	Town of Port Hedland
TPS	Town Planning Scheme
U	
UWMP	Urban Water Management Plan
W	
WA	Western Australia
WAPC	Western Australia Planning Commission

Stage 3 (The Stables)
East Port Hedland

FIGURES

Shaping the Future

LANDCORP

Site Location

FIGURE 1

1:50,000 Scale at A4

Cardno

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Date: 29-01-2015
Coordinate System: GDA 1994 MGA Zone 50
Project: V14018
Map: V14018 FIG01 (Site Location 28.11.14).mxd 01

LANDCORP

Indigenous Heritage Sites

FIGURE 2

Legend

━ Site Boundary

🟨 Indigenous Heritage Sites

1:10,000 Scale at A4

Metres

0 25 50 100 150 200 250 300 350

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Date: 29-01-2015
Coordinate System: GDA 1994 MGA Zone 50
Project: V14018
Map: V14018 FIG02 (Indigenous Heritage 5.12.14).mxd 01

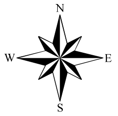
Topography

FIGURE 3

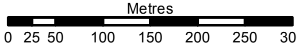
Legend

🟥 Site Boundary

— Topographic Contours



1:8,000 Scale at A4



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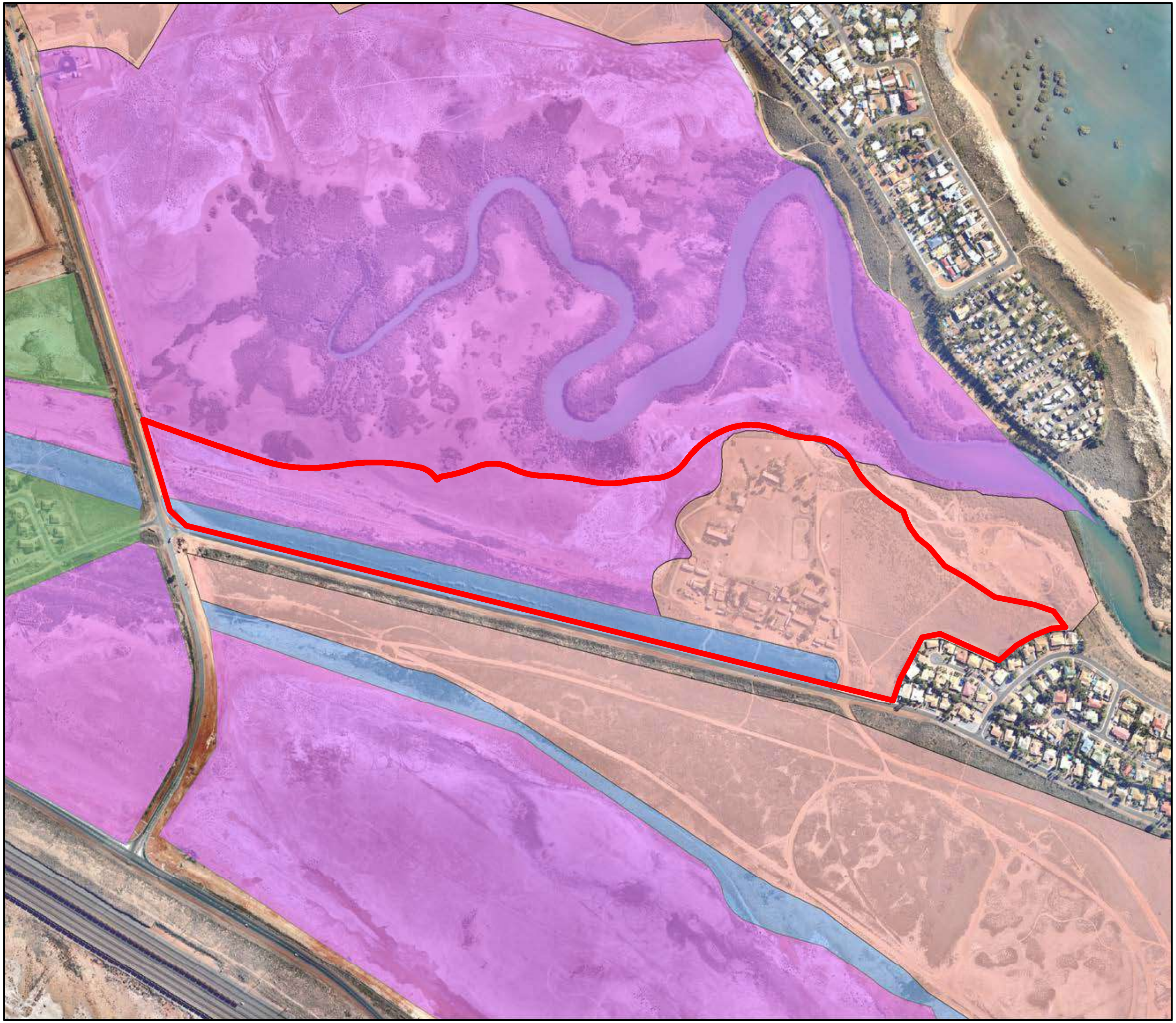

LANDCORP

Surface Geology

FIGURE 4

Legend

━ Site Boundary
🟦 Limestone (Calcrete/Calcarenite)
▨ Sand
🟪 Silty Clay
🟩 Silty Clayey Sand

Map Reference:
GHD, 2011
Coffey, 2014

1:8,000 Scale at A4

Metres
0 25 50 100 150 200 250 300

Cardno

Map Produced by CARDNO
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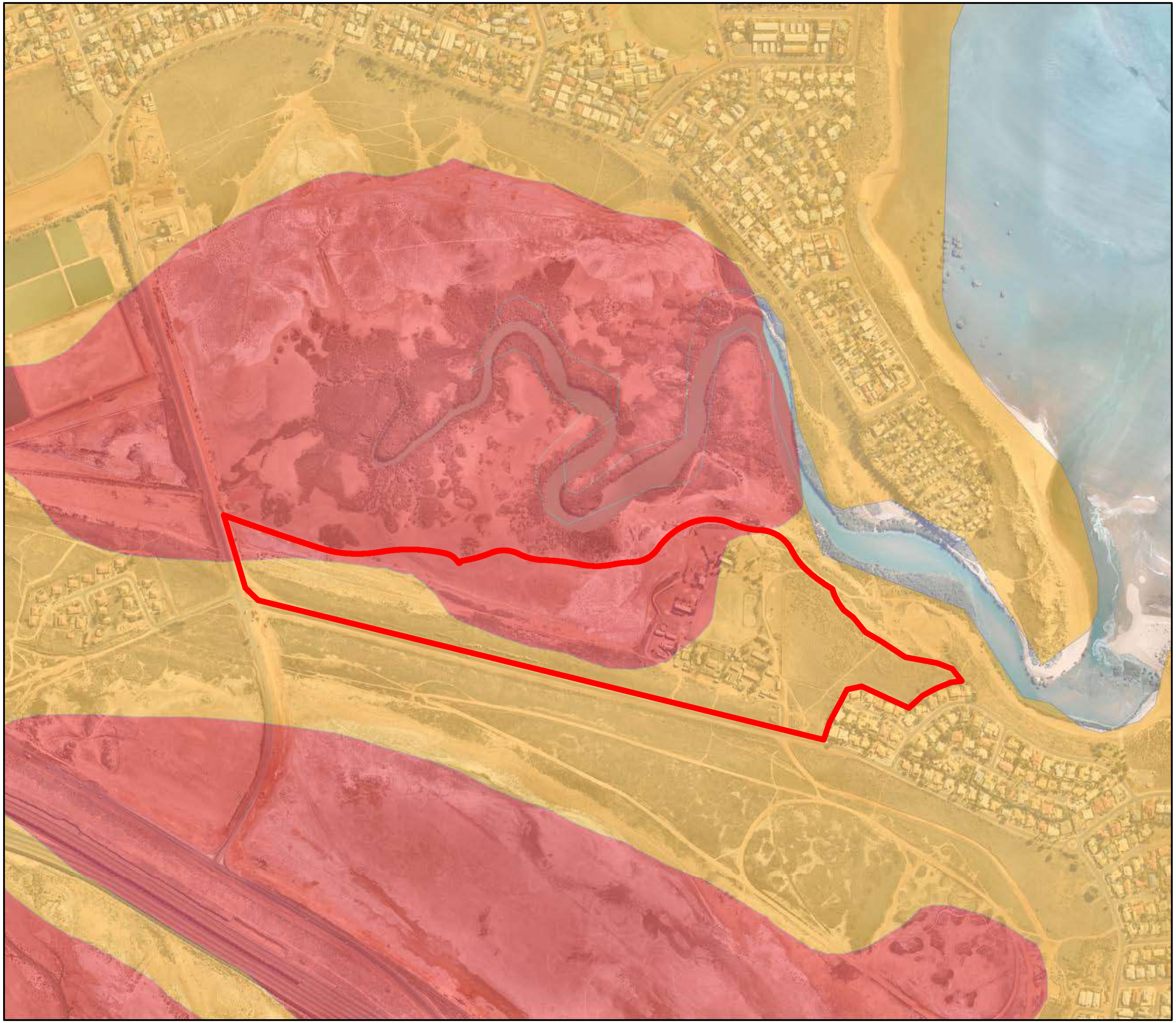
Coordinate System: GDA 1994 MGA Zone 50
Project: V14018
Map: V14018 FIG04 (Surface Geology 5.12.14).mxd 01



LANDCORP

Acid Sulfate Soils

FIGURE 5

Legend

━ Site Boundary

🟥 High to moderate ASS disturbance

🟧 Moderate to low ASS disturbance

🟨 No known ASS disturbance

N
W E
S

1:10,000 Scale at A4

Metres

0 25 50 100 150 200 250 300 350

Cardno

Map Produced by CARDNO
Date: 29-01-2015
Coordinate System: GDA 1994 MGA Zone 50
Project: V14018
Map: V14018 FIG05 (Acid Sulfate Soils Mapping 5.12.14).mxd 01

LANDCORP

Pre-Development Catchments and Flow Paths

FIGURE 6

Legend

- 🟥 Site Boundary
- → Flow Paths
- ▭ Pre Development Catchments

N
W E
S

1:5,000 Scale at A3

Metres

0 50 100 150 200 250 300

Cardno

Map Produced by CARDNO
Date: 29-01-2015
Coordinate System: GDA 1994 MGA Zone 50
Project:V14018
Map: V14018 FIG06 (Pre Dev Catchments Flow Paths 5.12.14).mxd 01

LANDCORP

Post Development Catchments and Flow Paths of Conceptual Development Option 1

FIGURE 7

Legend

- 🟥 Site Boundary
- → Flow Paths
- 🟨 Indigenous Heritage Sites
- ▨ Trees
- 🟦 Dual Use Paths
- 🟩 Swale
- 🟨 Post Development Catchments
- 🟩 Verges
- 🟥 Medium Density Residential (R40)
- 🟧 Low Density Resdidential (R20)
- 🟩 Public Open Space (POS)
- 🟥 Proposed Roads
- 🟦 Caravan Park

N
W E
S

1:5,000 Scale at A3

Metres
0 50 100 150 200 250 300

Cardno

Map Produced by CARDNO
Date: 23-02-2015
Coordinate System: GDA 1994 MGA Zone 50
Project: V14018
Map: V14018 FIG07 (Post Dev Catchments of Site Concept 01 23.2.15).mxd 01

LANDCORP

Post Development Catchments and Flow Paths of Conceptual Development Option 2

FIGURE 8

Legend

- ━ Site Boundary
- → Flow Paths
- ━ Dual Paths
- ▨ Trees
- ☐ Swale
- ☐ Post Development Catchments
- ■ Indigenous Heritage Sites
- ■ Verges
- ■ Proposed Roads
- ■ Medium Density Residential (R40)
- ■ Low Density Residential (R20)
- ■ Public Open Space (POS)
- ■ Caravan Park

N
W E
S

1:5,000 Scale at A3

Metres
0 50 100 150 200 250 300

Cardno

Map Produced by CARDNO
Date: 24-02-2015
Coordinate System: GDA 1994 MGA Zone 50
Project:V14018
Map: V14018 FIG08 (Post Dev Catchments of Site Concept 02 5.12.14).mxd 01

LANDCORP

Conceptual Development Option 1 First 15mm Rainfall Storage

FIGURE 9

Legend

🟥	Site Boundary
🟦	Dual Paths
🟩	Swale
🟪	First 15mm Rainfall
🟩	Trees
🟩	Verges
🟥	Proposed Roads
🟥	Medium Density Residential (R40)
🟨	Low Density Resdidential (R20)
🟨	Indigenous Heritage Sites
🟩	Public Open Space (POS)
🟦	Caravan Park

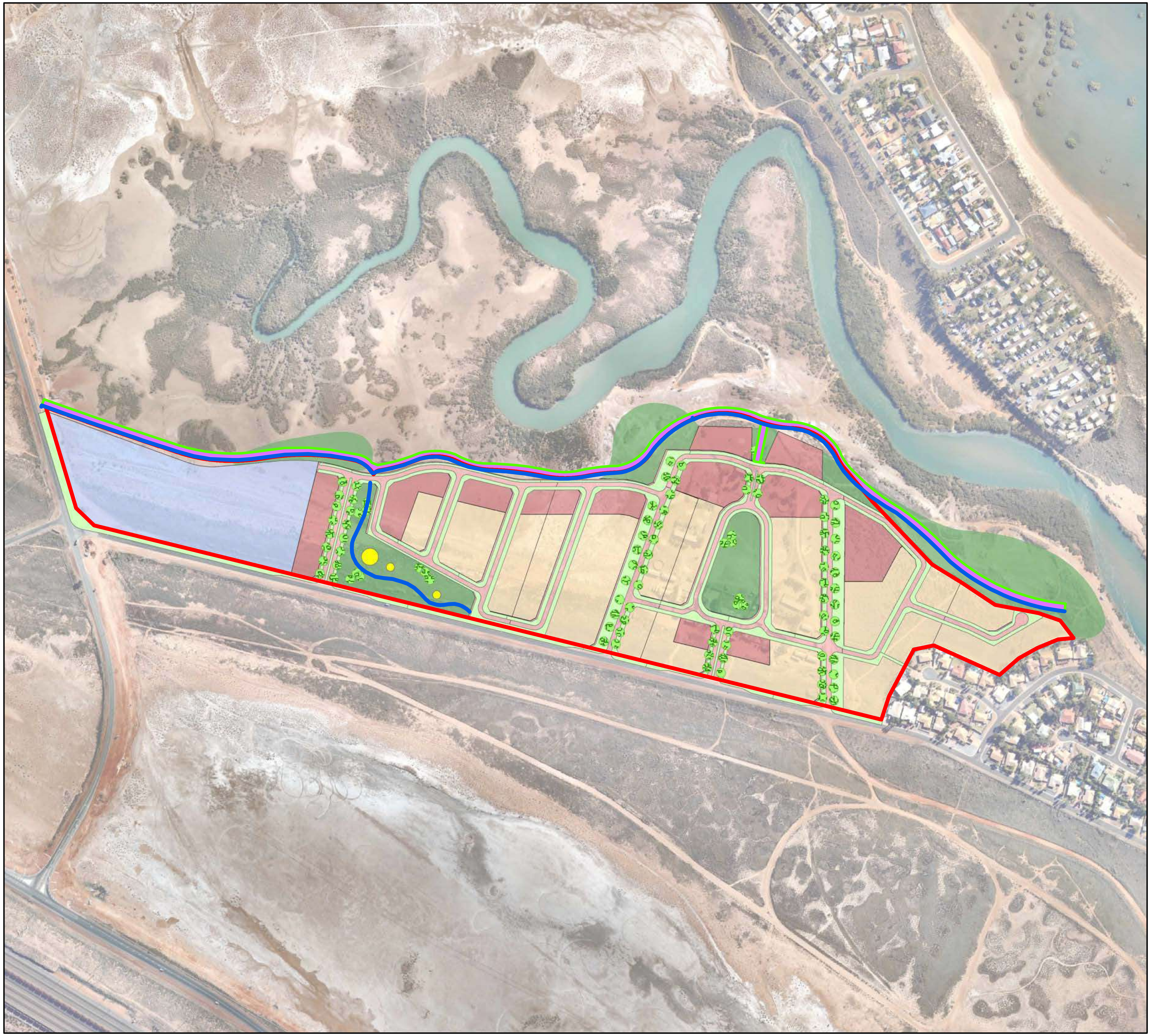
N
W E
S

1:5,000 Scale at A3

Metres
0 50 100 150 200 250 300

Cardno

Map Produced by CARDNO
Date: 23-02-2015
Coordinate System: GDA 1994 MGA Zone 50
Project: V14018
Map: V14018 FIG09 (Concept 01 15mm Rainfall Storage 5.12.14).mxd 01



LANDCORP

Conceptual Development Option 2 First 15mm Rainfall Storage

FIGURE 10

Legend

- Dual Paths
- Site Boundary
- Swale
- First 15mm of Rainfall
- Trees
- Verges
- Proposed Roads
- High Density Residential (R40)
- Low Density Residential (R20)
- Indigenous Heritage Sites
- Public Open Space (POS)
- Caravan Park

1:5,000 Scale at A3

Metres
0 50 100 150 200 250 300

Cardno

Map Produced by CARDNO
Date: 24-02-2015
Coordinate System: GDA 1994 MGA Zone 50
Project:V14018
Map: V14018 FIG10 (Concept 02 15mm Rainfall Storage 5.12.14).mxd 01

Stage 3 (The Stables)
East Port Hedland

APPENDIX A
MANGROVE AND EROSION IMPACTS ASSESSMENT

Stage 3 (The Stables) East Port Hedland

Mangrove & Potential Erosion Impacts Assessments

V14018

Prepared for
LandCorp

5 February 2015

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RevA	28/11/2014	DRAFT for client	Paul Branson Joanna Garcia-Webb	Justine Jones
RevB	5/2/2015	Footprint assessment	Joanna Garcia-Webb Jo Buckee	Paul Branson Justine Jones

Table of Contents

Tables

Figures

1 Introduction

Port Hedland has been identified in the Pilbara Cities Program as an area that should be supported to diversify and grow economically to support a population of 50,000 permanent residents. LandCorp has received funding from the Northern Planning Program to undertake concept planning, and initiate a Scheme Amendment to allow development of Stage 3 (The Stables) East Port Hedland (the site). This is located on the southern side of Pretty Pool Creek, as outlined by the red outline in Figure 1-1.

Figure 1-1 Development locality plan. The Stables (Stage 3) outlined in red (Image source – Nearmap & Google Earth)

Cardno was commissioned by LandCorp to assist them in undertaking background investigations to ensure the site is developable. This will allow a secondary developer to fast track the development process should an opportunity arise.

Cardno's involvement in these background investigations include analysis of:

> Constraints to the developable area due to storm surge

> Potential impacts on the mangroves due to the proposed development

> Potential for erosion of the spit forming the north-western side of the creek mouth

Any impacts to the mangrove system resulting from modification to the Pretty Pool Creek system require investigation as part of State Planning Policy N^{o}. 2.6 - State Coastal Planning Policy (SPP2.6, WAPC, 2013). This includes an assessment of the required setback of the development to allow for coastal processes. In addition, the OEPA and EPA requirements must be met, as stipulated by the EPA Bulletin No. 14 'Guidance for the Assessment of Benthic Primary Producer Habitat Loss in and Around Port Hedland' (EPA 2011).

To comply with SPP2.6, any future development in this region of Port Hedland will be required to be above the 500-year Average Recurrence Interval (ARI) storm tide inundation level for the 100-years planning period

(2110). From the recommendations in the Port Hedland Coastal Vulnerability Study (Cardno 2011), the site would be required to be filled to a minimum level of +6.6 m AHD.

The development site includes a portion of supra-tidal salt flats which are flooded about once a month during the spring tides. Whilst the development footprint does not directly intersect with mangrove vegetation, there is still potential for impacts to mangroves due to the proximity of the development. This would be as a result of alterations of the tidal prism during high water level events and through altered groundwater and surface water regimes.

Hydrodynamic modelling was used to determine any impacts on the mangroves due to decreased tidal prism as a result of changed land levels, with particular reference to:

> Changes to the current velocity through the mangrove area

> Change in mangrove inundation level and duration

> Change in flushing characteristics of the Pretty Pool Creek

The potential for impacts to mangroves from altered groundwater and surface water regimes was investigated using the results of the Local Water Management Strategy (Cardno 2014b).

The eastern portion of the development is located near the mouth of Pretty Pool Creek. It is sheltered from the open ocean by the spit forming the north-western side of the creek mouth. Should the spit be reduced over the planning timeframe, the development may be more susceptible to wave action and erosion processes. In accordance with the risk assessment approach outlined in SPP2.6, an assessment of the risk of erosion of this spit is also documented here.

1.2 Additional Investigations

Cardno completed the above scope of works in November 2014 (Cardno 2014a). LandCorp subsequently requested that additional modelling be undertaken of the Pretty Pool Creek area to minimise the potential impact of the Stables development. In addition, it was recommended to assess the combined potential impact of the proposed Stables development in conjunction with the planned development along Athol Street.

This report assesses the revised footprint, together with the Athol Street footprint. The results herein present the revised Stables development in place of the original footprint presented in Cardno (2014). The revised footprint is presented in Figure 1-2 below. The dashed line shows the original development outline.

Figure 1-2 Development locality plan. The revised Stables (Stage 3) development footprint outlined in red; original footprint is dashed red line. (Image source – Nearmap & Google Earth)

2 Hydrodynamic Modelling

To investigate the effects of changed tidal prism characteristics on the mangroves, Cardno has developed a high resolution Delft3D hydrodynamic model of Pretty Pool Creek that has been coupled to the large scale, calibrated storm tide Delft3D model utilised in the Port Hedland Coastal Vulnerability Study (PHCVS) (Cardno, 2011). The tidal processes were simulated for the existing bathymetry, the revised Stables developed layout, and the revised Stables layout combined with the Athol Street footprint. This enabled differences in exchange and velocity to be investigated.

The following scenarios were simulated for each of the existing, Stables and Stables / Athol combined development layouts:-

- Scenario 1: 4-week scenario under ambient conditions. This captured the full spring-neap tidal cycle, enabling an understanding of the extent of the inundation of the mangroves under ambient conditions.
- Scenario 2: 2-years ARI storm event. Changes to the more frequently occurring conditions could impact the mangroves more than the large storms. As such, simulating the 2 year ARI event provides a better understanding of these impacts.
- Scenario 3: 20-year ARI storm event. This storm event is more likely to occur during the design life of the development than Scenario 4 below, so provides information from which to assess potential impacts on the mangroves during extreme conditions.
- Scenario 4: 500-years ARI simulation. This event is selected to be in line with the SPP2.6 storm event for erosion for this region of Western Australia. A cyclonic event was selected from a database of 16,000 synthetic cyclone tracks (Cardno, 2011) that is equivalent to a 500-years ARI storm tide event near this site. In line with the planning policy, this is coupled with the recommended 0.9 m sea-level rise.

2.1 Model Setup

The model grid and bathymetry for the Port Hedland Town and Pretty Pool Creek areas is presented in Figure 2-2 and Figure 2-2 below. A high resolution grid through the Pretty Pool Creek and adjacent township was developed. For display purposes only every second grid line is shown for the Town grid and every third grid line for the Pretty Pool grid. Throughout the narrow creek region, the model has a resolution of approximately 5 m, providing approximately five grid points across the creek which reproduces the creek bed bathymetry well. This finer grid over the creek is omitted from Figure 2-1 for clarity.

A multi-beam hydrographic survey was carried out over Pretty Pool Creek for a previous study undertaken by Cardno for LandCorp (Surrich, 2012). This is incorporated into Cardno's Digital Elevation Model (DEM) of the Port Hedland region, which includes high resolution LiDAR data of the surrounding land regions. In addition LandCorp provided LiDAR data from 2014, and this data was utilised to update the bathymetry of the Pretty Pool Creek entrance and nearshore tidal flats.

Due to the large, flat mangrove and salt-marsh area surrounding Pretty Pool, which becomes inundated under extreme water levels, the 'Flooding' momentum advection scheme has been utilised (Stelling and Duinmeijer, 2003). This scheme has been specifically developed for the inundation of dry land with obstacles involved, such as roads.

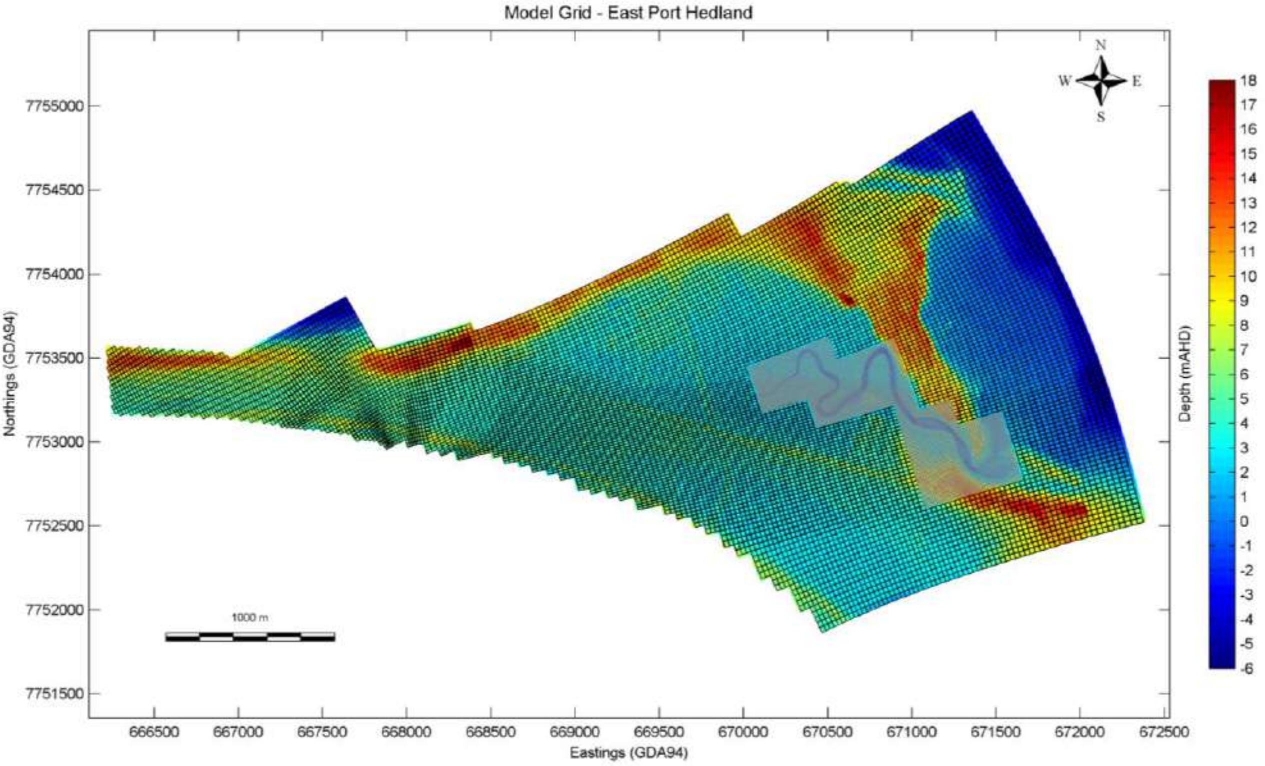

Figure 2-1 Model grid and bathymetry of Inner Port Hedland Town. Note that only every 2nd gridline is displayed

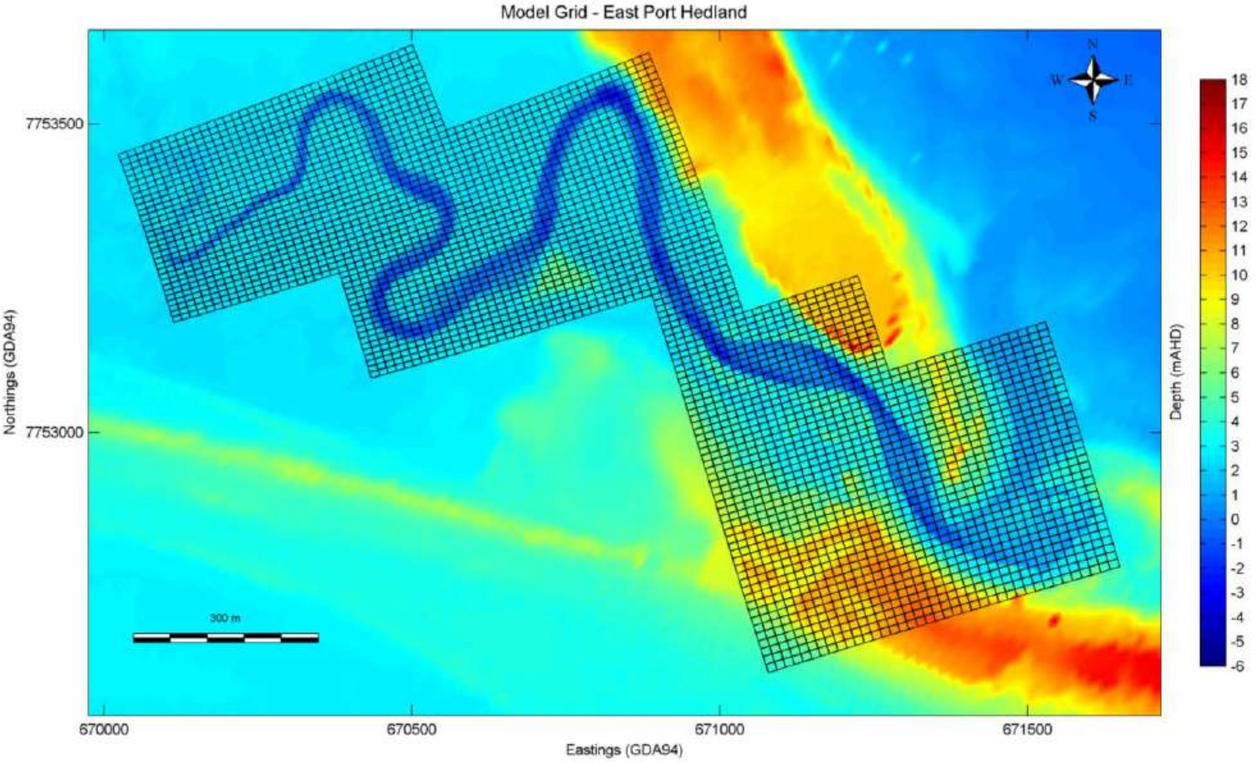

Figure 2-2 Model grid and bathymetry of Pretty Pool Creek area. Note that only every 3rd gridline is displayed

2.2 Model Calibration and Hydraulic Roughness

A spatial roughness map was implemented throughout the Pretty Pool Creek region and surrounding East Port Hedland township that utilised the Manning's 'n' roughness scheme. The prescribed hydraulic roughness was based on digitising different land use and vegetation zones. These are consistent with the overland flow model utilised in the PHCVS (Cardno, 2011). In addition, a specific calibration of the creek bed roughness was undertaken. The mangrove regions and creek bed were prescribed with a Manning's 'n' value of 0.18 and 0.02, respectively. Figure 2-3 presents a plot of the measured and modelled water level at two locations within the creek. Very good agreement between modelled and measured water levels is evident.

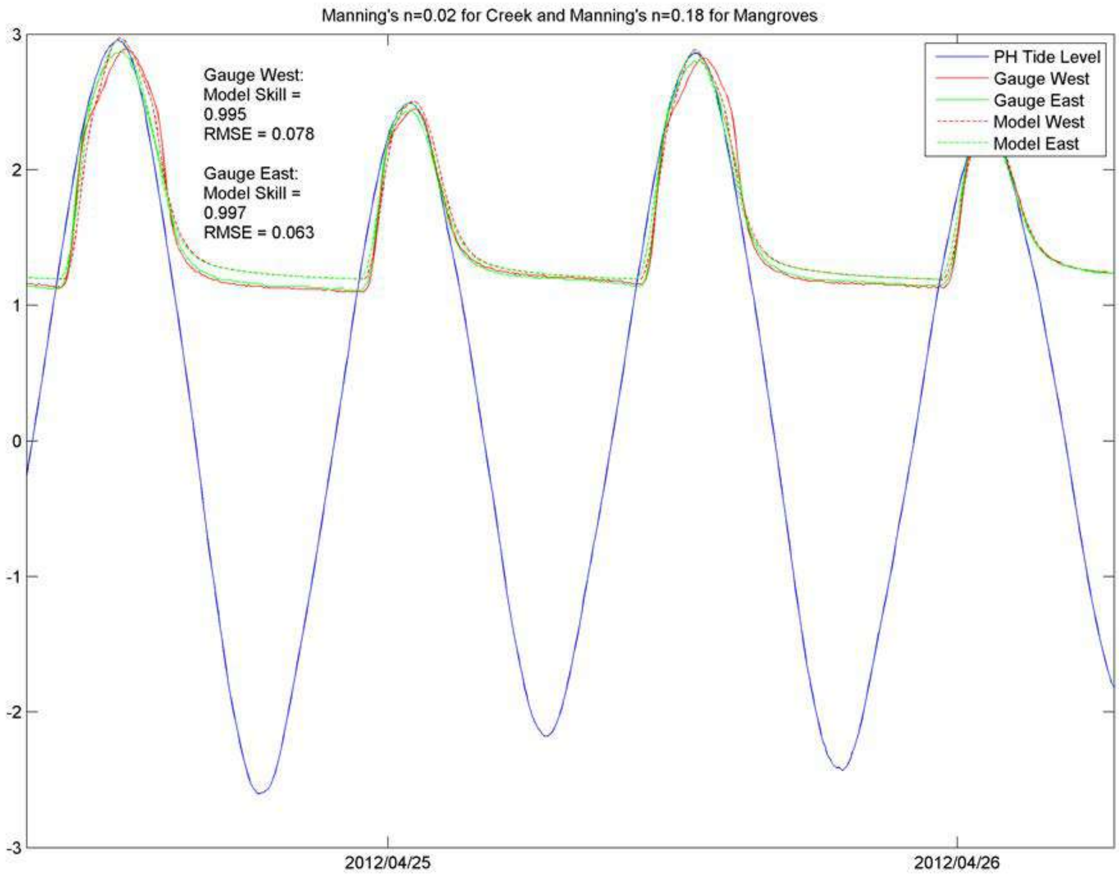

Figure 2-3 Model validation against measured water level data at two gauging locations within Pretty Pool Creek

2.3 Development Footprint Refinement

To select an optimised development footprint, the 500-years ARI scenario was simulated for 3 layout adjustments: Options 1 to 3. These layouts are presented in Figure 2-4. The options aimed at increasing the channel width near the creek mouth, so as to minimise the change to flow conditions. This is the area showing the most change to conditions for the original development footprint (Cardno 2014a).

The difference in inundation depth and current speed between the three options and the existing (base) case are presented in Figure 2-5 and Figure 2-6 respectively. Each option showed improvement compared to the original development footprint (as reported in Cardno 2014a). As negligible differences were observed between Options 2 and 3, Option 2 was considered optimal for the channel width, and selected as the revised development footprint for further analysis. This is the footprint displayed in Figure 1-2 in Section 1.2.

Figure 2-4 Development Options 1 to 3, and original footprint

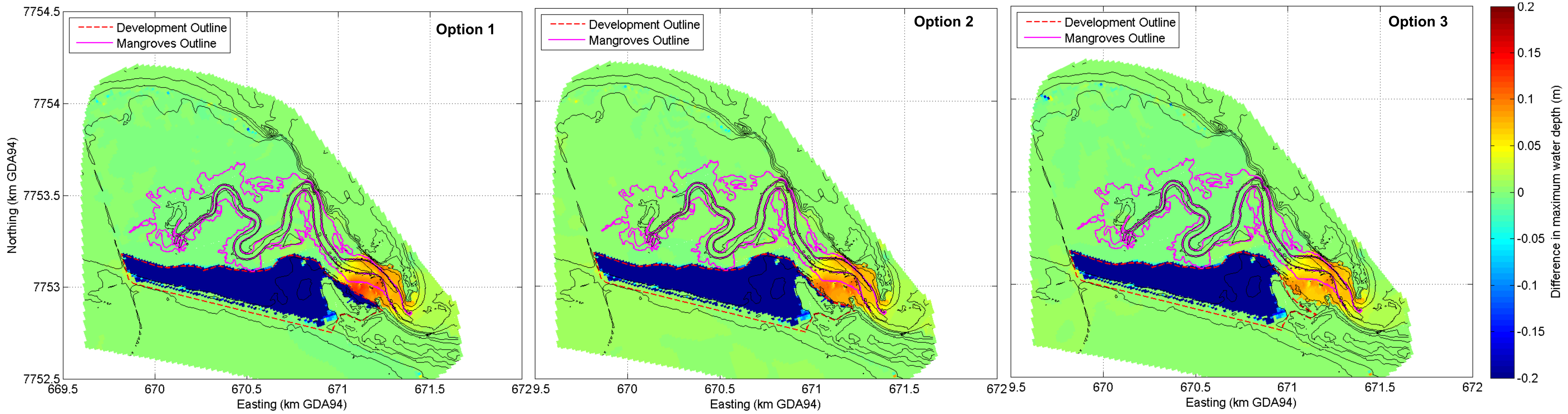

Figure 2-5 Differences in maximum inundation depth for 500-years ARI storm conditions. Positive change indicates that the depth is greater for the Design Case. The dark blue areas indicate regions that are no longer inundated

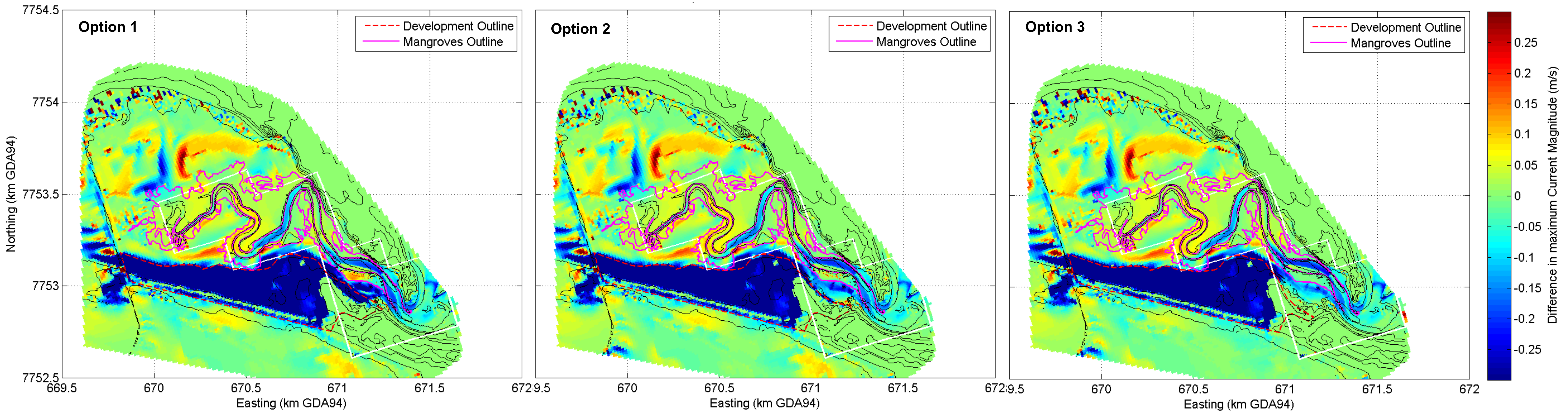

Figure 2-6 Differences in maximum current magnitude for 500-years ARI storm conditions. Positive change indicates that the current magnitude is greater for the Design Case. White outline is the boundary between domains

2.4 Model Scenarios

Four forcing scenarios were modelled:

> Scenario 1: An ambient 1-month simulation that encompassed two spring tides with a mean high water level equal to approximately MHWS (2.8 m AHD). This is a typical tidal scenario.

> Scenario 2: A 7-day simulation with for a 2-years ARI spring tide level of approximately 3.3 m AHD

> Scenario 3: An extreme 20-years ARI tropical cyclone event (TC Kerry, Jan 1973)

> Scenario 4: An extreme 500-years ARI tropical cyclone event, incorporating 0.9 m sea-level rise (SLR).

2.4.1 Development Cases

A design fill level of +6.6 m AHD across the proposed development areas was incorporated into the model to assess the influence of the development layouts on the mangrove hydrodynamics; refer to Figure 2-7 to Figure 2-9 for the existing, Stables, and Stables combined with Athol Street design bathymetry respectively. All layouts were modelled with the forcing scenarios described above. For ease of reference, the following labels are used herein to refer to each of the cases:

> Base case – no development

> Design Case - Stables only development

> Athol Design Case - Stables combined with Athol Street development.

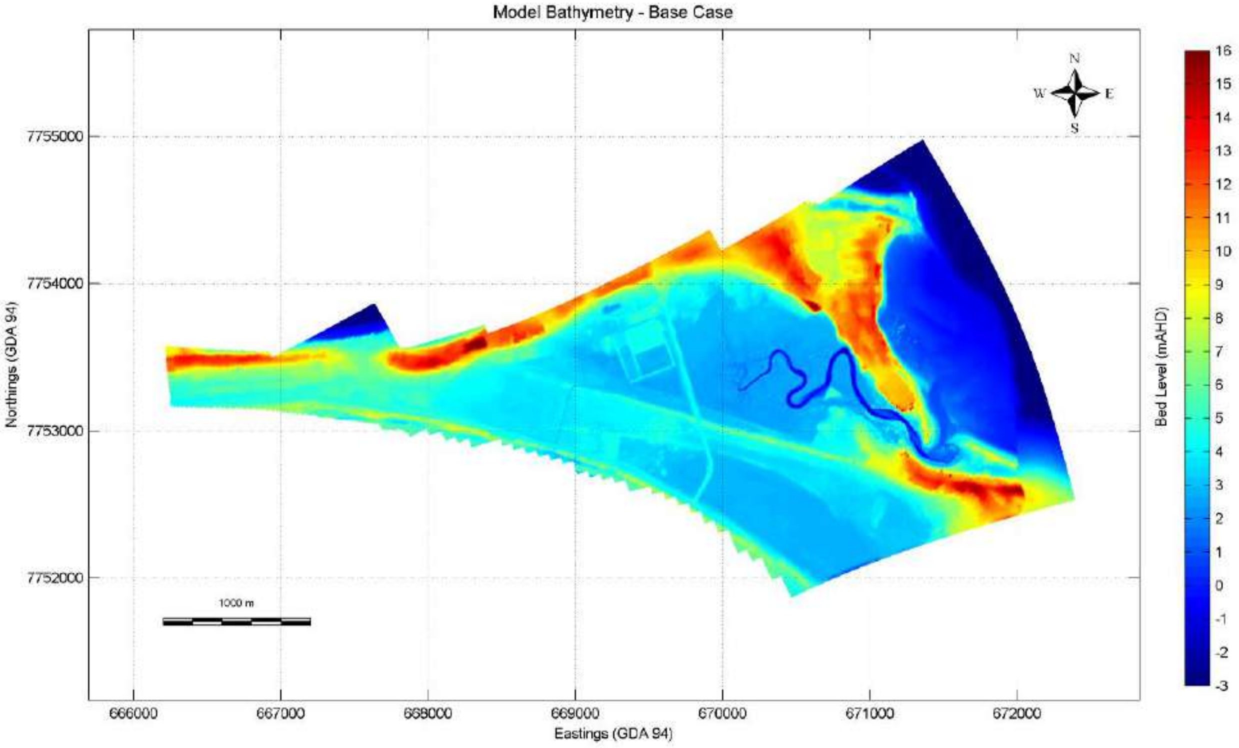

Figure 2-7 Base Case bathymetry of the East Port Hedland area

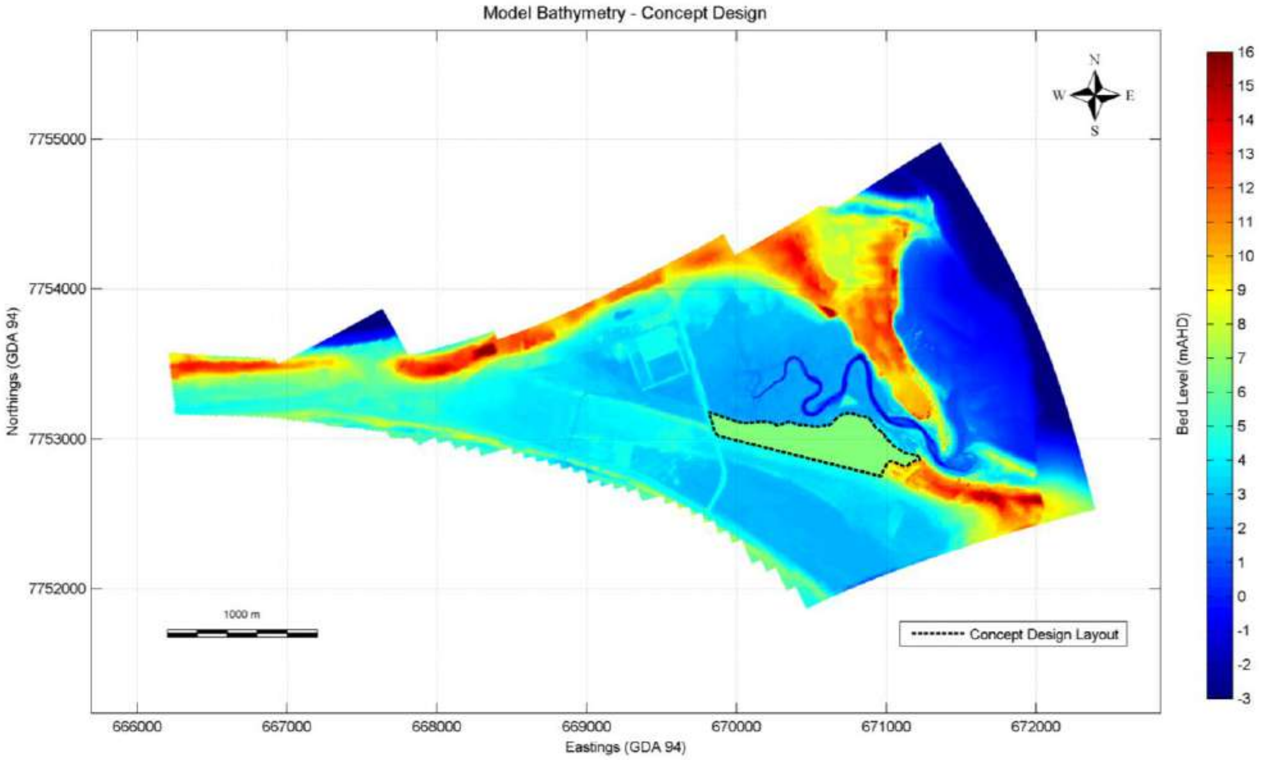

Figure 2-8 Design Case bathymetry of the East Port Hedland area, including the proposed Stables development Design Outline

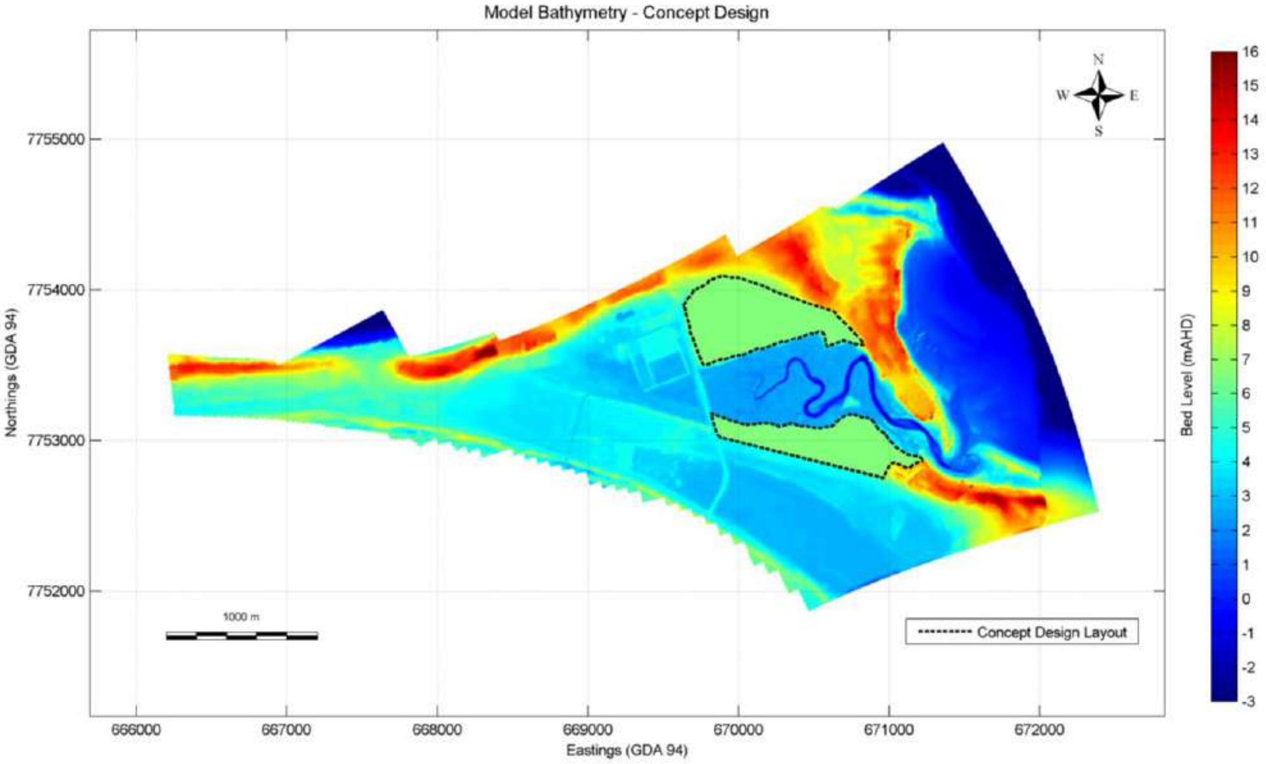

Figure 2-9 Athol Design Case bathymetry of the East Port Hedland area, including both the proposed Stables and Athol Street development Design Outlines

2.5 Model Results

The change in discharge through a cross section at the entrance to Pretty Pool Creek due to the Stables development is shown in Table 2-1. For each simulation, the total discharge was calculated across this cross-section for both the flood and ebb tides. The mean of the flood and ebb magnitudes was taken and is displayed in the table.

Table 2-1 Difference in discharge through the Pretty Pool Creek entrance.

Scenario	Discharge Through Cross-Section Over Simulation (Mean of Flood & Ebb Magnitudes)			Difference Design (%)	Difference Athol Design (%)
	Existing (m^3)	Design (m^3)	Athol Design		
1	5.08×10^6	5.05×10^6	5.05×10^6	-0.4	-0.5
2	1.80×10^6	1.80×10^6	1.79×10^6	-0.2	-0.3
3	3.75×10^6	3.63×10^6	3.39×10^6	-3.1	-9.5
4	1.24×10^7	1.18×10^7	1.04×10^7	-5.4	-16.1

These results indicate that there is a very minor reduction in the volume of water flowing into and out of the creek across a 1-month tidal cycle (Scenario 1) and a 2-year ARI tidal condition (Scenario 2). This suggests there is little modification to the hydrodynamic regime of the Pretty Pool Creek under Scenarios 1 and 2.

For Scenario 3, the 20-years ARI storm event, there is a 3% reduction in the volume of water that flows into and out of the creek as a result of the Stables Development. With the addition of the Athol Street footprint, there is a 9% reduction.

For Scenario 4, the 500-years ARI storm event, there is a 5% reduction in the volume of water that flows into and out of the creek as a result of the Stables Development. With the addition of the Athol Street footprint, there is a 16% reduction.

The development layouts reduce the area available to be inundated under high water level. This in turn reduces the volume flux and associated frictional losses, allowing the water level within the creek region and surrounds to reach a higher quasi-equilibrium with the oceanic water level. Note for the Stables footprint by itself, these reductions are less than that predicted from just the Athol Street Development (Scenarios 3 and 4 predicted 6% and 11% reductions respectively (Cardno, 2012)).

Water levels are increased by approximately 3-7 cm across parts of the mangrove regions for the extreme events due to the Stables Development, and 5 - 20 cm for the Athol Design Case (refer Sections 2.5.4 and 2.5.5 below).

2.5.2 Scenario 1: Ambient/monthly event

Maximum water levels and current magnitudes for the pre and post-development cases are mostly comparable across the mangrove region for the typical tidal scenario (Figure 2-10 and Figure 2-11).

There is a minor increase in the extent of inundation of the salt flats, with negligible changes within the creek and mangrove areas under ambient conditions. Some areas of the salt flats that were previously inundated are no longer due to the presence of the development layout (shown in dark blue).

For the Athol Design Case, these is an increase in water depth throughout the area of approxiomately 3 cm due to the reduced area available for inundation. The currents are similar for both the Design Case and the Athol Design Case.

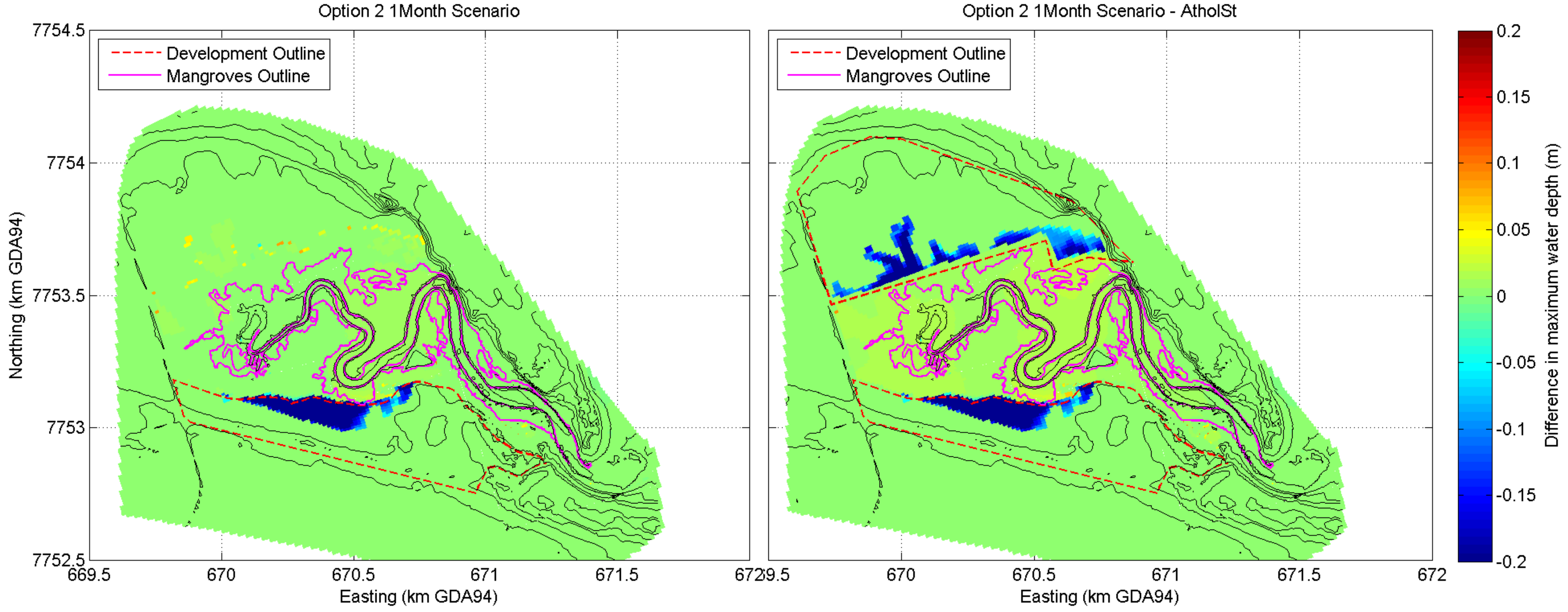

Figure 2-10 Differences in maximum inundation depth for Scenario 1 - Design and Athol Design Cases. Positive change indicates depth greater for Design Cases. Dark blue areas indicate regions no longer inundated

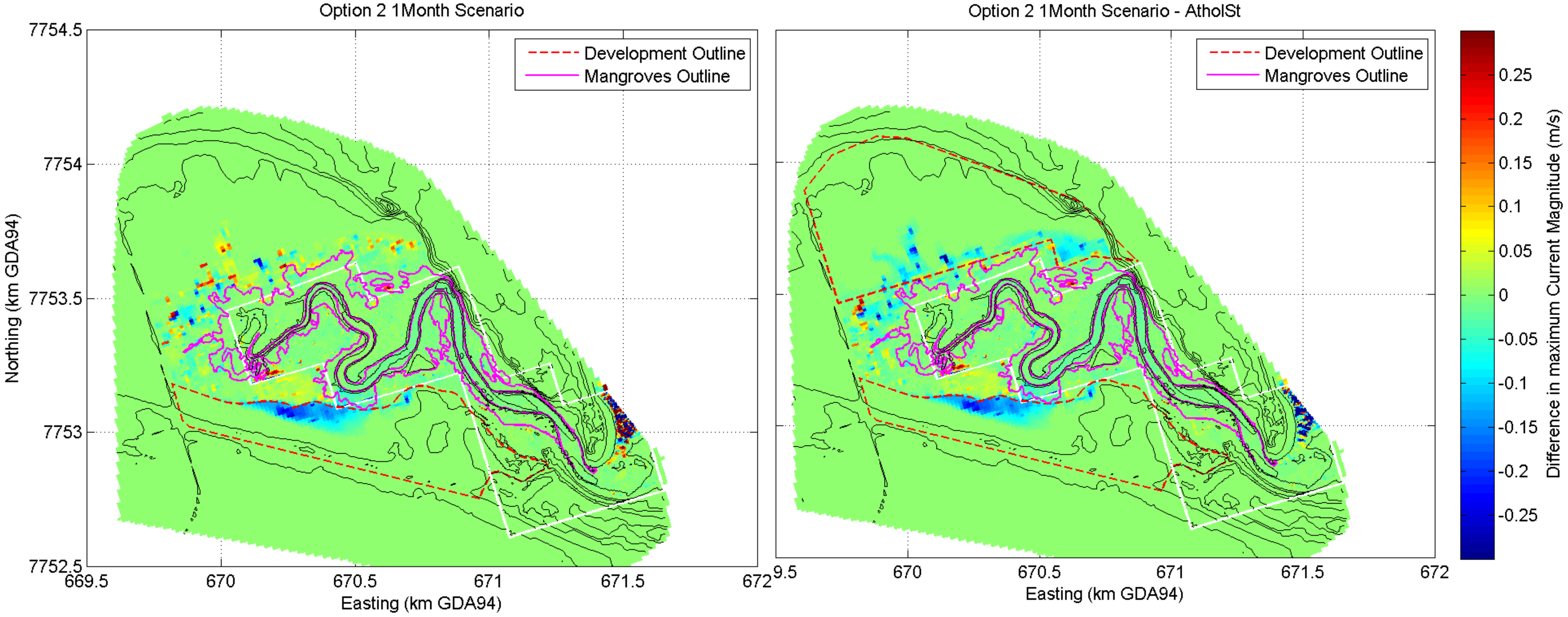

Figure 2-11 Differences in maximum current magnitude for Scenario 1 - Design and Athol Design Cases. Positive change indicates current magnitude greater for Design Cases. White outline is boundary between domains

2.5.3 Scenario 2: 2-year ARI Event

Maximum water levels and current magnitudes for the pre and post-Stables development cases are mostly comparable across the mangrove region for the 2-years ARI high tide scenario (Figure 2-12 and Figure 2-13).

There is a minor increase in the extent of inundation of the salt flats, with negligible changes within the creek and mangrove areas under ambient conditions. Some areas of the salt flats that were previously inundated are no longer due to the presence of the development layout (shown in dark blue).

There is an increase in current magnitude in the tidal flats of approximately 5 cm/s adjacent to the development to the west (indicated by the arrow in Figure 2-13).

For the Athol Design Case, these is an increase in water depth throughout the area of approxiomately 4 cm due to the reduced area available for inundation. The currents are similar for both the Design Case and the Athol Design Case.

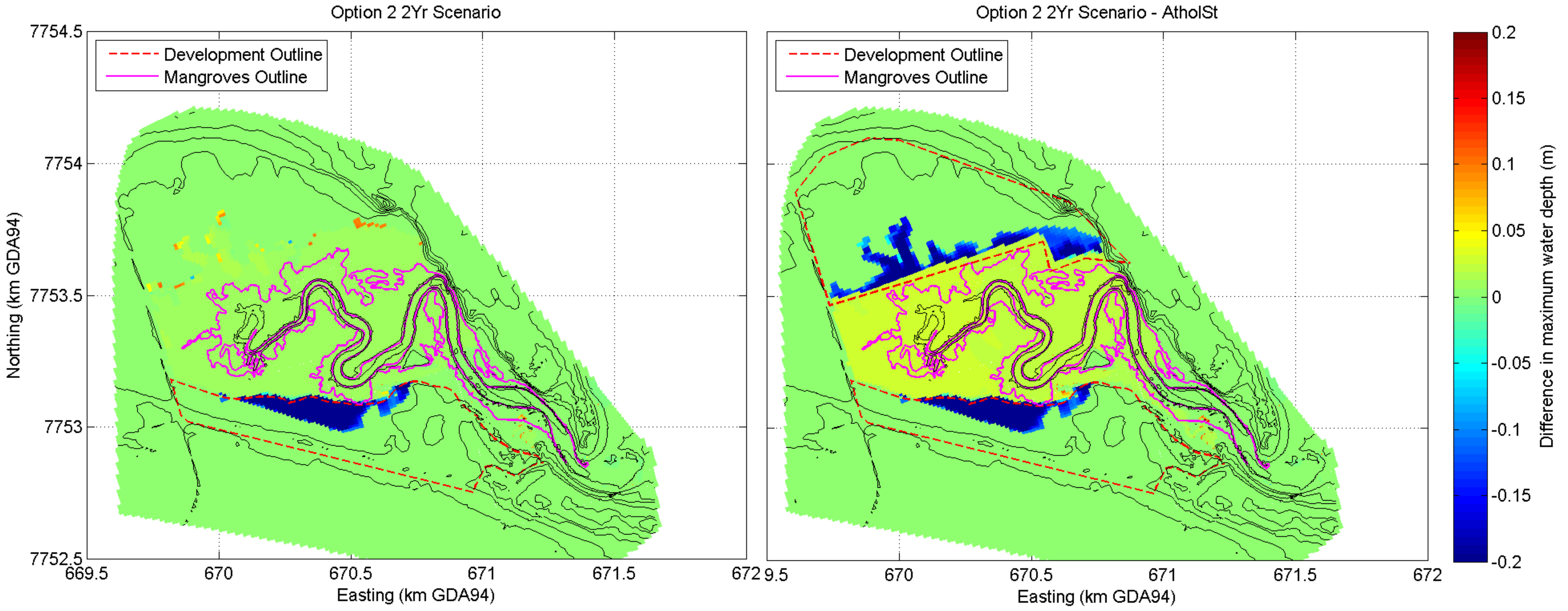

Figure 2-12 Differences in maximum inundation depth for Scenario 2 - Design and Athol Design Cases. Positive change indicates depth is greater for Design Cases

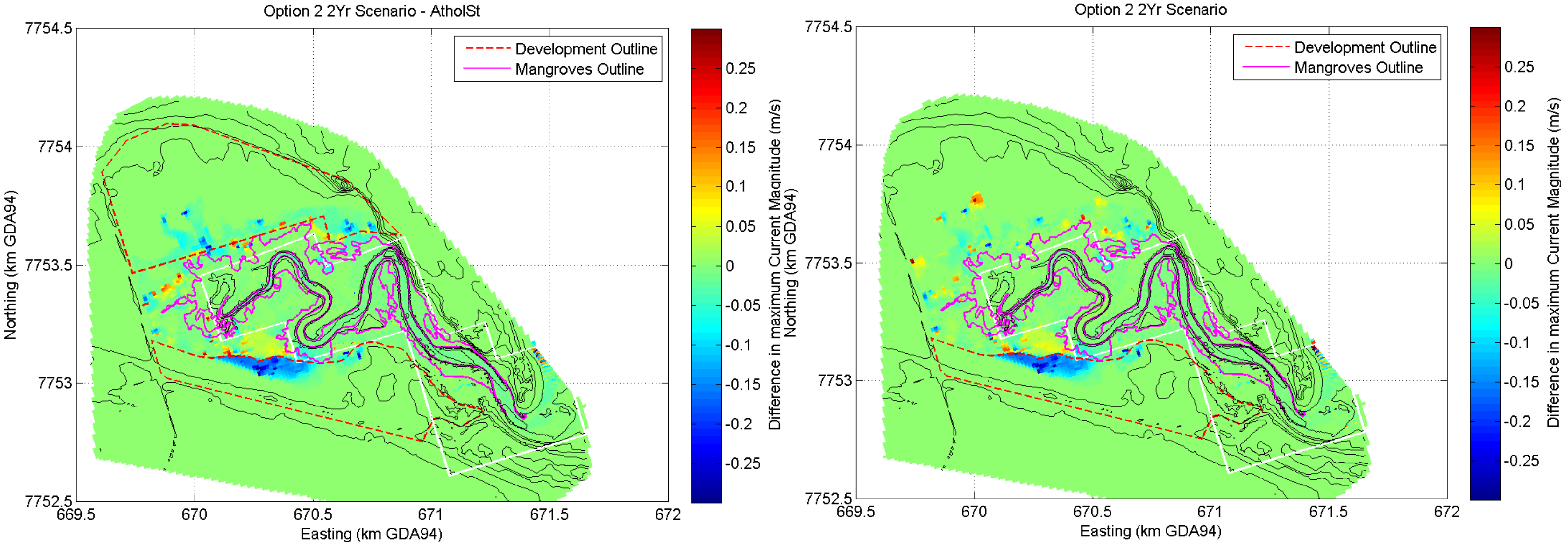

Figure 2-13 Differences in maximum current magnitude for Scenario 2 - Design and Athol Design Cases. Positive change indicates current magnitude is greater for Design Cases. White outline is boundary between domains

2.5.4 Scenario 3: 20-year ARI Event

The difference plots of the modelled maximum inundation depth, Figure 2-14, shows water depths are predicted to be approximately 3-5 cm higher across the Pretty Pool region during a 20-years ARI storm due to the Design Case alone. The Athol Design case shows increases of up to 7 cm. This is a small increase compared to the inundation depth of 2-2.5 m shown in Figure 2-15; roughly a 1-3% increase.

The difference in current magnitudes over the duration of the storm for both the existing and design cases and the maximum current magnitudes are plotted in Figure 2-16 and Figure 2-17 respectively. The maximum current magnitude through the majority of the mangroves is approximately 30-60 cm/s for the existing layout. Current speeds in the channels near the entrance exceed 100 cm/s.

The presence of the Design Case development slightly reduces the width of a flow path on the southern side of the creek near the entrance (indicated by the arrow in Figure 2-16). This has in turn increased the current magnitude through this section by approximately 7 cm/s. The high variability in the results in this area is due to the variations in the flow paths and peak currents associated with the modelled wetting and drying process (indicated by the arrow in Figure 2-17).

The addition of the Athol St footprint leads to increases in currents at the development footprint boundary of up to 20 cm/s.

Assuming (a smooth) Nikuradse equivalent sand grain roughness for the mangrove sediments of approximately 1 mm; suspension of fine material (with a nominal critical shear stress for mobilisation between 0.2 and 0.6 N/m^2) occurs for current magnitudes that exceed approximately 40 to 60 cm/s, at flow depths of approximately 2 m. The Base Case model results indicate that these conditions are present for the 20-years ARI. An increase of 7 cm/s and 20 cm/s due to the Design Case and Athol Design Case respectively will result in slight alteration to the sediment redistribution that occurs during these extreme events. This may result in slight redistribution of the mangrove habitat, however given the frequency of these events it is likely that other direct impacts (i.e. wind) will likely be more significant than the alterations to the hydrodynamic regime due to the development.

Due to the predicted increased water levels within the proximity of Pretty Pool Creek resulting from the Design and Athol Design Case developments, alterations to the inundation of adjacent areas can occur (Figure 2-18). Overtopping of Cook Point Drive is predicted to occur in the 20-year ARI event leading to approximately 20 cm of inundation over an increased area to the west of Cook Point Drive compared to the existing layout for both the Design Cases. The inclusion of the Athol Street development (Athol Design Case) results in a significantly broader area being inundated compared to the Design Case alone. The corresponding change to current magnitude is also included in Figure 2-19 for this zoomed-out view.

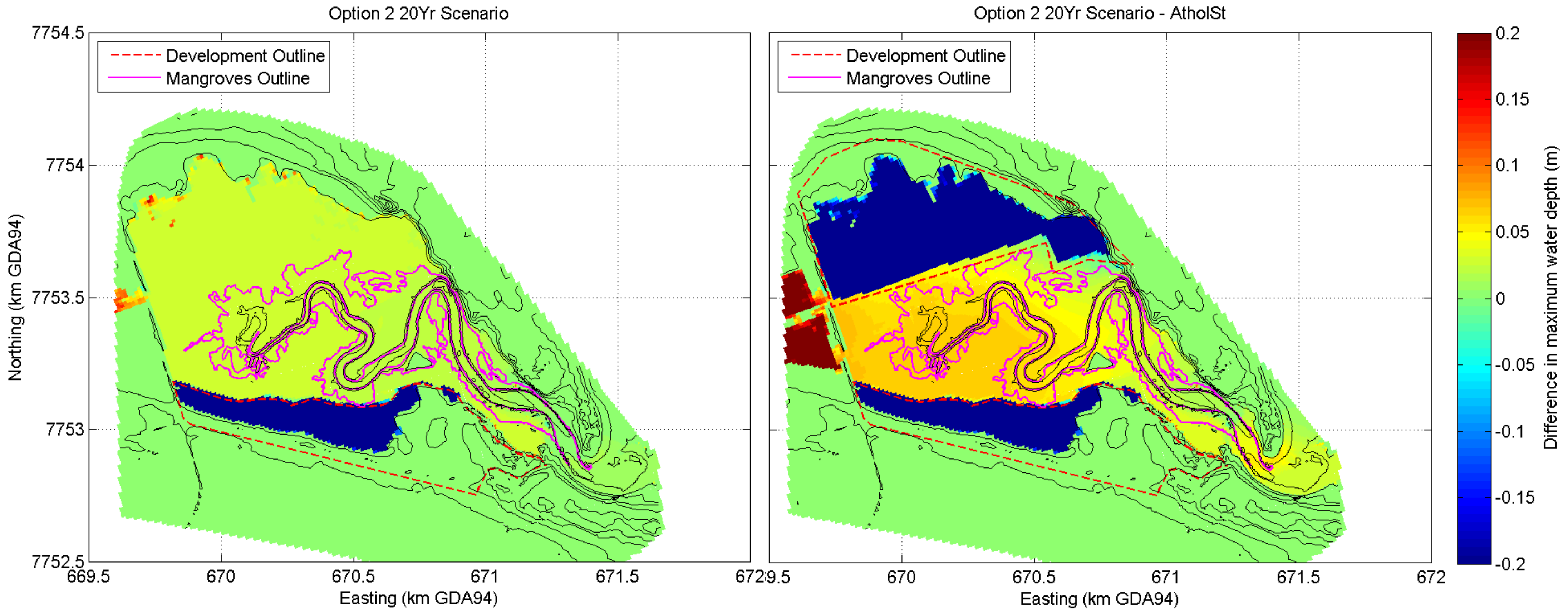

Figure 2-14 Differences in maximum inundation depth for Scenario 3 - Design and Athol Design Cases. Positive change indicates depth is greater for the Design Cases

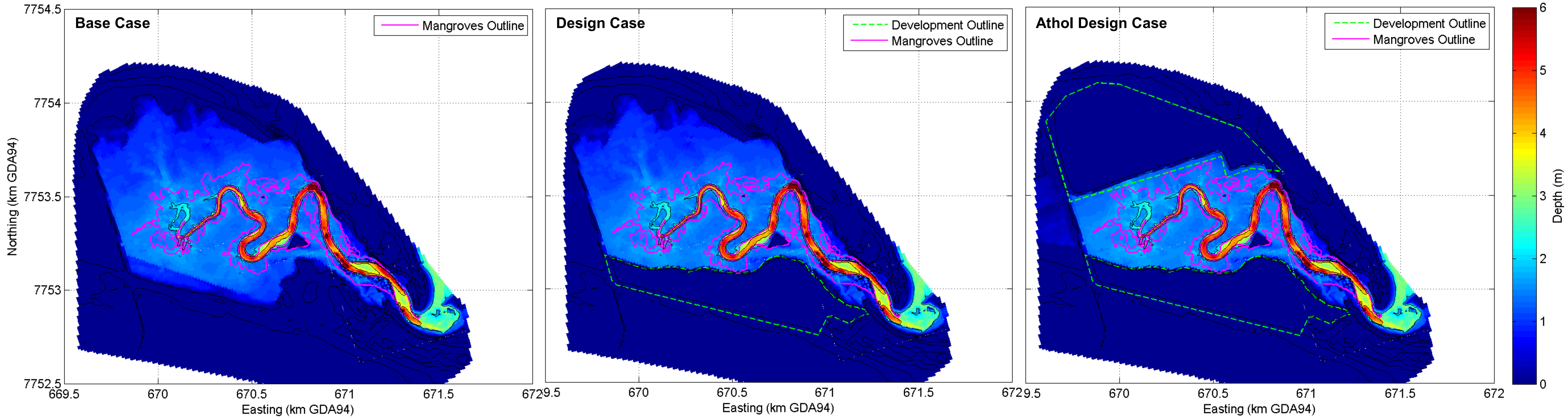

Figure 2-15 Maximum water depth for Base, Design and Athol Design Cases for Scenario 3

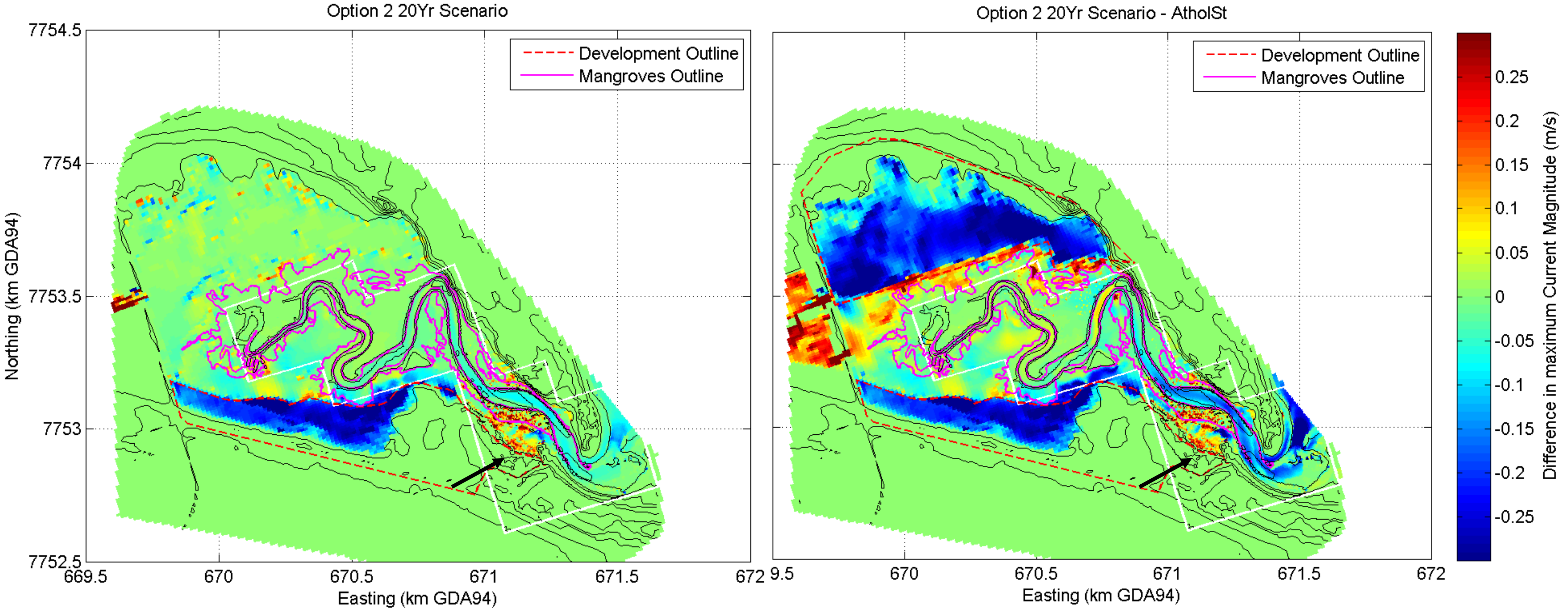

Figure 2-16 Differences in maximum current magnitude for Scenario 3 - Design and Athol Design Cases. Positive change indicates current magnitude is greater for Design Cases. White outline is boundary between domains. Arrow indicates current variability at entrance due to modelled wetting/drying processes

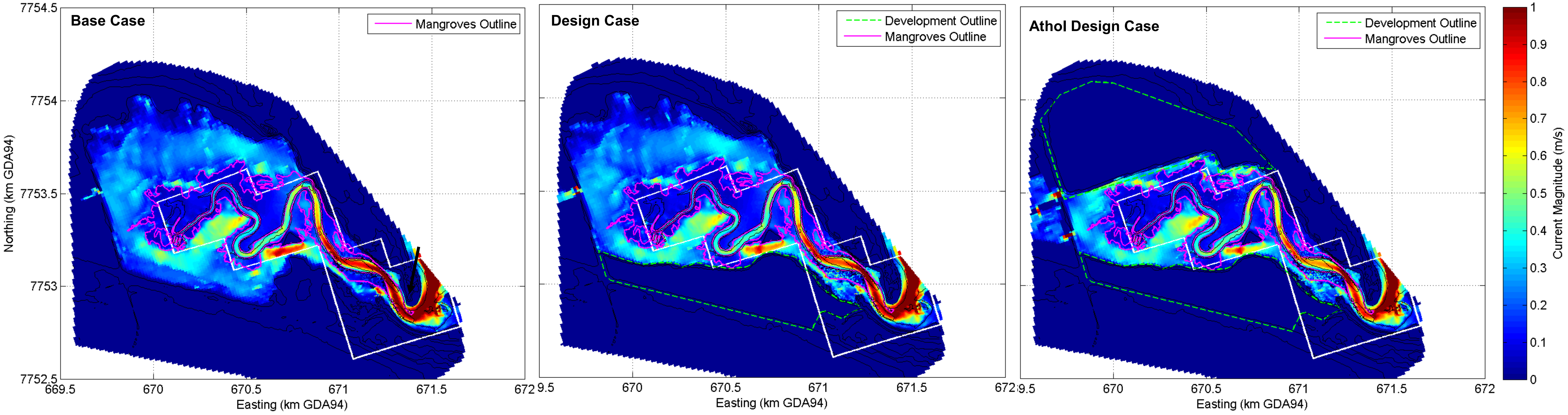

Figure 2-17 Maximum current magnitude for Base, Design and Athol Design Cases for Scenario 3. White outline is boundary between domains

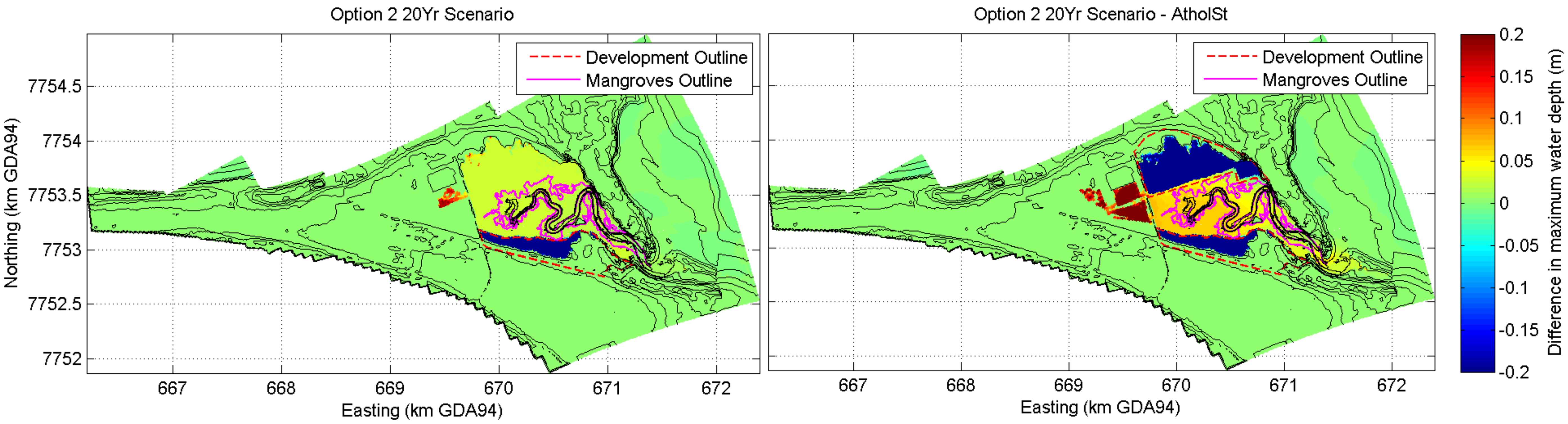

Figure 2-18 Differences in maximum inundation depth for Scenario 3 - Design and Athol Design Cases, zoomed-out view. Positive change indicates depth is greater for the Design Cases

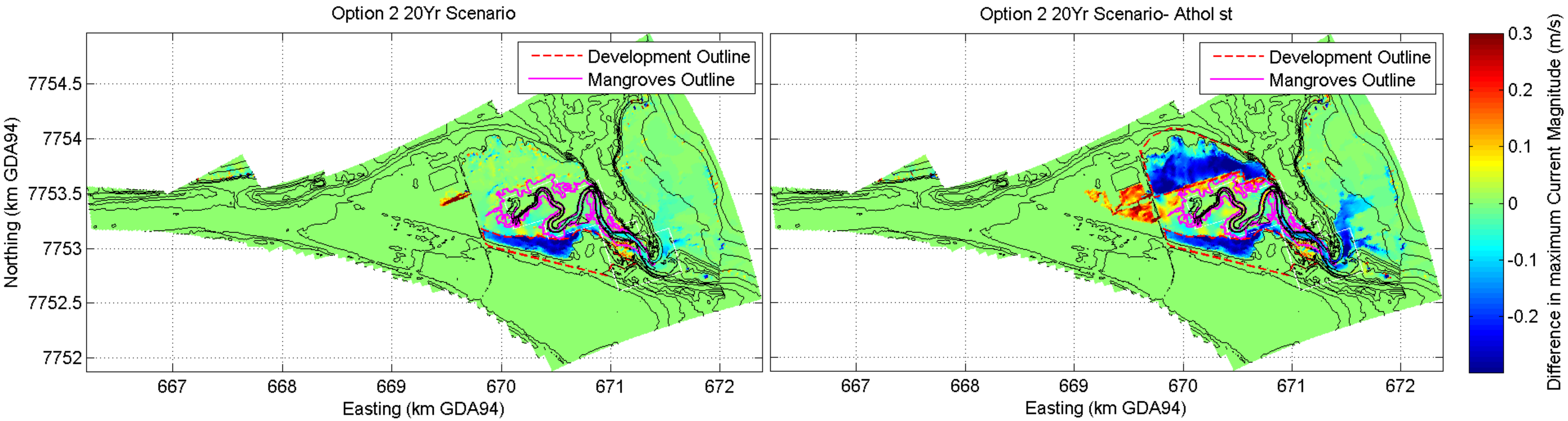

Figure 2-19 Differences in maximum current magnitude for Scenario 3 - Design and Athol Design Cases, zoomed-out view. Positive change indicates current magnitude is greater for the Design Cases

2.5.5 Scenario 4: 500-year ARI Event

The difference between the existing and developed cases in the modelled maximum inundation depth, for the 500-years ARI simulation, is presented in Figure 2-20. Overall, water depth changes in the mangroves are predicted to be minimal, however over an area adjacent to the creek entry, water depths are predicted to be up to 7 cm higher during this event. As discussed in Cardno (2014), this is due to an effective reduction in the 'total' channel width, during extreme events within this region (first demonstrated at the 20-year ARI event). The reduced width on the low friction salt flats (indicated by the arrow in Figure 2-20) increases the flow through the higher friction mangroves, which results in an increased water level required to drive the flow through this area. The selection of Option 2 has limited the increase in water depth to 7 cm for the Design Case, as opposed to the 15 cm observed with the original concept footprint.

The presence of the Athol St development reduces the area available for inundation over the peak of the event. The reduced inundation area results in a reduction in energy dissipated over the tidal flats. This allows the water level within Pretty Pool to reach a higher level over the peak of the inundation event. This effect due to the Athol Street development results in an increase in water depth across Pretty Pool of approximately 5 cm. This combined with the influence of the Stables developments shows a 15 cm increase in water levels near the entrance to Pretty Pool.

The maximum water depth for each of the Base, Design and Athol Design Cases are plotted in Figure 2-21 to enable the depth changes to be placed in context. The changes in water depth in the channel correspond to a change of approximately 3% and 6% for the Design and Athol Design Cases respectively. The change to the depth in the other mangrove areas for the Athol Design Case is also approximately 3%.

The difference in current magnitudes and the maximum current magnitudes over the duration of the storm for the Base, Design and Athol Design Cases are plotted in Figure 2-22 and Figure 2-23 respectively. The maximum current magnitude through the mangroves is approximately 5 cm/s to greater than 100 cm/s for the existing layout.

Maximum current magnitudes in the proximity of the mangroves are predicted to increase by up to approximately 15 cm/s for the Design Case. The Athol Design Case predicts increases of up to 30 cm/s, which will likely result in sediment redistribution during extreme events.

As discussed in Section 2.5.4, the Base Case model results indicate that conditions for sediment suspension are evident in the 20-year ARI Scenario. As expected, conditions for the 500-year ARI scenario also cause sediment suspension. An increase of 15 cm/s and 30 cm/s due to the Design Case and Athol Design Case respectively will result in alteration to the sediment redistribution that occurs during these extreme events. This may result in slight redistribution of the mangrove habitat, however given the frequency of these events it is likely that other direct impacts (i.e. wind) will likely be more significant than the alterations to the hydrodynamic regime due to the development.

For the Design Case, there is negligible change in the overall depth of flooding for areas adjacent to the development (Figure 2-24). This is in contrast to the results of the Athol Design Case (and that assessed in Cardno 2012) where additional flood depth (up to 15 cm) is exhibited adjacent to the rail loop to the west (Figure 2-24). This is due to the overall smaller development footprint of the Design Case within the tidal flats compared to both the Athol Design Case and the Athol Street development assessed in Cardno (2012). For the Athol Design Case, the depth is predicted to increase by up to 15 cm. These changes are shown in Figure 2-24 and Figure 2-25 for the water depths and currents respectively.

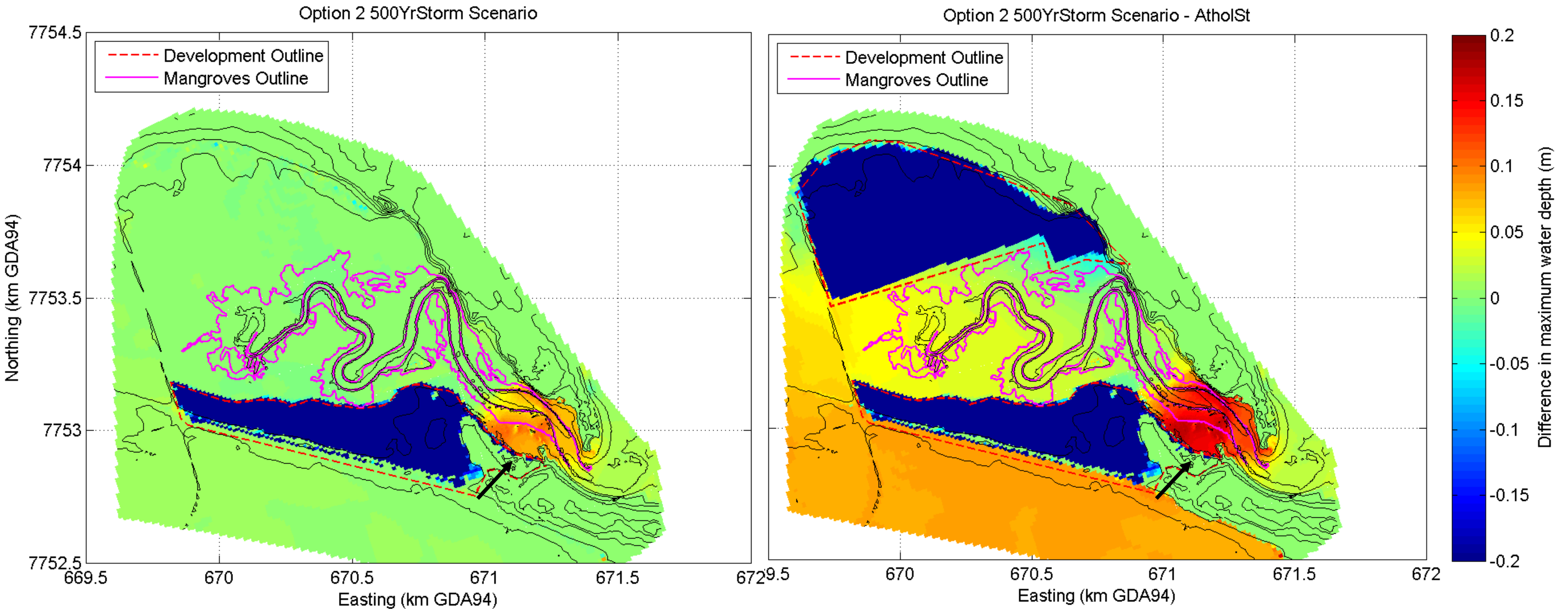

Figure 2-20 Differences in maximum inundation depth for Scenario 4 - Design and Athol Design Cases. Positive change indicates depth is greater for Design Cases

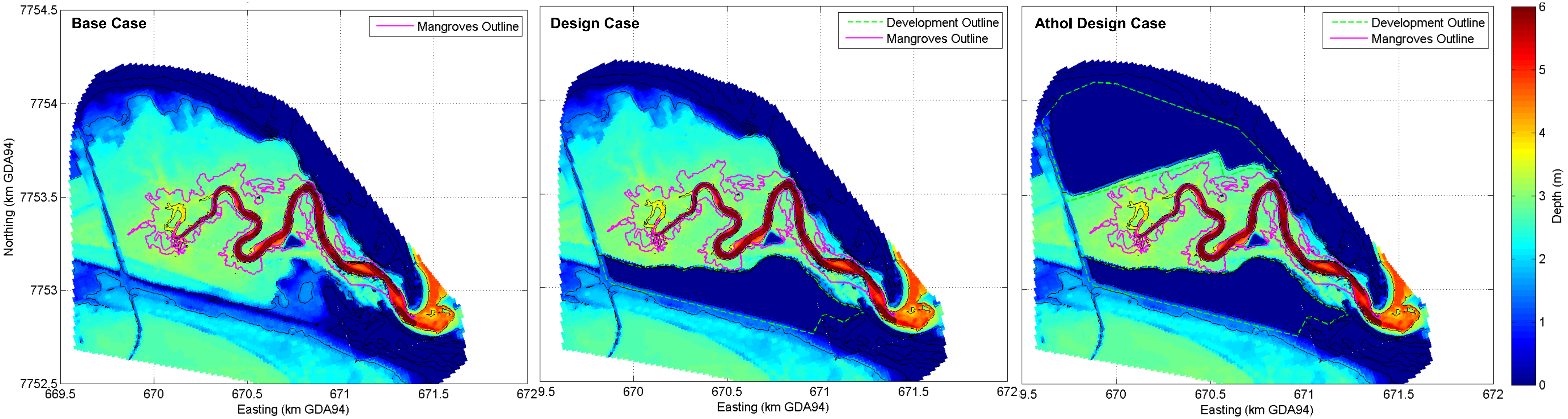

Figure 2-21 Maximum water depth for Base, Design and Athol Design Cases for Scenario 4

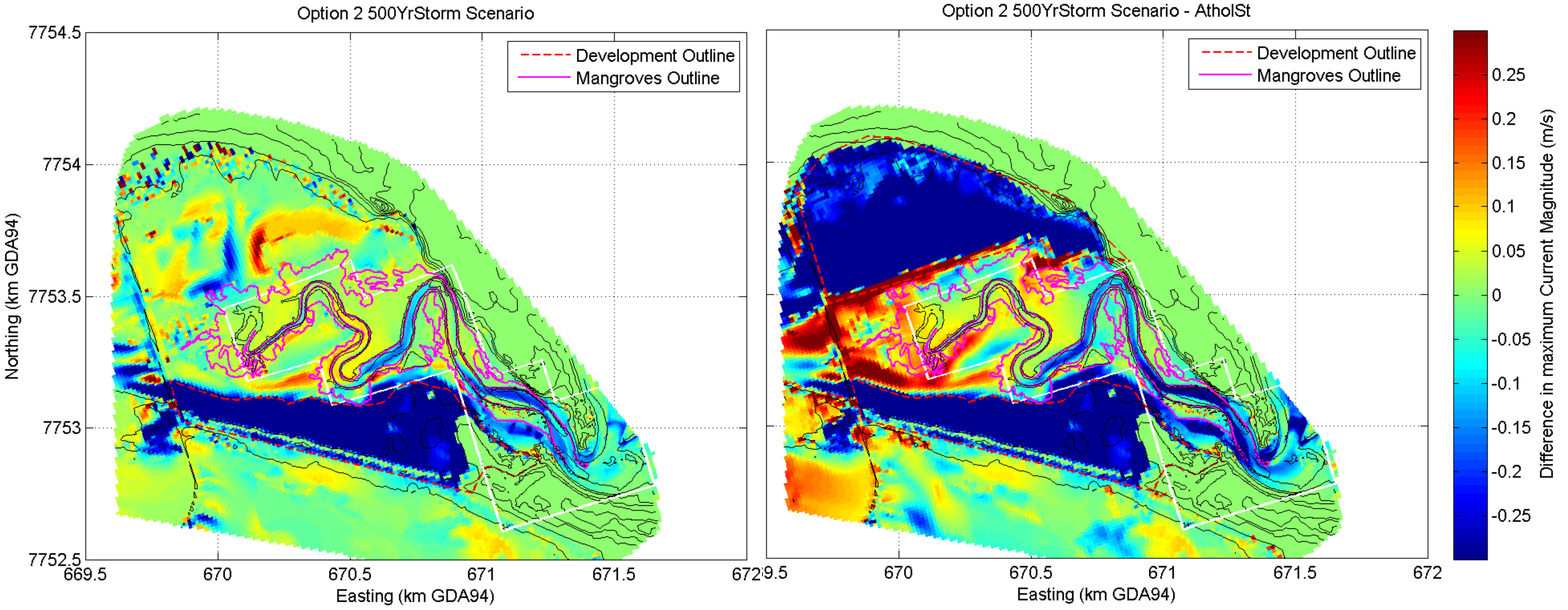

Figure 2-22 Differences in maximum current magnitude for Scenario 4 - Design and Athol Design Cases. Positive change indicates current magnitude is greater for Design Cases. White outline is boundary between domains

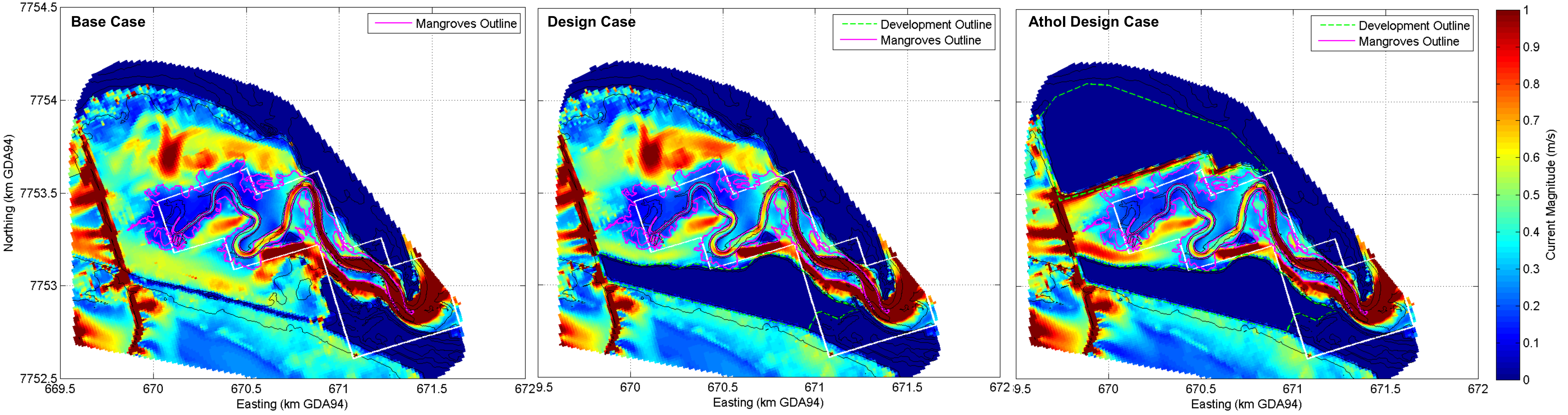

Figure 2-23 Maximum current magnitude for the Base, Design and Athol Design Cases for Scenario 4. White outline is boundary between domains

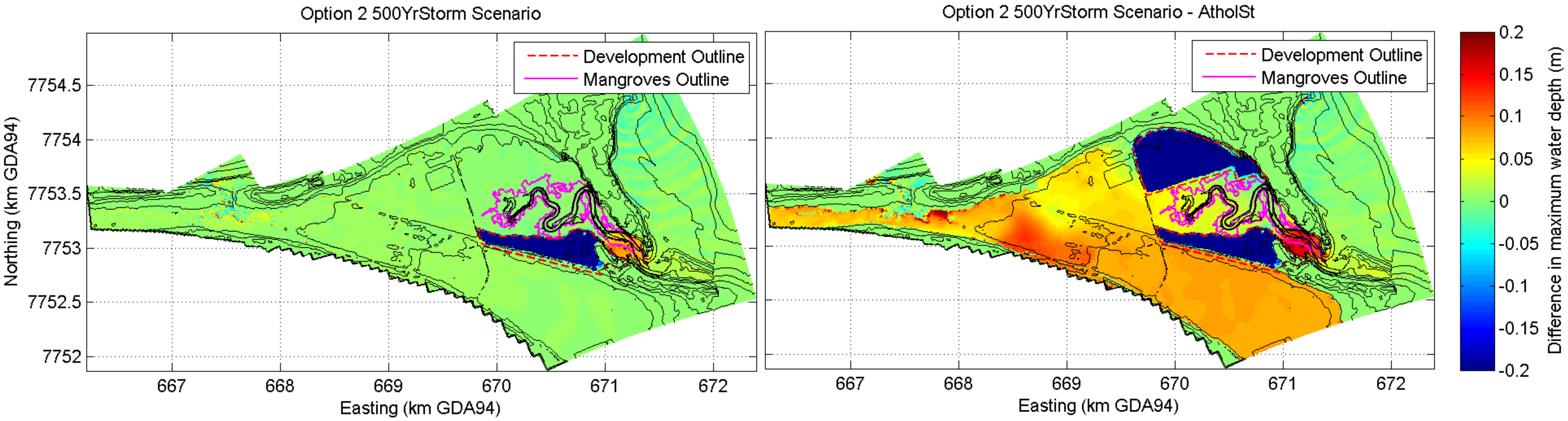

Figure 2-24 Differences in maximum inundation depth for Scenario 4 - Design and Athol Design Cases, zoomed-out view. Positive change indicates depth is greater for the Design Cases

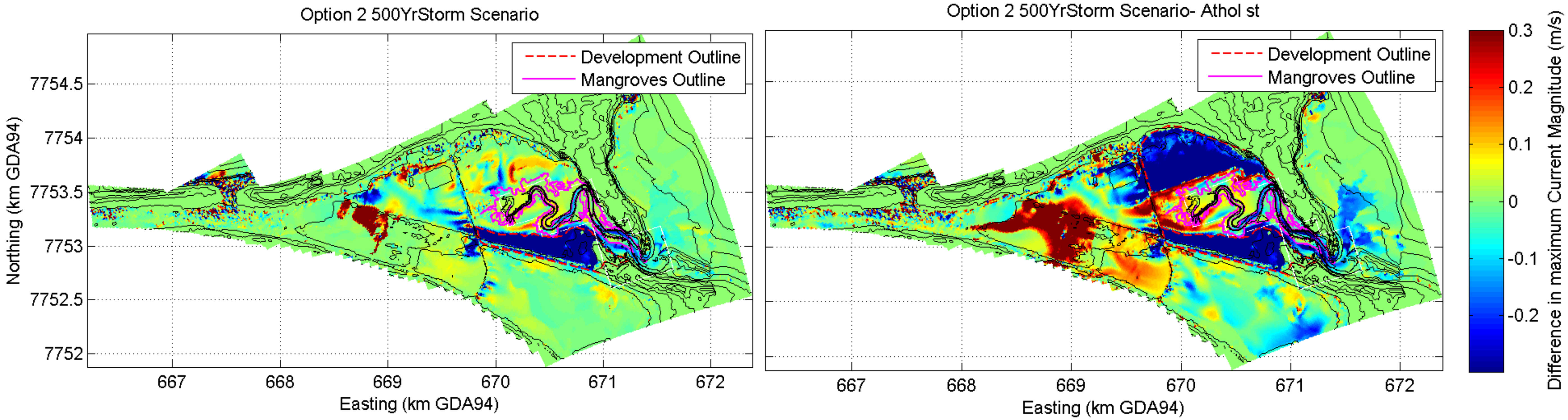

Figure 2-25 Differences in maximum current magnitude for Scenario 4 - Design and Athol Design Cases, zoomed-out view. Positive change indicates current magnitude is greater for the Design Cases

3 Hydrological Assessment

A one dimensional XPSWMM model was developed to assess the existing hydrological environment (Cardno 2014b). The assessment was undertaken to:

> Develop an understanding of how stormwater is currently managed onsite.

> Determine if the site acts as a drainage sump to surrounding land.

> Ensure that if the site is acting as a sump to surrounding land that sufficient space is set aside for stormwater in the masterplan.

The modelling found that currently stormwater flows from the high ridgeline in the south of the site north towards Pretty Pool Creek. There is also a small amount of run-off which flows south towards Styles Road. In larger storm events from the 10 year to 100 year ARI storm event there will be sheet runoff across the site from south to north into the Pretty Pool Creek. Under the existing site conditions no run-off is held onsite.

The site does not act as a drainage sump to surrounding land. Although run-off from the residential land to the south east does flow onto the site, it flows to the north of the site into Pretty Pool Creek.

The volume of run-off predicted to be produced across the site is presented in Table 3-1 for the 10-year and 100-year ARI events.

Table 3-1 Run-off volumes at the development site

Flow Direction	6 minute 5-year ARI (m^3)	10-year ARI (m^3)	100-year ARI (m^3)
North to Pretty Pool Creek	1,200	6,050	11,300
South to Styles Road	250	1,050	1,950

The modelling volumes presented in Table 3-1 give an indication of the amount of water the site generates in each storm event. If insufficient measures are taken during development, these volumes would increase due to the introduction of more impermeable surfaces. It is anticipated however that post development run-off generated during these events will decrease due to the requirement of detaining and infiltrating the first 15 mm of any rainfall event. The anticipated volumes provided in Table 3-1 do not account for the 5 m/day infiltration rate provided by the geotechnical investigation for use in the design of soakwells.

4 Mangrove Impact Assessment

The proposed development has the potential to have both positive and negative impacts on the mangrove community adjacent to the development. The development site includes a portion of supra-tidal salt flats which are flooded about once a month during the spring tides. Whilst the development footprint does not directly intersect with mangrove vegetation, there is still potential for impacts to mangroves due to the proximity of the development from alteration of the tidal prism during high water level events, and through altered groundwater and surface water regimes.

RPS provided Cardno with a spatial map of vegetation types identified through a site visit in March 2010. These are presented in Figure 4-1. The mangroves were observed to comprise of a low closed forest of *Avicennia marina* on the tidal mud flats, with *Rhizophora stylosa* along the limestone embankment and creek line of Pretty Pool Creek. The outline of mangroves in the figure corresponds to the outline shown by the pink line in the model result plots.

There is potential for impacts on the mangroves associated with the decreased tidal prism as a result of changed bathymetry in the development area, due to changes to the current velocity through the mangrove area, and changes in mangrove inundation level and duration. Mangrove distribution in the Pilbara is dependent on a number of factors, including:

- Frequency of inundation (height in the tidal profile, connectivity with the ocean)
- Sediment type, substrate and grain size
- Salinity
- Drainage
- Current speed
- Wave height (Semeniuk and Wurm, 1987)

It is well documented that mangroves typically grow within a narrow topographical band, in general from the contour representing mean water level (MWL) at 0 m AHD, to the contour for mean high water springs (MHWS). Within this range, the frequency of inundation by seawater is sufficient to flush out the groundwater salinity and waste products and provide mangroves with nutrients. However, below MWL, the frequency of inundation is too great and waterlogging occurs. Above MHWS, mangroves cannot survive because the frequency of inundation is too low and groundwater salinity remains too high.

Increases or decreases in water level have the potential to result in waterlogging or inadequate inundation. Changes to current magnitude may result in changes to creek structure or erosion and accretion within the mangroves which could have a negative impact on health and survival.

High salinities in sediments landward of mangrove habitats in the Pilbara are the result of occasional inundation by high spring tides and evaporation (Paling et al. 2003). In these areas salt flats form, which may be devoid of vegetation or contain samphire vegetation which is very salt tolerant. Mangroves at higher elevations adjoining hyper-saline tidal flats are at the extreme margin of their tolerance and are highly susceptible to even minor alterations in naturally occurring environmental conditions. Reduced rainfall or decreased flushing due to sedimentation of peripheral creek lines can result in higher salinity and therefore a decrease in mangrove condition, whereas increased inundation can lead to decreases in salinity which promote an increase in condition and growth.

Mangroves may also grow along the hinterland margin of salt flats. This is more pronounced in mangroves growing in the wet tropics, however it is also occurs in the Pilbara. Figure 4-2 displays examples of this for the study area. Two examples are shown, one of which shows a naturally-occurring example and the second is an example of how this effect can also be created by structures, such as roads, which are constructed over salt flats. In these areas, fresh ground and surface water flows into the mudflats, reducing the salinity of the sediments to below the tolerance limit for mangrove survival (Semeniuk et al. 1978).

Figure 4-1 Mangrove spatial distribution (figure provided by RPS, 2014)

Previous developments in Port Hedland have resulted in incremental loss of mangrove and other intertidal habitats (EPA 2011). This has either been through direct impacts such as clearing, or indirect impacts such as altered hydrology, causing either ponding or reduction in seawater inundation. For example, the construction of causeways that cut off creek lines or impound seawater. Impacts have also been from more subtle long-term effects associated with altered groundwater hydrological regimes, for example impacts resulting from the construction of large scale solar salt ponds (AECOM 2005).

Increased growth of mangroves has also occurred in areas where the salinity of salt flats has been reduced, for example from the leaking of seawater from ponds, or the construction of channels across the salt flats, allowing the inundation of these areas by seawater. This has occurred at the Dampier Salt Eastern Lease Site from the construction of the bitterns channel (Maunsell AECOM 2006).

Figure 4-2 Examples of mangroves growing along the hinterland margin in the Study Area (Image source – Nearmap * Google Earth).

4.2 Impacts Suggested by Results of Hydrodynamic Modelling

Hydrodynamic modelling of the proposed development typical tidal scenarios: 1-month ambient and 2-year ARI spring tide (Scenarios 1 & 2) has shown the following impacts on hydrodynamics for a typical tidal scenario:

> Very minor reduction (<0.5 %) in volume of water flowing into and out of Pretty Pool Creek across a 1-month tidal cycle (Table 2-1).

> Mostly comparable maximum water levels and current magnitudes across the mangroves for pre- and post-development scenarios for the typical tidal scenario.

> Little or no decreases in in maximum inundation water levels within existing mangrove habitat which may cause a negative impact on health and survival. Water levels are predicted to be very slightly higher and

therefore extend further into the salt flats to the north of the study area for the Design Case, however these are outside the vegetated mangrove areas and, given that they are high in the tidal profile, would tend to reduce the salinity of the salt flats and promote mangrove growth rather than cause negative impacts along the landward margin of the existing vegetation. Similarly for the Athol Design Case, maximum water levels are predicted to be slightly higher (3 cm); however this would also tend to promote mangrove growth on the seaward edge of the salt flats.

- Little or no increases or decreases in current magnitude predicted within existing mangrove habitat.
- Small increases in current magnitude (up to 5 cm/s) are predicted in some salt flat areas immediately adjacent to the development area. There is potential for this to encourage the development of drainage and promote the colonisation of mangroves along the edge of the channels.

Impacts on mangroves are therefore considered likely to be minimal as a result of hydrodynamic changes during typical tidal conditions for either the Design Case or the Athol Design Case. It is possible that increases in water levels and current magnitude on the salt flats leads to development of new creeks and therefore a landward expansion of mangrove habitat in this area.

Results of hydrodynamic modelling for a 20-years and 500-yrs ARI Cyclone Scenario, has shown the following impacts on hydrodynamics for an extreme event:

- Up to 5% reduction in volume of water flowing into and out of Pretty Pool Creek for the Design Case, and up to 16 % reduction for the Athol Design Case.
- Small increases in maximum inundation water depths of up to 5 cm across the mangroves and salt flats during the 20-years ARI storm conditions for the Design Case and 7 cm for the Athol Design Case, which are likely to be inconsequential given the transient nature of the conditions.
- For the Design Case, maximum inundation water depths were unchanged for the majority of the study area from the Base Case during a 500-years ARI Cyclone Scenario. However, there was an area of mangroves towards the mouth of the creek that is predicted to experience increased water levels of up to 7 cm.
- For the Athol Design Case, the majority of the study area showed an increase of up to 5 cm maximum water levels during a 500-years ARI Cyclone Scenario, and the mangroves towards the mouth of the creek are predicted to experience increased water levels of up to 15 cm.
- The 500-years ARI Cyclone Scenario is predicted to have a considerable effect on the current flows in the study area for the Base Case, the Design Case and the Athol Design Case. High current speeds are predicted for the salt flats between the mouth of Pretty Pool and the Stables development footprint (Figure 2-23), which would likely result in mobilisation of sediments of the salt flat. Currents through within the mangroves are considerably less, and mostly similar for the Base Case, the Design Case and the Athol Design Case in this area.
- The Design Case and the Athol Design Case results in increased current speeds of 15 cm/s and 30 cm/s respectively towards the western end of the mangroves and salt flats (Figure 2-22). This results in increases in current speed of up to 15 cm/s and 30 cm/s for the Design Case and the Athol Design Case respectively. While this is a relatively large increase, current speeds in the mangroves are low in comparison to those predicted for the salt flats (Figure 2-23). The Base, Design and Athol Design Cases are all likely to result in mobilisation of salt flat sediments leading to damage to the mangroves in this area for this scenario, with slightly increased currents due to the development predicted.

On the basis of these results, an increase in the severity of impacts on mangroves as a result of hydrodynamic changes during extreme events are possible; however, these are likely to be minimal and insignificant in comparison to likely wind damage at such times.

4.3 Impacts Suggested by Results of Hydrological Assessment

The potential for impacts to mangroves from altered groundwater and surface water regimes was investigated using the results of the Local Water Management Strategy (Cardno 2014b). The results from this suggest that there will be decreased surface runoff from the developed site in comparison to the existing salt flats and the hinterland. None the less, storm water discharges are predicted (Figure 4-3) to flow into the mangroves. The predicted decrease is a result of the increased permeability of the fill material than the existing soils. However, given the relative permeability of underlying layers, groundwater discharge is likely to occur at the base of the fill area where it meets the salt flats.

This could in fact result in an overall increase in freshwater onto the tidal flat. It is likely to create a hinterland effect at the base of the development bund wall and potentially allow for colonisation of mangroves along the wall and on the margins of any drainage channels forming due to the altered patterns of freshwater run-off.

The water budget of the site is also likely to be changed due to altered land use. Residential and public open space will be irrigated using scheme water from offsite, potentially leading to increased infiltration to groundwater. Nutrients discharged from these areas have the potential to lead to increases in growth of mangroves.

The additional freshwater and nutrients associated with suburban land use also has the potential to lead to increased cyanobacterial mat (algal) growth on the salt flats (Paling et al. 1989) which may be visually apparent from the development area.

There is a possibility that the altered surface flows and the weight of the development could create a hydrostatic head and alter groundwater flows such that hyper-saline groundwater associated with salt flats under and adjacent to the development moves towards the mangroves. When groundwater salinity exceeds mangrove tolerance limits, negative impacts on mangrove health can occur along the salt flat / mangrove vegetation boundary. This phenomenon has been observed in the region in the past in relation to the placement of solar salt ponds on supratidal mudflats (AECOM 2005). However, there is no evidence of this occurring from similar historical land developments in the area, and increases in freshwater flow from the development are likely to counteract this potential impact. This is therefore considered to be an unlikely impact.

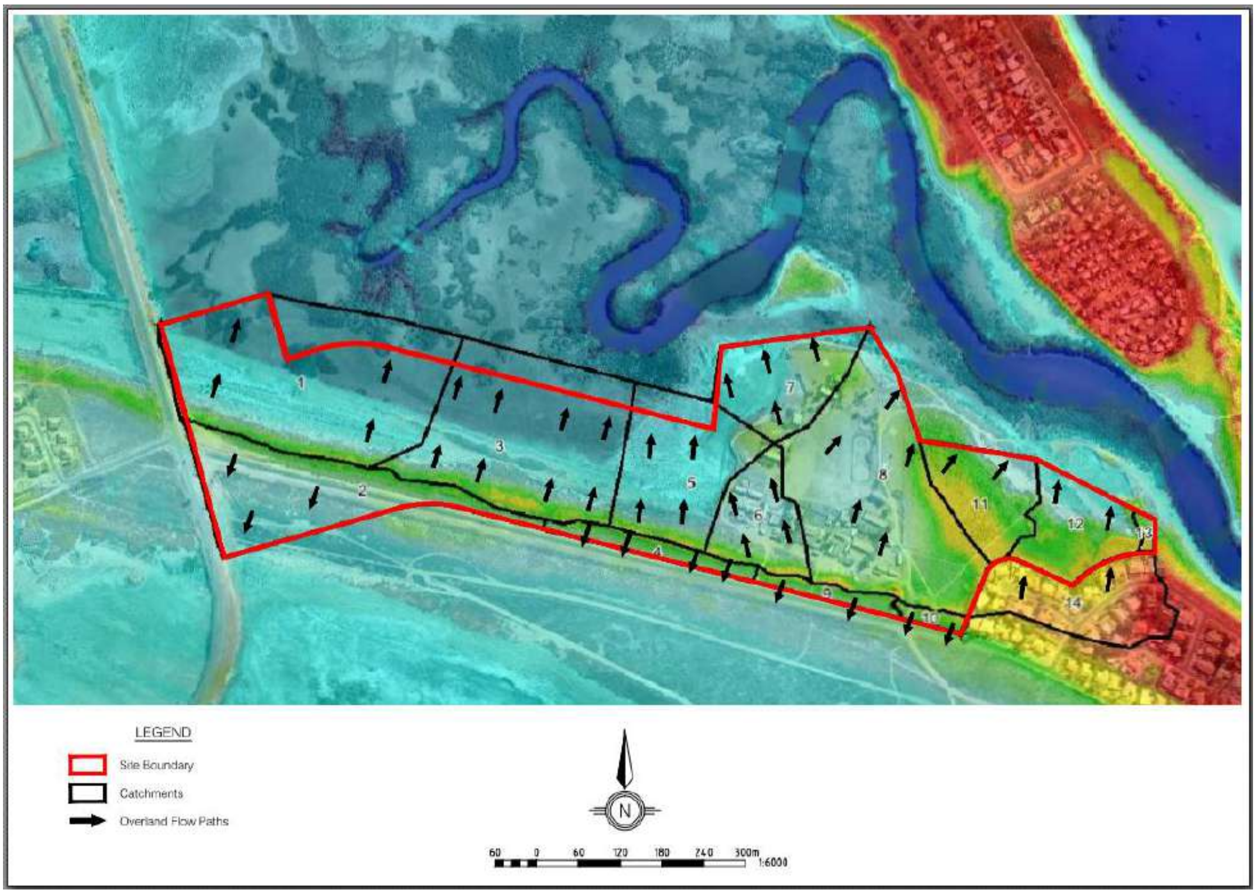

Figure 4-3 Surface water flow paths (Cardno 2014b).

4.4 Conclusions

The potential impacts associated with the development are summarised in the matrix below, Table 4-1.

Table 4-1 Mangroves impact and effect matrix

	Mechanism for positive impacts	Mechanism for negative impacts	Conclusions
Water Level	Increased water levels associated with storm events may increase flushing of hyper-saline flats and increase area suitable for mangrove growth.	Increased water levels during extreme storm events	Water level differences during typical conditions are patchy and of small magnitude. Therefore water level changes are considered likely to have minimal impact on mangroves. An increase in the severity of impacts on mangroves as a result of hydrodynamic changes during extreme events is possible; however, these are likely to be minimal and insignificant in comparison to likely wind damage at such times.
Current Flows	Increased flows during storm events may lead to erosion of salt flat sediments, creation of new drainage lines, reduction in salinity and increase in area available for mangrove recruitment.	Negative impacts to mangroves near the mouth of the creek are indicated during extreme storm events (cyclones).	Direct cyclonic impacts on vegetation likely to be greater than effects from altered hydrodynamics associated with the development, therefore impacts on mangroves associated with altered current flows are also considered to be minimal. As for water level increases, an increase in the severity of impacts on mangroves as a result of hydrodynamic changes during extreme events is considered to be insignificant in comparison to likely wind damage at such times.
Groundwater Salinity	Increased localised freshwater flows due to hinterland effect, stormwater drainage and altered land use. Localised freshwater input is predicted to result in a decrease in groundwater salinity (and increased nutrient concentrations) in tidal flats, potentially promoting mangrove colonisation and growth, particularly on the salt flat along the development margin.	Altered hydrology and weight of development may cause hydrostatic head and alter groundwater flows such that hyper-saline groundwater under and adjacent to the development moves towards mangroves.	Mangrove recruitment along the bund wall is predicted. Mangrove condition on the seaward margin of the salt flats may improve due to decreased salinity associated slight increases in inundation and current flow, conversely there is potential for delayed negative impacts on creek mangroves along salt flat margin. On balance, it is considered most likely that the development will decrease the salinity of the salt flats and promote the survival and growth of mangroves.
Nutrients	Nutrients introduced by altered land use may result in increased growth in mangroves.	Nutrients may cause increased cyanobacterial mat (algal) growth on the salt flats which may be visually apparent from the development area	Both positive and negative impacts from increased nutrients are likely to be minimal.

5 Erosion Potential Investigation

5.1 Geomorphic Setting

The general coastal morphology of the Port Hedland region is a limestone barrier system which is typified by the low coastal cliff and rock outcrop formations along the shoreline. In general, there are limited mobile sediments present at the shoreline, however, the development of the Spoil Bank from dredge spoil since the 1960’s has provided a source of mobile sediment. Eliot et al (2013) found the Port Hedland area to consist of one secondary compartment with four tertiary sediment cells; the study area lies in the Beebingarra cell. A sediment cell is considered to be an area where sediment movement outside the cell is largely constrained. The area was found to differ from the ‘typical’ Pilbara behaviour described by Semeniuk (1996), as there is limited fluvial sediment input, although there is some sediment supply through coastal transport.

The coastline is identified as a mixture of Pleistocene and more recent overlying Holocene formations (Semeniuk, 1996). The large tidal range combined with wave forcing provides a highly energetic environment near the shoreline, which results in limited mobile sediments remaining in the nearshore zone. Sandy beaches in the Port Hedland region are normally perched on rock platforms or are constrained by rock formations. As a result of the underlying rock along much of the coastline, the mobility and erosive potential is limited under the combined effects of waves and currents.

Cooke Point is located at the narrowest point in the tidal flats along the Beebingarra cell, in an area of limited sediment. The sediment in the inter-tidal terrace is highly dynamic. Changes to sediment availability have a significant impact on these types of areas. The analysis conducted by Eliot et al (2013) noted a reduction in sediment availability in the last 50-years, and the onshore migration of the bar immediately offshore from the study area. This could be due to changes up-drift, or due to modifications to the tidal creek networks, including roads and drainage pathways.

Adjacent to Pretty Pool Creek the beach is backed by a vegetated dune system and fronted by sand flats extending up to 700 m offshore.

Mobile sediments in the nearshore zone generally have an eastward movement (translating to southerly in the study area) although this can vary seasonally. The predominantly eastward sediment transport in the nearshore zone at Port Hedland is illustrated by the movement of the Spoil Bank since its formation (Figure 5-1). Eliot et al (2013) suggested the recent spit formation in the vicinity of Pretty Pool could be contributed to sediment supply from the Spoil Bank formation.

The Spoil Bank extends out from the coastline as a sand-spit, parallel to the Newman/Goldsworthy channel. The spoil bank is a major man-made nearshore feature that has developed as a result of dredge spoil from the development of Port Headland Inner Harbour and navigation channel.

Dredging commenced from the mid 1960's when the first iron ore berths were developed. Expansion of the inner harbour facilities and subsequent deepening to accommodate Cape Class vessels required major capital dredging programs in the years 1976 to 1977 (1.9 million m^3) and 1984 to 1987 (12.7 million m^3). Ongoing maintenance dredging has occurred at three to four-year intervals with 600,000 m^3 removed in each of the periods 1998 to 1999 and 2000 to 2001 (Paul, 2001).

The northern end of the spoil bank curves to the east suggesting that eastward sediment transport is the dominant sediment transport direction, associated with the prevailing swell direction. The evolution of the spoil bank between the years 1949 to 2009 is shown in Figure 5-1.

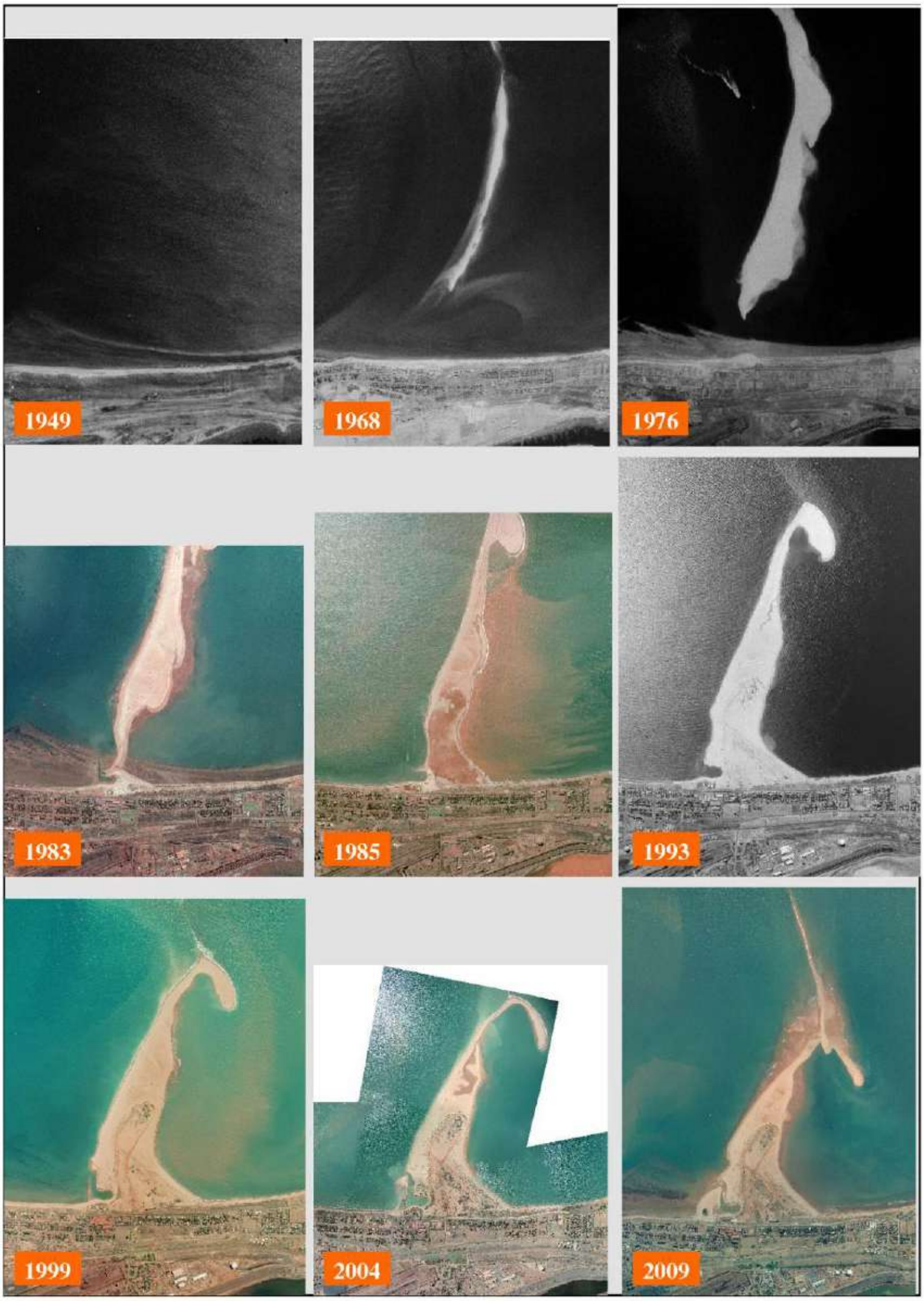

Figure 5-1 Evolution of the Spoil Bank 1968 to 2009 - Port Hedland (Cardno 2011)

5.2 State Coastal Planning Policy (SPP2.6)

The WAPC gazetted the latest SPP2.6 in July 2013. The purpose of SPP 2.6 is to provide guidance for decision making within the coastal zone, including managing development and land use change. Schedule One of SPP 2.6 provides guidance for calculating the coastal foreshore reserve to allow for coastal processes including present day erosion, historical shoreline movement, sea-level rise and storm surge inundation. The component of the coastal foreshore reserve to allow for coastal processes should be sufficient to mitigate the risks of coastal hazards by allowing for landform stability, natural variability and climate change. The coastal foreshore reserve is a critical input into the coastal hazard risk management and adaptation planning framework outlined in SPP 2.6.

This study examines the effects of predicted coastal erosion on the stability of the creek entrance. The area to be assessed is treated as sandy coast, as per the policy recommendations. The allowance for erosion on sandy coasts is calculated as the sum of the S1, S2 and S3 Erosion components, plus 0.2 m per year allowance for uncertainty, and should be measured from the horizontal shoreline datum (HSD):

1. (S1 Erosion) Allowance for the current risk of storm erosion
2. (S2 Erosion) Allowance for historic shoreline movement trends
3. (S3 Erosion) Allowance for erosion caused by future sea level rise

SPP 2.6 states that the coastal foreshore reserve should be defined on a case by case basis including S1, S2 and S3, where relevant. Each of these components is assessed in this report by the following methods:

- S1 Erosion: Selected profile modelling of storm erosion using the storm erosion model system SBEACH (Storm-Induced Beach CHange).
- S2 Erosion: Analysis of historical aerial photography to establish historical shoreline changes.
- S3 Erosion: Application of an allowance of 90 m of shoreline recession based on a vertical SLR of 0.90 m over the 100 years planning horizon to 2110.

The coastal foreshore reserve is applied from a horizontal shoreline datum (HSD), a fixed line that is defined on the basis of the type of coastline being assessed. The HSD defines the active limit of the shoreline under storm activity, and should be determined against the physical and biological features of the coast. In most cases it should be defined as the seaward shoreline contour representing the peak steady water level under storm activity.

Schedule One of SPP2.6 describes different areas for the definition of the storm event for use as the defined storm event in the assessment of inundation and erosion. The Port Hedland region lies in an area of the Western Australian coast that is affected by severe tropical cyclones. Policy guidance for coastal erosion is that a cyclone event corresponding to the 100-years ARI ocean forces and coastal processes should be selected, tracking to maximise its erosion and inundation potential.

Included in SPP 2.6 is the current policy relating to the Sea Level Rise (SLR) projection for the 100-years planning period up to 2110. This has been adopted for this study and +0.9m for a 100-years (2110) planning period.

5.3 Allowance for the Current Risk of Storm Erosion (S1 Erosion)

Storm-induced erosion was investigated in the study area using the SBEACH numerical model as part of the PHCVS (Cardno, 2011). Results were extracted for Transects 6 and 7 from the PHCVS, as shown in Figure 5-2. SBEACH (Storm-induced BEAch Change) was developed to calculate beach and dune erosion under storm wave action, as described in Wise et al (1995).

The following parameters were input into the SBEACH model:

- Beach profile from the top of the foredune to offshore based on the digital terrain model (approx. +8m to -8m AHD).
- Depth of available sand below the beach profile.
- Depth of underlying rock strata (SBEACH 'hard bottom' feature).
- Sediment grain size.
- Time-series of water-level for a Category 5 Cyclone Event (tide + storm surge).
- Time-series of significant wave Height (H_s) for a Category 5 Cyclone Event.
- Time-series of peak wave period (T_p) for a Category 5 Cyclone Event.

The response of the beach profile was assessed for short-term erosion based on design storms representative of a Category 5 Cyclone. This was selected as per the earlier revision of the State Coastal Planning Policy, current at the time of writing the PHCVS. The 500-year design storm was run three times consecutively. The latest SPP 2.6 recommends the 100-year ARI design storm, as discussed in Section 5.2. For comparison purposes, SBEACH modelling of Cyclone Connie and Cyclone John was additionally undertaken on each SBEACH profile and presented along with the 500-years design storm results. Cyclones Connie and John are two of the three most severe events recorded at Port Hedland as of 2011.

Figure 5-2 SBEACH transect locations from PHCVS

The PHCVS model was run using a 0.3 mm grain size. Subsequent studies by Cardno (Cardno 2013) show this is a conservative simulation as sediment samples taken from the area had a D_{50} of 0.48 to 0.78 mm. The smaller grain size is more mobile so results will potentially show greater erosion than is likely to occur. Sensitivity analysis on grain size conducted in the PHCVS showed that an increase in modelled grain size to 0.4 mm reduced the erosion by 43%.

The change to the shoreline profile from the SBEACH model results were assessed at the vegetation / Horizontal Shoreline Datum (HSD) line (4.2m AHD). The results from the SBEACH model are presented in Figure 5-3 and Figure 5-4. Profile 6 is considered to be more representative of the entrance conditions. The results for the three storms are summarised in Table 5-1 below.

The maximum distance of erosion from the HSD line is predicted to be 19 m for Profile 6 for the 500-year design storm event. For Cyclones Connie and John, this recession is predicted to only be 1 and 2 m respectively. The HAT contour is predicted to move seaward by 4 m for the 500-year design storm, as the dune face slumps. This contour is predicted to recede for Cyclones Connie and John. Note SBEACH assumes the material to be eroded consists solely of sand, and doesn't take into consideration any vegetation or matting that may reduce erosion. The results should be interpreted as a worst case scenario of the potential storm-induced erosion at the site.

The location of the underlying rock structure was set as part of Cardno (2011). The results show the profile eroded back to this location for the 500-year design storm. If this rock structure was not at the location assumed in the model, there could potentially be more erosion experienced at the site. It should be noted that review of aerial photography and landforms strongly suggest that the northern bank of the Pretty Pool Creek entrance is underlain by rock due to the generally stable configuration of this area – see Section 5.4.

Table 5-1 Results From SBEACH Modelling, Profile 6, D_{50} 0.3 mm

Storm Event	HSD Line (4.2m AHD)	HAT Line (3.6 m AHD)
500-year Design Storm	-19 m	+4 m
Cyclone Connie	-1 m	-3 m
Cyclone John	-2 m	-4 m

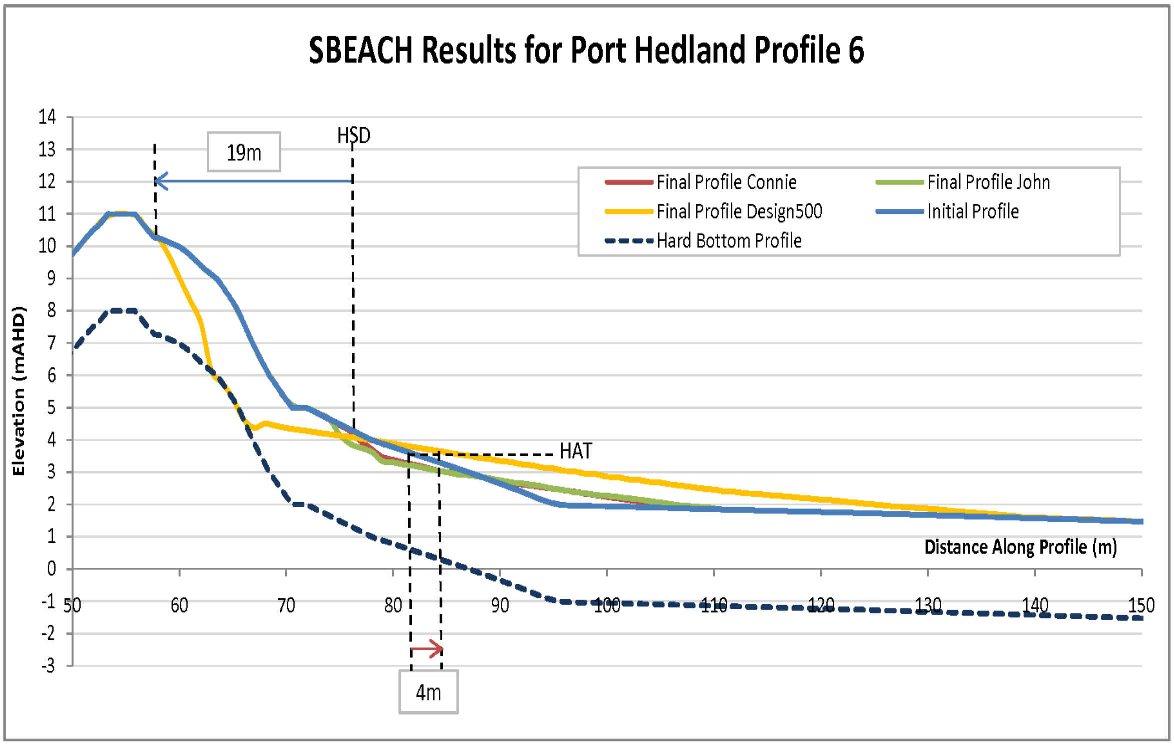

Figure 5-3 SBEACH results for Profile 6, north of the creek entrance

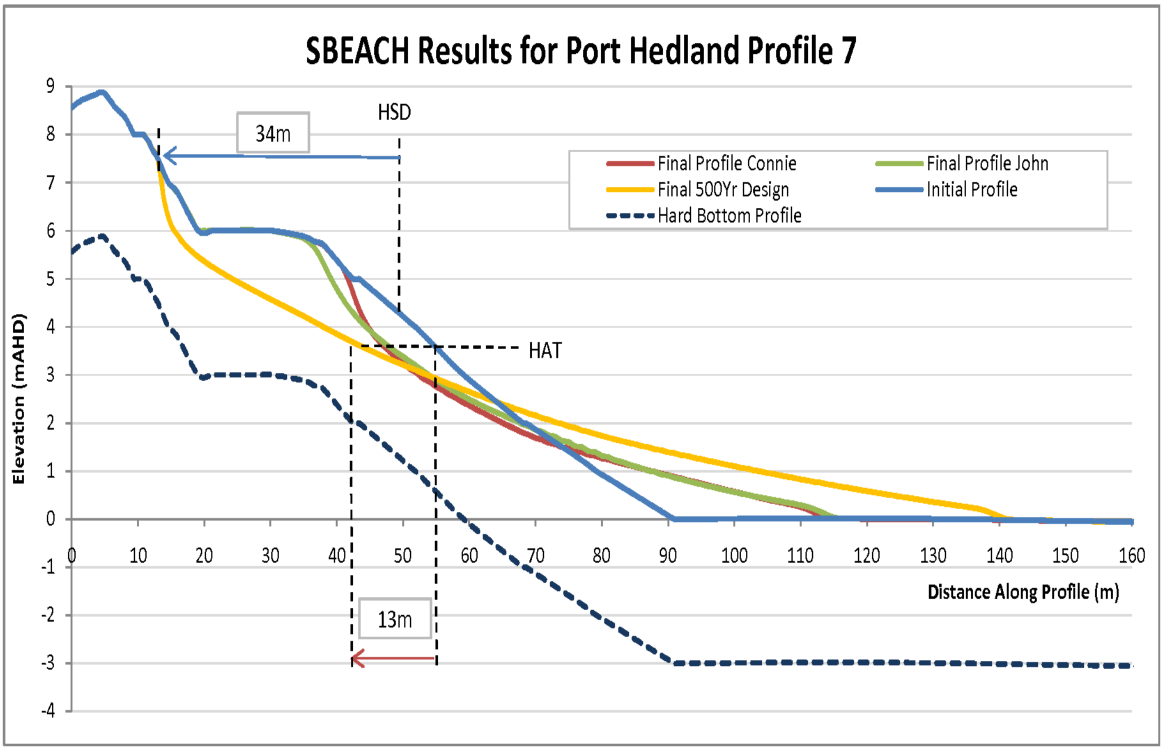

Figure 5-4 SBEACH results for Profile 6, north of the creek entrance

5.4 Allowance for Historic Shoreline Movement Trends (S2 Erosion)

Nine aerial data sets were obtained from Landgate Imagery as part of Cardno (2011) covering the 60-years period between 1949 and 2009 as shown on Table 5-2**.** Major cyclones preceding each of the aerial datasets are also shown.

Table 5-2 Port Hedland Photogrammetric Sources

Date	Source	Resolution	Preceding Major Cyclone Event
1 August 1949	LANDGATE Imagery	1:50000	Unknown
2 June 1968	LANDGATE Imagery	1:80000	Shirley (Mar 1966)
15 November 1976	LANDGATE Imagery	1:34500	Joan (Dec 1975)
1 September 1983	LANDGATE Imagery	1:12000	Jane (Jan 1983)
7 July 1985	LANDGATE Imagery	1:25000	Chloe (Feb 1984)
4 August 1993	LANDGATE Imagery	1:50000	Connie (Jan 1987)
25 July 1999	LANDGATE Imagery	1:25000	Gwenda (April 1999)
1 September 2004	LANDGATE Imagery	1:7500	Monty (Feb 2004)
18 May 2009	LANDGATE Imagery	1:25000	George (Feb 2007)

As part of the PHCVS, photogrammetric analysis was carried out on the aerial photographs. Aerial images were converted to 3D vector data by triangulating survey points within each of the aerial photography datasets. Following this the MHWS and HAT lines were determined within each of the datasets and used to assess shoreline movement.

- Mean High Water Springs MHWS = 2.8m AHD
- Highest Astronomical Tide HAT = 3.6m AHD

Transects were cast at 100 m intervals along the shoreline. Figure 5-5 shows the position of transects along the present study area. For each of the years of photogrammetric data, the transect lines were measured to the intersection point of the MHWS contour. This contour was plotted over the aerial photographs, and the movement over time assessed. For this study, the MHWS contour was extracted from the LiDAR data provided by LandCorp and added to the figure. This assessment is described below in Section 5.4.2.

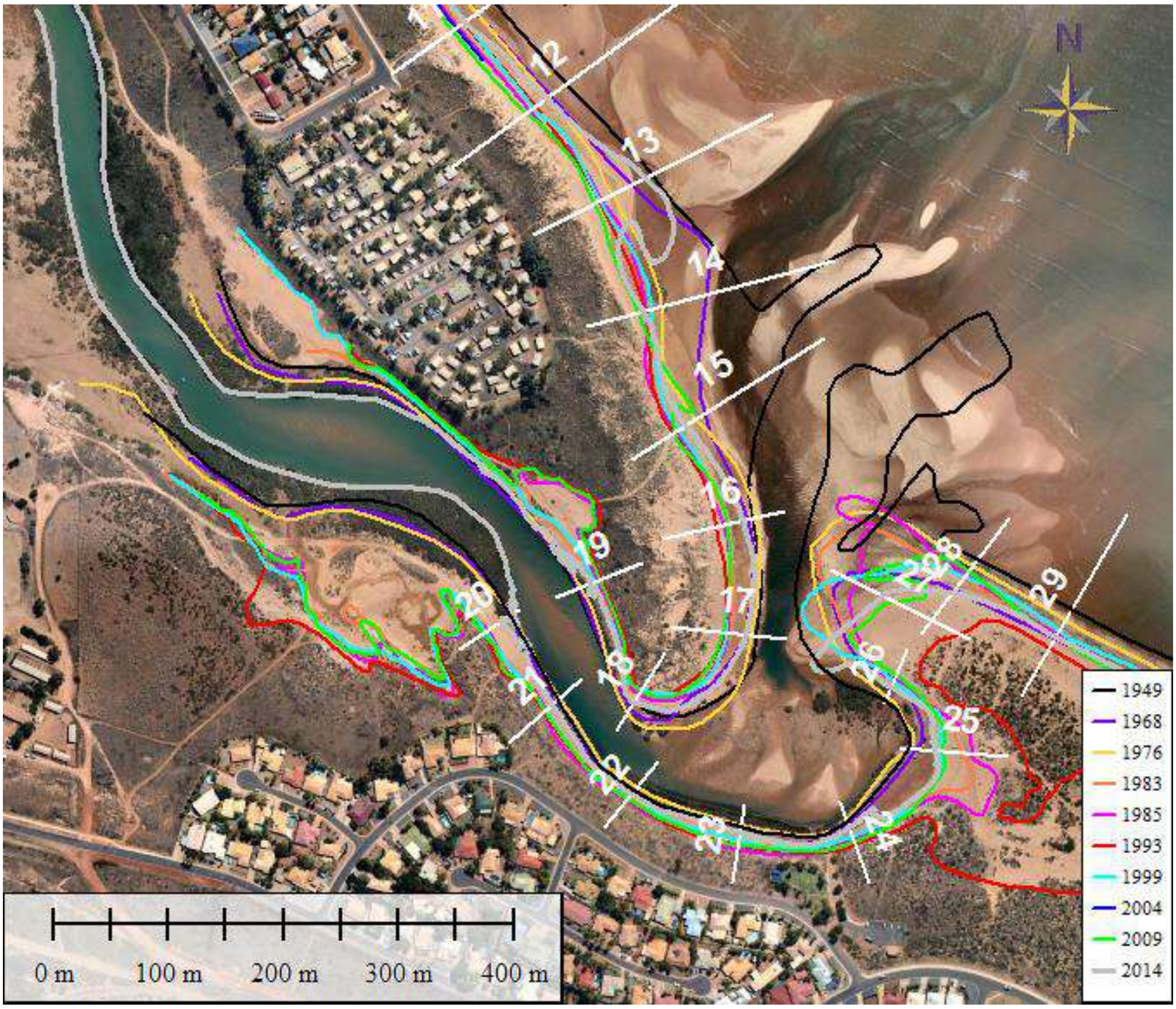

Figure 5-5 Transects 12 to 29, cast at 100 m intervals. Coloured lines indicate the MHWS contour for each aerial photograph year

Shoreline position change was calculated as the difference in transect length relative to the 1985 dataset. The baseline year of 1985 was selected as this was the year in which the spoil bank was established as a connected landform on the Port Hedland shoreline (refer Figure 5-1). The shoreline position by transect is analysed in Section 5.4.3.

5.4.2 Spatial Analysis

Transects relevant for this study area are transects 16 and 17. Figure 5-6 presents these in a zoomed-in view between the year 1949 and 2014. The shoreline position receded in the survey periods 1968, 1976 and 1983. There was very little movement in subsequent years until 2009. The 2014 MHWS contour indicates significant accretion, almost to the 1968 level.

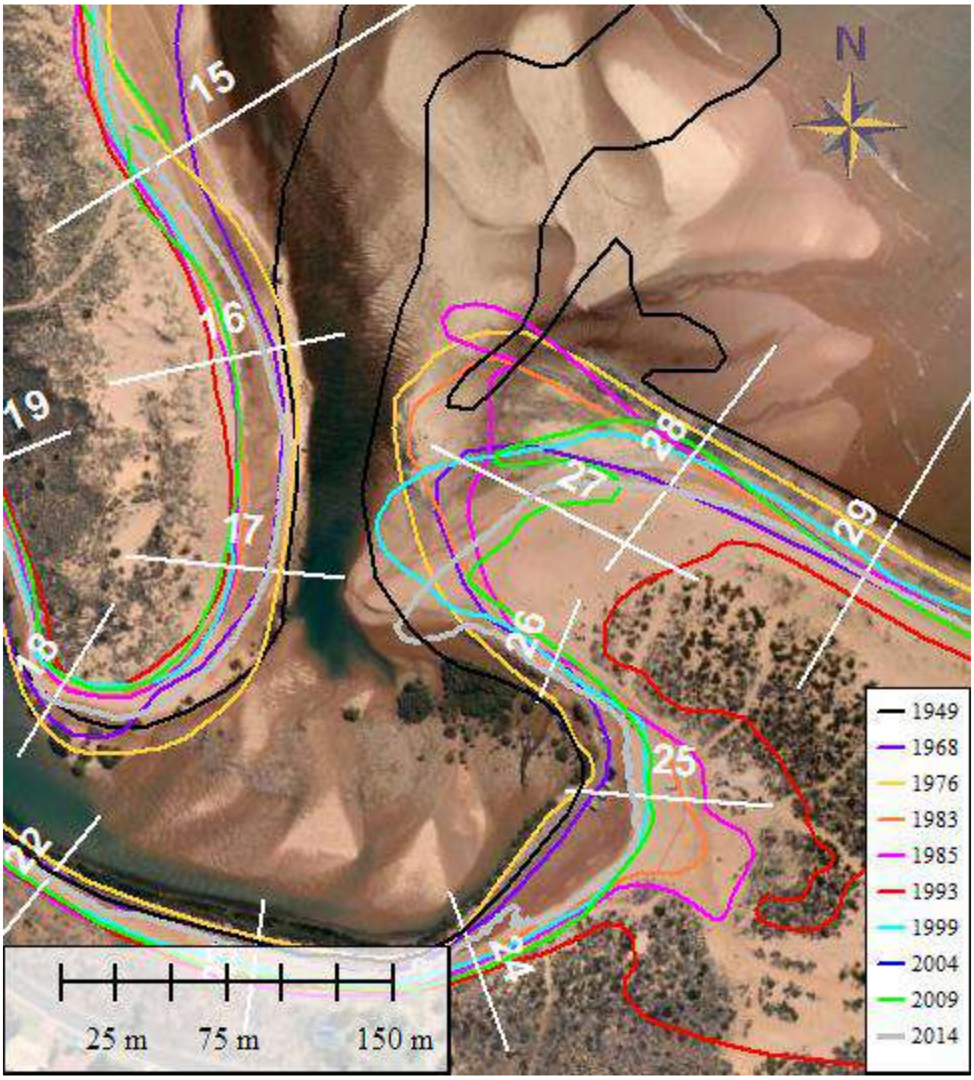

Figure 5-6 Historical shoreline position change for transects 16 and 17

5.4.3 Transect Analysis

The net change in the shoreline position was assessed over the 65-years period from 1949 to 2014 based on the shoreline position in the first and last photogrammetric data sets. To measure change in shoreline position across the study site, each of the transect lines was measured to the intersection point of the MHWS contour for a given photogrammetric set.

The net shoreline change over the period is shown for transects 16, 17 and 28 in Figure 5-7. Transect 28 is included to allow a comparison with the southern side of the creek mouth. All transects show a net recession of the shoreline. Note this movement could oscillate over the time period; this figure indicates the underlying trend. Transects 16 and 17 have a net recession of less than 10 m.

To further understand the timing and causes for the shoreline position changes, a breakdown of the shoreline position change into the years 1949 to 1983 and 1985 to 2014 is shown in Figure 5-8 and Figure 5-9. From 1949 to 1983 the shoreline receded for all transects. From 1985 to 2014, transects 16 and 17, accreted on average by 23 m.

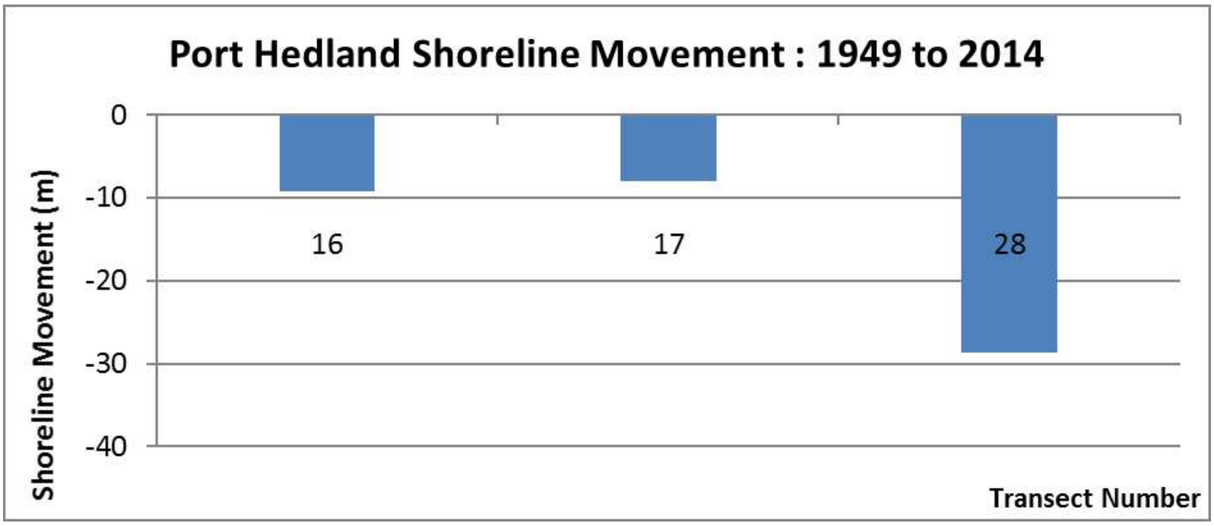

Figure 5-7 Net Shoreline Changes 1949 to 2014

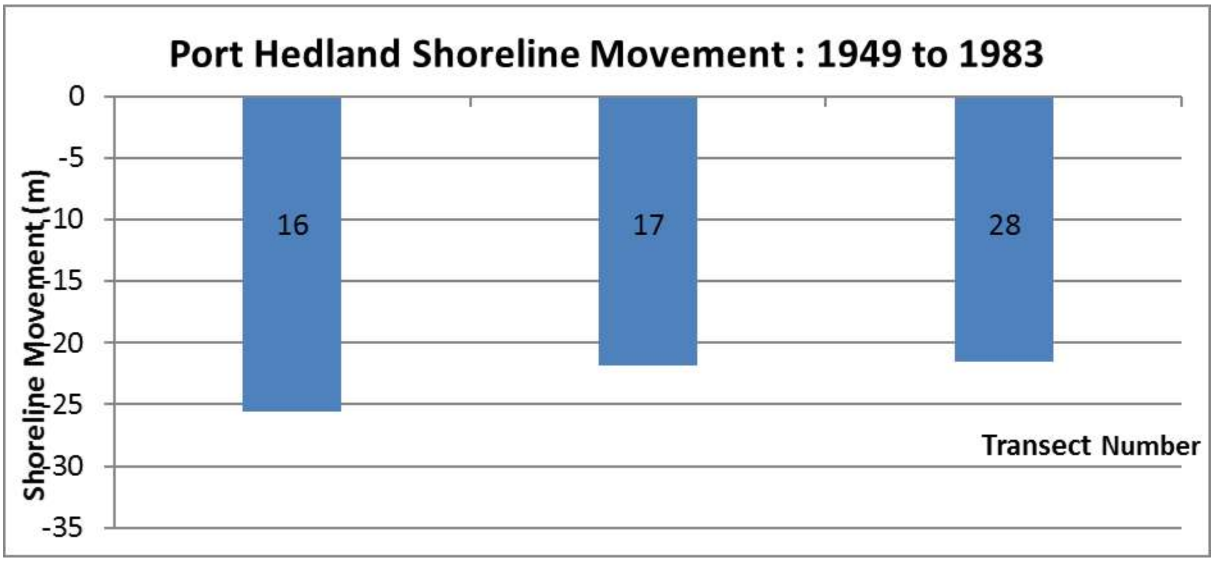

Figure 5-8 Net Shoreline Changes 1949 to 1983

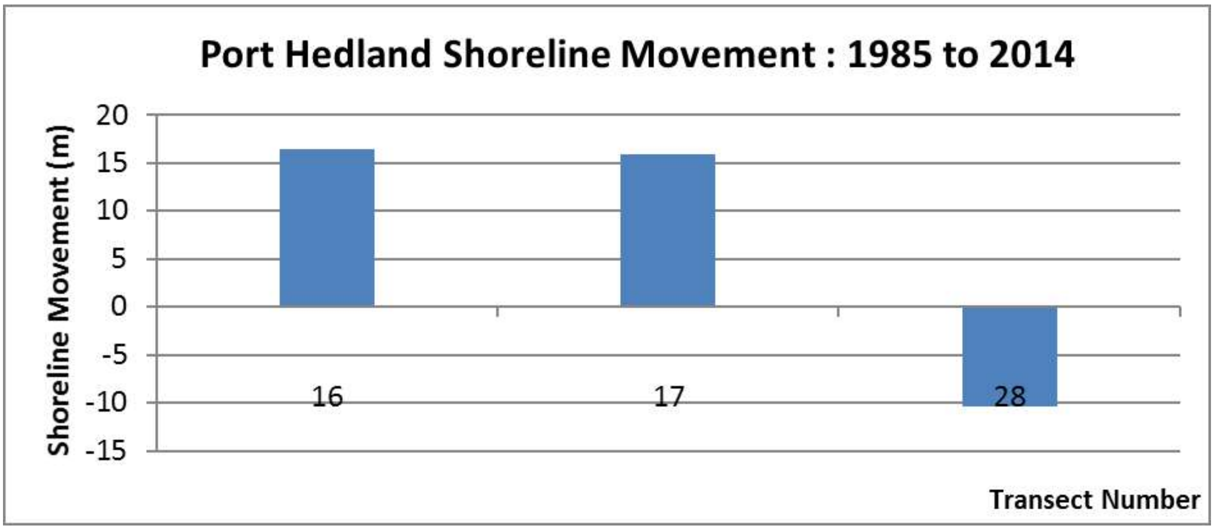

Figure 5-9 Net Shoreline Changes 1985 to 2014

5.5 Allowance for Erosion Caused by Future Sea Level Rise (S3 Erosion)

SPP2.6 recommends a response to sea-level rise of 100 times the vertical sea-level rise. This corresponds to a recession of 90 m for the 2110 planning period.

5.6 Total Erosion Potential

As discussed in Section 5.2, the allowance for erosion on sandy coasts is calculated as the sum of the S1, S2 and S3 erosion components, plus 0.2 m per year allowance for uncertainty. This is presented in Table 5-3.

The S1 value calculated in Section 5.3 is not directly applicable at the mouth of Pretty Pool Creek. The presence of the sand bar system at the mouth will significantly attenuate the wave action resulting in less erosion occurring at the spit than predicted at Profile 6. For an indication of the potential variation, results are presented for Cyclones Connie, John as well as the 500-year design storm.

The S2 allowance presented in Table 5-3 is calculated as 100 times the historic annual rate of erosion, as per SPP2.6 requirements. The maximum historic erosion presented in Section 5.4 at the study site is 10 m over the 65-year analysis period. This corresponds to an S2 value of 15 m.

The S3 allowance is conservative as it assumes the Bruun rule is applicable at the site. It is anticipated that the presence of the bed rock would limit the erosion to a much smaller value.

The average width of the vegetated dune on the spit is 115 m, and the distance from the HSD line to the concept development footprint is 230 m. Whilst applying these methods is not directly applicable at the mouth of the creek, these conservative results provide sufficient confidence that the spit will remain to protect the development site for the 100-year planning period.

Table 5-3 Predicted erosion allowance

S1 Result	Acute Erosion (S1)	Long-term Erosion (S2)	Sea Level Rise Erosion (S3)	Uncertainty Allowance	Erosion Setback (m behind HSD)
500-year Design Storm	19 m	15 m	90 m	20 m	**144 m**
Cyclone Connie	1 m	15 m	90 m	20 m	**126 m**
Cyclone John	2 m	15 m	90 m	20 m	**127 m**

6 Conclusions & Recommendations

A calibrated hydrodynamic model has been developed for Pretty Pool Creek, surrounding mangroves and adjacent township. Simulations suggest that the post-development layout will result in little alteration to the hydrodynamic regime of the mangroves and the creek under normal tidal conditions. During extreme events, the post-development layout results in alterations to the hydrodynamic regime of the mangroves and creek with an average recurrence interval less than 1 in 20 years.

Following initial modelling results (Cardno 2014), the development footprint has been modified to minimise the potential for impact on mangroves. The original design reduced the channel width in the salt flats to the near the entrance of Pretty Pool Creek and resulted in increases to the current magnitude flowing through the mangroves under extreme conditions. Three different design options were examined and Option 2 was considered optimal for the channel width, and selected as the revised development footprint for further analysis.

For typical conditions, model results for the revised development footprint (Design Case) showed very little change in inundation level or current speed within the mangroves. Slight increases in both inundation level and current speed were predicted over the salt flats, which would tend to have a positive effect on mangrove condition, particularly at the seaward margin of the salt flats.

During extreme events, current speeds are likely to be sufficiently high to result in the erosion of sediments from the salt flats. This is predicted to occur for the existing conditions (Base Case), and the presence of the development (Design Case) increases the speed of currents and also therefore increases the likelihood of mobilisation of sediments. The Athol Design Case results in further increases in current speed, particularly in the salt flats to the west of the mangroves. This may result in redistribution of the mangrove habitat, however given the frequency of these events it is likely that other direct impacts (i.e. wind) will likely be more significant than the alterations to the hydrodynamic regime due to the development

The replacement of the very high salinity salt marsh (which limits the mangroves) with development fill will likely concentrate the fresh water input from the local catchment to the periphery of the developed area. This concentration of freshwater input may provide favourable conditions for the mangroves, with colonisation occurring in areas adjacent to the development that previously were limited due to high salinity.

Assessment of the stability of the Pretty Pool Creek entrance due to the effects of storm bite, historical trends and sea level rise has been undertaken. On the basis of the assumptions and assessment undertaken here it is concluded that this area is likely to remain relatively stable over the design life. However it is recommended that a geotechnical investigation be performed to establish the presence and depth of bedrock in this area to add additional confidence to this conclusion. Based on the hydrodynamic modelling undertaken it is unlikely that the development will result in hydrologic changes that effect the morphology of the entrance under ambient conditions, however under extreme conditions there may be some different morphological response of the creek and entrance due to the altered flow paths predicted.

On the basis of this preliminary assessment, the Stables development alone is not anticipated to have significant negative impacts on the mangroves. With the addition of the Athol Street development, higher levels of inundation are observed by water flowing over Cooke Point Drive. This road could be raised as part of the development process if this predicted increase of 15-20 cm in inundation is undesired.

6.1 Implications for Development

The development footprints have been modelled assuming the full Design footprint is to be used as residential development for a planning timeframe of 100 years. That is, it was assumed that the full footprint will be filled to a level of +6.6 m AHD and the area protected by a bund wall of suitable rock design for stability. This meets the SPP2.6 inundation criteria for the 100-year planning timeframe – above the 500-year ARI water level. As per the erosion investigation summarised in Section 5.6, the site is also landward of the erosion hazard line for the area, so the erosion hazard criteria of SPP2.6 for the 100-year planning timeframe are also met.

Should short term development be preferred in any portion of the Design footprint, the requirements of the site can be less demanding than a fully filled site. For example, if shorter design life, say 30 years, accommodation options are desired, these may be located within the Design development footprint without bunding, as long as the finished floor level (FFL) of any permanent structures are raised above the corresponding planning timeframe inundation level with associated localised scour protection. Plans for a managed retreat should be put in place during the lifetime of the development, to ensure appropriate use of the land occurs in line with climate change.

It is understood that a concept plan for a caravan park in the eastern portion of the Design footprint was put forward in 2013. This had caravan sites located within the 3.5 m AHD to 5 m AHD contours, with the more permanent structures located above the 5.5 m AHD contour. The Port Hedland Coastal Vulnerability Study (Cardno 2011) calculated the return period water levels for East Port Hedland. These are presented for the present and 2110 climate scenarios in Table 6-1.

From this table, it is apparent that the caravan sites would be inundated during the 2-year to 20-year ARI events. The permanent structures would only be inundated under the present day 500-year ARI event. Therefore, the caravan park site is probably suitable for a planning timeframe of roughly 50-years, however the caravan sites would likely be inundated several times during this timeframe.

Any short-term development proposed within the Design footprint should take these levels into consideration.

Table 6-1 Design Peak Total Still Water Level (TSWL), excluding wave setup, for East Port Hedland (Cardno, 2011)

ARI (years)	Peak TSWL (m AHD) Present Climate Scenario	Peak TSWL (m AHD) 2110 Climate Scenario
2	3.5	4.4
10	4.0	4.9
20	4.1	5.0
50	4.4	5.3
100	5.0	5.9
200	5.1	6.0
500	5.6	6.6

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Stage 3 (The Stables)
East Port Hedland

APPENDIX B
GEOTECHNICAL INVESTIGATION REPORT

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JDSi Consulting Engineers

Report on Geotechnical Investigation

Stage 3, The Stables, East Port Hedland

30 September 2014

Pour trust
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foundations
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can build
anything

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Report on Geotechnical Investigation

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30 September 2014

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For and on behalf of Coffey

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Richard Moyle
Principal Geotechnical Engineer

Quality information

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1. Introduction

This report presents the results of the geotechnical investigation carried out by Coffey Geotechnics Pty Ltd (Coffey) for JDSi Consulting Engineers (JDSi) associated with the Stables Development, East Port Hedland.

This work was commissioned by Glenn Coffey of JDSi on 13 August 2014 via a purchase order dated 25 July 2014 (Ref. 00000759).

2. Proposed development

We understand that the subject site is located 4km east of the Port Hedland Townsite and occupies approximately 28 hectares over three lots (Lot 5770, Lot 556 and Lot 300). The site is bound by Styles Road to the south, Cooke Point Drive to the west and the existing Pretty Pool residential subdivision to the east. To the north is Pretty Pool.

We understand that the part of the subject site is being leased to the Port Hedland Pony Club, which expires in December 2018. LandCorp are looking to rezone the subject site for residential development.

3. Objectives

The objectives of the geotechnical investigation were to complete Phase 2 works as outlined in our proposal (Ref. GEOTPERT10160AA-AA) and to provide key input in to the following activities:

- Conduct geotechnical and ASS field and laboratory testing and sampling, as appropriate, to satisfy the objectives of the investigation;
- Interpret laboratory and in situ test results to assess engineering soil parameters, as relevant to the development;
- Provide a preliminary assessment of the permeability of the materials;
- Prepare geotechnical reports as appropriate; and
- Provide a geotechnical report outlining the suitability of the site for development. This would also include a discussion of the key geotechnical risks and opportunities for the development.

4. Information supplied by JDSi

You have provided us with the following information:

- East Port Hedland Concept Plan Report (August 2012);
- East Port Hedland Geotechnical Reconnaissance;
- Phase 1 East Port Hedland Urban Water Advice;
- Port Hedland Coastal Vulnerability Study;
- Preliminary Environmental Assessment Report;
- Preliminary Noise Assessment;
- Stage 3 East Port Hedland – Request for Services;
- KMZ files for aboriginal site data and Pretty Pool site;

- LiDAR files covering project area; and
- Aerial Video footage of the site.

5. Fieldwork

5.1. General

Fieldwork was carried out on 11 September 2014 in the full time presence of personnel from Coffey. Test Pit locations were measured by handheld GPS relative to MGA94 and elevations were assessed using LiDAR contour plans provided.

Access to the site was from Styles Road and Sheridan Road. Access within the site was typically along existing unsealed tracks and was limited in in some area areas due to presence of soft estuarine deposits and spring tides. Access into the Stables area was limited due to presence of livestock. Trafficability at the time of fieldwork was suitable for 4 wheel drive and an excavator. Weather conditions were clear and fine.

Approximate investigation locations and general site photograph locations and directions are shown on Figure 1. General site photographs are shown in Figure 5 to 20.

5.2. Test pit excavations

A total of 16 test pits (TP1 to TP16) were excavated by a 5 tonne rubber tracked excavator to depths varying from 0.05m to 2.6m below the existing ground surface. Details of the test pit locations, including coordinates and elevations (based on client supplied LiDAR plan), are shown in Table 1.

Table 1 – Test Pit Coordinates and Elevations

Test Number	Easting (50 MGA 1994)	Northing (50 MGA 1994)	Elevation (mAHD)
TP1	670603	7752904	3.9
TP2	670569	7752944	2.9
TP3	670450	7752947	3.2
TP4	670463	7752984	2.6
TP5	670329	7753030	2.6
TP6	670218	7753068	2.4
TP7	670222	7753014	3.2
TP8	670184	7753019	3.1
TP9	670047	7753073	3.0
TP10	669953	7753102	3.0
TP11	670152	7753028	3.1
TP12	670328	7752994	3.7
TP13	670961	7752994	6.2
TP14	671155	7752923	3.8
TP15	671137	7752922	3.4
TP16	670703	7753138	2.8

The records of the test pit logs showing the major strata that were intersected, the depths at which the samples were taken, in-situ tests carried out, and the results of these tests, together with photographs and Explanation Sheets defining the terms used, are presented in Appendix A.

5.3. Hand probes

Due to the soft nature of the estuarine deposits and the spring tides, access to areas containing estuarine muds using an excavator was limited. In order to assess the thickness of estuarine deposits overlying the limestone hand probes were used to push through the soft estuarine deposits. The depth to limestone as assessed using the hand probes is illustrates on Figure 1.

5.4. Infiltration testing

Two falling head permeability tests, P1 and P2, were carried out across the site, as shown on Figure 1. Tests were completed within the upper 0.5m from ground surface level. The recommended design permeability value is discussed in Section 8.4.

6. Laboratory testing

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

A summary of the results are presented in Table 2. Test certificates are attached in Appendix B.

Table 2 – Laboratory Testing Results

Test Location	Depth (m)	Particle Size Distribution			Acid Sulfate Soil Results
		% Gravel	% Sand	% Fines	
P1	0.5	4	92	4	-
P2	0.5	1	94	5	-
TP2	0.1	-	-	-	Awaiting Results
TP2	0.4	-	-	-	Awaiting Results
TP4	0.5	-	-	-	Awaiting Results
TP4	1.0	-	-	-	Awaiting Results
TP5	1.4	-	-	-	Awaiting Results
TP6	1.3	-	-	-	Awaiting Results

We are awaiting the laboratory results of the Acid sulfate soils testing. Once results are received an assessment will be provided as an addendum to this report.

7. Site conditions

7.1. Surface conditions

The site occupies an irregular shaped area predominately bound by Styles Road to the south, Cooke Point Drive to the west and the existing Pretty Pool residential subdivision to the east and tidal flats to the north.

The site is approximately 28 hectares over three lots (Lot 5770, Lot 556 and Lot 300) and is situated on topography with ground elevations ranging from 8m AHD to about 2.4m. Lot 5770 is currently leased to the Port Hedland Pony Club for horse stable and pony club activities.

Vegetation predominantly comprises low lying shrubs, small trees grass and mangroves. A number of unsealed access track tracks exist across the site.

7.2. Subsurface conditions

The 1:50,000 Geology Series map (Port Hedland sheet) indicates that the subsurface profile comprises dune limestone, mud and silt, older dune shelly sand and mobile dunes as shown on Figure 2.

Based on the field investigation and the above map the site has a generalised subsurface profile presented in Table 3.

Table 3 – Generalised Subsurface Profile

Area	Unit	Description	Remarks
A	Dune Sand	Sand; Fine to coarse grained sand with trace silt gravels and shell, loose to medium dense	Previous investigations in the area indicate the dune sand is underlain by Estuarine muds as illustrated in TP15, or by limestone.
B	Estuarine Deposits	Sandy Clay/Clay: low to high plasticity, grey and brown, generally very soft to soft, stiff to hard in some areas	Typically underlain by Limestone, and overlain by Dune Sand
C	Limestone	Pale brown/yellow, well to very well cemented, low to high strength, occasional voids	Calcarnite and Calcisilite likely to be underlain by red brown silty Sand (Red Beds). Typically overlain by Estuarine deposits and Dune Sands. Overlain by thin layer of clay/sand in some areas.

Inferred boundaries delineating Areas A, B and C within the site are illustrated on Figure 3. In the western portion of the site a shallow basin of estuarine deposits overlies the limestone as illustrated by the hatched area on Figure 3.

Figure 1 includes the location of sub-surface sections through the site. The sections are presented on Drawings 1 to 4 and show the interpolated sub-surface profile across the site.

It should be noted Cooke Point Drive boarders the western boundary of the site and it is likely that fill material associated with the construction of the road exists in this area.

7.3. Groundwater

Groundwater levels measured during the course of the investigation are presented in Table 4.

Table 4 – Groundwater Elevations

Test Number	Depth to Groundwater (m)	Approx. Surface Level (mAHD)	Approx. Level of Groundwater (mAHD)
TP1	Not Encountered	3.9	Not Encountered
TP2	Not Encountered	2.9	Not Encountered
TP3	Not Encountered	3.2	Not Encountered
TP4	0.9	2.6	1.7
TP5	1.4	2.6	1.2
TP6	1.4	2.4	1
TP7	Not Encountered	3.2	Not Encountered
TP8	Not Encountered	3.1	Not Encountered
TP9	0.9	3.0	2.1
TP10	1.1	3.0	2.9
TP11	0.4	3.1	2.7
TP12	Not Encountered	3.7	Not Encountered
TP13	Not Encountered	6.2	Not Encountered
TP14	Not Encountered	3.8	Not Encountered
TP15	1.9	3.4	1.5
TP16	1.9	2.8	0.9

It should be noted that groundwater levels on a particular site are influenced by several factors including:

- Regional groundwater levels;
- Local Geology;
- Rainfall;
- Tides;
- Local and Regional Drainage;
- Changes in land use;
- Groundwater extraction.

Rainfall has a major effect on groundwater levels, particularly from November through to March (i.e. during “the wet season”). The hydrology and stormwater diversion for the area will need to be considered, but fall outside the scope of this study. The process of urbanisation can affect groundwater levels. Road paving and house construction removes a portion of the soil surface from which evaporation can take place. Whether or not roof runoff is piped off site or returned to the soil via soak wells or directly off the roof will also have an effect.

Groundwater levels recorded in July 2013 in the vicinity of the site indicate that groundwater levels would be approximately R.L. 2.5m AHD to R.L. 3m AHD. Generally this coincides with a groundwater level perched on the Estuarine Muds. As such, there is likely to be a significant range in groundwater level, particularly after a rain event or “the wet season”.

Tides are likely to influence the groundwater levels at the site. Based on Foulsham (2010), the following tidal data is relevant:

- Highest Astronomical Tide (HAT): 3.59m AHD;
- Mean high water spring tide: 2.79m AHD;
- Mean Sea Level: 0.0m AHD;
- Mean low water spring tide: -3.01m AHD
- Lowest Astronomical Tide (LAT): -3.92m AHD;
- 1 in 50 year storm surge level: 4.9m AHD; and
- 1 in 100 year storm surge level: 5.4m AHD.

8. Recommendations

8.1. General

It should be noted that the ground encountered by the test pits 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. Acid sulfate soils

Figure 6 of the Western Australia Planning Commission (WAPC) Planning Bulletin 64 – shows the site to be located in an area of low to high risk of ASS occurring within 3m of natural soil surface (or deeper).

We are awaiting the laboratory results of the acid sulfate soils testing. Once results are received they will an assessment will be provided as an addendum to this report.

8.3. Site classification

Australian Standard AS2870-2011 provides a system of site classification for residential slabs and footing design as follows:

Table 5 – 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 may experience moderate ground movement from moisture changes
H1	Highly reactive clay site, which may experience high ground movement from moisture changes
H2	Highly reactive clay site, which may experience very high ground movement from moisture changes
E	Extremely reactive sites, which may 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

Port Hedland is located to the north of the Tropic of Capricorn and as such experiences a dry climate. Australian Standard AS 2870, *Residential Slabs and Footings* adopts a depth of design suction change (H_s) of 4m for site classification foundation design.

The standard recommends that for sites with deep-seated moisture changes characteristic of dry climates and corresponding to H_s equal to or greater than 3m, the classification shall be M-D, H1-D, H2-D or E-D as appropriate.

As such a minimum foundation design of **Class M-D** should be adopted for construction within Area A on Figure 1.

In the case of the Area B a classification of **Class P** would be appropriate given their very low bearing capacity and excessive settlements. In such cases foundations are to be designed based on engineering principles. As granular fill will be required to bring the site to design levels the standard allows for the reclassified, in accordance with engineering principles, to a classification lower than Class P and the adoption of the standard footing designs.

In the case of the Area C a classification of **Class A** would be appropriate.

These classifications are judged to be appropriate for the site provided that the recommendations contained in this report are adopted.

It is anticipated that the Area A and B could potentially be classified as **Class A-D**, as fill may be required to bring ground level up to design level and as such the maximum depth to seasonal moisture variation may be located within non-cohesive soil, resulting in negligible potential for surface movement due to seasonal variation.

8.4. Soak wells and sumps

The natural sand soils identified in the TP13 and in Area A are considered to be free draining, whilst the estuarine deposits and Limestone are not.

The process of urbanisation can lead to an increase in the rate of runoff from rainfall events. Rainfall that would otherwise infiltrate and move slowly through the soil to streams, lakes and rivers, when directed into gullies and pipes will move rapidly and create adverse environmental effects. The use of soak wells is likely to slow the movement of water there is likely to be compatible with the principles of Water Sensitive Urban Design. However the use of soak wells can have adverse effects on footing performance and/or amenity of a residential development.

In Port Hedland, it is common to have houses without gutters and rainfall runs directly off the roof onto the ground (or a designed gravel drainage layer). Therefore, the design of a surface water disposal, including rainfall runoff and collection, becomes an issue rather than groundwater disposal.

Should soak wells be considered, then they need to be designed based on a perched water table sitting on or above the Estuarine Muds. As a guide, for the purpose of soak well/ sump design, the water table is regarded as shallow if the depth to water table below the base of the soak well/sump is less than the square root of the base area. For a typical domestic soak well with a nominal height of 600mm and a nominal diameter of 600m, a depth to the winter water level (from finished lot level) of about 1.2m to 1.5m is required for soak wells to operate efficiently.

The use of a mixed system involving provision of sufficient storage volume in soak wells for short duration high intensity rainfall events and provision of controlled over flow for long duration rainfall events can be considered.

Based on our experience, analysis of laboratory results of the sand soils within Area A and to allow for silting effects a permeability value of 5m per day should be used in the design of soakwells and basins with in Area A. Consideration should be given to grading of development towards road reserves and low lying areas in order to direct runoff to these areas.

8.5. Foundations

8.5.1. Shallow foundations

We recommend an allowable bearing capacity of 150kPa provided the following:

- Area A - ground surface is prepared in accordance with the recommendations provided in Section 9.2.
- Area B - ground improvement recommendations provided in Section 10 are undertaken, including a detailed design phase of the works,
- Area C - ground surface is prepared in accordance with the recommendations provided in Section 9.4.

The following should be noted about the shallow foundations:

- Where foundations are founded in engineered fill material that that material should be compacted to accordance with Table 7;
- There should be at least 2m of fill between the top of the estuarine deposits layer and the bottom of the foundation; and
- The allowable bearing pressure for the footings should be limited to no more than 150kPa.
- Allowable bearing pressures are based on the following assumptions:
  - Load eccentricity is less than 10% of footing width;
  - Load inclination (H/V) is less than 10%;
  - The ground surface is horizontal; and
  - There is no interaction between adjacent footings.

Where the above recommendations cannot be achieved, then the ground improvement works recommended in Section 10 may have to be refined. These adjustments could be made during the detailed design phase of the works.

8.5.2. Deep foundations

Deep foundations may be considered for the structures in lieu of carrying out significant ground improvement works. Pile design parameters are provided in the following sub-sections.

It should be noted that if piling is considered for the structures then adequate allowance has to be made for differential settlement between piled and non-piled sections of the site. The differential settlements will typically be the greatest at connections to houses and as such services and connections to houses will need to be designed accordingly.

Pile Types

It is recommended that bored piles be considered for use at the site. Bored piles have the advantage of relatively low vibrations during the installation process and can be implemented with high quality control procedures.

The bored piles would also be effective in assessing that the founding stratum (Limestone) has been intersected and an adequate embedment has been achieved.

Estimated Safe Working Loads

Safe working loads for a range of pile diameters have been estimated using the recommendations provided in Fleming *et al* (1992) and are presented in Table 6. The estimation of the pile capacity is assuming on end bearing piles founding on the Limestone.

Table 6 - Safe Working Loads for Pile Under Axial Compression

Pile Diameter (mm)	Safe Working Load (kN)
300	45
400	85
500	130
600	185

The safe working loads have been estimated assuming a global factor of safety of three. Should piling be considered further for the site, further analysis will need to be undertaken to confirm the pile capacity in accordance with AS 2159 – 2009, taking into account a geotechnical strength reduction factor (which is based on the number and type of pile testing undertaken, and the average risk rating for the development).

8.6. Flexible pavements

8.6.1. Subgrade CBR

In Area A that is underlain by Dunal Deposits, a preliminary design subgrade California Bearing Ratio (CBR) of 10% is recommended. The adoption of this design value is contingent upon strict compliance with the site preparation recommendations given in Section 9.2

Where excess limestone in from Area C won on site, this material may be crush and reused as structural fill. A preliminary design subgrade CBR of 30% is recommended for crushed limestone material.

Where areas are to be built up to the design level using imported fill materials, the design CBR value will be dependent upon the material used in the filling process. Based on our experiences in the Port Hedland area, the range in CBR values could be between 5% and 10%. As part of the quality assurance testing programme of the importation of fill, CBR testing should be undertaken of the near surface materials to confirm the design CBR values.

The estuarine muds are considered to form poor quality subgrade. For design of temporary haul roads to facilitate construction, a subgrade CBR of 2% is recommended.

8.6.2. Pavement design

For medium and heavily trafficked public roads with an asphalt surface, pavement thickness design should be/have been based on Austroads (2012) Guide to Pavement Technology Part 2: Pavement Structural Design.

For lightly trafficked public roads, pavement thickness design should be/have been based on the Austroads (2006) Supplement to Austroads Pavement Design Guide. For public roads with a sprayed seal surface, pavement thickness design may be/has been based on the empirical design chart in Main Roads WA Engineering Road Note 9 (2013).

In intersections and tight turning areas, asphalt surfacing must be provided at intersections and tight turning areas.

Based on our experiences with pavements for the Pretty Pool Stage 1 Development, the recommended pavement composition is:

- Surface 30mm thickness of dense graded asphalt with 10mm aggregate
    - tack coat
    - 2 coat emulsion primer seal
    - prime
- Base Course 150mm Crushed Rock Base / Lateritic Gravel
- Sub Base 150mm Crushed Lateritic Gravel / Pindan Sand

8.6.3. Pavement materials

Pavement materials for public roads 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 (2003).

It must be understood that some cracking is normal if self-stabilising materials (lateritic gravel, ferricrete, calcrete), cement stabilised material or material with a significant linear shrinkage is used. Cracking is more visually apparent when asphalt surfacing is used compared to a sprayed seal. Cracking (which may originate in the base course) is more apparent when asphalt manufactured using laterite or ferricrete (ie red asphalt) is used as the surfacing.

The method for construction must comply with current MRWA specifications.

8.7. Earthquake parameters and liquefaction

Based on the site investigation and AS 1170.4 – 2007 Structural Design Actions – Part 4: Earthquake actions in Australia, the site subsoil class is estimated as follows:

- Class C_e (shallow soil site) in Area A (Dune Sand);
- Class D_e (Deep of soft soil site) in Area B (Estuarine deposits); and
- Class B_e (rock site) in Area C (Limestone).

The Hazard Factor (Z), as defined in AS 1170.4 – 2007, for Port Hedland is 0.12.

Soil liquefaction tends to occur in saturated, loose sandy soils that are subject to high seismic stress (cyclic). As a result, the sandy soils lose strength and stiffness and may undergo significant settlement or displacement. In the Dune Deposits, there is potential for isolated loose zones that may be susceptible to liquefaction. The result of an isolated loose zone liquefying would result in surface settlements.

It should be noted that identification of such layers through target geotechnical investigations would be difficult. Therefore, it is recommended that the structures be designed for liquefaction using the above parameters, and should an earthquake occur, then a maintenance regime be adopted for any damages that occur.

9. Earthworks

9.1. General

Earthworks should be carried out in accordance with the principles set out in AS3798-2007 Earthworks for Residential and Commercial Developments.

9.2. Area A (dune sands)

All organic materials (and any uncontrolled fill) should be stripped and stockpiled. This would include the stripping of surface vegetation.

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. As such, site preparation procedures may differ from the above if development proceeds during the wet season.

After the site has been stripped to the satisfaction of the Supervising Engineer, the Dunal Deposits should be proof compacted using a heavy, self-propelled, smooth drum vibrating roller, capable of operating in variable frequency modes. A Dynapac CA250D, or equivalent, is recommended (subject to the protection of adjacent buildings from damaging ground vibrations).

For sand with a fines content of less than 8%, a smooth drum roller should be used. For material with fines content exceeding 8% a pad foot roller will be required.

The following proof compaction procedure is recommended:

- The entire site should be given a minimum of 4 passes with the roller operating in 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 low amplitude mode.
- All weak areas that deform excessively under rolling, should be removed and replaced with suitable material.
- 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.

It should be noted that this area may have deeper underlying Estuarine muds and as such may require further geotechnical investigation and ground improvement options, as discussed in Sections 10 and 11.2.

9.3. Area B (estuarine deposits)

All organic materials (and any uncontrolled fill) should be stripped and stockpiled. This would include the stripping of surface vegetation.

Stripping of vegetation over the estuarine deposits may be problematic, in particular during the wet season or during periods of high tide. As such, engineering judgement should be made regarding the benefit of stripping topsoil versus the difficulty in accessing the softer areas.

Consideration could be given to the placement of a geosynthetic layer over the estuarine deposits to assist in providing a trafficable surface. The geosynthetic layer would also provide tensile strength within the fill and act as a separation layer between the Estuarine deposits and the placed fill materials. At this preliminary stage, a product with a tensile strength of >20kN/m at 2% strain should be used.

In areas where there is estuarine deposits, proof rolling is not recommended.

It is anticipated that the estuarine deposits may be excavated to depth of approximately 2m to expose limestone beneath, prior to back fill with structural fill. The intersection of the estuarine deposits with the limestone at ground surface (0m thickness contour) and also the inferred 2m thickness contour are shown on Figure 3.

Alternatively or in addition to earthworks above, Coffey recommend deep foundations or ground improvement options in areas of Estuarine deposits. These options are outlined in Sections 8.5.2 and 10.

It should be noted that although it common practice to remove organic material; it may be beneficial to leave the mangrove root mat in place in order to act as a natural raft and improve trafficability in the area. This method could be adopted provided it is factored into the end design.

9.4. Area C (limestone)

All organic materials (and any uncontrolled fill) should be stripped and stockpiled. This would include the stripping of surface vegetation. It is anticipated that rock breaking or ripping of the limestone will be required where lowering of existing ground surface is necessary, and importing of structural fill material may be required where raising of ground level is required.

9.5. Temporary slopes during earthworks

Excavated slopes should be constructed not steeper than IV:3H. Generally the temporary slopes should have the following:

- slope drainage consisting of catch drains; and,
- erosion protection should be provided.

9.6. Suitability of site materials for use as fill

Based on limited geotechnical investigation, the dunal deposits and limestone excavated from site may be used as structural fill. However, the material or additional material imported on to the site should be the subject of an investigation and laboratory testing regime to confirm the grading and compaction characteristics of the material.

It is unlikely that the Estuarine Materials will be suitable for use as structural fill.

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

9.7. Compaction requirements

Earthworks should be compacted to achieve the density requirements set out in Table 7.

Table 7 – Compaction Requirements

Item	Application	Compaction Criteria		
		Minimum density ratio (Cohesive soils)	Minimum density index (Cohesionless soils)	Minimum Dry Density Ratio (Perth sands)
1	Residential – lot fill, house sites	95% std	65%	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	70%	96% mod

10. Preliminary ground improvement options

10.1. General

At this stage, Coffey recommend three potential ground improvement options for development across the containing estuarine deposits.

The proposed options for site development include:

- Preloading with wick drains;
- Vibro-replacement columns (stone or sand columns); and
- Controlled modulus columns.

Preliminary design information regarding these options can be provided if required.

10.2. Preloading and wick drains

Preloading the area following installation of wick drains can be designed to accommodate 90% consolidation to be completed within significantly less time period than that of preloading alone, depending on the spacing and performance of the drains. When wick drains are introduced, rapid dissipation of pore pressure occurs leading to higher settlements in shorter time. However, the effects of smearing during installation, reduced permeability under increased stress and possibility of kinking are concerns associated with wick drains.

Wick drains have become a very common method to improve soft ground and have become routine.

10.3. Vibro-replacement

Vibro-replacement is a method of forming sand or stone columns within the Estuarine deposits; founding in the underlying Limestone layer. The use of stone or sand columns would need to be incorporated with a load transfer platform at (or near) the design finish ground level.

The stone or sand columns would act as a means of transferring the load of the development through the soil to a hard founding layer (similar to that of a pile) but also have the added benefit of assisting in the consolidation of the soft clayey material.

The economic viability of stone or sand columns is highly dependent upon the supply of suitable stone or sand; hence the availability of this resource would need to be assessed before considering this option further.

10.4. Controlled modulus columns with load transfer platform

Controlled Modulus Columns (CMC) with a Load Transfer Platform (LTP) is considered to be in the same class of deformable foundation systems (DFS) such as stone columns, dynamic replacement columns, etc. However, due to the advancement of installation technology, quality control aspects and speed of construction, this method is now considered bridging the gap between Rigid Deep Foundations such as, reinforced concrete columns, steel caissons, etc., and DFS. These DFS's utilise comparatively deformable inclusions made of granular materials, cement grouts etc., and supports the structural or other loads through a distribution mat without a structural connection between the columns and the distribution mat (i.e. load transfer platform (LTP)).

11. Geotechnical considerations

11.1. Issues

Based on the results of the investigation, our understanding of the development and our understanding of the geotechnical issues in the Port Hedland area, we believe the main geotechnical issues are as follows:

- The Estuarine deposits will have a significant amount of settlement when fill material is placed over them to bring the site up to the design service level. The amount of settlement will need to be allowed for when initially constructing the site such that the ground surface level remains above the design level.

- Services within area B will be subject to a large amount of settlement. Considering the type of development being proposed, it is recommended that replacement of services be factored into a maintenance regime. This should include water, drainage, electricity, sewerage and gas.
- Sourcing of fill in Port Hedland is different to the Perth region, in that the fill often contains a large amount of fines. Potential sources of fill material should be identified as early as possible, and the supplier should provide classification testing to confirm the quality of the available material.
- Area A covered by Dune deposits may have deeper / underlying Estuarine deposits. As such, this area should be subject to a geotechnical investigation using boreholes to confirm the stratigraphy in this area.
- The use of soak wells should be designed bearing in mind the potential for a high groundwater level during the wet season perched on top of the Estuarine deposits. The soak well design should also be commensurate with the nature of any imported fill materials. However, issues associated with soak wells can be mitigated by not incorporating gutters into the housing design.

11.2. Recommendations for further geotechnical investigations

Based on the results of the initial investigation, we would suggest undertaking the following additional geotechnical investigation once a more detailed site layout has been established: This investigation could include, but is not limited to:

- Boreholes or Cone Penetration Test (CPT) up to 10m depth in the Dune Deposits;
- Additional test pits for the collection of samples for laboratory testing;
- Due to limited access to the stables and livestock within the, the area should be targeted for future geotechnical investigations;
- Laboratory testing;
- Permeability testing; and
- Reporting to address the above mentioned geotechnical issues.

For budgeting purposes, it is recommended that an allowance of say $50,000 be made for the additional investigation, laboratory and reporting works.

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.

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

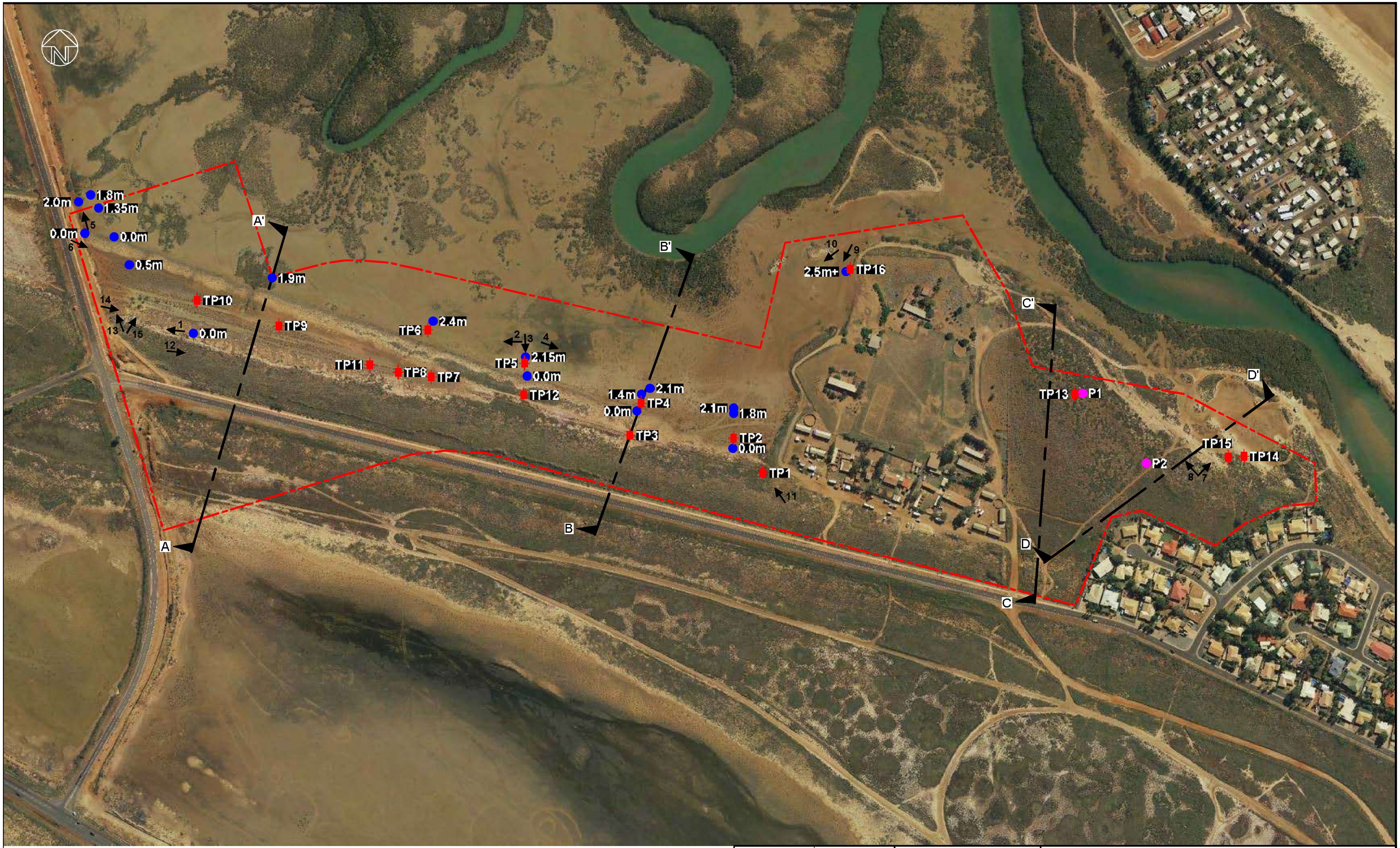
Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As 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



LEGEND

- ■ TEST PIT LOCATION
- ● PERMEABILITY TEST LOCATION
- ● HAND PROBE TEST LOCATION
- ↙ PHOTO LOCATION AND DIRECTION
- – · – SITE BOUNDARY
- — · — SECTION LOCATION

0 40 80 120 160m

drawn	AMG
approved	RM
date	25/09/2014
scale	1:4000
original size	A3

coffey

client: JDSi CONSULTING ENGINEERS

project: STAGE 3 - THE STABLES
EAST PORT HEDLAND, WA

title: TEST LOCATION AND SITE PLAN WITH AERIAL OVERLAY

project no: GEOTPER10160AA fig no: FIGURE 1 rev:

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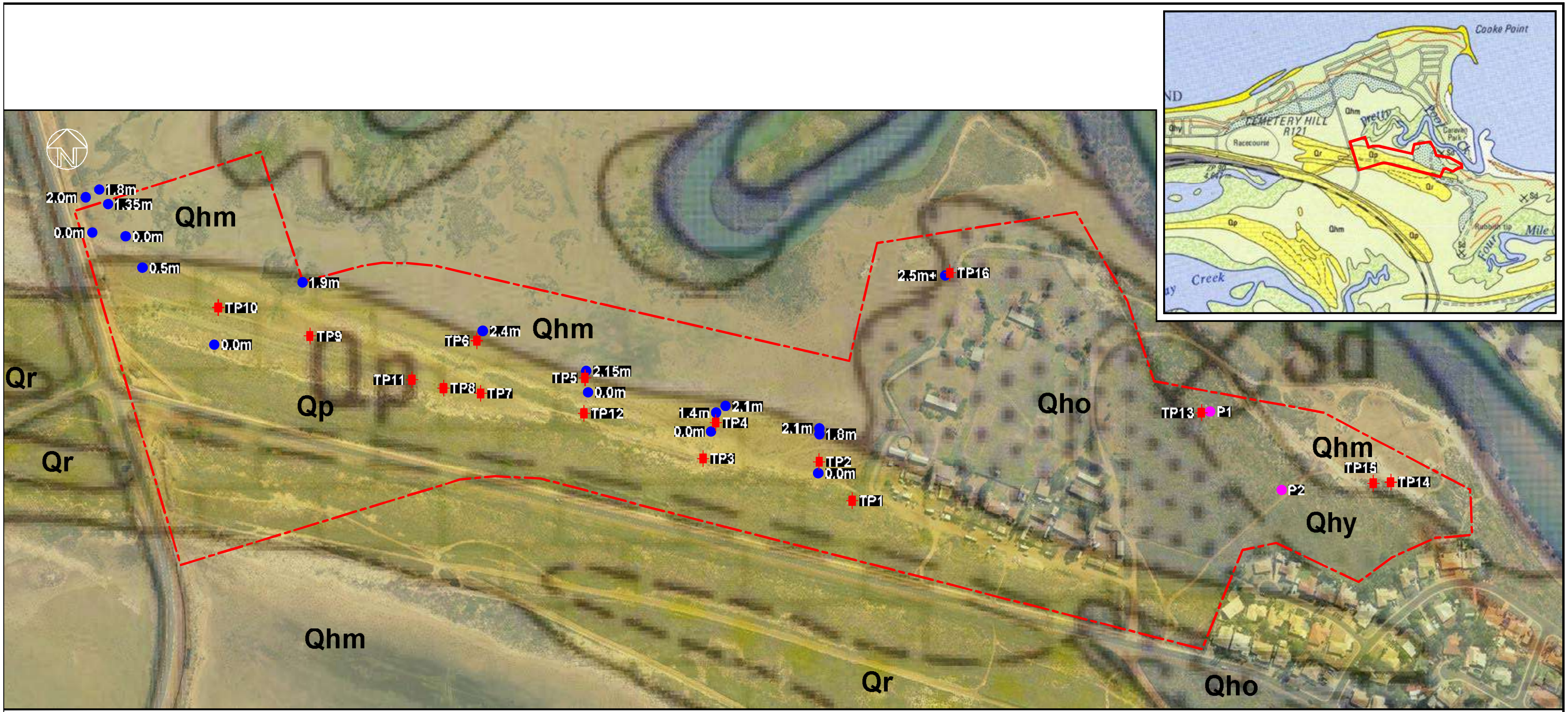
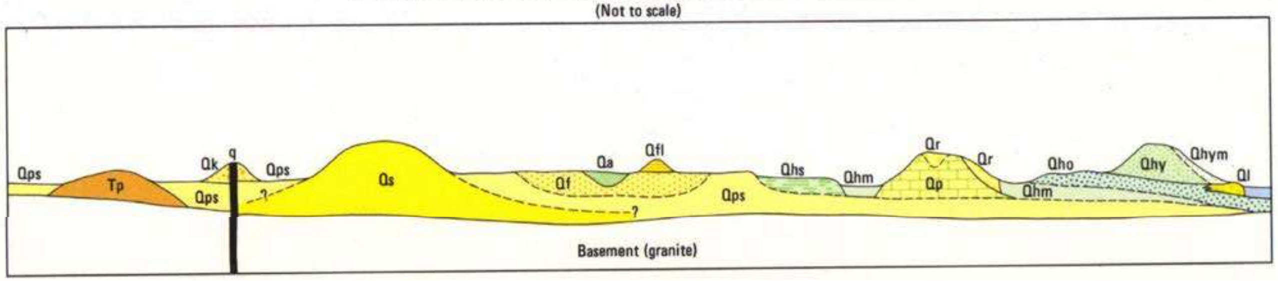


QUATERNARY SEDIMENT RELATIONSHIP DIAGRAM

(Not to scale)



	MAXIMUM THICKNESS (m)	
Qhm	5	Mangrove flats (tidal) Mud and silt
Qhym	2	Mobile dunes
Qhy	20	Younger beach and dune shelly sand
Qho	5	Older dune shelly sand
Qhs	3	Silty sand, red-brown, containing ......
Qr	3	Residual sand
Qp	? 20	Dune limestone
Ql	? 10	Lime-cemented beach conglomerate
Qfl	? 10	Levees
Qf	? 15	Flood-plain sediments
Qa	15	Alluvium, gravel, sand and silt
Qk	10	Colluvium, quartz scree

Qc	? 5	Clayey sand, abundant claypans
Qps	? 30	Silty sand, red-brown
Qs	? 40	High-level sands
Tp	20	POONDANOO FORMATION : laterite
q	30	Quartz; milky-white to grey

LEGEND

✚	TEST PIT LOCATION
●	PERMEABILITY TEST LOCATION
●	HAND PROBE TEST LOCATION
– – –	SITE BOUNDARY

0 40 80 120 160m

drawn	AMG
approved	RM
date	25/09/2014
scale	1:4000
original size	A3

client:	JDSi CONSULTING ENGINEERS
project:	STAGE 3 - THE STABLES EAST PORT HEDLAND, WA
title:	GEOLOGY AND AERIAL OVERLAY PLAN
project no:	GEOTPER10160AA
fig no:	FIGURE 2
rev:	

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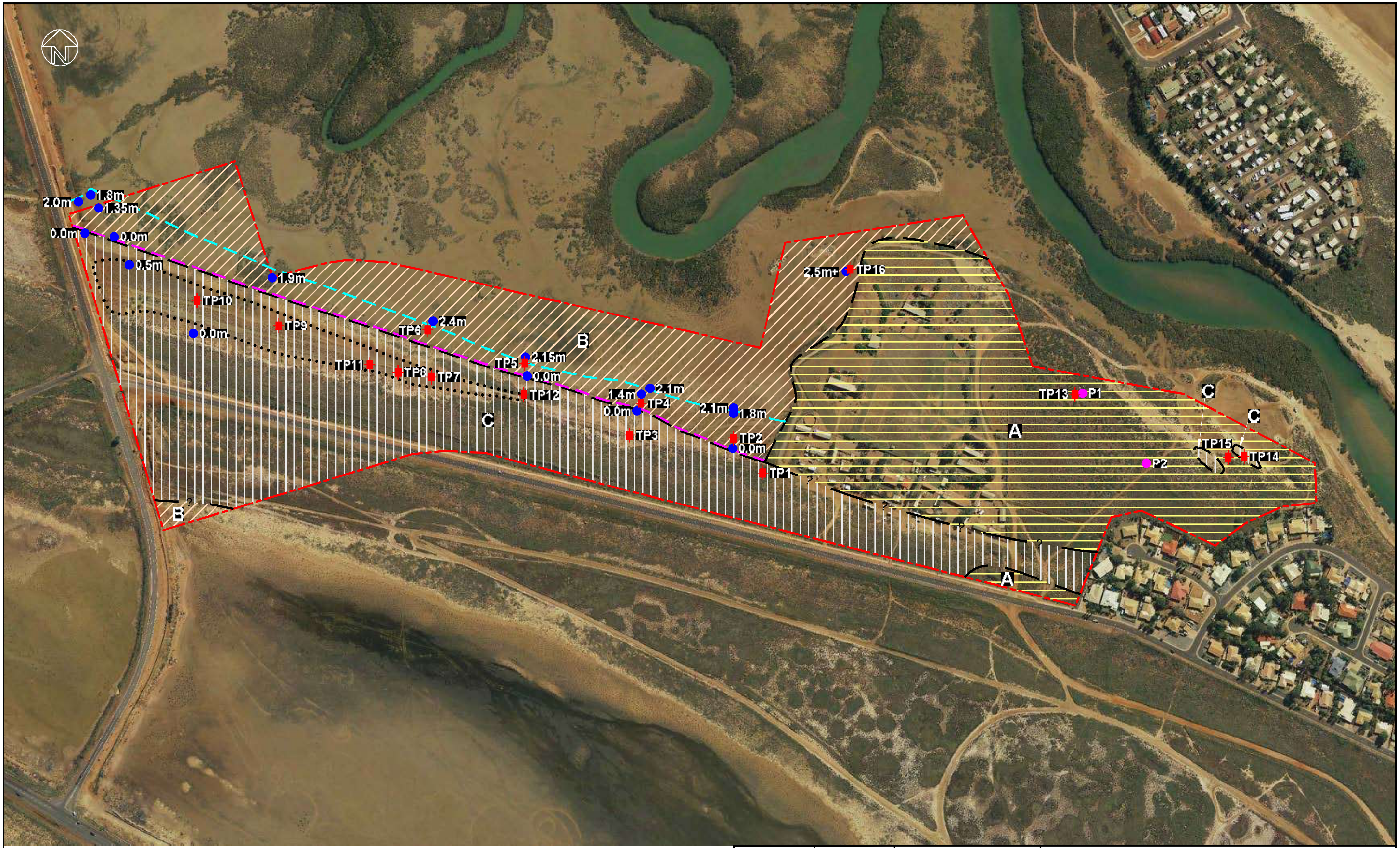

0 40 80 120 160m

LEGEND

- TEST PIT LOCATION
- PERMEABILITY TEST LOCATION
- HAND PROBE TEST LOCATION
- SITE BOUNDARY
- SHALLOW BASIN OF ESTUARINE DEPOSIT OVERLYING LIMESTONE
- AREA A - DUNE SAND
- AREA B - ESTUARINE DEPOSIT
- AREA C - LIMESTONE
- 2m ESTUARINE DEPOSIT THICKNESS CONTOUR
- 0m ESTUARINE DEPOSIT THICKNESS CONTOUR

drawn	AMG
approved	RM
date	25/09/2014
scale	1:4000
original size	A3

coffey

client: JDSi CONSULTING ENGINEERS

project: STAGE 3 - THE STABLES
EAST PORT HEDLAND, WA

title: GEOLOGICAL AREA LOCATION PLAN

project no: GEOTPER10160AA fig no: FIGURE 3 rev:

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0 40 80 120 160m

LEGEND

- ■ TEST PIT LOCATION
- ● PERMEABILITY TEST LOCATION
- ● HAND PROBE TEST LOCATION
- — - — SITE BOUNDARY
- —— CONTOUR LINE

drawn	AMG
approved	RM
date	25/09/2014
scale	1:4000
original size	A3

coffey

client:	JDSi CONSULTING ENGINEERS		
project:	STAGE 3 - THE STABLES EAST PORT HEDLAND, WA		
title:	SITE PLAN WITH TOPOGRAPHY OVERLAY PLAN		
project no: GEOTPER10160AA	fig no: FIGURE 4	rev:	

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PHOTOGRAPH 1

PHOTOGRAPH 2

NOTE: SEE FIGURE 1 FOR PHOTOGRAPH LOCATION AND DIRECTION

drawn	**AMG**	client:	**JDSi CONSULTING ENGINEERS**
approved	**RM**	project:	**STAGE 3 - THE STABLES EAST PORT HEDLAND, WA**
date	**25/09/2014**		
scale	**NOT TO SCALE**	title:	**SITE PHOTOGRAPHS**
original size	**A4**	project no:	**GEOTPER10160AA**
		fig no:	**FIGURE 5**
		rev:	

coffey

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PHOTOGRAPH 3

PHOTOGRAPH 4

NOTE: SEE FIGURE 1 FOR PHOTOGRAPH LOCATION AND DIRECTION

drawn	**AMG**
approved	**RM**
date	**25/09/2014**
scale	**NOT TO SCALE**
original size	**A4**

coffey

client: **JDSi CONSULTING ENGINEERS**

project: **STAGE 3 - THE STABLES**
EAST PORT HEDLAND, WA

title: **SITE PHOTOGRAPHS**

project no: **GEOTPER10160AA**	fig no: **FIGURE 6**	rev:

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PHOTOGRAPH 5

PHOTOGRAPH 6

NOTE: SEE FIGURE 1 FOR PHOTOGRAPH LOCATION AND DIRECTION

drawn	**AMG**
approved	**RM**
date	**25/09/2014**
scale	**NOT TO SCALE**
original size	**A4**

client: **JDSi CONSULTING ENGINEERS**

project: **STAGE 3 - THE STABLES**
EAST PORT HEDLAND, WA

title: **SITE PHOTOGRAPHS**

project no: **GEOTPER10160AA**

fig no: **FIGURE 7**

rev:

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PHOTOGRAPH 7

PHOTOGRAPH 8

NOTE: SEE FIGURE 1 FOR PHOTOGRAPH LOCATION AND DIRECTION

drawn	**AMG**	coffey	client:	**JDSi CONSULTING ENGINEERS**		
approved	**RM**		project:	**STAGE 3 - THE STABLES EAST PORT HEDLAND, WA**		
date	**25/09/2014**					
scale	**NOT TO SCALE**		title:	**SITE PHOTOGRAPHS**		
original size	**A4**		project no:	**GEOTPER10160AA**	fig no: **FIGURE 8**	rev:

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PHOTOGRAPH 9

PHOTOGRAPH 10

NOTE: SEE FIGURE 1 FOR PHOTOGRAPH LOCATION AND DIRECTION

drawn	**AMG**
approved	**RM**
date	**25/09/2014**
scale	**NOT TO SCALE**
original size	**A4**

client: **JDSi CONSULTING ENGINEERS**

project: **STAGE 3 - THE STABLES**
EAST PORT HEDLAND, WA

title: **SITE PHOTOGRAPHS**

project no: **GEOTPER10160AA**
fig no: **FIGURE 9**
rev:

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PHOTOGRAPH 11

PHOTOGRAPH 12

NOTE: SEE FIGURE 1 FOR PHOTOGRAPH LOCATION AND DIRECTION

drawn	**AMG**	coffey	client:	**JDSi CONSULTING ENGINEERS**
approved	**RM**		project:	**STAGE 3 - THE STABLES EAST PORT HEDLAND, WA**
date	**25/09/2014**			
scale	**NOT TO SCALE**		title:	**SITE PHOTOGRAPHS**
original size	**A4**		project no: **GEOTPER10160AA**	fig no: **FIGURE 10** rev:

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PHOTOGRAPH 13

PHOTOGRAPH 14

NOTE: SEE FIGURE 1 FOR PHOTOGRAPH LOCATION AND DIRECTION

drawn	**AMG**	coffey	client:	**JDSi CONSULTING ENGINEERS**		
approved	**RM**		project:	**STAGE 3 - THE STABLES** **EAST PORT HEDLAND, WA**		
date	**25/09/2014**		title:	**SITE PHOTOGRAPHS**		
scale	**NOT TO SCALE**					
original size	**A4**		project no:	**GEOTPER10160AA**	fig no: **FIGURE 11**	rev:

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PHOTOGRAPH 15

NOTE: SEE FIGURE 1 FOR PHOTOGRAPH LOCATION AND DIRECTION

drawn	**AMG**	client:	**JDSi CONSULTING ENGINEERS**
approved	**RM**	project:	**STAGE 3 - THE STABLES** **EAST PORT HEDLAND, WA**
date	**25/09/2014**		
scale	**NOT TO SCALE**	title:	**SITE PHOTOGRAPH**
original size	**A4**	project no: **GEOTPER10160AA**	fig no: **FIGURE 12** rev:

coffey

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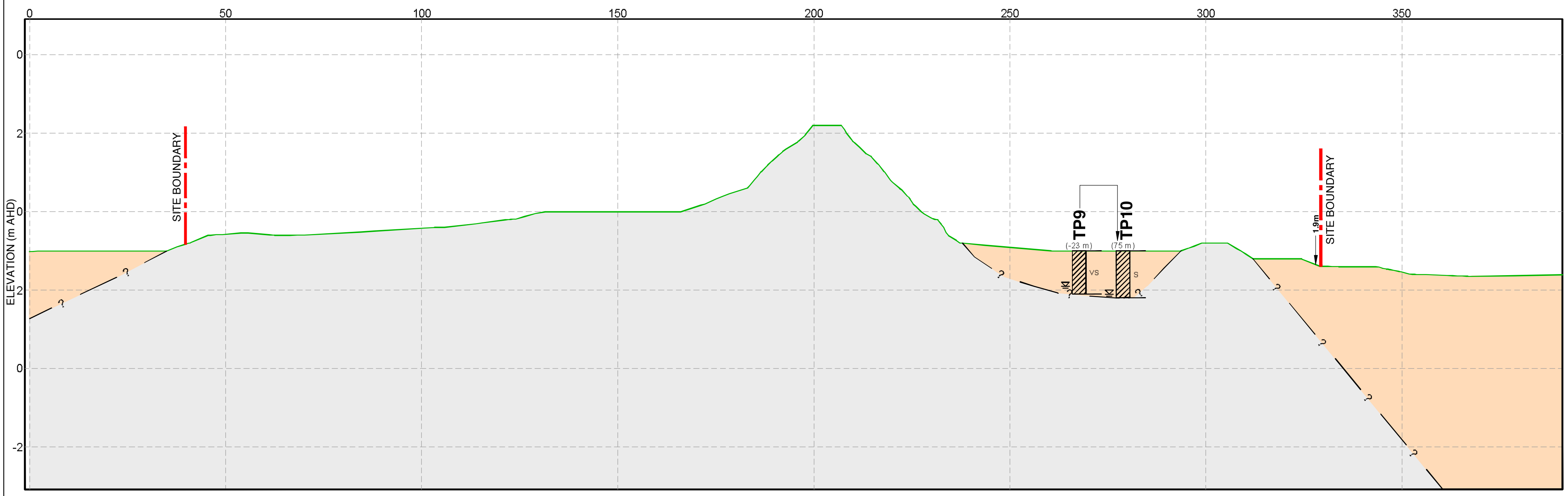
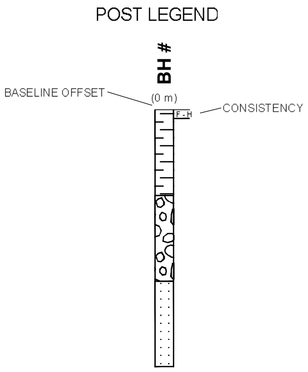
Drawings





MATERIAL GRAPHIC

▨ CLAY

LEGEND

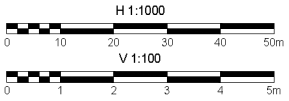
🟧 ESTUARINE DEPOSIT

⬜ LIMESTONE

— ? — INFERRED BOUNDARY

— NATURAL SURFACE

Geological boundaries are only known at the test site locations and have been inferred between the test sites. These geological boundaries have been provided to assist with the geological interpretation and should not be considered to represent actual boundaries that may vary from these lines.



drawn	AMG
approved	RM
date	25/09/2014
scale	1:1000H 1:100V
original size	A3

coffey

client:	JDSi CONSULTING ENGINEERS
project:	STAGE 3 - THE STABLES EAST PORT HEDLAND, WA
title:	SUB-SURFACE SECTION A-A'
project no:	GEOTPER10160AA
fig no:	DRAWING 1
rev:	

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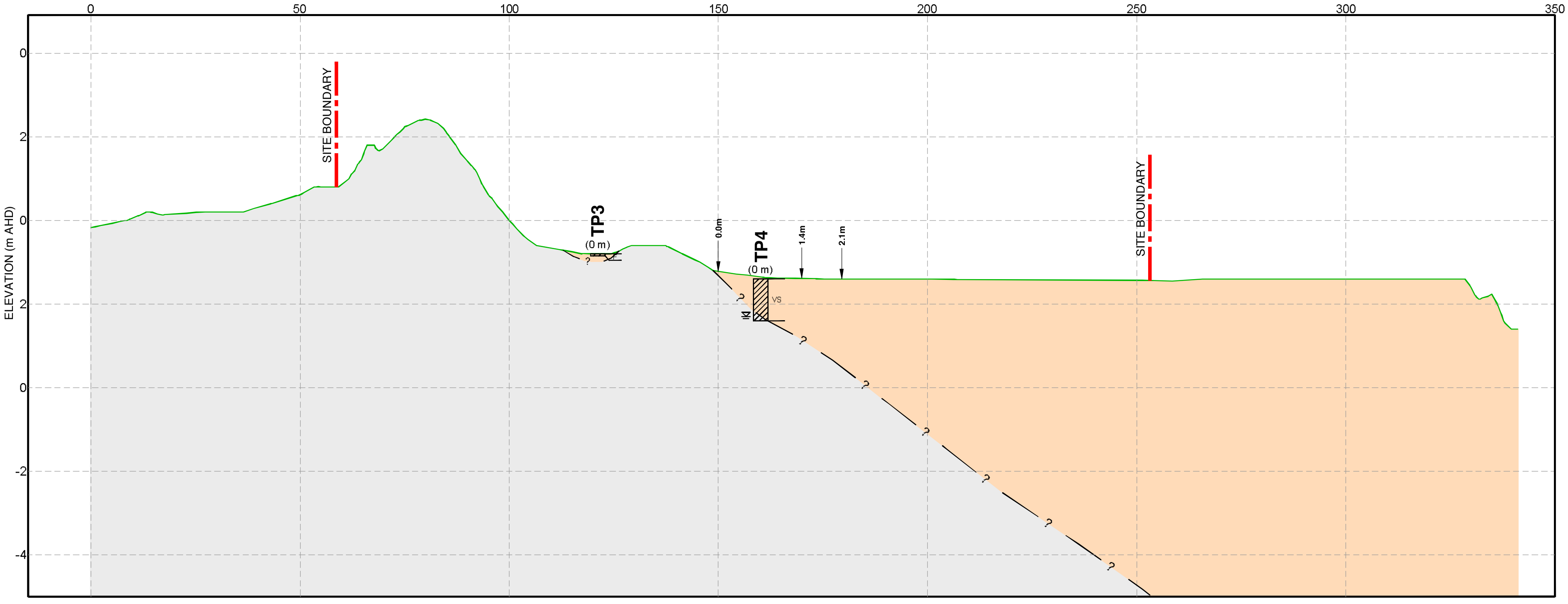

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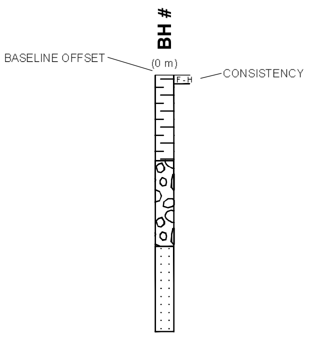


MATERIAL GRAPHIC

▨ CLAY

LEGEND

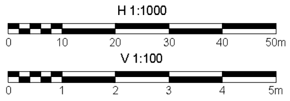
🟧 ESTUARINE DEPOSIT

⬜ LIMESTONE

— ? — INFERRED BOUNDARY

— NATURAL SURFACE

Geological boundaries are only known at the test site locations and have been inferred between the test sites. These geological boundaries have been provided to assist with the geological interpretation and should not be considered to represent actual boundaries that may vary from these lines.

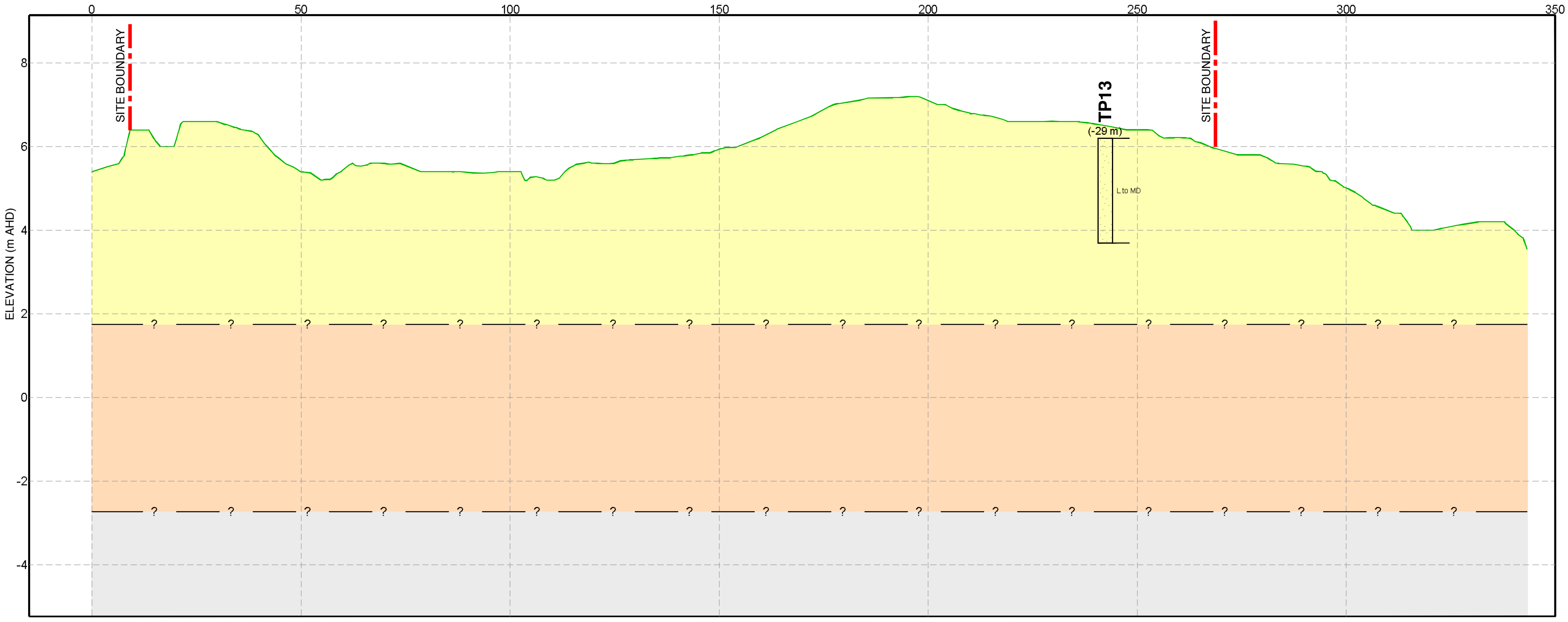


drawn	AMG
approved	RM
date	25/09/2014
scale	1:1000H 1:100V
original size	A3

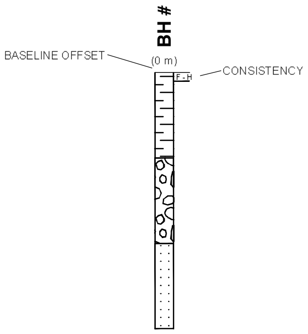
coffey

client:	JDSi CONSULTING ENGINEERS
project:	STAGE 3 - THE STABLES EAST PORT HEDLAND, WA
title:	SUB-SURFACE SECTION B-B'
project no:	GEOTPER10160AA
fig no:	DRAWING 2
rev:	

DWG: G:\GEOT\GEOTPERT\10000\10160AA Stage 3, East Port Hedland\7. Drawings\GEOTPERT10160AA - TEST LOCS AND SECTIONS.dwg



POST LEGEND

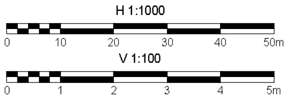


MATERIAL GRAPHIC

▨ SAND

LEGEND

🟨	DUNE SAND
🟧	ESTUARINE DEPOSIT
⬜	LIMESTONE
— ? —	INFERRED BOUNDARY
—	NATURAL SURFACE



Geological boundaries are only known at the test site locations and have been inferred between the test sites. These geological boundaries have been provided to assist with the geological interpretation and should not be considered to represent actual boundaries that may vary from these lines.

drawn	AMG
approved	RM
date	25/09/2014
scale	1:1000H 1:100V
original size	A3

coffey

client: JDSi CONSULTING ENGINEERS

project:
STAGE 3 - THE STABLES
EAST PORT HEDLAND, WA

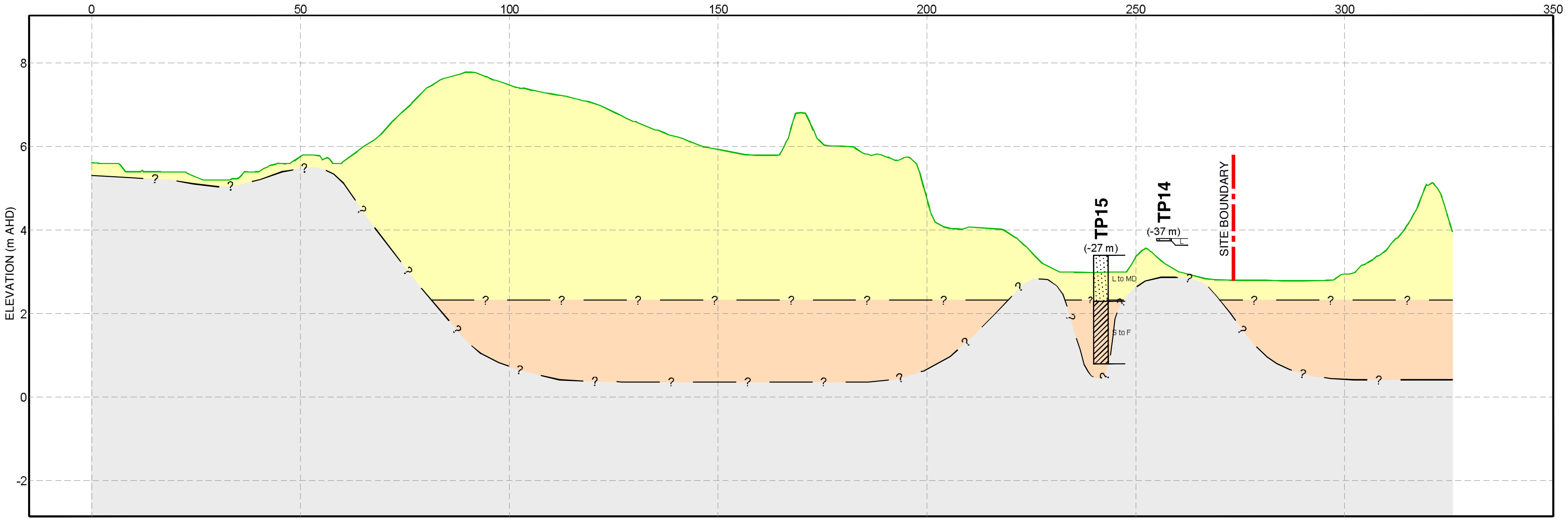
title: SUB-SURFACE SECTION C-C'

project no: GEOTPER10160AA

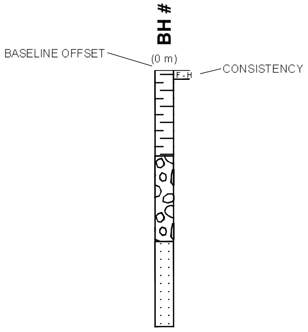
fig no: DRAWING 3

rev:

DWG: G:\GEOT\GEOTPERT\10000\10160AA Stage 3, East Port Hedland\7. Drawings\GEOTPERT10160AA - TEST LOCS AND SECTIONS.dwg



POST LEGEND



MATERIAL GRAPHIC

▨ SAND

▨ CLAY

LEGEND

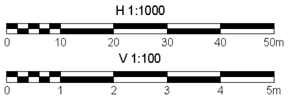
🟨 DUNE SAND

🟧 ESTUARINE DEPOSIT

⬜ LIMESTONE

— ? — INFERRED BOUNDARY

— NATURAL SURFACE



Geological boundaries are only known at the test site locations and have been inferred between the test sites. These geological boundaries have been provided to assist with the geological interpretation and should not be considered to represent actual boundaries that may vary from these lines.

drawn	AMG
approved	RM
date	25/09/2014
scale	1:1000H 1:100V
original size	A3

coffey

client:	JDSi CONSULTING ENGINEERS
project:	STAGE 3 - THE STABLES EAST PORT HEDLAND, WA
title:	SUB-SURFACE SECTION D-D'
project no:	GEOTPER10160AA
fig no:	DRAWING 4
rev:	

DWG: G:\GEOT\GEOTPERT\10000\10160AA Stage 3, East Port Hedland\7. Drawings\GEOTPERT10160AA - TEST LOCS AND SECTIONS.dwg

Appendix A -
Test Pit Excavation Logs and Photographs

coffey geotechnics

Engineering Log - Excavation

Excavation No. **TP1**
Sheet No. 1 of 1
Project No. **GEOTPERT10160AA**

Client : ***JDSi Consulting Engineers***
Principal : ***Landcorp***
Project : ***Geotechnical Investigation Styles Road***
Location : ***East Port Hedland, WA***

Date excavated ***11/9/14***
Date completed ***11/9/14***
Logged by : ***JC***
Checked by : ***RM***

Position : E: 670602.911, N: 7752903.902 (50 MGA94)   Surface Elevation : 3.9m (AHD)
Equipment type : 5t Excavator   Method : Bucket Excavator   Excavation dimensions : 0.50m long 0.50m wide

excavation information | **material substance**

method	penetration VE E F H VH	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 Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa 100 200 300 400	Blows/ 150mm	structure and other observations
E		N	Not Observed			0.0			**CLAYEY SAND**, fine to medium, brown; clay, low to medium plasticity; trace of , roots	D	MD			
									Testpit terminated on Limestone EXCAVATION TP1 TERMINATED AT 0.25 m					
					3.5									
						0.5								
					3.0									
						1.0								
					2.5									
						1.5								
					2.0									
						2.0								
					1.5									
						2.5								
					1.0									

GEOTPERT_01.GLB Log EXCAVATION + PSP/DCP GEOTPERT10160AA.GPJ <<DrawingFile>> 30/09/2014 09:41

method

N	Natural Exposure
X	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper
E	Excavator

support

T Timbering

penetration

1 2 3 4
minor resitance
ranging to
refusal

water

▼ 10 Oct., 73 Water Level on Date shown
► 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	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
W_P	Plastic Limit
W_L	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

TEST PIT 1

SPOIL EXCAVATED FROM TP1

drawn	**AMG**	coffey	client:	**JDSi CONSULTING ENGINEERS**
approved	**RM**		project:	**STAGE 3 - THE STABLES EAST PORT HEDLAND, WA**
date	**25/09/2014**		title:	**TEST PIT EXCAVATION PHOTOGRAPH - TP1**
scale	**NOT TO SCALE**			
original size	**A4**		project no: **GEOTPER10160AA**	fig no: **APPENDIX A** rev:

DWG: G:\GEOT\GEOTPERT\10000\10160AA Stage 3. East Port Hedland\7. Drawings\GEOTPERT10160AA - TEST PIT PHOTOS - APPENDIX A.dwg

coffey geotechnics

Engineering Log - Excavation

Excavation No.	*TP2*
Sheet No.	1 of 1
Project No.	*GEOTPERT10160AA*
Date excavated	*11/9/14*
Date completed	*11/9/14*
Logged by :	*JC*
Checked by :	*RM*

Client : *JDSi Consulting Engineers*

Principal : *Landcorp*

Project : *Geotechnical Investigation Styles Road*

Location : *East Port Hedland, WA*

Position : E: 670569, N: 7752944 (50 MGA94)

Surface Elevation : 2.9m (AHD)

Equipment type : 5t Excavator

Method : Bucket Excavator

Excavation dimensions : 0.50m long 0.50m wide

excavation information							material substance							
method	penetration VE E F H VH	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 Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa 100 200 300 400	Blows/ 150mm	structure and other observations
E		N	Not Observed	ASS ASS		0.0			**CLAYEY SAND**, fine to coarse, brown; clay, medium to high plasticity	M	L			
					2.5	0.40			Testpit terminated on Limestone EXCAVATION TP2 TERMINATED AT 0.40 m					
						0.5								
					2.0									
						1.0								
					1.5									
						1.5								
					1.0									
						2.0								
					0.5									
						2.5								
					0.0									

GEOTPERT_01.GLB Log EXCAVATION + PSP/DCP GEOTPERT10160AA.GPJ <<DrawingFile>> 30/09/2014 09:41

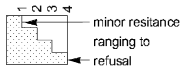
method

N	Natural Exposure
X	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper
E	Excavator

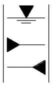
support

T Timbering

penetration



water



samples & field tests

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	Dry
M	Moist
W	Wet
W_P	Plastic Limit
W_L	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

TEST PIT 2

SPOIL EXCAVATED FROM TP2

drawn	**AMG**
approved	**RM**
date	**25/09/2014**
scale	**NOT TO SCALE**
original size	**A4**

coffey

client:	**JDSi CONSULTING ENGINEERS**		
project:	**STAGE 3 - THE STABLES** **EAST PORT HEDLAND, WA**		
title:	**TEST PIT EXCAVATION PHOTOGRAPH - TP2**		
project no:	**GEOTPER10160AA**	fig no: **APPENDIX A**	rev:

DWG: G:\GEOT\GEOTPERT\10000\10160AA Stage 3. East Port Hedland\7. Drawings\GEOTPERT10160AA - TEST PIT PHOTOS - APPENDIX A.dwg

coffey geotechnics

Engineering Log - Excavation

Excavation No.	*TP3*
Sheet No.	1 of 1
Project No.	*GEOTPERT10160AA*

Client : ***JDSi Consulting Engineers***

Principal : ***Landcorp***

Project : ***Geotechnical Investigation Styles Road***

Location : ***East Port Hedland, WA***

Date excavated ***11/9/14***

Date completed ***11/9/14***

Logged by : ***JC***

Checked by : ***RM***

Position : E: 670450.02, N: 7752947.252 (50 MGA94)
Surface Elevation : 3.2m (AHD)

Equipment type : 5t Excavator
Method : Bucket Excavator
Excavation dimensions : 0.60m long 0.50m wide

excavation information | **material substance**

method	penetration VE E F H VH	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 Minor Components	moisture condition	consistency / relative density	hand penetro-meter kPa 100 200 300 400	Blows/ 150mm	structure and other observations
E		N	Not Observed			0.0	▨		**SANDY CLAY**, low to medium plasticity, brown; sand, fine to medimum grained; trace of , roots	D	F			
									Testpit terminated on Limestone EXCAVATION TP3 TERMINATED AT 0.05 m					
					3.0									
						0.5								
					2.5									
						1.0								
					2.0									
						1.5								
					1.5									
						2.0								
					1.0									
						2.5								
					0.5									

method

N	Natural Exposure
X	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper
E	Excavator

support

T Timbering

penetration

1 2 3 4
minor resitance
ranging to
refusal

water

10 Oct., 73 Water Level on Date shown
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 -	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
W_P -	Plastic Limit
W_L -	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

GEOTPERT_01.GLB Log EXCAVATION + PSP/DCP GEOTPERT10160AA.GPJ <<DrawingFile>> 30/09/2014 09:41

TEST PIT 3

drawn	AMG
approved	RM
date	25/09/2014
scale	NOT TO SCALE
original size	A4

client: **JDSi CONSULTING ENGINEERS**

project: **STAGE 3 - THE STABLES**
EAST PORT HEDLAND, WA

title: **TEST PIT EXCAVATION PHOTOGRAPH - TP3**

project no: **GEOTPER10160AA**

fig no: **APPENDIX A**

rev:

DWG: G:\GEOT\GEOTPERT\10000\10160AA Stage 3. East Port Hedland\7. Drawings\GEOTPERT10160AA - TEST PIT PHOTOS - APPENDIX A.dwg

coffey geotechnics

Engineering Log - Excavation

Excavation No.	*TP4*
Sheet No.	1 of 1
Project No.	*GEOTPERT10160AA*
Date excavated	*11/9/14*
Date completed	*11/9/14*
Logged by :	*JC*
Checked by :	*RM*

Client : *JDSi Consulting Engineers*
Principal : *Landcorp*
Project : *Geotechnical Investigation Styles Road*
Location : *East Port Hedland, WA*

Position : E: 670463, N: 7752984 (50 MGA94)
Surface Elevation : 2.6m (AHD)
Equipment type : 5t Excavator
Method : Bucket Excavator
Excavation dimensions : 1.00m long 0.50m wide

excavation information						material substance								
method	penetration VE E F H VH	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 Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa 100 200 300 400	Blows/ 150mm	structure and other observations
E		N				0.0	▨		**SANDY CLAY**, low to medium plasticity, grey brown and brown; sand, fine to medium grained	M	VS			
					2.5									
				ASS		0.5								
					2.0									
			▽											
				ASS		1.0			Testpit terminated on Limestone EXCAVATION TP4 TERMINATED AT 1.00 m					
					1.5									
						1.5								
					1.0									
						2.0								
					0.5									
						2.5								
					0.0									

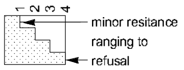
method

N	Natural Exposure
X	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper
E	Excavator

support

T	Timbering

penetration



water

▼	10 Oct., 73 Water Level on Date shown
►	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	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
W_P	Plastic Limit
W_L	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

TEST PIT 4

SPOIL EXCAVATED FROM TP4

drawn	**AMG**	coffey	client:	**JDSi CONSULTING ENGINEERS**	
approved	**RM**		project:	**STAGE 3 - THE STABLES** **EAST PORT HEDLAND, WA**	
date	**25/09/2014**		title:	**TEST PIT EXCAVATION PHOTOGRAPH - TP4**	
scale	**NOT TO SCALE**				
original size	**A4**		project no: **GEOTPER10160AA**	fig no: **APPENDIX A**	rev:

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coffey geotechnics

Engineering Log - Excavation

Excavation No.	*TP5*
Sheet No.	1 of 1
Project No.	*GEOTPERT10160AA*
Date excavated	*11/9/14*
Date completed	*11/9/14*
Logged by :	*JC*
Checked by :	*RM*

Client : *JDSi Consulting Engineers*
Principal : *Landcorp*
Project : *Geotechnical Investigation Styles Road*
Location : *East Port Hedland, WA*

Position : E: 670329, N: 7753030 (50 MGA94)
Surface Elevation : 2.6m (AHD)
Equipment type : 5t Excavator
Method : Bucket Excavator
Excavation dimensions : 1.00m long 0.50m wide

excavation information / material substance

method	penetration VE E F H VH	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 Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa 100 200 300 400	Blows/ 150mm	structure and other observations
E		N				0.0	▨		**CLAY**, low to medium plasticity, brown; trace of , shell fragments throughout	M	VS			
					2.5									
					2.0	0.5								
						1.0			...becoming grey at 1.0m					
					1.5									
			▽	ASS						W				
						1.5			Testpit terminated on Limestone EXCAVATION TP5 TERMINATED AT 1.50 m					
					1.0									
					0.5	2.0								
					0.0	2.5								

GEOTPERT_01.GLB Log EXCAVATION + PSP/DCP GEOTPERT10160AA.GPJ <<DrawingFile>> 30/09/2014 09:41

method

N	Natural Exposure
X	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper
E	Excavator

support

T	Timbering

penetration

1 2 3 4
minor resitance ranging to refusal

water

▼ 10 Oct., 73 Water Level on Date shown
▶ 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	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
W_P	Plastic Limit
W_L	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

TEST PIT 5

SPOIL EXCAVATED FROM TP5

drawn	**AMG**	coffey	client:	**JDSi CONSULTING ENGINEERS**	
approved	**RM**		project:	**STAGE 3 - THE STABLES** **EAST PORT HEDLAND, WA**	
date	**25/09/2014**				
scale	**NOT TO SCALE**		title:	**TEST PIT EXCAVATION PHOTOGRAPH - TP5**	
original size	**A4**		project no: **GEOTPER10160AA**	fig no: **APPENDIX A**	rev:

DWG: G:\GEOT\GEOTPERT\10000\10160AA Stage 3. East Port Hedland\7. Drawings\GEOTPERT10160AA - TEST PIT PHOTOS - APPENDIX A.dwg

coffey geotechnics

Engineering Log - Excavation

Excavation No.	***TP6***
Sheet No.	1 of 1
Project No.	***GEOTPERT10160AA***

Client : ***JDSi Consulting Engineers***
Principal : ***Landcorp***
Project : ***Geotechnical Investigation Styles Road***
Location : ***East Port Hedland, WA***

Date excavated ***11/9/14***
Date completed ***11/9/14***
Logged by : ***JC***
Checked by : ***RM***

Position : E: 670218, N: 7753068 (50 MGA94)
Surface Elevation : 2.4m (AHD)
Equipment type : 5t Excavator
Method : Bucket Excavator
Excavation dimensions : 1.20m long 0.50m wide

excavation information							**material substance**							
method	penetration VE E F H VH	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 Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa 100 200 300 400	Blows/ 150mm	structure and other observations
E		N				0.0	▨		**CLAY**, low to medium plasticity, brown; trace of , shell fragments; trace of , roots (mangrove roots)	M	VS			
					2.0									
						0.5								
					1.5									
						1.0								
				ASS										
			▽		1.0					W				
						1.5			Testpit terminated on Limestone EXCAVATION TP6 TERMINATED AT 1.50 m					
					0.5									
						2.0								
					0.0									
						2.5								
					-0.5									

GEOTPERT_01.GLB Log EXCAVATION + PSP/DCP GEOTPERT10160AA.GPJ <<DrawingFile>> 30/09/2014 09:41

method

N	Natural Exposure
X	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper
E	Excavator

support

T	Timbering

penetration

1 2 3 4 minor resitance ranging to refusal

water

▼ 10 Oct., 73 Water Level on Date shown
▶ 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	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
W_P	Plastic Limit
W_L	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

TEST PIT 6

drawn	AMG	coffey	client:	JDSi CONSULTING ENGINEERS
approved	RM		project:	STAGE 3 - THE STABLES EAST PORT HEDLAND, WA
date	25/09/2014			
scale	NOT TO SCALE		title:	TEST PIT EXCAVATION PHOTOGRAPH - TP6
original size	A4		project no: GEOTPER10160AA	fig no: APPENDIX A	rev:

DWG: G:\GEOT\GEOTPERT\10000\10160AA Stage 3. East Port Hedland\7. Drawings\GEOTPERT10160AA - TEST PIT PHOTOS - APPENDIX A.dwg

coffey geotechnics

Engineering Log - Excavation

Excavation No.	*TP7*
Sheet No.	1 of 1
Project No.	*GEOTPERT10160AA*
Date excavated	*11/9/14*
Date completed	*11/9/14*
Logged by :	*JC*
Checked by :	*RM*

Client : *JDSi Consulting Engineers*
Principal : *Landcorp*
Project : *Geotechnical Investigation Styles Road*
Location : *East Port Hedland, WA*

Position : E: 670222, N: 7753014 (50 MGA94)
Surface Elevation : 3.2m (AHD)
Equipment type : 5t Excavator
Method : Bucket Excavator
Excavation dimensions : 1.00m long 0.50m wide

excavation information							material substance							
method	penetration VE E F H VH	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 Minor Components	moisture condition	consistency / relative density	hand penetro-meter kPa 100 200 300 400	Blows/ 150mm	structure and other observations
E		N	Not Observed	HP =200kPa HP =250kPa	3.0	0.0	▨		**SANDY CLAY**, medium to high plasticity, brown; sand, fine to medium grained	M	H	×		
									Testpit terminated on Limestone EXCAVATION TP7 TERMINATED AT 0.28 m					
					2.5	0.5								
					2.0	1.0								
				BULK	1.5	1.5								
					1.0	2.0								
					0.5	2.5								

GEOTPERT_01.GLB Log EXCAVATION + PSP/DCP GEOTPERT10160AA.GPJ <<DrawingFile>> 30/09/2014 09:41

method

N	Natural Exposure
X	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper
E	Excavator

support

T	Timbering

penetration

1 2 3 4 minor resitance ranging to refusal

water

10 Oct., 73 Water Level on Date shown
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	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
W_P	Plastic Limit
W_L	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

TEST PIT 7

drawn	**AMG**
approved	**RM**
date	**25/09/2014**
scale	**NOT TO SCALE**
original size	**A4**

client: **JDSi CONSULTING ENGINEERS**

project: **STAGE 3 - THE STABLES**
EAST PORT HEDLAND, WA

title: **TEST PIT EXCAVATION PHOTOGRAPH - TP7**

project no: **GEOTPER10160AA**

fig no: **APPENDIX A**

rev:

DWG: G:\GEOT\GEOTPERT\10000\10160AA Stage 3. East Port Hedland\7. Drawings\GEOTPERT10160AA - TEST PIT PHOTOS - APPENDIX A.dwg

coffey geotechnics

Engineering Log - Excavation

Excavation No. TP8
Sheet No. 1 of 1
Project No. GEOTPERT10160AA

Client : *JDSi Consulting Engineers*
Principal : *Landcorp*
Project : *Geotechnical Investigation Styles Road*
Location : *East Port Hedland, WA*

Date excavated 11/9/14
Date completed 11/9/14
Logged by : JC
Checked by : RM

Position : E: 670183.956, N: 7753019.448 (50 MGA94)
Surface Elevation : 3.1m (AHD)
Equipment type : 5t Excavator
Method : Bucket Excavator
Excavation dimensions : 1.00m long 0.50m wide

excavation information							material substance							
method	penetration VE E F H VH	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 Minor Components	moisture condition	consistency / relative density	hand penetro-meter kPa 100 200 300 400	Blows/ 150mm	structure and other observations
E		N	Not Observed	HP =250kPa HP =300kPa	3.0	0.0	▨		**CLAY**, medium to high plasticity, brown	M	H			
					2.5	0.5			Testpit terminated on Limestone EXCAVATION TP8 TERMINATED AT 0.50 m					
					2.0	1.0								
					1.5	1.5								
					1.0	2.0								
					0.5	2.5								

GEOTPERT_01.GLB Log EXCAVATION + PSP/DCP GEOTPERT10160AA.GPJ <<DrawingFile>> 30/09/2014 09:41

method
N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper
E Excavator

support
T Timbering

penetration
1 2 3 4 minor resitance ranging to refusal

water
10 Oct., 73 Water Level on Date shown
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 - 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
W_P - Plastic Limit
W_L - 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

TEST PIT 8

SPOIL EXCAVATED FROM TP8

drawn	**AMG**
approved	**RM**
date	**25/09/2014**
scale	**NOT TO SCALE**
original size	**A4**

coffey

client: **JDSi CONSULTING ENGINEERS**

project: **STAGE 3 - THE STABLES**
EAST PORT HEDLAND, WA

title: **TEST PIT EXCAVATION PHOTOGRAPH - TP8**

project no: **GEOTPER10160AA**

fig no: **APPENDIX A**

rev:

DWG: G:\GEOT\GEOTPERT\10000\10160AA Stage 3. East Port Hedland\7. Drawings\GEOTPERT10160AA - TEST PIT PHOTOS - APPENDIX A.dwg

coffey geotechnics

Engineering Log - Excavation

Excavation No.	*TP9*
Sheet No.	1 of 1
Project No.	*GEOTPERT10160AA*

Client : *JDSi Consulting Engineers*
Principal : *Landcorp*
Project : *Geotechnical Investigation Styles Road*
Location : *East Port Hedland, WA*

Date excavated *11/9/14*
Date completed *11/9/14*
Logged by : *JC*
Checked by : *RM*

Position : E: 670046.922, N: 7753072.883 (50 MGA94)   Surface Elevation : 3m (AHD)
Equipment type : 5t Excavator   Method : Bucket Excavator   Excavation dimensions : 1.50m long 0.50m wide

excavation information							material substance							
method	penetration VE E F H VH	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 Minor Components	moisture condition	consistency / relative density	hand penetro-meter kPa 100 200 300 400	Blows/ 150mm	structure and other observations
E		N			3.0	0.0	▨		**SANDY CLAY**, low to medium plasticity, brown; sand, fine to medium grained	M	VS			
					2.5	0.5								
			▽											
					2.0	1.0								
									Testpit terminated on Limestone EXCAVATION TP9 TERMINATED AT 1.10 m					
					1.5	1.5								
					1.0	2.0								
					0.5	2.5								

method
N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper
E Excavator

support
T Timbering

penetration
1 2 3 4
minor resitance
ranging to
refusal

water
▼ 10 Oct., 73 Water Level on Date shown
▶ 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 - 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
W_P - Plastic Limit
W_L - 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

TEST PIT 9

drawn	**AMG**
approved	**RM**
date	**25/09/2014**
scale	**NOT TO SCALE**
original size	**A4**

client: **JDSi CONSULTING ENGINEERS**

project: **STAGE 3 - THE STABLES**
EAST PORT HEDLAND, WA

title: **TEST PIT EXCAVATION PHOTOGRAPH - TP9**

project no: **GEOTPER10160AA**

fig no: **APPENDIX A**

rev:

DWG: G:\GEOT\GEOTPERT\10000\10160AA Stage 3. East Port Hedland\7. Drawings\GEOTPERT10160AA - TEST PIT PHOTOS - APPENDIX A.dwg

coffey geotechnics

Engineering Log - Excavation

Excavation No. *TP10*
Sheet No. 1 of 1
Project No. *GEOTPERT10160AA*

Client : *JDSi Consulting Engineers*
Principal : *Landcorp*
Project : *Geotechnical Investigation Styles Road*
Location : *East Port Hedland, WA*

Date excavated *11/9/14*
Date completed *11/9/14*
Logged by : *JC*
Checked by : *RM*

Position : E: 669953, N: 7753102 (50 MGA94)
Surface Elevation : 3m (AHD)
Equipment type : 5t Excavator
Method : Bucket Excavator
Excavation dimensions : 1.50m long 0.50m wide

excavation information							material substance							
method	penetration VE E F H VH	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 Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa 100 200 300 400	Blows/ 150mm	structure and other observations
E	VE–E	N			3.0	0.0	▨		**SANDY CLAY**, low to medium plasticity, brown; sand, fine to medium grained	M	S			
					2.5	0.5								
					2.0	1.0								
			▽											
									Testpit terminated on Limestone EXCAVATION TP10 TERMINATED AT 1.20 m					
				BLK	1.5	1.5								
					1.0	2.0								
					0.5	2.5								

GEOTPERT_01.GLB Log EXCAVATION + PSP/DCP GEOTPERT10160AA.GPJ <<DrawingFile>> 30/09/2014 09:41

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration
1 2 3 4
minor resitance
ranging to
refusal

water
- ▼ 10 Oct., 73 Water Level on Date shown
- ▶ 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 - 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
- W_P - Plastic Limit
- W_L - 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

TEST PIT 10

SPOIL EXCAVATED FROM TP10

drawn	**AMG**	coffey	client:	**JDSi CONSULTING ENGINEERS**	
approved	**RM**		project:	**STAGE 3 - THE STABLES EAST PORT HEDLAND, WA**	
date	**25/09/2014**				
scale	**NOT TO SCALE**		title:	**TEST PIT EXCAVATION PHOTOGRAPH - TP10**	
original size	**A4**		project no: **GEOTPER10160AA**	fig no: **APPENDIX A**	rev:

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coffey geotechnics

Engineering Log - Excavation

Excavation No.	TP11
Sheet No.	1 of 1
Project No.	GEOTPERT10160AA

Client : *JDSi Consulting Engineers*
Principal : *Landcorp*
Project : *Geotechnical Investigation Styles Road*
Location : *East Port Hedland, WA*

Date excavated *11/9/14*
Date completed *11/9/14*
Logged by : *JC*
Checked by : *RM*

Position : E: 670151.558, N: 7753028.043 (50 MGA94)
Surface Elevation : 3.1m (AHD)
Equipment type : 5t Excavator
Method : Bucket Excavator
Excavation dimensions : 1.50m long 0.50m wide

excavation information / material substance

method	penetration VE E F H VH	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 Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa (100 200 300 400)	Blows/ 150mm	structure and other observations
E		N	▽	HP =150kPa	3.0 2.5	0.0 0.5	▨		**SANDY CLAY**, medium to high plasticity, brown; sand, fine to medium grained	M	VSt	☒		
					2.0 1.5 1.0 0.5	1.0 1.5 2.0 2.5			Testpit terminated on Limestone EXCAVATION TP11 TERMINATED AT 0.70 m					

GEOTPERT_01.GLB Log EXCAVATION + PSP/DCP GEOTPERT10160AA.GPJ <<DrawingFile>> 30/09/2014 09:41

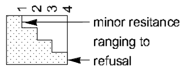
method

N	Natural Exposure
X	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper
E	Excavator

support

T	Timbering

penetration



water

▼	10 Oct., 73 Water Level on Date shown
▶	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	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
W_P	Plastic Limit
W_L	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

TEST PIT 11

drawn	AMG	client:	JDSi CONSULTING ENGINEERS
approved	RM	project:	STAGE 3 - THE STABLES EAST PORT HEDLAND, WA
date	25/09/2014	title:	TEST PIT EXCAVATION PHOTOGRAPH - TP11
scale	NOT TO SCALE		
original size	A4	project no: GEOTPER10160AA	fig no: APPENDIX A rev:

coffey

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coffey geotechnics

Engineering Log - Excavation

Excavation No.	*TP12*
Sheet No.	1 of 1
Project No.	*GEOTPERT10160AA*

Client : ***JDSi Consulting Engineers***

Principal : ***Landcorp***

Project : ***Geotechnical Investigation Styles Road***

Location : ***East Port Hedland, WA***

Date excavated ***11/9/14***

Date completed ***11/9/14***

Logged by : ***JC***

Checked by : ***RM***

Position : E: 670328.015, N: 7752993.545 (50 MGA94) Surface Elevation : 3.7m (AHD)

Equipment type : 5t Excavator Method : Bucket Excavator Excavation dimensions : 1.00m long 0.50m wide

excavation information							material substance							
method	penetration VE E F H VH	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 Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa 100 200 300 400	Blows/ 150mm	structure and other observations
E		N	Not Observed	HP =350kPa		0.0	▨		**CLAY**, medium to high plasticity, brown	D	H	×		
									Testpit terminated on Limestone EXCAVATION TP12 TERMINATED AT 0.10 m					
					3.5									
						0.5								
					3.0									
						1.0								
					2.5									
						1.5								
					2.0									
						2.0								
					1.5									
						2.5								
					1.0									

method

N	Natural Exposure
X	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper
E	Excavator

support

T Timbering

penetration

1 2 3 4 minor resitance ranging to refusal

water

▼ 10 Oct., 73 Water Level on Date shown

► 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	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
W_P	Plastic Limit
W_L	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

TEST PIT 12

drawn	AMG	coffey	client:	JDSi CONSULTING ENGINEERS		
approved	RM		project:	STAGE 3 - THE STABLES EAST PORT HEDLAND, WA		
date	25/09/2014		title:	TEST PIT EXCAVATION PHOTOGRAPH - TP12		
scale	NOT TO SCALE					
original size	A4		project no: GEOTPER10160AA	fig no: APPENDIX A	rev:	

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coffey geotechnics

Engineering Log - Excavation

Excavation No.	*TP13*
Sheet No.	1 of 1
Project No.	*GEOTPERT10160AA*

Client : *JDSi Consulting Engineers*

Principal : *Landcorp*

Project : *Geotechnical Investigation Styles Road*

Location : *East Port Hedland, WA*

Date excavated *11/9/14*

Date completed *11/9/14*

Logged by : *JC*

Checked by : *RM*

Position : E: 670960.932, N: 7752994.273 (50 MGA94) Surface Elevation : 6.2m (AHD)

Equipment type : 5t Excavator Method : Bucket Excavator Excavation dimensions : 2.00m long 0.50m wide

excavation information / material substance

method	penetration VE E F H VH	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 Minor Components	moisture condition	consistency / relative density	hand penetro-meter kPa 100 200 300 400	Blows/ 150mm	structure and other observations
E		N	Not Observed		6.2	0.0			**SAND**, fine to coarse, pale brown; trace of , silt; trace of , shell and shell fragments; trace of roots to 2.0m	D	L to MD			
					6.0									
						0.5								
					5.5									
						1.0								
					5.0									
						1.5								
					4.5									
						2.0								
					4.0									
						2.5			EXCAVATION TP13 TERMINATED AT 2.50 m					
					3.5									

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration

1 2 3 4 minor resitance ranging to refusal

water

▼ 10 Oct., 73 Water Level on Date shown

▶ 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 - 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
- W_P - Plastic Limit
- W_L - 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

TEST PIT 13

SPOIL EXCAVATED FROM TP13

drawn	**AMG**	client:	**JDSi CONSULTING ENGINEERS**
approved	**RM**	project:	**STAGE 3 - THE STABLES** **EAST PORT HEDLAND, WA**
date	**25/09/2014**	title:	**TEST PIT EXCAVATION PHOTOGRAPH - TP13**
scale	**NOT TO SCALE**	project no:	**GEOTPER10160AA**
original size	**A4**	fig no:	**APPENDIX A**
		rev:	

coffey

DWG: G:\GEOT\GEOTPERT\10000\10160AA Stage 3. East Port Hedland\7. Drawings\GEOTPERT10160AA - TEST PIT PHOTOS - APPENDIX A.dwg

coffey geotechnics

Engineering Log - Excavation

Excavation No.	*TP14*
Sheet No.	1 of 1
Project No.	*GEOTPERT10160AA*

Client : ***JDSi Consulting Engineers***
Principal : ***Landcorp***
Project : ***Geotechnical Investigation Styles Road***
Location : ***East Port Hedland, WA***

Date excavated **11/9/14**
Date completed **11/9/14**
Logged by : **JC**
Checked by : **RM**

Position : E: 671154.984, N: 7752923.005 (50 MGA94) Surface Elevation : 3.8m (AHD)
Equipment type : 5t Excavator Method : Bucket Excavator Excavation dimensions : 0.50m long 0.50m wide

excavation information							material substance							
method	penetration VE E F H VH	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 Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa 100 200 300 400	Blows/ 150mm	structure and other observations
E		N	Not Observed			0.0			**SAND**, fine to coarse, pale brown; with some , fine to medium sub rounded to sub angular gravels	D	L			
									Testpit terminated on Limestone EXCAVATION TP14 TERMINATED AT 0.05 m					
					3.5									
						0.5								
					3.0									
						1.0								
					2.5									
						1.5								
					2.0									
						2.0								
					1.5									
						2.5								
					1.0									

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration
1 2 3 4 minor resitance ranging to refusal

water
- 10 Oct., 73 Water Level on Date shown
- 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 - 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
- W_P - Plastic Limit
- W_L - 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

TEST PIT 14

drawn	**AMG**		client:	**JDSi CONSULTING ENGINEERS**		
approved	**RM**		project:	**STAGE 3 - THE STABLES** **EAST PORT HEDLAND, WA**		
date	**25/09/2014**		title:	**TEST PIT EXCAVATION PHOTOGRAPH - TP14**		
scale	**NOT TO SCALE**					
original size	**A4**		project no:	**GEOTPER10160AA**	fig no: **APPENDIX A**	rev:

DWG: G:\GEOT\GEOTPERT\10000\10160AA Stage 3. East Port Hedland\7. Drawings\GEOTPERT10160AA - TEST PIT PHOTOS - APPENDIX A.dwg

coffey geotechnics

Engineering Log - Excavation

Excavation No.	***TP15***
Sheet No.	1 of 1
Project No.	***GEOTPERT10160AA***
Date excavated	***11/9/14***
Date completed	***11/9/14***
Logged by :	***JC***
Checked by :	***RM***

Client : ***JDSi Consulting Engineers***

Principal : ***Landcorp***

Project : ***Geotechnical Investigation Styles Road***

Location : ***East Port Hedland, WA***

Position : E: 671137, N: 7752922 (50 MGA94)

Surface Elevation : 3.4m (AHD)

Equipment type : 5t Excavator

Method : Bucket Excavator

Excavation dimensions : 2.00m long 0.50m wide

excavation information / material substance

method	penetration VE E F H VH	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 Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa 100 200 300 400	Blows/ 150mm	structure and other observations
E (0.0 to 2.60 m)		N	▽ (at RL 1.5)			0.0	░		**SAND**, fine to coarse, pale brown; trace of , sub rounded fine to medium gravels; trace of , shell and shell fragments	D	L to MD			
					3.0	0.5				M				
					2.5	1.0								
						1.1	▨		**SANDY CLAY**, low plasticity, grey and green grey; sand, fine frained		S to F			
					2.0	1.5								
					1.5	1.9				W				
						2.0								
					1.0	2.5								
						2.6			EXCAVATION TP15 TERMINATED AT 2.60 m					
					0.5									

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration

1 2 3 4 — minor resitance ranging to refusal

water
- ▼ 10 Oct., 73 Water Level on Date shown
- ▶ 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 - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT - Plate Bearing Test

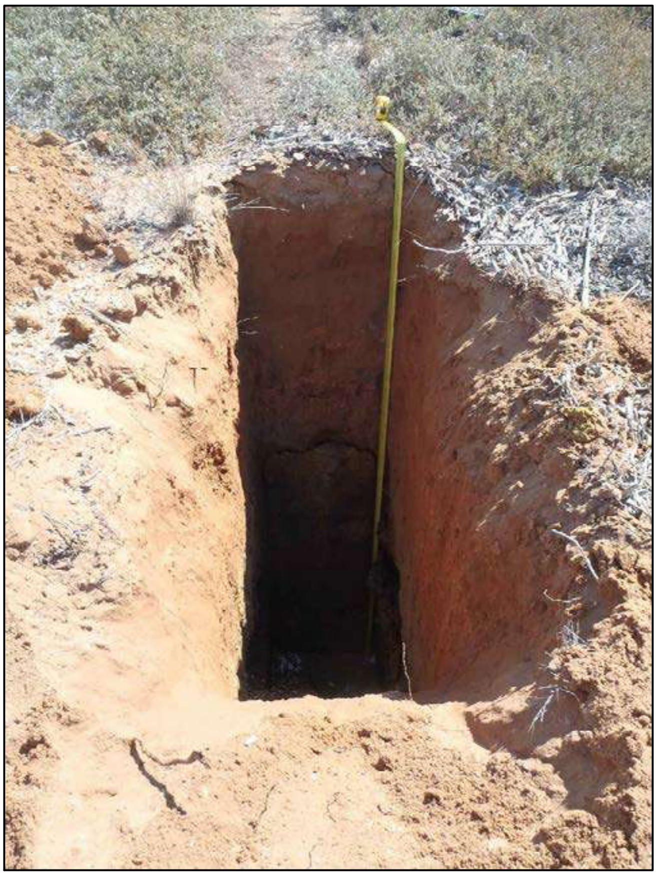
classification symbols & soil description
Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

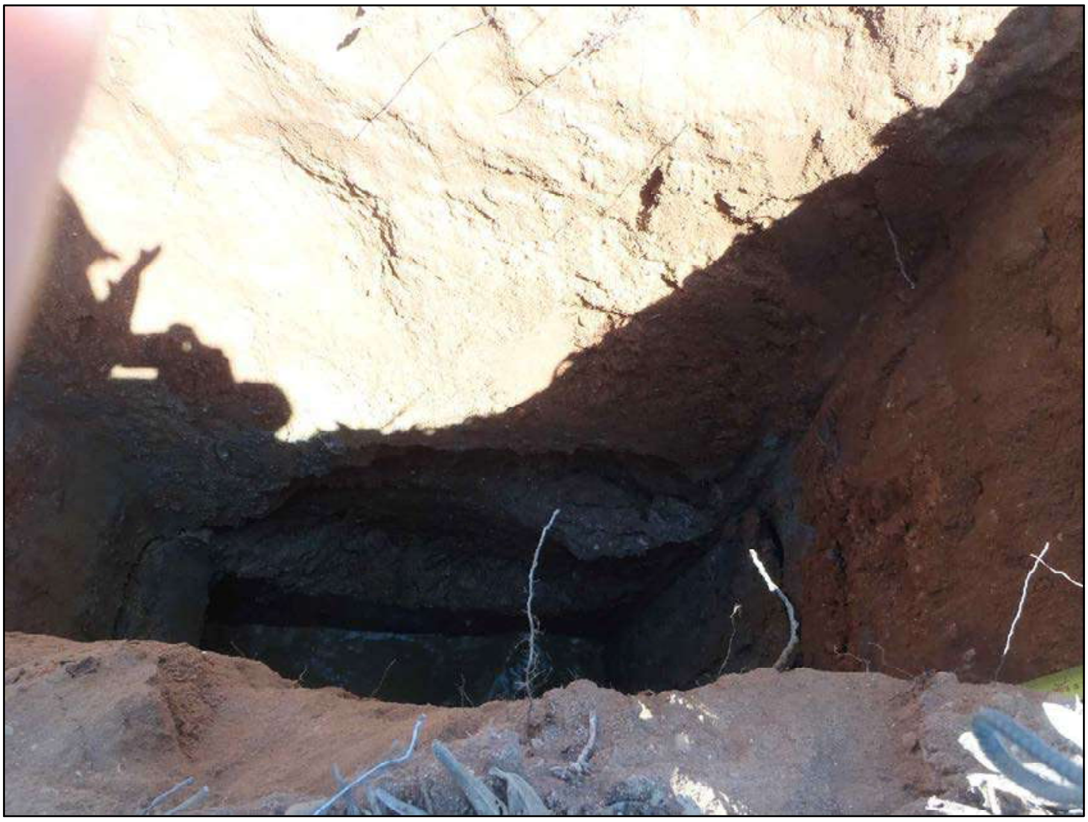
consistency / relative density

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

GEOTPERT_01.GLB Log EXCAVATION + PSP/DCP GEOTPERT10160AA.GPJ <<DrawingFile>> 30/09/2014 09:41



TEST PIT 15



TEST PIT 15

drawn	**AMG**		client:	**JDSi CONSULTING ENGINEERS**
approved	**RM**		project:	**STAGE 3 - THE STABLES** **EAST PORT HEDLAND, WA**
date	**25/09/2014**	coffey		
scale	**NOT TO SCALE**		title:	**TEST PIT EXCAVATION PHOTOGRAPH - TP15 (PAGE 1 OF 2)**
original size	**A4**		project no: **GEOTPER10160AA**	fig no: **APPENDIX A** rev:

DWG: G:\GEOT\GEOTPERT\10000\10160AA Stage 3. East Port Hedland\7. Drawings\GEOTPERT10160AA - TEST PIT PHOTOS - APPENDIX A.dwg


SPOIL EXCAVATED FROM TP15


SPOIL EXCAVATED FROM TP15

drawn	AMG	coffey	client:	JDSi CONSULTING ENGINEERS
approved	RM		project:	STAGE 3 - THE STABLES EAST PORT HEDLAND, WA
date	25/09/2014		title:	TEST PIT EXCAVATION PHOTOGRAPH - TP15 (PAGE 2 OF 2)
scale	NOT TO SCALE			
original size	A4		project no: GEOTPER10160AA	fig no: APPENDIX A rev:

DWG: G:\GEOT\GEOTPERT\10000\10160AA Stage 3. East Port Hedland\7. Drawings\GEOTPERT10160AA - TEST PIT PHOTOS - APPENDIX A.dwg

coffey geotechnics

Engineering Log - Excavation

Excavation No.	*TP16*
Sheet No.	1 of 1
Project No.	*GEOTPERT10160AA*
Date excavated	*11/9/14*
Date completed	*11/9/14*
Logged by :	*JC*
Checked by :	*RM*

Client : *JDSi Consulting Engineers*
Principal : *Landcorp*
Project : *Geotechnical Investigation Styles Road*
Location : *East Port Hedland, WA*

Position : E: 670703.096, N: 7753137.713 (50 MGA94) Surface Elevation : 2.8m (AHD)
Equipment type : 5t Excavator Method : Bucket Excavator Excavation dimensions : 2.00m long 0.50m wide

excavation information | **material substance**

method	penetration VE E F H VH	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 Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa 100 200 300 400	Blows/ 150mm	structure and other observations
E		N				0.0	▨		**CLAY**, low to medium plasticity, brown	M	S to F			
					2.5									
						0.5	▨		**SANDY CLAY**, low to medium plasticity, grey; sand, fine to medium grained					
					2.0									
						1.0								
					1.5									
						1.5								
					1.0									
			▽											
						2.0			EXCAVATION TP16 TERMINATED AT 2.00 m	W				
					0.5									
						2.5								
					0.0									

GEOTPERT_01.GLB Log EXCAVATION + PSP/DCP GEOTPERT10160AA.GPJ <<DrawingFile>> 30/09/2014 09:41

method

N	Natural Exposure
X	Existing Excavation
BH	Backhoe Bucket
B	Bulldozer Blade
R	Ripper
E	Excavator

support

T	Timbering

penetration

1 2 3 4
minor resitance
ranging to
refusal

water

▼ 10 Oct., 73 Water Level on Date shown
▶ 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	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
W_P	Plastic Limit
W_L	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

TEST PIT 16

SPOIL EXCAVATED FROM TP16

drawn	**AMG**	coffey	client:	**JDSi CONSULTING ENGINEERS**
approved	**RM**		project:	**STAGE 3 - THE STABLES** **EAST PORT HEDLAND, WA**
date	**25/09/2014**			
scale	**NOT TO SCALE**		title:	**TEST PIT EXCAVATION PHOTOGRAPH - TP16**
original size	**A4**		project no: **GEOTPER10160AA**	fig no: **APPENDIX A** rev:

DWG: G:\GEOT\GEOTPERT\10000\10160AA Stage 3. East Port Hedland\7. Drawings\GEOTPERT10160AA - TEST PIT PHOTOS - APPENDIX A.dwg

Appendix B -
Laboratory Test Results

Welshpool, Perth Laboratory

Coffey Testing Pty Ltd
ABN 92 114 364 046
269A Treasure Road (Cnr Poole St)
Welshpool WA 6106

Phone: +61 8 6466 2400
Fax: +61 8 6466 2450

Material Test Report

Report No: WELS14S-06336-1
Issue No: 1

Client: Coffey Geotechnics Pty Ltd (Burswood)
53 Burswood Road
Burswood WA 6100

Principal: JDSi
Project No.: INFOWELS01719AA
Project Name: GEOTPERT10160AA - Stage 3, East Port Hedland
Lot No.: NA **TRN:** NA

WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

J. Barry
Approved Signatory: Jonathan Barry
(Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 24/09/2014

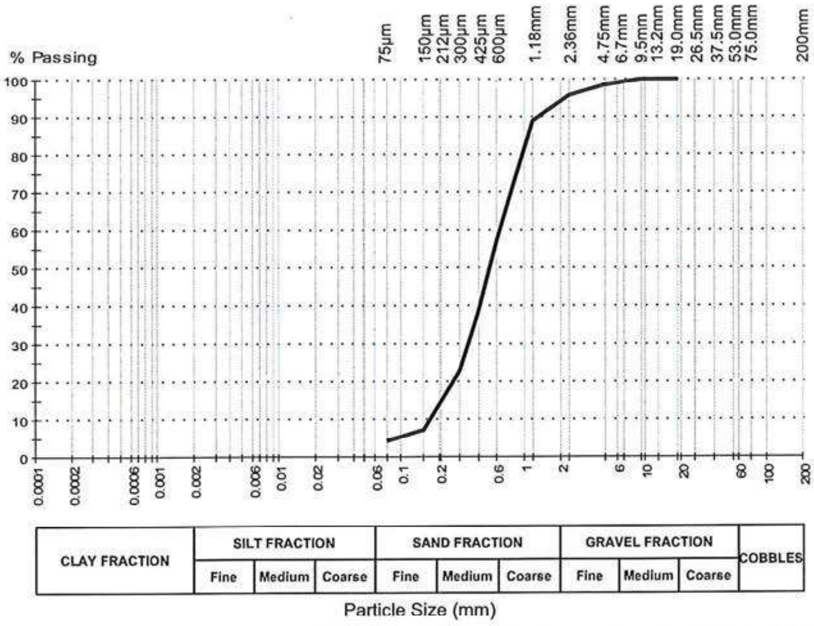
Sample Details

Sample ID: WELS14S-06336
Client Sample: permeability 1
Date Sampled:
Source: Unknown
Material:
Specification: Determined by client
Sampling Method: Submitted by client
Project Location: Styles Road, Port Headland
Sample Location: permeability 1

Other Test Results

Description	Method	Result	Limits

Particle Size Distribution



Method: AS 1289.3.6.1
Drying by: Oven
Date Tested: 22/09/2014
Note:

Sieve Size	% Passing	Limits
19.0mm	100	
9.5mm	100	
4.75mm	99	
2.36mm	96	
1.18mm	89	
600µm	57	
425µm	39	
300µm	23	
150µm	7	
75µm	4	

Comments

Sample supplied by client.

Welshpool, Perth Laboratory

Coffey Testing Pty Ltd
ABN 92 114 364 046
269A Treasure Road (Cnr Poole St)
Welshpool WA 6106

Phone: +61 8 6466 2400
Fax: +61 8 6466 2450

Material Test Report

Report No: WELS14S-06337-1
Issue No: 1

Client:	Coffey Geotechnics Pty Ltd (Burswood) 53 Burswood Road Burswood WA 6100
Principal:	JDSi
Project No.:	INFOWELS01719AA
Project Name:	GEOTPERT10160AA - Stage 3, East Port Hedland
Lot No.:	NA
TRN:	NA

Accredited for compliance with ISO/IEC 17025.

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

NATA
WORLD RECOGNISED ACCREDITATION

J. Barry
Approved Signatory: Jonathan Barry
(Geotechnician)
NATA Accredited Laboratory Number:431
Date of Issue: 24/09/2014

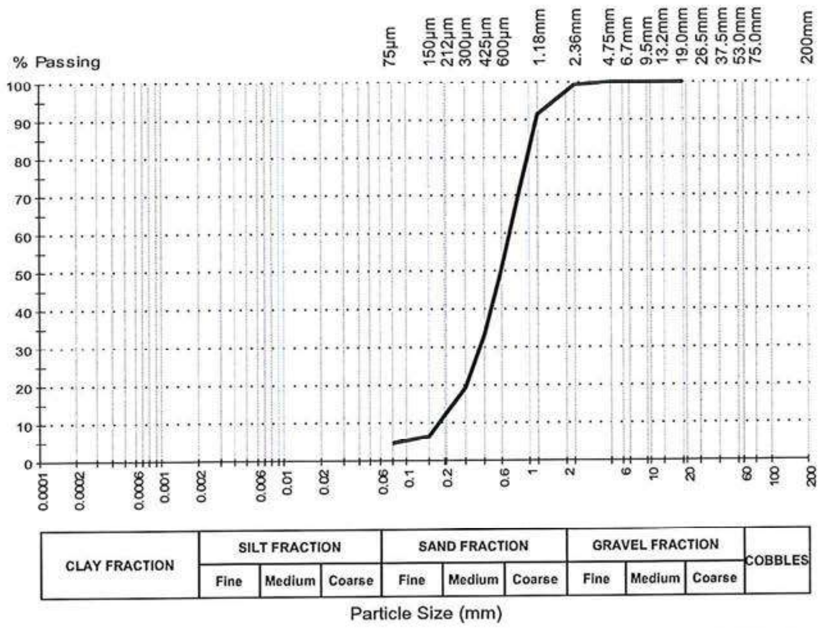
Sample Details

Sample ID:	WELS14S-06337
Client Sample:	Permeability 2
Date Sampled:	
Source:	Unknown
Material:	
Specification:	Determined by client
Sampling Method:	Submitted by client
Project Location:	Styles Road, Port Headland
Sample Location:	Permeability 2

Other Test Results

Description	Method	Result	Limits

Particle Size Distribution



Method: AS 1289.3.6.1
Drying by: Oven
Date Tested: 22/09/2014
Note:

Sieve Size	% Passing	Limits
19.0mm	100	
9.5mm	100	
4.75mm	100	
2.36mm	99	
1.18mm	91	
600µm	50	
425µm	33	
300µm	19	
150µm	7	
75µm	5	

Comments

Sample supplied by client.

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Stage 3 (The Stables)
East Port Hedland

APPENDIX C
INDICATIVE DESIGN CONCEPTS

LEGEND

🟨	LOW DENSITY RESIDENTIAL (R20)
🟫	MEDIUM DENSITY RESIDENTIAL (R40)
🟩	PUBLIC OPEN SPACE
▭	30 METRE BUFFER TO HORSE STABLES SUBJECT TO FURTHER INVESTIGATION
●	ABORIGINAL HERITAGE SITES
---	INDICATIVE DEVELOPMENT BOUNDARY
🟩	MANGROVES
=	DUAL USE PATH

LAND USE / LOT YIELD ANALYSIS

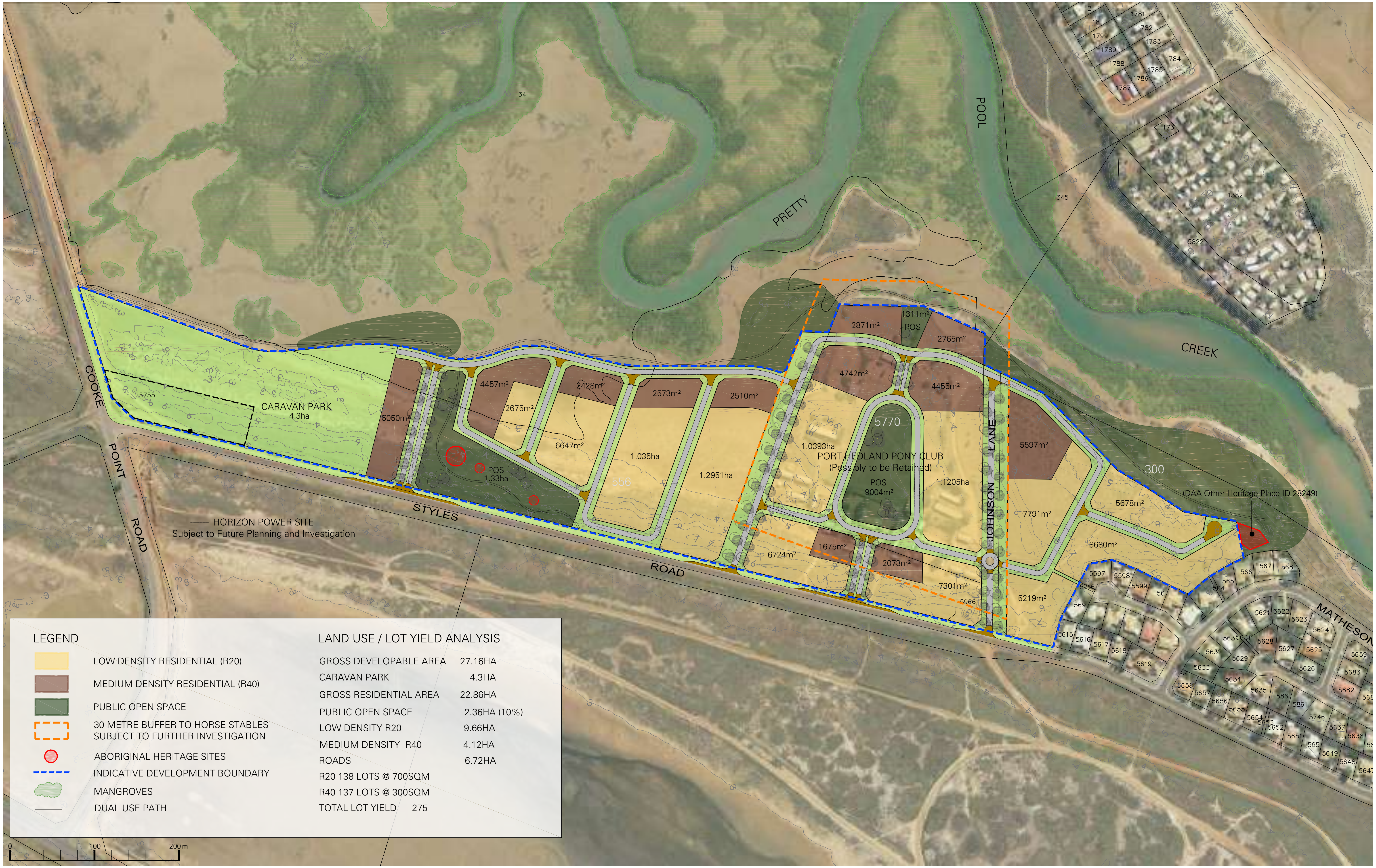
GROSS DEVELOPABLE AREA	27.16HA
CARAVAN PARK	4.2HA
GROSS RESIDENTIAL AREA	22.96HA
PUBLIC OPEN SPACE	2.36HA (10%)
LOW DENSITY R20	9.03HA
MEDIUM DENSITY R40	4.44HA
ROADS	7.13HA
R20 129 LOTS @ 700SQM	
R40 148 LOTS @ 300SQM	
TOTAL LOT YIELD	277

INDICATIVE DEVELOPMENT CONCEPT - OPTION 1
LOTS 556, 5770 AND 300 STYLES ROAD
PORT HEDLAND

NORTH

Date: 17.2.2015
Scale @ A3: 1:4000
Project / Plan
P006 CON 003A

RFF
CHESTERMAN



LEGEND

🟨	LOW DENSITY RESIDENTIAL (R20)
🟫	MEDIUM DENSITY RESIDENTIAL (R40)
🟩	PUBLIC OPEN SPACE
▭	30 METRE BUFFER TO HORSE STABLES SUBJECT TO FURTHER INVESTIGATION
●	ABORIGINAL HERITAGE SITES
- - -	INDICATIVE DEVELOPMENT BOUNDARY
☁	MANGROVES
═	DUAL USE PATH

LAND USE / LOT YIELD ANALYSIS

GROSS DEVELOPABLE AREA	27.16HA
CARAVAN PARK	4.3HA
GROSS RESIDENTIAL AREA	22.86HA
PUBLIC OPEN SPACE	2.36HA (10%)
LOW DENSITY R20	9.66HA
MEDIUM DENSITY R40	4.12HA
ROADS	6.72HA
R20 138 LOTS @ 700SQM	
R40 137 LOTS @ 300SQM	
TOTAL LOT YIELD	275

INDICATIVE DEVELOPMENT CONCEPT - OPTION 2
LOTS 556, 5770 AND 300 STYLES ROAD
PORT HEDLAND

NORTH

Date: 17.2.2015
Scale @ A3: 1:4000
Project / Plan
P006 CON 004A

RFF
CHESTERMAN

Stage 3 (The Stables)
East Port Hedland

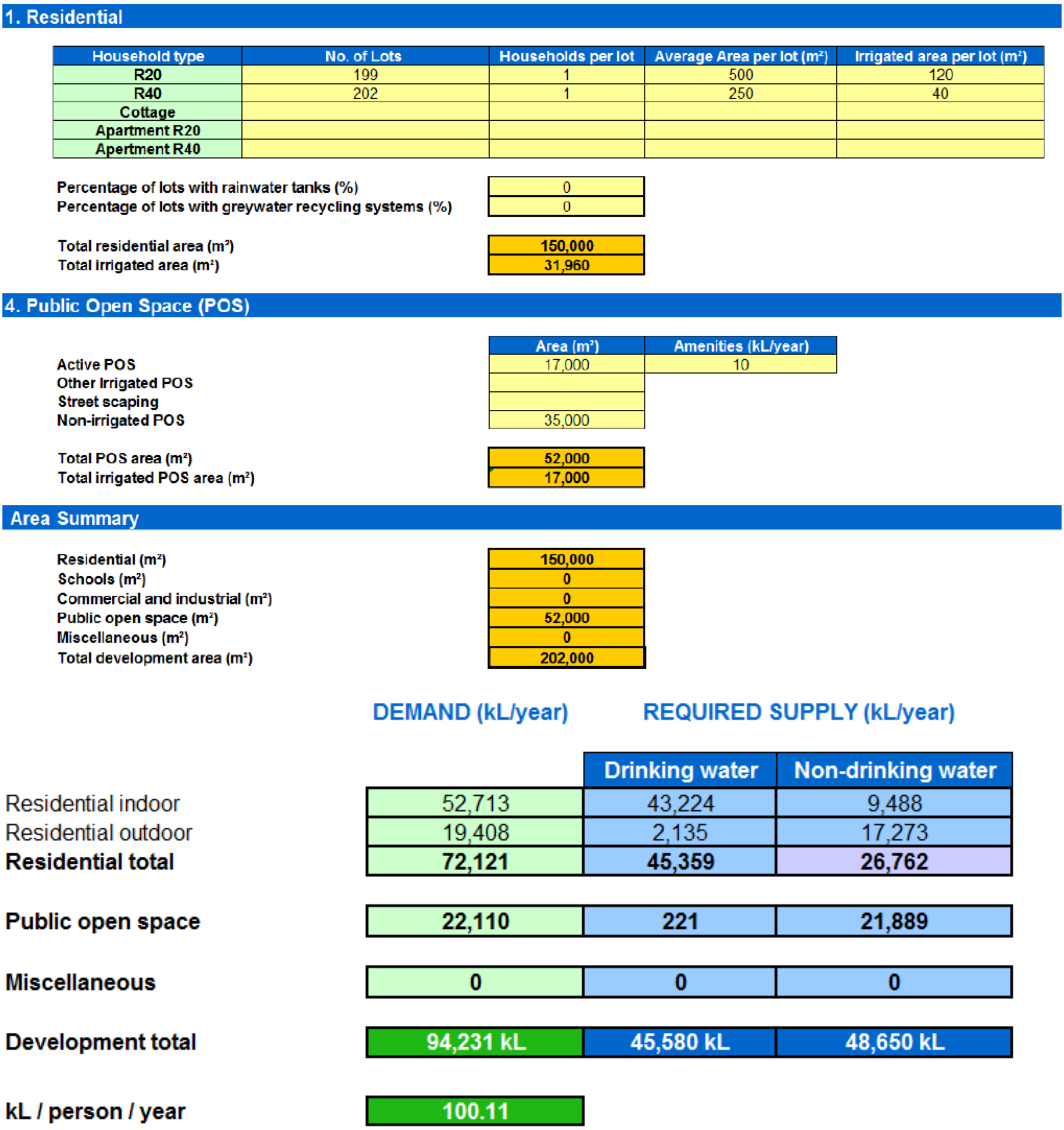
APPENDIX D
WATER BALANCE

Modelling Methodology

Water Balance

The water balance results given in Section 5.3.4 were calculated with the assumptions detailed below by conceptual development option.

Conceptual Development Option 1



1. Residential

Household type	No. of Lots	Households per lot	Average Area per lot (m²)	Irrigated area per lot (m²)
R20	199	1	500	120
R40	202	1	250	40
Cottage				
Apartment R20				
Apertment R40				

Percentage of lots with rainwater tanks (%)	0
Percentage of lots with greywater recycling systems (%)	0
Total residential area (m²)	150,000
Total irrigated area (m²)	31,960

4. Public Open Space (POS)

	Area (m²)	Amenities (kL/year)
Active POS	17,000	10
Other Irrigated POS		
Street scaping		
Non-irrigated POS	35,000	

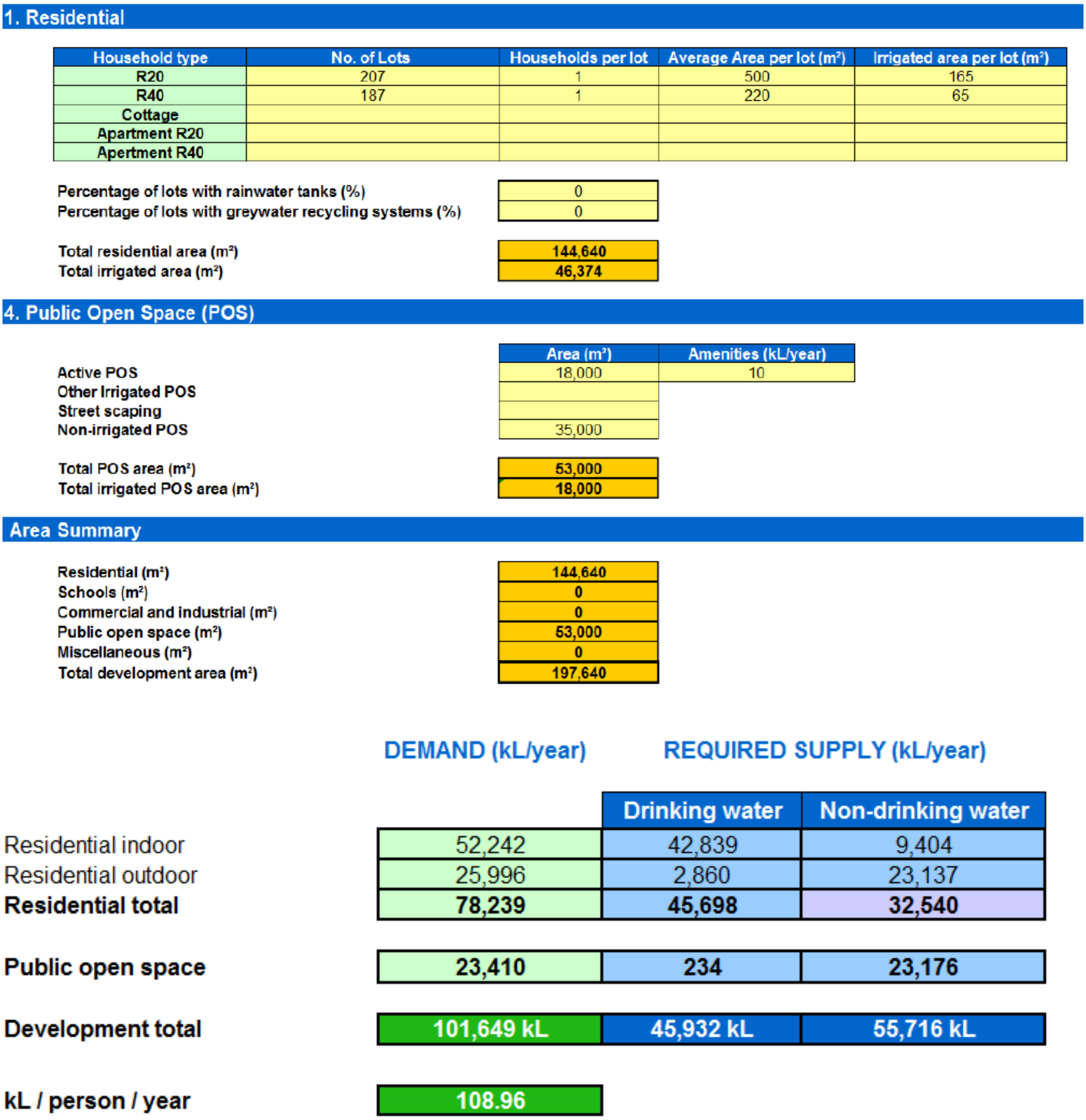
Total POS area (m²)	52,000
Total irrigated POS area (m²)	17,000

Area Summary

Residential (m²)	150,000
Schools (m²)	0
Commercial and industrial (m²)	0
Public open space (m²)	52,000
Miscellaneous (m²)	0
Total development area (m²)	202,000

	DEMAND (kL/year)	REQUIRED SUPPLY (kL/year)	
		Drinking water	Non-drinking water
Residential indoor	52,713	43,224	9,488
Residential outdoor	19,408	2,135	17,273
Residential total	**72,121**	**45,359**	**26,762**
Public open space	**22,110**	**221**	**21,889**
Miscellaneous	**0**	**0**	**0**
Development total	**94,231 kL**	**45,580 kL**	**48,650 kL**
kL / person / year	**100.11**		

Conceptual Development Option 2



1. Residential

Household type	No. of Lots	Households per lot	Average Area per lot (m²)	Irrigated area per lot (m²)
R20	207	1	500	165
R40	187	1	220	65
Cottage				
Apartment R20				
Apertment R40				

Percentage of lots with rainwater tanks (%)	0
Percentage of lots with greywater recycling systems (%)	0
Total residential area (m²)	144,640
Total irrigated area (m²)	46,374

4. Public Open Space (POS)

	Area (m²)	Amenities (kL/year)
Active POS	18,000	10
Other Irrigated POS		
Street scaping		
Non-irrigated POS	35,000	

Total POS area (m²)	53,000
Total irrigated POS area (m²)	18,000

Area Summary

Residential (m²)	144,640
Schools (m²)	0
Commercial and industrial (m²)	0
Public open space (m²)	53,000
Miscellaneous (m²)	0
Total development area (m²)	197,640

	DEMAND (kL/year)	REQUIRED SUPPLY (kL/year)	
		Drinking water	Non-drinking water
Residential indoor	52,242	42,839	9,404
Residential outdoor	25,996	2,860	23,137
Residential total	**78,239**	**45,698**	**32,540**
Public open space	**23,410**	**234**	**23,176**
Development total	**101,649 kL**	**45,932 kL**	**55,716 kL**
kL / person / year	**108.96**		

Stage 3 (The Stables)
East Port Hedland

APPENDIX E
XPSWMM MODELLING

Shaping the Future

Modelling Methodology

XPSWMM Modelling

Modelling was undertaken using XPSWMM, an industry standard hydrologic and hydraulic modelling software system. It routes flow from hydrological sub-catchments through 1D connection, allowing an analysis of the hydraulics of the Site drainage. All hydrological sub-catchments modelled use the Laurenson Routing Method, with a B value calculated by the XPSWMM software.

Rainfall Parameters

Design rainfall events for Port Hedland were determined following the procedure detailed in Australian Rainfall and Runoff *(*Engineers Australia 1997). Catchment areas and slopes are determined from analysis of topographical data. The catchment roughness and percentage imperviousness are conservative and were determined from a combination of field experiments, review of AR&R and other technical documents (e.g. Stream Channel Analysis (Water and Rivers Commission 2001)).

Pre-development Modelling

No modelling of the pre-development conditions was undertaken.

Post Development Modelling

The post development was modelled as 11 subcatchments for both indicative development concepts. Areas, slopes and runoff assumptions are provided in Table C1 and Table C2**Error! Reference source not found.**.

Topographic survey data covering the Site was provided by LandCorp through 0.5 m contours. This enabled the development of a Digital Elevation Model to define the existing overland flow paths. In some cases the overland flow paths have not been easily defined, engineering judgement has been applied to determine catchment sizes and expected flow paths. A 2 m grid cell size has been adopted. This was considered an appropriate resolution for the Site as it adequately represents topographical features such as roads and drains.

The aim of the post development modelling is to demonstrate the proposed drainage design is capable of detaining and infiltrating the first 15 mm of rainfall and to show that the development is able to safely convey the critical storm events through/around the Site.

The model nodes and links for the post development of conceptual development options 1 and 2 are shown in Figures A3 and A4, respectively. The points of interest in the model are the swale cells. The peak flow rate of water leaving the Site can be determined from these features. The post development model has been designed to detain the first 15mm of any storm event on lots and to convey the first 15 mm of any storm event on the road reserve to the swale system on the northern boundary of the Site for infiltration or, for rainfalls greater than 15 mm, overtop the swale.

The model nodes and links for both the conceptual option 1 and 2 models are shown in Figure C1 and Figure C2, respectively.

Delineation of contributing uses to lot areas for both R20 and R40 densities was based on the Western Australian Residential Design Codes (WAPC, 2013). Contributing uses for both R-densities are provided in Table C3.

Table C1 Post Development Catchment Breakup –Option 1

						Developed Lot Areas (ha)				General Lot Areas (ha)		
Sub-catchment	Total Area (ha)	Slope	Total Road Reserve	Road	Verge	Total Number of Lots	Roof	Paved	Garden	POS	Path	Caravan Park
A	2.28	0.001	0.58	0.29	0.29	40	0.89	0.22	0.43	-	0.05	-
B	3.20	0.001	1.15	0.57	0.57	68	1.37	0.24	0.46	-	-	-
C	0.68	0.001	-	-	-	0	-	-	-	0.59	0.05	-
D	5.13	0.001	1.33	0.67	0.67	66	1.40	0.30	0.59	1.27	0.11	-
E	4.39	0.001	1.41	0.71	0.71	69	1.61	0.47	0.90	-	-	-
F	0.95	0.001	-	-	-	0	-	-	-	0.90	0.04	-
G	0.98	0.001	-	-	-	26	0.32	0.08	0.16	0.13	0.04	-
H	7.30	0.001	2.58	1.29	1.29	122	2.30	0.74	1.43	0.89	-	-
I	4.20	0.001	-	-	-	0	-	-	-	-	-	4.20
J	2.56	0.001	-	-	-	0	-	-	-	2.47	0.81	-
K	2.53	0.015	0.31	0.15	0.15	0	0.90	-	1.35	-	-	-

Table C2 Post Development Catchment Breakup –Option 2

						Developed Lot Areas (ha)				General Lot Areas (ha)		
Sub-catchment	Total Area (ha)	Slope	Total Road Reserve	Road	Verge	Total Number of Lots	Roof	Paved	Garden	POS	Path	Caravan Park
A	4.62	0.001	-	-	-	0	-	-	-	-	0.06	4.40
B	1.11	0.001	0.24	0.12	0.12	18	0.45	0.14	0.28	-	-	-
C	0.63	0.001	-	-	-	0	-	-	-	0.59	0.04	-
D	6.08	0.001	1.77	0.88	0.88	90	1.82	0.33	0.65	1.27	0.11	-
E	4.40	0.001	1.41	0.71	0.71	69	1.61	0.47	0.91	-	-	-
F	0.96	0.001	-	-	-	0	-	-	-	0.90	0.04	-
G	0.98	0.001	-	-	-	26	0.48	0.04	0.07	0.13	0.04	-
H	7.53	0.001	2.58	1.29	1.29	113	2.43	0.55	1.07	0.89	-	-
I	3.04	0.001	0.67	0.34	0.34	63	1.25	0.41	0.79	-	-	-
J	2.56	0.001	-	-	-	0	-	-	-	2.49	0.08	-
K	2.54	0.015	0.31	0.15	0.15	45	0.90	-	1.35	-	-	-

Table C3 Lot Breakup by R-Density

R-Density	Average Lot Area (m^2)	Open Space (%)	Roof Area	Garden	Paved
R20	500	50%	250	66%	34%
R40	220	45%	121	66%	34%

Figure C1 XPSWMM Model Nodes and Links for Conceptual Development Option 1

Figure C2 XPSWMM Model Nodes and Links for Conceptual Development Option 2

About Cardno

Cardno is an ASX200 professional infrastructure and environmental services company, with expertise in the development and improvement of physical and social infrastructure for communities around the world. Cardno's team includes leading professionals who plan, design, manage and deliver sustainable projects and community programs. Cardno is an international company, listed on the Australian Securities Exchange [ASX: CDD].

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Cardno
Shaping the Future

Appendix C
Coastal and Hydrological Review

Our Ref: CW1122600:FSC
Contact: Frederic Saint-Cast

Wednesday, 27 May 2020

Element
Level 18, 1991 St Georges Tce

Perth WA 6000

Attention: Justin Page

Cardno (WA) Pty Ltd
ABN 77 009 119 000

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Dear Justin,

SCHEME AMENDMENT - THE STABLES - COASTAL AND HYDROLOGICAL REVIEW

This letter was prepared by Cardno to support the submission of the new scheme amendment proposal for the Stables ("the Development") with respect to coastal and hydrology matters considering existing documentation, including the following references:

[1] Cardno (2011) **Port Hedland Coastal Vulnerability Study.** *Prepared by Cardno for LandCorp. File Ref: Job Number: LJ15014 - Report Number: Rep1022p - 10 August 2011. Version: 2 Final - 10 August 2011.*

[2] Cardno (2015a) **Mangrove & Potential Erosion Impacts Assessments - Stage 3 (The Stables) East Port Hedland.** *Prepared by Cardno for LandCorp. File Ref: V14018_005_R001_RevB_MangroveAssessment - 5 February 2015. Version: Rev B - 5 February 2015.*

[3] Cardno (2015b) **Local Water Management Strategy – Stage 3 (The Stables) East Port Hedland.** *Prepared by Cardno for LandCorp. File Ref: V14018-WA-R002-D-LWMS – April 2015. Version: D – 13/08/2015.*

[4] GHD (2019) **Port Hedland Townsite CHRMAP - Coastal Hazard Risk Management and Adaptation Plan.** *Prepared by GHD for the Town of Port Hedland. File Ref: 6136239 - April 2019. Version: Rev 0 - 29/03/2019.*

In consideration of the findings provided in the references above, Cardno has structured this letter as follows:

- Part 1 addresses the review of the Coastal Hazard Risk Management and Adaptation Plan (CHRMAP, GHD 2019) recently completed by the Town of Port Hedland ("the Town"). It briefly summaries the implications of the CHRMAP for future development of The Stables ("the Site"). It also includes an adjustment to the Rare inundation level which was missed reported in GHD (2019) report. This adjustment corresponds to an upward revision of +0.1m of the Rare inundation level for the 500ARI event to 2120. This revised level, equivalent to 6.7mAHD, is adopted as the minimum development level at the Site, in compliance with SPP2.6 to effectively mitigate the future risk of coastal inundation at the Site.

- Part 2 addresses the review of the Mangrove & Potential Erosion Impacts (Cardno, 2015a) completed by LandCorp in 2015, prior to the release of the Town CHRMAP. It acknowledges the validity of the study and its findings in the context of the CHRMAP and outlines minor addendums to the Cardno (2015a) technical report.

- Part 3 addresses the review of the Local Water Management Strategy (Cardno, 2015b) completed by LandCorp in 2015, prior to the release of the Town CHRMAP. It acknowledges the validity of the study and its findings in the context of the Town CHRMAP and outlines minor addendums to the Cardno (2015b) technical report.

Part 1 – Review of the Town Coastal Hazard Risk Management and Adaptation Plan

Cardno reviewed of the Town CHRMAP (GHD, 2019) with a focus on its implication for the Site.

The Town CHRMAP provides clear recommendations for future development at the Site. It recognises that future coastal inundation hazard may be posing a threat to certain land use in the area, and that it would constitute an unacceptable risk for residential development at the Site without further mitigation measure put in place. In accordance with SPP2.6, the Town CHRMAP recommends that any future development at the Site will be required to be above the Rare inundation level defined as the 500-year Average Recurrence Interval (ARI) storm tide inundation level for the 100-years planning period (2120).

The 2120 intolerable risk of inundation extent for the Almost certain, Possible and Rare uncertainty level is shown in the Town CHRMAP (GHD, 2019, p.54 *Figure 4-10 East Townsite inundation hazard and recommended adaptation*). The inundation likelihood levels are provided in the Town CHRMAP (GHD, 2019, *Table 2-10 Inundation likelihood levels*). In the case of the 2120 planning horizon, if the elevation of the asset is below the Rare inundation level of 6.6mAHD the asset is defined as impacted by inundation. Conversely, if the asset is defined as not impacted by inundation if the minimum elevation of the asset is above the rare inundation level of 6.6mAHD.

Upon further inspection of the source of water level information cross-referenced in the Town CHRMAP (GHD, 2019, p22. *Table 5-3 Inundation water levels Area 1. Blue values are taken from Cardno 2011*), it was noted that the water level reported in the Port Hedland Coastal Vulnerability Study (Cardno, 2011) were provided for 2110 and not for 2120 as reported in GHD (2019). The sea level rise allowance increases by 0.1m between 2110 and 2120. So, the 500year ARI design water level for 2120 should have been 6.7mAHD and not 6.6mAHD.

In consideration of the above, Cardno recommends an adjustment to the 2120 Rare inundation hazard level reported in the Town CHRMAP for the Site. This adjustment corresponds to an upward revision of +0.1m of the original Rare inundation level for the 500ARI event to 2120, equivalent to 6.7mAHD. This revision was subsequently raised in pre-lodgement consultations with the Town and supported at officer level. As a result, the Development will be filled to 6.7mAHD to comply with the revised CHRMAP guidance and comply with SPP2.6 to effectively mitigate the future risk of coastal inundation at the Site.

Part 2 - Review of the Mangrove & Potential Erosion Impacts

Cardno reviewed the Mangrove & Potential Erosion Impacts (Cardno, 2015a) with a focus on the implication of the Town CHRMAP review findings (Part 1) on its validity.

The only departures from the original assumptions made in the Mangrove & Potential Erosion Impacts (Cardno, 2015b) is related to a minor revision of the inundation level for the 500ARI event incorporating sea level rise, which would affect the modeling study as follows:

i. The horizontal footprint of the development in the model remains unchanged and the vertical level of the development in the model would be raised by +0.1m, from 6.6mAHD to 6.7mAHD.

ii. The allowance for sea level rise in Scenario 4 (500ARI event incorporating sea level rise) would increase by +0.1m, from 0.9m to 1.0m, in line with the time horizon revision from 2110 to 2120.

These minor revisions are not expected to change the findings of the study with respect to Mangrove & Potential Erosion Impacts for the following reasons:

1. The revised development level does not affect the modelling results for the original scenarios which covers the vast majority of the scope of the investigation.
    a. The original Scenarios 1, 2 and 3 remain unchanged and are still applicable.
    b. The original Scenario 4 remain unchanged and are still applicable to 2110.
2. The original Scenario 4 to 2110 can be seen has a hazard with a probability of occurrence of 16.5% over the time horizon considered, while an extended Scenario 4 to 2120 would be seen as a hazard with a probability of occurrence of 18.1% over the time horizon considered. These two hazard likelihoods are not meaningfully different.

3. At the Site, with a tidal range in the order of 6.5m, a surge height in the order of 2m and sea level rise projection in the order of 1m to 2120, a nominal water level variation in the order of 0.1m is within the general accuracy of the storm surge model and within the general vertical tolerance of bathymetric and topographic survey for a model of this scale.
4. The mangrove & potential erosion impacts are assessed by comparing the hydrodynamic model results before and after development. This assessment show that the consequences of the development are not deemed significant with respect to mangrove & potential erosion impacts. So, a minor alteration of the water level is not expected to result in any significant deviation from the original modelled mangrove & potential erosion impacts findings.

In consideration of the Part 1 and the above review, Cardno confirm that the Mangrove & Potential Erosion Impacts study (Cardno, 2015a) is still applicable with no changes to 2110. The subsequent minor changes in design level reflecting the extension of time horizon to 2120 are not expected to significantly change the Mangrove & Potential Erosion Impacts risk profile original assessed. As a result, Cardno confirm that the Mangrove & Potential Erosion Impacts is still applicable to 2120 with respect to mangrove & potential erosion impacts subject to the following minor addendums to the Mangrove & Potential Erosion Impacts technical report (Cardno, 2015a):

1 Introduction

References to “To comply with SPP2.6, any future development in this region of Port Hedland will be required to be above the 500-year Average Recurrence Interval (ARI) storm tide inundation level for the 100-years planning period (~~2110~~). From the recommendations in the Port Hedland Coastal Vulnerability Study (Cardno 2011), the site would be required to be filled to a minimum level of ~~+6.6 m AHD~~.” should be read as “To comply with SPP2.6, any future development in this region of Port Hedland will be required to be above the 500-year Average Recurrence Interval (ARI) storm tide inundation level for the 100-years planning period (2120). From the recommendations in the Port Hedland Coastal Vulnerability Study (Cardno 2011), the site would be required to be filled to a minimum level of +6.7 m AHD.”

2.4.1 Development Cases

References to “design fill level of ~~+6.6 m AHD~~” should be read as “design fill level of +6.7 m AHD”.

6.1 Implications for Development

References to “the full footprint will be filled to a level of ~~+6.6 m AHD~~” should be read as “the full footprint will be filled to a level of +6.7 m AHD”.

Part 3 - Review of the Local Water Management Strategy

Cardno reviewed the Local Water Management Strategy (Cardno, 2015b) with a focus on the implication of the Town CHRMAP review findings (Part 1) and the Mangrove & Potential Erosion Impacts review findings (Part 2) on its validity.

The Local Water Management Strategy (Cardno, 2015a) was *Approved by Department of Water and Environmental Regulation (then Department of Water) 25 August 2015.*

In consideration of the Part 1 and Part 2 above, Cardno confirm that the Local Water Management Strategy is still applicable subject to the following minor addendums to the Local Water Management Strategy (Cardno, 2015b):

Section 2.5.2 Flooding

Revised 6.7m AHD finished level to be applied to the site for long term accommodation (i.e. residential) in accordance with the CHRMAP.

Section 2.5.2.1 Mangrove and Erosion Impact Assessment

Third dot point to be updated to read the site will need to be filled to 6.7mAHD.

Appendix A: Mangrove and Erosion Impacts Assessment

Appendix A, Mangrove and Erosion Impacts Assessment (Cardno, 2015b) to be consistent with the addendum noted in part 2 above.

Yours sincerely,

Frederic Saint-Cast
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for Cardno
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Appendix D

Surveys of Migratory Waterbirds at the Pretty Pool development, Port Hedland

Surveys of Migratory Waterbirds at the Pretty Pool development, Port Hedland (spring 2008 to spring 2011)

Pretty Pool at low tide, with tidal flats in background (M. Bamford)

Prepared for: RPS Environment and Planning Pty Ltd
38 Station Street
Subiaco WA 6008

Prepared by: Mike Bamford

M.J. & A.R. Bamford,
CONSULTING ECOLOGISTS.
23 Plover Way,
Kingsley, WA, 6026

19th March 2012

EXECUTIVE SUMMARY

LandCorp is developing a new urban area at Pretty Pool, on the outskirts of Port Hedland, and during the impact assessment for this project the possible effect upon migratory waterbirds on the nearby coastline was discussed. This concern was raised because large numbers of migratory waterbirds are known to utilise the general area. As a result, Bamford Consulting Ecologists carried out monitoring of waterbirds in the area, with field surveys on 19-20 October 2008, 28-29 March 2009, 8-9 October 2010 and 13-14 November 2011. The timing of the surveys was intended to coincide with the expected migration peaks in migratory waterbird numbers, particularly during southward migration (October-November). Surveys were also timed to coincide with spring tides when waterbirds are most readily surveyed.

The field surveys involved high and low tide counts of all waterbirds (including non-migratory species) and observations on landbirds (including mangrove-dependent species) in the Pretty Pool to Four Mile Creek area, and some nearby sites around Port Hedland. In addition, aerial surveys of the coastline from Port Hedland Harbour to the Rio Tinto (formerly Cargill) salt ponds on Rock Cod Hole Creek were carried out. Human activities were also observed during all surveys, as this type of disturbance was identified as a concern with respect to impacts of the Pretty Pool proposal upon migratory waterbirds.

In the Pretty Pool and Four Mile Creek area, the surveys recorded 21 species of migratory waterbirds, 14 species of non-migratory waterbirds and 21 species of land-birds, of which one is migratory and five are mangrove-dependent. Waterbirds were using the tidal mudflats adjacent to Pretty Pool and Four Mile Creeks for foraging during low tide, with over 1000 birds present on two occasions (spring 2008). The birds did attempt to roost at the site, focussing on a rocky point between Pretty Pool and Four Mile Creeks, but they were regularly disturbed by pedestrians with dogs, and even four wheel drive vehicles on the beach, and flew either east or south when these disturbances occurred. Some of the birds, particularly the smaller species such as Greater Sand Plover, Sanderling and Red-necked Stint, also roost on the upper Six Mile Creek adjacent to Grey Street, while larger species (Great Knot and Bar-tailed Godwit) were observed roosting on a rocky bar within mangroves just west of the mouth of Six Mile Creek. The ground counts and aerial survey found that the closest site to the east of Port Hedland with moderate numbers of waterbirds was the Pretty Pool area, with much higher numbers occurring further east, including around Petermarer Creek and the coast adjacent to the Rio Tinto salt ponds.

All migratory bird species observed during field investigations were recorded in numbers that are low even in a regional context, although the maximum count of Sanderling represents almost a third of the Pilbara coastline population estimate for this species.

Mangrove-dependent birds were better represented amongst the mangroves at Four Mile Creek than at Pretty Pool Creek, most likely due to the mangroves at the former site being much more extensive. A small colony of the Black Flying-fox was also found at Four Mile Creek.

One of the other sites visited was the sewage farm, where there are extensive, nutrient rich pools. These pools were consistently found to support large numbers of non-migratory waterbirds but only small numbers of migratory species. The most notable observation was a flock of almost 2000 Plumed Whistle-Ducks in November 2011. This may be the largest aggregation of the species ever recorded in the Pilbara.

During all surveys, it was noted that there were high levels of human activity along the coastline. This was especially notable at high tide, when fishing and swimming are possible. These activities are likely to be disturbing the roosting of waterbirds in the Port Headland area. There was also some human activity at low tide on the tidal flats adjacent to Pretty Pool. The tidal flats area is extensive and therefore the effect of disturbance from current levels of human activity on foraging birds is likely to be low.

Human activity resulting in the disturbance of waterbirds may require management. Signage and low fencing at Pretty Pool could encourage people to avoid the rocky point where birds try to roost, and as the suburban area expands, consideration could be given to restricting access to parts of the tidal mudflats so that birds can forage undisturbed. In addition, the site on the upper Four Mile Creek adjacent to Grey Street may need some protection.

CONTENTS

TABLES

FIGURES

APPENDICES

1 INTRODUCTION

LandCorp is developing a new urban area at Pretty Pool, on the outskirts of Port Hedland, and during the impact assessment for this project the possible effect upon migratory waterbirds on the nearby coastline was discussed. As a result, a commitment was made to undertake surveys of migratory waterbirds in the area. The aim of these surveys was to identify the species, abundance and distribution of migratory waterbirds on the nearby coastline, and to provide some regional context. In addition to observations of these species, mangrove-dependent birds and land-birds were recorded.

RPS Environment and Planning Pty Ltd (RPS) was commissioned to carry out this work, and Bamford Consulting Ecologists was sub-contracted to undertake the investigations. This report presents the results of four field surveys carried out in October 2008, March 2009, October 2010 and November 2011.

2 SITE AND PROJECT DESCRIPTION

Pretty Pool is an existing urban development about 5km east of Port Hedland, and is adjacent to Pretty Pool Creek (see Figures 1 and 2). The expansion of the urban area is immediately to the east of the existing suburb, and lies between existing houses and Four Mile Creek. Both Pretty Pool and Four Mile Creeks are tidal and mangrove-lined, with the former having a clear pool that is used for recreational purposes. There are extensive tidal mudflats right along the coast in this area, with those opposite Pretty Pool Creek being several hundred metres wide at low tide. The tidal zone around Port Hedland has a largely sandy or rocky substrate, with Pretty Pool Bay being the first area of tidal flat with a mud/silt substrate to the east of Port Hedland.

The coastline from Port Hedland to the mouth of the De Grey River, some 50km east, consists of rocky headlands alternating with sandy beaches, tidal mudflats and mangrove-lined tidal creeks. Extensive salt marshes exist inland of these mangrove lined creeks. Except in the immediate vicinity of Port Hedland, there is limited coastal development. The Cargill Salt evaporation ponds, which lie immediately inland of the coast about half way between Port Hedland and the De Grey River, are recognised as a site of international importance for migratory waterbirds. Information on the waterbirds present within the evaporation ponds collated by Lane and Jaensch (1993) and the results of surveys carried out for Cargill Salt (Bamford 1993, 1995) provide background information on waterbirds in the region.

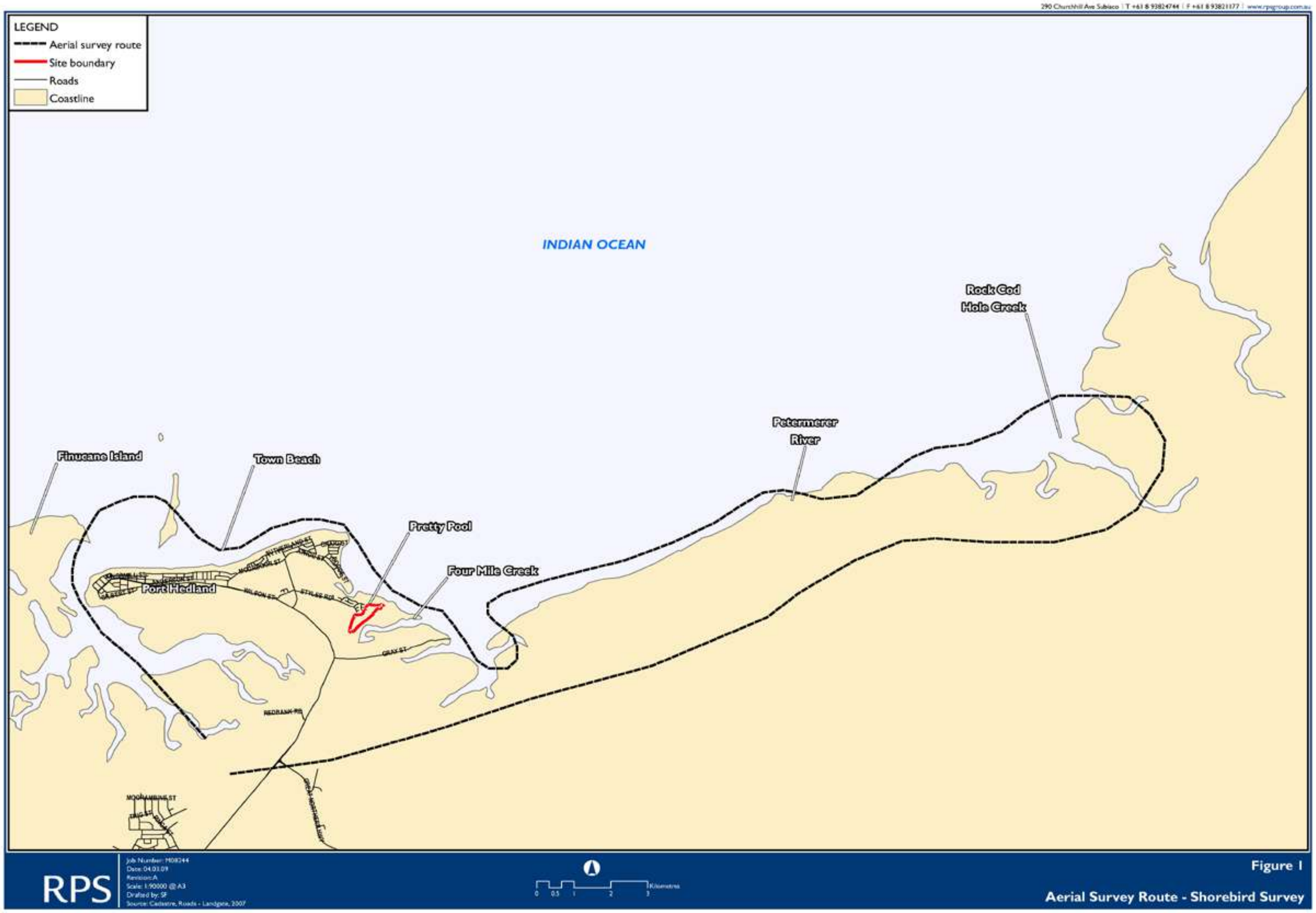

Figure 1 **The Pilbara coastline from Port Hedland to the mouth of the De Grey River, indicating the Pretty Pool area and the route taken on the aerial survey**

RPS

Job Number: L10110
Date: 05.01.11
Scale: 1:25000 @ A4
Revision: A
Drafted by: SF
Source: Air photo (Nov 2009) - Landgate, 2011.

Figure 2

Pretty Pool Area Indicating Key Locations Mentioned in the Text

3 METHODS

3.1 Definition of Migratory Waterbirds

For the purposes of this investigation, migratory waterbirds are those species of waterbirds listed as migratory under the Federal *Environment Protection and Biodiversity Conservation Act* (1999) (EPBC Act), also listed under Schedule 3 of the *WA Wildlife Conservation Act* (1950). These include all species of sandpipers (Scolopacidae) that visit Australia, as well as some plovers (Charadriidae), pratincoles (Glareolidae), terns (Laridae), egrets (Ardeidae), ibis (Threskiornithidae) and birds of prey (Accipitridae). Note that some listed migratory species are not migratory in Australia, but are included under the EPBC Act because the same species are migratory in other countries and are listed as such under the Bonn Convention, to which Australia is a signatory. There are also several listed migratory species that are not waterbirds that have been included in this review. Observations on mangrove-dependent birds (and some other wildlife) were also made and are presented.

In addition to migratory species of significance under the EPBC Act, one species, the Fairy Tern, is listed as Vulnerable under the Act.

3.2 Field Investigations

Field investigations took place on the 19-20 October 2008, 28-29 March 2009, 8-9 October 2010 and 13-14 November 2011, and were carried out by Dr Mike Bamford (B.Sc. Hons. Ph.D.) and Mrs Mandy Bamford (B. Sc. Hons). The timing of the survey was designed to coincide with spring tides and with the southward (October-November) or northward (March) migration period of the majority of migratory waterbirds. Southward migration in particular is when numbers are highest on the Pilbara coast (Bamford *et al.* 2008). Spring tides are favourable for waterbird surveys, as the birds are concentrated during high water periods, making the identification of important roost sites possible, and making the birds relatively easy to count. Therefore, most waterbird counts were conducted within a few hours of the high tide. Counts were also carried out at low tide to identify foraging areas utilised by the birds. The high tides used for surveys occurred around midday. The time and height of high tides were (for Port Hedland, data from the website of the National Tide Centre of the Bureau of Meteorology):

Date	Time	Height (AHD)
19th October 2008	13:20	6.13m
20th October 2008	13:54	5.70m
28th March 2009	12:09	7.09m
29th March 2009	12:35	7.20m
8th October 2010	11:10	6.72m
9th October 2010	11:46	6.85m
13th November 2011	12:17	6.21m
14th November 2011	12:43	6.14m

During all surveys, field-work involved visiting Pretty Pool and Four Mile Creeks, and the adjacent coastline, on several occasions. This included locations within the town of Port Hedland (sewage farm, Town Oval, Cemetery (Town) Beach and adjacent spoil bank, Six Mile Creek and the upper flats of Four Mile Creek along Grey Street. In addition, aerial surveys took place on 20th October 2008, 29th March 2009, 9th October 2010 and 14th November 2011, and coincided with high tide on each occasion. These surveys took place from a fixed-wing light aircraft (Cessna 172) flying over the water at a height of approximately 300m. Locations of interest were circled where necessary. This survey made it possible to identify major roosts of waterbirds and to identify some species. The approximate route followed is illustrated on Figure 1. Refer to Table 4 for data on aerial surveys.

The programme of surveys is outlined below. In summary, the programme consisted of:

- October 2008: two low tide (foraging) counts of the Pretty Pool to Four Mile Creek area; one high tide (roosting) count of the Pretty Pool to Four Mile Creek area; visits made to locations around Port Hedland such as Cemetery (Town) Beach (including spoil bank); aerial survey.
- March 2009: one low tide (foraging) count of the Pretty Pool to Four Mile Creek area; two high tide (roosting) counts of the Pretty Pool to Four Mile Creek area; visits made to locations around Port Hedland such as Cemetery (Town) Beach (including spoil bank), town oval and the ponds of the sewage farm; one visit to upper Four Mile Creek along Grey Street and mouth of Six Mile Creek; aerial survey.
- October 2010: one complete and one partial low tide count of the Pretty Pool to Four Mile Creek area; one high tide (roosting) count of the Pretty Pool to Four Mile Creek area; visits made to locations around Port Hedland such as Cemetery (Town) Beach (including spoil bank), town oval and the ponds of the sewage farm; one visit to upper Four Mile Creek along Grey Street and mouth of Six Mile Creek; aerial survey.
- November 2011: one complete low tide and one complete high tide count of the Pretty Pool to Four Mile Creek; visits made to locations around Port Hedland such as Cemetery (Town) Beach (including spoil bank), town oval and the ponds of the sewage farm; one visit to upper Four Mile Creek along Grey Street and mouth of Six Mile Creek; aerial survey.

The general programme of the field surveys was as follows:

- 19th October 2008.
    - 0800 to 1100. Walked from Pretty Pool lower carpark to beach, east to Four Mile Creek, along Four Mile Creek upstream towards end of development, then back along margin of development and west along Pretty Pool Creek. Tide was low and still rushing out of creeks initially, but starting to come in by end of survey.
    - 1255 to 1330. Aerial survey from Finucane Island within the port to Cargill Salt Ponds at Rock Cod Hole Creek.

- 20th October 2008.
    - 0700 to 0900. Low tide count of foraging birds in Pretty Pool Bay. Mudflats very extensive. Walked in reverse direction (Four Mile Creek to Pretty Pool Creek) from previous day to reduce sun glare.

  - 0915 to 1000. Surveyed sites around Port Hedland, including Town (Cemetery) Beach which had previously been identified as an area used by waterbirds (see Figure 1).
  - 1015 to 1045. Surveyed along Pretty Pool Creek on rising tide.
  - 1045 to 1230. Walked from Pretty Pool lower carpark to beach, east to Four Mile Creek, along Four Mile upstream towards development, then back through Pretty Pool suburb to return to carpark. Count carried out during the last stages of rising tide, with mudflats still exposed initially in Pretty Pool Bay, but these rapidly disappeared and were completely inundated by 1100.

- 28th March 2009.
  - 11:00 to 13:00. High tide count in Pretty Pool Bay. Walked along Four Mile Creek and back via samphire flats and Pretty Pool Urban area. Tide very high throughout.
  - 13:15. Surveyed birds on sewage farm ponds and flooded flats around ponds.
  - 15:45 to 17:30. Tide low and still falling. Sand and mudflats extensive at Pretty Pool and Four Mile Creeks. Walked across tidal flats of both creeks and return. Waders scattered cross flats foraging in small numbers.

- 29th March 2009.
  - 07:30. Surveyed Cemetery Beach (Town Beach)
  - 09:00. Surveyed sewage farm ponds and flooded flats around ponds.
  - 09:45. Pretty Pool tidal flats 60% inundated and fully covered by 10:30. Walked from recreation area to mouth of Four Mile Creek, then back via suburb. Very few birds around. The only concentration of waterbirds was in a a roost on the beach just west of the mouth of Four Mile Creek.
  - 12:45 to 1310 Aerial Survey. Same route as previously in Oct 08 (Town Beach, Cooke Point, Pretty Pool bay, Four Mile Creek). Tide very high.
  - 14:30. Six Mile Creek, falling tide.

- 8th October 2010.
  - 10:00 to 11:45. High tide count from Pretty Pool to Four Mile Creek and back via samphire flats and Pretty Pool Urban area. Tide very high throughout.
  - 12:30. Surveyed birds on sewage farm ponds and flooded flats around ponds.
  - 13:00. Visited Cemetery (Town) Beach. Tide still high.
  - 14:00. Visited Six Mile Creek and upper Four Mile Creek off Grey Street; tide still high.
  - 16:15 to 17:30. Mudflats west of Pretty Pool channel surveyed at low tide.

- 9th October 2010.
  - 06:00 to 09:15. Low tide survey from Pretty Pool to Four Mile Creek and back via samphire flats and Pretty Pool Urban area. Tide very low throughout.
  - 10:00 and 13:00. Visited sites around Port Hedland, including town oval, Cemetery Beach and spoil bank.
  - 11:15 to 12:00. Aerial survey (same route as previously).
  - 13:15. Revisited sewage farm.

- 13th November 2011.
    - 12:00 to 14:00. High tide count from Pretty Pool to Four Mile Creek and back via samphire flats and Pretty Pool Urban area. Tide very high throughout.
    - 14:30 to 16:00. Surveyed birds on sewage farm ponds and flooded flats around ponds.

- 14th November 2011.
    - 06:00 to 06:30. Low tide count of Cemetery Beach.
    - 07:00 to 09:00. Low tide survey from Pretty Pool to Four Mile Creek and back via samphire flats and Pretty Pool urban area.
    - 10:00 and 11:00. Visited sites around Port Hedland, including town oval, Cemetery Beach and spoil bank. Tide rising.
    - 11:15 to 12:00. Grey Street mudflats; high tide.
    - 12:30 to 13:15. Aerial survey (same route as previously undertaken).
    - 14:30. Six Mile Creek survey on falling tide.

3.3 Limitations of investigations

Conditions were ideal during the survey periods and all sites could be visited. People disturbed some birds during surveys on 19th October 2008 (Sunday), and on both days during the March 2009 and October 2010 surveys, and this may have affected results, but was also an important observation. There was disturbance during the high tide survey at Pretty Pool on 13th November 2011.

4 RESULTS AND DISCUSSION

4.1 The distribution of waterbirds in the Pretty Pool area

The waterbird surveys recorded 29 species of migratory waterbirds and 32 species of non-migratory waterbirds (Tables 1 to 3 and Appendix 1). In addition, there were 23 species of land-birds recorded, of which one is migratory and seven are mangrove-dependent (Table 7 and Appendix 1). The migratory waterbird species were among those listed by Metcalf and Bamford (2006) as likely to occur at the site. The other bird species observed were also listed as expected to occur (Appendix 1). The list of recorded species includes species found only on the ponds at the Port Hedland sewage farm. The sewage farm supports a rich assemblage of bird species including many not found elsewhere in the Port Hedland area.

In the Pretty Pool area, most birds were observed on the shoreline and tidal flats (see Table 1) with numbers highest at low tide, when the birds were dispersed and foraging across the tidal flats. High tide counts were almost always affected by disturbance from people and dogs. There would almost certainly be larger numbers of birds roosting at high tide without this disturbance, and the main roost-site is a small rocky point that lies between Pretty Pool Creek and Four Mile Creek (see Figure 3). Pretty Pool Creek and Four Mile Creek (Table 2) supported only small numbers of birds. The creeks offered little tidal shoreline for foraging, with little use being made of the tidal mudflats and samphire areas behind the mangroves. They were also subject to high levels of human activity (Table 9).

Just south of Pretty Pool, a major concentration of migratory waterbirds (almost entirely shorebirds or waders) was recorded on the upper reaches of Four Mile Creek adjacent to Grey Street (see Figure 4). This site was not found until March 2009 and appears to be an important high tide roost free from disturbance. On 8th October 2010, a flock of birds roosting on the rocky point between Pretty Pool and Four Mile Creeks was disturbed by a pedestrian with two dogs and flew in the direction of the Grey Street site. When this site was visited an hour later, 451 birds were present (see Table 2) and it is likely that this was the same flock that had been flushed from the coastline earlier. The Grey Street sites appears to be consistently important for roosting waders, with nearly 1000 birds present on 14th November 2011; the largest concentration of waders recorded at any one location around Port Hedland in this study. Another occasional concentration of several hundred migratory waterbirds was found near the mouth of Six Mile Creek. There appeared to be regular movement of migratory waterbirds in the Pretty Pool to Six Mile Creek area, with birds possibly roosting somewhat opportunistically where they were not disturbed.

In the Pretty Pool area, the highest counts were in spring and particularly in October 2008 (19th and 20th October), however the low tide counts in October 2010 and November 2011 were comparable. High counts were due to a few species such as Bar-tailed Godwit, Great Knot, Red-necked Stint and Grey-tailed Tattler. Table 5 summarises annual maxima of migratory species (Pretty Pool area). The Ruddy Turnstone was unusual in being the only migratory species with greater abundance in autumn than in any of the spring surveys (Table 5: 41 in March 2009 compared with eight in October 2010 and five in each of October 2008 and November 2011 surveys). This suggests a difference in migration patterns. Despite this, similar numbers of species were observed in each survey with many represented by just one or two individuals.

The abundance of waterbirds can vary for a variety of reasons and because they are mobile and react to rainfall over large areas, results from occasional counts must be viewed with caution. However, the low spring 2010 counts of Bar-tailed Godwit and Great Knot are consistent with anecdotal reports that these species have been badly affected by loss of habitat due to coastal development in South Korea (Birds Korea 2010).

4.2 The distribution of waterbirds in the Port Hedland region

In addition to counts around Pretty Pool and nearby areas (e.g., Six Mile Creek, Four Mile Creek including Grey Street), counts were made at other locations around Port Hedland, and along the coast to the east during aerial surveys.

Counts made around Port Hedland are presented in Table 3 (Port Hedland beaches and Town Oval) and Table 4 (sewage ponds). The sewage ponds generally display high numbers of birds with a large variety of species (although the majority are not migratory). In November 2011this area recorded the highest count of all the sites in the Port Hedland area. Results show that there were nearly 2,000 Plumed Whistling-Ducks in this area, representing nearly 2% of the minimum population estimate (see Appendix 2) of this species.

Results of aerial surveys are presented in Table 7. The large count of shorebirds in October 2010 and again in November 2011 was due mostly to about 2,000 birds roosting along the coast just east of Petermarer Creek and close to the salt evaporation ponds (see Figure 1). The large count of gulls and terns in October 2010 was due to a flock on the eastern shore of Six Miler Creek. The aerial surveys found that these two locations were consistently important for roosting waterbirds, but the Grey Street roost was not detected from the air. Although the location was visited, the birds at this site were spread out and difficult to see against the background of rocks and shallow water, whereas flocks on the beach are readily seen. Counts of waterbirds were very low around Port Hedland from the harbour to Six Mile Creek, which corresponds with the area where people are able to access the coastline.

4.3 Waterbirds at Pretty Pool in a Local, Regional and Flyway Context

Counts carried out around Port Hedland and during aerial surveys provide some local context to the abundance of waterbirds at Pretty Pool (Table 2). Numbers of waterbirds on Cemetery Beach in Port Hedland, and on the playing fields, were low, while counts at the sewage farm ponds recorded a high degree of species richness with several species recorded in high numbers. Many of the birds species recorded are not typically found on marine coastlines. During the aerial survey (Table 5), most waterbirds were recorded east of Six Mile Creek in locations away from areas prone to human disturbance.

Waterbird counts can be placed into the regional context through comparison with data collected in the mid 1990s (Bamford Consulting 1993 and 1995). An aerial survey conducted on 26th March 1993 from Port Hedland to the mouth of the De Grey River recorded just over 9,000 waterbirds, with 930 of these birds west of Petermarer Creek, which roughly corresponds to the survey area of October 2008 and March 2009. The number present between Port Hedland and Petermarer Creek was therefore similar on 26th March 1993 and on the 2008 and 2009 surveys. On 23rd March 1995, an aerial survey from Port Hedland to the mouth of the De Grey River recorded 14,000 waterbirds, but also noted that most birds were in the east, particularly around the De Grey River.

Surveys conducted in the 1990s included detailed counts of the Cargill Salt ponds, just east of Petermarer Creek. There were about 20,000 waterbirds on the ponds in March 1993 and 19,000 in March 1995. Note that much higher waterbird counts have been reported from the Cargill salt ponds, including over 66,000 on both 19th November 1982 and 16th October 1984 (unpublished data from Birds Australia), although it is not known if such numbers still occur at the site.

In a regional context, it would seem that the Pretty Pool to Four Mile Creek area supports a small proportion of the waterbirds present between Port Hedland and the mouth of the De Grey River, however it is the closest site to Port Hedland to support waterbirds in moderate numbers.

On a broader scale, waterbird numbers can be considered in the context of the Pilbara/Gascoyne coast, Australia and even the East Asian-Australasian Flyway which migratory species traverse (Appendix 2). As would be expected, globally and even regionally, waterbird numbers around

Pretty Pool are minor, but in the context of the Pilbara/Gascoyne coast, the maximum count of Sanderling (145 in November 2011, see Table 1) is 72% of the number in the region estimated by Bamford *et al.* (2008). This is a conservative estimate and is based on the non-breeding period, whereas the November 2011 count was made during southward migration when numbers are likely to be higher. However, it indicates that the Pretty Pool area is at least locally important for the species, and the count is close to the 1% criterion (220 birds) under the Ramsar Convention, suggesting that Pretty Pool comes close to being a site on international importance for Sanderling. The count of 145 was made on the upper reaches of Four Mile Creek, adjacent to Grey Street. This is a roosting site and may attract Sanderling from beaches many kilometres away. Sanderling are very rarely recorded on the Cargill salt ponds, with none seen in 1993 or 1995, and a maximum count from Birds Australia data of 29 in April 1985.

A second (non-migratory) species with a notable count, again in November 2011, is the Plumed Whistling Duck, with 1,900 birds on the Port Hedland sewage ponds. While not strictly part of the Pretty Pool survey, it must be noted as this count probably represents the largest aggregation of the species in the Pilbara and 1.9% of the minimum population estimate for the species (see Appendix 2).

The vulnerable (under EPBC Act) but non-migratory Fairy Tern, with 100 birds present during low tide in November 2011, was also present in significant numbers. This count represents 1.1% of the species' minimum population estimate (Appendix 2). These birds were roosting and foraging along the low tide edge of the Pretty Pool tidal flats.

For all other species, the Pretty Pool count and other counts made during this project are <10% of the Pilbara/Gascoyne population estimate.

4.4 Land-birds, including mangrove-dependent species, in the Pretty Pool area

The land-birds recorded were mostly widespread species in small numbers (see Table 8). The migratory Rainbow Bee-eater was observed, with a single specimen observed around Pretty Pool in March 2009 and October 2010, but other migratory land-bird species listed as expected by Metcalf and Bamford (2006), the Fork-tailed Swift and Barn Swallow, were not seen. The seven mangrove-dependent species recorded were typical of that area, and all of them were present along Four Mile Creek in at least one survey, but only three, the Yellow White-eye, White-breasted Whistler and Mangrove Robin, were recorded along Pretty Pool Creek. Four Mile Creek supports much larger and taller areas of mangroves than Pretty Pool Creek (Figure 5).

A colony of Black Flying-fox *Pteropus alecto* were noted in the mangroves at the mouth of Four Mile Creek. They were located in a patch of unusually tall mangroves. The bats could not be seen clearly, but the colony numbered at least 100 animals. These were present in October 2008 and 2010, and in November 2011, but not in March 2009. This may indicate a seasonal difference in their use of the site.

4.5 The Presence of People in the Project Area

Metcalf and Bamford (2008) identified increased levels of disturbance as a concern for waterbirds with respect to the Pretty Pool development. People were present regularly at the recreational area at Pretty Pool and along the adjacent shoreline, with some observations of birds being disturbed (Table 9 summarises observations on people). Furthermore, during the aerial survey it was noted that people were present on almost every accessible piece of shoreline from Port Hedland harbour to Six Mile Creek. There were fresh vehicle tracks around Four Mile Creek, and roosting birds were disturbed at high tide on almost every survey. Waterbirds attempt to roost on a small rocky point between Pretty Pool and Four Mile Creeks at high tide, but are almost invariably disturbed. A disturbance recorded during the 8th October 2010 survey was caused by one pedestrian with two (off lead) dogs. Vehicles moving through the area (despite signs advising that beach access is prohibited) have led to some degradation of salt marsh vegetation (see Figure 6). Vehicles ("quad" all-terrain vehicles) were also seen on the tidal flats of Pretty Pool on 29th March 2009, although disturbance at low tide is less critical than at high tide, as at low tide there are large areas of alternative tidal flat for the birds to move to.

The level of human activity along the coastline at Pretty Pool, particularly at high tide, is likely to be having a great influence on waterbirds in the area. Fortunately, there is a fairly secure roosting site in the upper reaches of Four Mile Creek alongside Grey Street to which the birds appear to retreat.

5 CONCLUSIONS

The Pretty Pool area is being used by waterbirds, including migratory species, primarily for foraging, as levels of disturbance are too high to permit roosting at the site. Despite this the birds do attempt to roost at the site and may do so on days when levels of human activity are low. The alternative roosting site, the upper reaches of Four Mile Creek alongside Grey Street, may be essential to the birds that forage around Pretty Pool.

The waterbirds are able to forage on the tidal mudflats adjacent to Pretty Pool and Four Mile Creeks because levels of human activity across the site at low tide are low, and because the large area of available habitat means that birds can avoid people readily. An increase in numbers of people across the site at low tide, however, could cause the birds to abandon the site.

In a regional context the numbers of most bird species using the Pretty Pool area is low, but the tidal flats around Pretty Pool and Four Mile Creeks are the closest to Port Hedland that do support foraging birds in at least moderate numbers. For the Sanderling, however, the number present is sometimes at least regionally significant. Four Mile Creek is also of local importance through providing well-developed mangroves that support a range of mangrove-dependent bird species and a colony of the Black Flying-fox.

The high count of Plumed Whistling-Ducks on the sewage ponds and even the variety of species present on these ponds is regionally significant.

For the management of waterbirds in the Pretty Pool area, the key actions are to control levels of human activity along the shoreline and tidal mudflats, and ensure that the Grey Street roosting site is protected. At Pretty Pool, signage and low fencing could encourage people to avoid the rocky point where birds do try to roost, and as the suburban area expands, consideration could be given to restricting access to parts of the tidal mudflats so that birds can forage undisturbed.

Table 1. Counts of waterbirds in Pretty Pool Bay/Four Mile Creek coast, October 2008, March 2009, October 2010 and November 2011. Shaded = listed migratory species.

	2008			2009			2010			2011	
Date	19/10	20/10	20/10	28/3	28/3	29/3	8/10	8/10	9/10	13/11	14/11
Tide	Low	Low	High	High	Low	High	High	Low	Low	High	Low
Species*											
Pied Cormorant	-	-	-	-	-	-	-	2	-	-	-
Australian Pelican	1	-	-	-	-	-	-	-	-	-	-
Eastern Great Egret	-	1	-	-	-	-	-	-	-	-	-
Eastern Reef Egret	-	2	1	-	2	-	1	-	-	1	3
Little Egret	1	1	-	-	-	-	-	-	-	-	1
Striated Heron	-	3	-	-	-	-	-	-	-	-	3
Straw-necked Ibis	-	-	-	-	-	-	-	-	-	-	-
Australian White Ibis	-	-	-		-	-	-	-	-	-	-
Black-necked Stork	-	-	-	-	-	-	-	-	-	-	1
Eastern Osprey	3	-	2	-	-	-	-	1	-	-	1
Brahminy Kite	-	-	-	-	-	-	-	-	-	-	-
Eastern Curlew	-	-	-	-	-	-	-	-	-	-	2
Bar-tailed Godwit	300	150	30	84	117	88	1	110	75	94	166
Whimbrel	5	3	-	-	1		-	-	-	-	3
Little Curlew	-	-	-	-	-	-	-	-	-	-	-
Common Greenshank	5	2	2	-	4	-	-	-	3	2	7
Common Sandpiper	-	-	-	-	-	-	-	-	-	-	-
Grey-tailed Tattler	100	85	60	-	98	-	21	20	30	38	133
Marsh Sandpiper	-	-	-	-	-	-	-	-	-	-	1
Ruddy Turnstone	-	5	-	6	41	-	8	-	5	20	5
Great Knot	-	210	50	-	-	-	-	-	50	13	93
Sanderling	-	58	49	33	20	11	33	13	60	8	27
Curlew Sandpiper	-	1	-	-	-	-	4	-	-	-	-
Sharp-tailed Sandpiper	-	-	-	-	-	-	-	1	-	-	-
Terek Sandpiper	-	-	-	-	5	-	-	-	-	1	1
Red-necked Stint	500	300	250	-	62	-	28	45	250	2	160
Pied Oystercatcher	-	2	2	24	4	-	2	-	-	-	1
Sooty Oystercatcher	-	2	2	-	1	-	-	-	-	2	2

	2008			2009			2010			2011	
Date	19/10	20/10	20/10	28/3	28/3	29/3	8/10	8/10	9/10	13/11	14/11
Tide	Low	Low	High	High	Low	High	High	Low	Low	High	Low
Beach Stone-curlew	-	-	-	-	1	-	-		1	-	-
Grey Plover	-	3	-	-	5	-	-	-	1	1	2
Red-capped Plover	200	105	30	-	10	-	-	30	75	-	92
Greater Sand Plover	100	95	60	-	86	-	10	30	100	-	182
Lesser Sand Plover	-	-	-	-	1	-	-	-	-	-	2
Pacific Golden Plover	-	-	-	-	-	-	-	-	-	-	-
Silver Gull	100	150	6	-	-	-	-	70	150	26	-
Fairy Tern	-	-	-	-	-	-	-	10	2	-	100
Gull-billed Tern	-	-	-	-	-	-	-	-	2	-	-
Caspian Tern	-	-	-	2	-	-	4	-	-	-	-
Crested Tern	-	-	-	4	-	-	1	-	-	5	-
Common Tern	-	-	-	-	-	-	-	-	1	-	-
Lesser Crested Tern	-	-	-	-	-	-	5	-	-	-	-
Whiskered Tern	-	15	4	-	-	-	-	-	-	2	10
N species	11	20	14	6	15	2	12	11	15	14	24
Total count	1315	1193	548	153	458	99	118	332	805	210	998

NB 1: On low tide count of 19/10/08 in Pretty Pool Bay, not all species could be identified because birds were foraging and could not be approached.

NB 2: On high tide count in Pretty Pool Bay on 20/10/08 majority of birds on flats at mouth of Four Mile Creek but flew to east as tide covered last of the tidal flat. Virtually all birds gone once flats inundated.

NB 3: Low tide count of Pretty Pool Bay on 8/10/10 was only west of the creek channel so was incomplete.

* Refer to Appendix 1 for Latin names

Table 2. Counts of waterbirds along Pretty Pool Creek and Four Mile Creek, October 2008, March 2009, October 2010 and November 2011. Shaded = listed migratory species.

Survey Area	**Pretty Pool Creek**						**Four Mile Creek**							**Grey St (upper Four Mile Creek**		
Year	2008		2009		2010	2011	2008		2009		2010		2011	2009	2010	2011
Date	19/10	20/10	28/3	8/10	9/10	13/11	19/10	19/10	28/3	28/3	8/10	9/10	13/11	29/03	8/10	14/11
Tide	Low	High	High	High	Low	High	Low	Low	High	Low	High	Low	High	High	High	High
Species*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Striated Heron	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Australian White Ibis	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Brahminy Kite	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Eastern Curlew	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	1
Whimbrel	3	1	1	-	1	1	2	1	-	-	4	3	3	-	-	3
Bar-tailed Godwit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	88
Common Greenshank	6	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Common Sandpiper	2	-	-	2	-	1	2	-	-	-	1	-	-	-	-	-
Grey-tailed Tattler	-	-	-	-	-	-	-	-	-	-	-	-	3	-	1	2
Ruddy Turnstone	-	-	-	-	-	-	-	-	-	-	-	-	-	27	-	2
Sanderling	-	-	-	-	-	-	-	-	-	-	-	-	-	40	5	126
Broad-billed Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-	-		10	-
Grey Plover	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	2
Red-capped Plover	-	-	-	-	-	-	-	-	-	-	-	-	-	30	20	200
Greater Sand Plover	-	2	-	-	-	-	-	2	-	-	-	1	2	80	110	150
Lesser Sand Plover	-	-	-	-	-	-	-	-	-	-	-	-	-		25	5
Silver Gull	15	15	-	23	-	77	-	-	-	-	-	1	-			-
N species	4	4	1	4	1	3	2	3	1	0	4	3	4		-	-
Total count	30	23	1	27	1	79	4	4	1	0	8	5	9		-	-

Table 3. Birds recorded at sites along the Port Hedland coast (Cemetery or Town Beach, Spoil Bank), Port Hedland oval, sewage farm ponds and surrounding flooded flats, and upper Four Mile Creek adjacent to Grey Street. Shaded = listed migratory species.

Survey Area	Port Hedland Coast					Port Hedland Oval			
Year	2008	2009		2010	2011	2008	2009	2010	2011
Date	20/10	28/3	29/3	9/10	14/11	20/10	28/3	9/10	13/11
Tide	High	High	High	High	Low	High	Low	Low	High
Lesser Frigatebird	-	-	-	10	-	-	-	-	-
Pied Cormorant	-	-	-	-	1	-	-	-	-
Little Pied Cormorant	1	-	-	-	-	-	-	-	-
Eastern Great Egret	1	-	-	-	1	-	-	-	-
Eastern Reef Egret	-	-	1	-	2	-	-	-	-
Straw-necked Ibis	-	-	-	-	-	2	-	-	-
Australian White Ibis	1	-	8	-	30	-	14	-	-
Eastern Osprey	-	-	-	1	-	-	-	-	-
Brahminy Kite	-	1	-	-	-	-	-	-	-
Bar-tailed Godwit	6	11	57	70	50	-	-	-	-
Whimbrel	-	1	1	-	1	-	-	-	-
Little Curlew	-	-	-	-	-	27	-	6	20
Common Sandpiper	-	-	-	1	-	-	-	-	-
Grey-tailed Tattler	1	1	28	-	100	-	-	-	-
Common Greenshank	-	-	-	-	-	-	-	-	-
Ruddy Turnstone	-	6	10	4	10	-	-	-	-
Great Knot	-	24	10	-	-	-	-	-	-
Sanderling	-	-	10	-	-	-	-	-	-
Red-necked Stint	-	-	20	-	-	-	-	-	-
Pied Oystercatcher	1	2	1	-	1	-	-	-	-
Sooty Oystercatcher	-	4	-	-	-	-	-	-	-

Survey Area	Port Hedland Coast					Port Hedland Oval			
Year	2008	2009		2010	2011	2008	2009	2010	2011
Date	20/10	28/3	29/3	9/10	14/11	20/10	28/3	9/10	13/11
Tide	High	High	High	High	Low	High	Low	Low	High
Grey Plover	-	1	-	-	-	-	-	-	-
Greater Sand Plover	-	1	13	25	-	-	-	-	-
Pacific Golden Plover	-	1	-	-	-	-	-	-	-
Silver Gull	125	3	5	100	150	-	-	-	-
Caspian Tern	4	-	3	2	-	-	-	-	-
Lesser Crested Tern	4	-	-	-	-	-	-	-	-
N species	**9**	**12**	**13**	**8**	**10**	**2**	**1**	**1**	**1**
Total count	244	56	167	213	346	29	14	6	20

Table 4. Birds recorded at the sewage farm ponds and surrounding flooded flats, and upper Four Mile Creek adjacent to Grey Street. Shaded = listed migratory species.

Survey Area	Sewage farm ponds				
Year	2009	2009	2010	2010	2011
Date	28/03	29/03	8/10	9/10	13/11
Tide	High	High	High	High	High
Plumed Whistling-Duck	-	-	-	9	1900
Pacific Black Duck	4	14	20	14	350
Grey Teal	18	66	4	17	150
Hardhead	4	-	40	42	3
Australasian Grebe	-	-	5	5	-
Hoary-headed Grebe	-	-	-	-	1
Pied Cormorant	65	27	50	52	20
Little Pied Cormorant	-	2	10	17	7
Australian Pelican	10	5	14	14	21
Eastern Great Egret	5	9	-	1	1
Eastern Reef Egret	-	-	2	-	-
White-faced Heron	-	-	-	-	1
Little Egret	3	6	-	-	-
Glossy Ibis	-	-	1	-	-
Australian White Ibis	4	-	1	2	2
Royal Spoonbill	-	-	2	2	4
Eurasian Coot	1	1	10	10	-
Eastern Osprey	2	-	1	-	-
Brahminy Kite	-	-	-	-	1
Marsh Sandpiper	8	6	5	-	20
Common Sandpiper	-	1	3	4	6
Grey-tailed Tattler	18	-	2	2	4
Common Greenshank	-	-	1	-	10
Ruddy Turnstone	25	45	10	5	2
Sharp-tailed Sandpiper	15	40	-	-	30
Curlew Sandpiper	-	6	-	-	-
Red-necked Stint	4	6	10	-	-
Black-winged Stilt	20	76	1	2	34
Red-necked Avocet	-	-	5	-	-
Pacific Golden Plover	-	-	-	-	1
Red-capped Plover	6	6	9	-	-
Greater Sand Plover	-	1	-	-	-
Black-fronted Dotterel	-	2	-	2	6

Survey Area	Sewage farm ponds				
Year	2009	2009	2010	2010	2011
Date	28/03	29/03	8/10	9/10	13/11
Tide	High	High	High	High	High
Masked Lapwing	-		-	1	2
Silver Gull	-	-	100	64	150
Gull-billed Tern	-	-	1	6	-
Caspian Tern	33	-	1	3	-
Whiskered Tern	-	-	3	1	500
N species	**17**	**19**	**26**	**22**	**25**
Total count	241	323	311	275	3226

Table 5. Maximum annual counts in the Pretty Pool area (Pretty Pool Creek, Pretty Pool Bay and Four Mile Creek and associated flats, including upper Four Mile Creek near Grey Street) for migratory waterbird species.

Species	Maximum Count October 2008	Maximum Count March 2009	Maximum Count October 2010	Maximum Count November 2011
Eastern Great Egret	1	-	-	1
Eastern Osprey	3	-	1	1
Eastern Curlew	-	-	1	2
Bar-tailed Godwit	300	117	110	166
Whimbrel	5	1	4	3
Little Curlew	-	-	-	-
Common Greenshank	6	4	3	7
Common Sandpiper	2	-	2	
Grey-tailed Tattler	100	98	30	133
Marsh Sandpiper	-	-	-	1
Ruddy Turnstone	5	41	8	5
Great Knot	210	-	50	93
Sanderling	58	40	60	126
Curlew Sandpiper	1	-	30	4
Broad-billed Sandpiper	-	-	10	-
Terek Sandpiper	-	3	-	1
Red-necked Stint	500	120	250	450
Grey Plover	4	10	1	2
Greater Sand Plover	100	80	110	182
Lesser Sand Plover	-	1	25	5
Pacific Golden Plover	-	1	-	-
Caspian Tern	4	3	4	-
Crested Tern	-	-	1	5
Common Tern	-	-	1	-
Lesser Crested Tern	4	-	5	-
N species	**16**	**13**	**20**	**17**
Total	**1313**	**519**	**608**	**1182**

Table 6. Maximum annual counts of each waterbird species throughout project (including aerial surveys where species could be identified). Note that the sewage farm could not be accessed in October 2008

Species	October 2008	March 2009	October 2010	November 2011
Plumed Whistling-Duck	-	-	9	1900
Pacific Black Duck	-	14	20	350
Grey Teal	-	66	17	150
Hardhead	-	4	42	3
Australasian Grebe	-	-	5	-
Hoary-headed Grebe	-	-	-	1
Lesser Frigatebird	-	-	11	10
Pied Cormorant	-	65	52	20
Little Pied Cormorant	-	2	17	7
Australian Pelican	-	15	14	21
Black-necked Stork	-	2		1
Eastern Great Egret	1	9	1	1
Eastern Reef Egret	2	2	2	3
White-faced Heron	-	-	-	1
Striated Heron	3	-	-	3
Little Egret	1	6	-	1
Glossy Ibis		-	1	-
Straw-necked Ibis	2	-	-	-
Australian White Ibis	-	14	2	30
Royal Spoonbill	-	-	2	4
Eurasian Coot	-	1	10	-
Eastern Osprey	3	2	1	1
Brahminy Kite	1	1	1	1
Eastern Curlew	-	-	1	2
Bar-tailed Godwit	300	117	110	166
Whimbrel	5	1	4	3
Little Curlew	-	27	6	20
Marsh Sandpiper	-	8	5	20
Common Sandpiper	-	1	4	6
Grey-tailed Tattler	100	98	30	133
Common Greenshank	6	4	3	10
Ruddy Turnstone	10	45	27	20
Great Knot	210	24	50	93
Sanderling	58	33	60	146
Sharp-tailed Sandpiper	-	40	1	30

Table 6 (cont.)

Species	**October 2008**	**March 2009**	**October 2010**	**November 2011**
Curlew Sandpiper	1	6	30	4
Terek Sandpiper	-	5	-	1
Red-necked Stint	500	62	250	450
Broad-billed Sandpiper	-	-	10	-
Pied Oystercatcher	4	24	2	1
Sooty Oystercatcher	2	1	2	2
Beach Stone-curlew	-	1	1	-
Black-winged Stilt	-	76	2	34
Red-necked Avocet	-	-	5	-
Grey Plover	3	5	10	2
Red-capped Plover	200	10	75	200
Lesser Sand Plover	-	1	25	5
Greater Sand Plover	100	86	110	182
Pacific Golden Plover	-	-	-	1
Black-fronted Dotterel	-	2	2	6
Masked Lapwing	-	-	1	2
Silver Gull	150	5	1410	150
Fairy Tern	-	-	10	100
Gull-billed Tern	-	-	6	-
Caspian Tern	-	33	4	-
Whiskered Tern	15	3	-	500
Crested Tern	-	4	1	5
Common Tern	-	-	1	-
Lesser Crested Tern	4	-	5	-
N species	**24**	**41**	**50**	**49**
Total count	**1681**	**925**	**2470**	**4802**

Table 7. Results of aerial surveys. See Figure 1 for route.

<table>
<tr><td colspan="2">19/10/2008, 1255-1330hrs. High tide of 6.13m at 1320.</td></tr>
<tr><th>Location</th><th>Description of site and bird count</th></tr>
<tr><td>Harbour area</td><td>Little roosting habitat. Most shoreline mangrove-lined but outer shore of Finucane Island rocky. Spoil Bank with vehicles and people along its length; even some marooned on island formed by high tide. About 100 shorebirds roosting on this island.</td></tr>
<tr><td>Cemetery Beach</td><td>The coastline alongside Port Hedland townsite. Shoreline mostly rocky but some small sand sections; these mostly with people. Two groups of roosting shorebirds, each of 50 birds: one group on rocky shoreline near town centre and second group near water tower.</td></tr>
<tr><td>Pretty Pool area</td><td>No birds. Five cars in lower carpark (beside Pretty Pool) and about 10 people at the pool and adjacent beach.</td></tr>
<tr><td>Four Mile Creek</td><td>Five vehicles with people on western entrance. About 50 shorebirds and 50 gulls/terns roosting on point of eastern entrance.</td></tr>
<tr><td>Complex of mangrove creeks east of Four Mile Creek</td><td>On eastern side of creek complex, <i>ca.</i> 1000 roosting waterbirds: estimated 600 shorebirds and 400 gulls/terns. All birds on a sandy beach.</td></tr>
<tr><td>Petermarer and Tabba Tabba Creeks area</td><td>About 50 shorebirds and 50 gulls/terns roosting on rocky headland</td></tr>
<tr><td>Rock Cod Hole Creek and western end of P0 of the Cargill Salt evaporation ponds</td><td>Fewer than 20 gulls/terns and fewer than 20 egrets in western end of Pond 0.</td></tr>
<tr><td>Return flight over supra-tidal flats behind mangroves</td><td>1 Whimbrel</td></tr>
</table>

Table 7 (cont.)

<table>
<tr><td colspan="2">29/3/2009, 1245-1310hrs. Very high tide of 6.13m at 1320.</td></tr>
<tr><th>Location</th><th>Bird count</th></tr>
<tr><td>Harbour area and Cemetery Beach</td><td>1 Eastern Reef Egret, 1 Pied Oystercatcher</td></tr>
<tr><td>Cooke Point</td><td>6 Bar-tailed Godwit</td></tr>
<tr><td>Pretty Pool Bay</td><td>No birds.</td></tr>
<tr><td>Four Mile Creek</td><td>Medium waders: 100 (possibly mostly Bar-tailed Godwit)</td></tr>
<tr><td>Six Mile Creek</td><td>Small and medium waders scattered in several groups:350.</td></tr>
<tr><td>Petermarer Creek area</td><td>Small and medium waders:100; Terns:250; Australian Pelican:1</td></tr>
<tr><td>Immediately west of PO intake</td><td>Small and medium waders:400; Pied Oystercatcher:1</td></tr>
<tr><td>Pond O</td><td>Whimbrel:2; Black-necked Stork:2; Small waders:50; Pied Cormorant:50; Australian Pelican:15</td></tr>
<tr><td>Flats on return flight</td><td>Very few birds: 55 terns.</td></tr>
</table>

<table>
<tr><td colspan="2">9/10/2010, 1125-1200hrs. Very high tide of 6.76m at 1140.</td></tr>
<tr><th>Location</th><th>Bird count</th></tr>
<tr><td>Harbour area</td><td>Lesser Frigatebird: 4; Silver Gull: 5; Crested Tern: 1.</td></tr>
<tr><td>Spoil Bank and Cemetery Beach</td><td>Small and medium waders at base of bank: 100; Silver Gull: 160; Sooty Oystercatcher: 2</td></tr>
<tr><td>Cooke Point</td><td>Silver Gull: 200</td></tr>
<tr><td>Pretty Pool Bay</td><td>No birds (12 people).</td></tr>
<tr><td>Four Mile Creek</td><td>Medium to large waders (probably Bar-tailed Godwit): 100</td></tr>
<tr><td>Six Mile Creek eastern shore</td><td>Silver Gull: 1,000; Medium waders: 400</td></tr>
<tr><td>Six Mile Creek to Petermarer Creek</td><td>Silver Gull: 25; medium to large waders (probably Bar-tailed Godwit): 200; medium waders (tattlers and sand plovers): 230</td></tr>
<tr><td>Petermarer Creek to Rock Cod Hole Creek</td><td>Whimbrel: 10; Silver Gull: 20; mixed flock of small, medium and medium-to large waders: 2000</td></tr>
<tr><td>Rock Cod Hole Creek</td><td>Medium waders (tattler and sand plovers): 50</td></tr>
<tr><td>Tidal flats behind coast on return flight</td><td>Lesser Frigatebird: 11</td></tr>
</table>

14/11/2011, 1230-1315hrs. Very high tide of 6.14m at 1243hrs.	
Location	**Bird count**
Harbour area	Australian White Ibis: 4.
Spoil Bank and Cemetery Beach	Medium waders (probably Bar-tailed Godwit): 30; Silver Gull: 80; Lesser Frigatebird: 2
Cooke Point	Silver Gull: 40.
Pretty Pool Bay	Silver Gull: 50.
Six Mile Creek area	Silver Gull: 80; small terns: 50
Petermarer Creek to coast adjacent to salt ponds	Silver Gull: 60;medium waders: 2250, Pied Oystercatcher: 2; White-bellied Sea-Eagle: 1.

Summary of waterbird counts during aerial surveys.

Waterbird group	Oct 2008	March 2009	Oct 2010	Nov 2011
Shorebirds (waders)	900	1000	2900	2282
Gulls and terns	520	300	1420	410
Egrets and Ibis	20	1	-	4
Black-necked Stork	-	2	-	-
Pied Cormorant	-	50	-	-
Australian Pelican	-	15	-	-
Lesser Frigatebird	-	-	15	2
White-bellied Sea-Eagle	-	-	-	1

Table 8. Counts and observations of land-birds in October 2008, March 2009, October 2010 and November 2011.

Migratory species are shaded in grey. Asterisk indicates species present but not counted. Superscript "man" indicates mangrove-dependent species.

Species*	**Survey Area**	**Pretty Pool Creek**					**Four Mile Creek**						
	Year	2008		2009	2010	2011	2008		2009		2010		2011
	Date	19/10	20/10	28/3	8/10	13/11	19/10	20/10	28/3	28/3	8/10	9/10	13/11
	Tide	Low	High	High	High	High	Low	High	High	Low	High	Low	High
Bar-shouldered Dove				1			*	*	2				
Peaceful Dove					1		2	2				1	
Feral Pigeon						1							
Sacred Kingfisher		1	1		1					1	1	1	
Collared Kingfisher ^{man}.							1	1					
Rainbow Bee-eater			1	1		2							
Dusky Gerygone ^{man}								1					
Brown Honeyeater		20	12		6	3	*	10		2	10	6	2
Singing Honeyeater							*	1				1	1
White-plumed Honeyeater		10	4	4	4	10							
Mangrove Golden Whistler ^{man}											1	2	
White-breasted Whistler ^{man}				2		3	2	4	2	1			2
Mangrove Robin ^{man}						1							2
Mangrove Fantail ^{man}								1					
Yellow White-eye ^{man}		20	4		4	5	*	10	2	4	6	10	5
Zebra Finch		40	10	20			8					8	
White-winged Fairy-wren							*		3		10		10
Mangrove Grey Fantail ^{man}												1	
Willie Wagtail							*				1	1	1
White-breasted Woodswallow					2		*	2			3	2	2
Black-faced Cuckoo-shrike		2	1			2	*				2		
Magpie-lark			1				*	1		2			2
Australian Pipit							*						
Singing Bushlark		2	2			1							

* refer to Appendix 1 for species' Latin names.

Table 8 (cont.)

Species	**Survey area**	**Pretty Pool urban area**				
	Year	2008		2009	2010	2011
	Date	19/10	20/10	28/3	8/10	13/11
	Tide			High	high	High
Bar-shouldered Dove		8	10			
Crested Pigeon		2	2			
Peaceful Dove				2		1
Rainbow Bee-eater					1	
Brown Honeyeater			2			
White-plumed Honeyeater		2	2	10	4	2
Yellow White-eye ^{man}		2	4			
Zebra Finch		30	25	5	2	2
Black-faced Cuckoo-shrike				1		
Magpie-lark					2	
Australian Pipit		1	2			

* refer to Appendix 1 for species' Latin names.

Table 9. Observations on people.

Date	Time period	Location	Notes
19/10/2008	0800-0830	Pretty Pool beach and bay	A family of 4 with a dog (off-lead), two people with a small dog and 2 lone walkers. The family was out on the mudflat with birds flushed from within 50m, but other people were along the beach.
	1100	Pretty Pool Beach	24 people, 11 cars in lower carpark adjacent to pool, 5 dogs off-lead. Most people in the main pool area, swimming, but two walking across tidal flats and 4 walking along mangle upstream. Little evidence of people leaving the pool area, but a few tracks, some dog tracks and a horse track.
		Aerial survey	People on almost all beaches and headlands that were accessible from the harbour to Four Mile Creek.
20/10/2008	0700-0900	Pretty Pool Beach and bay	One person and an unleashed dog at 0830, and another person at 0845. Both kept to the beach and disturbed few birds.
	1230	Pretty Pool Beach	10 people, 3 dogs (off-lead) and 3 cars in lower carpark.
28/3/2009	1200	Pretty Pool swimming area	2 people, 1 dog
	1400	Pretty Pool swimming area	11 people, 2 dog
	1715	Pretty Pool – Four Mile Creek	4 Quad bikes on tidal mud flats, 15 people walking on mud flats. 2 4WD vehicles on beach
29/3/2009	0945	Pretty Pool Recreational Area	12 people, 2 dogs
8/10/2010	1130	Pretty Pool Recreational Area	14 people; 2 dogs (high tide)
	1030	Pretty Pool Bay, near rocky point close to Four Mile Creek	Woman with two dogs (off lead) walking along beach at high tide from Four Mile Creek to Pretty Pool Creek. Flushed over 300 waterbirds from rocky point; these birds flew inland, possibly to roost on upper four Mile Creek near Grey Street
	1700	Pretty Pool Bay tidal flats west of creek	Low tide and one man with two dogs (off lead) out on flats, with several people along shoreline.
9/10/2010	0615	Pretty Pool Bay tidal flats east of creek	Low tide and one woman with two dogs (off lead) flushed all birds from western tidal flats.
	0800	Four Mile Creek tidal flats	Low tide. Two cars, one motorbike and one quad being driven over tidal flats and samphire.
	0900	Pretty Pool Recreational Area	3 people and 1 dog (low tide)
13/11/2011	1215	Pretty Pool Recreational Area	High tide. 27 people, 2 kite surfers and 4 dogs.
	1330	Pretty Pool Creek	High tide. Two vehicles, 7 people and a small boat being launched into creek.
	1300	Four Mile Creek tidal flats	High tide. Four people and a dog in 2 vehicles fishing in Four Mile Creek
	1230	Pretty Pool Bay	High tide. One person walking along shoreline.
14/11/11	0700	Pretty Pool Bay	Low tide. One person walking across mudflats.

Figure 3 **Rocky point between Pretty Pool and Four Mile Creeks; location where shorebirds try to roost at high tide but are regularly disturbed.**

Figure 4 **Shorebirds (waders) roosting at high tide on the upper Four Mile Creek adjacent to Grey Street. This is a mixed flock of Greater and Lesser Sand Plovers, Red-capped Plover, Red-necked Stint, Curlew Sandpiper and Broad-billed Sandpiper.**

Figure 5 **Four Mile Creek at low tide, illustrating the extensive fringing mangroves.**

Figure 6 **Vehicle tracks across salt marsh at Four Mile Creek.**

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Appendix 1 Waterbirds and other species discussed in this report.

1.a. Waterbirds, including migratory species.

Family	Species		Mig.
Phalacrocoracidae (cormorants)	*Phalacrocorax melanoleucos*	Little Pied Cormorant	
	Phalacrocorax varius	Pied Cormorant	
	Phalacrocorax carbo	Great Cormorant	
Fregatidae (friagatebirds)	*Fregeta ariel*	Lesser Frigatebird	
Pelecanidae (Pelicans)	*Pelecanus conspicillatus*	Australian Pelican	
Ciconiidae (storks)	*Ephippiorhynchus asiaticus*	Black-necked Stork	
Ardeidae (Herons, Egrets, Bitterns)	*Egretta novaehollandiae*	White-faced Heron	
	Ardea modesta	Eastern Great Egret	mig
	Ardea garzetta	Little Egret	mig
	Ardea sacra	Eastern Reef Egret	
	Butorides striatus	Striated Heron	
Threskionithidae (Ibises and spoonbills)	*Plegadis falcinellus*	Glossy Ibis	mig
	Threskiornis molucca	Australian White Ibis	
	Threskiornis spinicollis	Straw-necked Ibis	
	Platalea regia	Royal Spoonbill	
Anatidae (Dabbling Ducks)	*Dendrocygna eytoni*	Plumed Whistling-Duck	
	Anas gracilis	Grey Teal	
	Anas superciliosa	Pacific Black Duck	
	Aythya australis	Hardhead	
Podicipedidae (grebes)	*Tachybaptus novaehollandiae*	Australasian Grebe	
	Poliocephalus poliocephalus	Hoary-headed Grebe	
Rallidae (crakes and rails)	*Fulica atra*	Eurasian Coot	
Accipitridae (hawks and eagles)	*Pandion cristatus*	Eastern Osprey	mig
	Haliastur indus	Brahminy Kite	
	Haliaeetus leucogaster	White-bellied Sea-Eagle	mig
Scolopacidae (sandpipers)	*Numenius madagascariensis*	Eastern Curlew	mig
	Limosa lapponica	Bar-tailed Godwit	mig
	Numenius minutus	Little Curlew	mig
	Numenius phaeopus	Whimbrel	mig
	Tringa nebularia	Common Greenshank	mig
	Tringa hypoleucos	Common Sandpiper	mig
	Tringa brevipes	Grey-tailed Tattler	mig
	Tringa stagnatilis	Marsh Sandpiper	mig
	Arenaria interpres	Ruddy Turnstone	mig

	Calidris acuminata	Sharp-tailed Sandpiper	mig
	Calidris tenuirostris	Great Knot	mig
	Calidris alba	Sanderling	mig
	Calidris ruficollis	Red-necked Stint	mig
	Calidris ferruginea	Curlew Sandpiper	mig
	Xenus cinereus	Terek Sandpiper	mig
	Limicola falcinellus	Broad-billed Sandpiper	mig
Burhinidae (Stone-curlews)	*Esacus neglectus*	Beach Stone-curlew	
Haematopodidae (Oystercatchers)	*Haematopus longirostris*	Pied Oystercatcher	
	Haematopus fuliginosus	Sooty Oystercatcher	
Family	Species		Mig.
Charadriidae (Plovers & Dotterels)	*Pluvialis fulva*	Pacific Golden Plover	mig
	Pluvialis squatarola	Grey Plover	mig
	Charadrius ruficapillus	Red-capped Plover	
	Charadrius mongolus	Lesser Sand Plover	mig
	Charadrius leschenaultii	Greater Sand Plover	mig
	Elseyornis melanops	Black-fronted Dotterel	
	Vanellus miles	Masked Lapwing	
Recurvirostridae (Stilts and Avocets)	*Himantopus himantopus*	Black-winged Stilt	
	Recurvirostra novaehollandiae	Red-necked Avocet	
Laridae (Gulls, Terns)	*Sternula nereis*	Fairy Tern	Vulnerable
	Gelochelidon nilotica	Gull-billed Tern	
	Chlidonia hybrida	Whiskered Tern	
	Sterna hirundo	Common Tern	mig
	Sterna caspia	Caspian Tern	mig
	Sterna bengalensis	Lesser Crested Tern	mig
	Sterna bergii	Crested Tern	
	Larus novaehollandiae	Silver Gull	

1.b. Land-birds, including migratory and mangrove-dependent species, mentioned in this report.

Family	Species		Migratory	Mangroves
Columbidae (pigeons)	*Ocyphaps lophotes*	Crested Pigeon		
	Geopelia humeralis	Bar-shouldered Dove		
	Geopelia striata	Peaceful Dove		
Apodidae (Swifts)	*Apus pacificus*	Fork-tailed Swift	Mig	
Halcyonidae (kingfishers)	*Todiramphis chloris*	Collared Kingfisher		Man
	Todiramphis sancta	Sacred Kingfisher		
Meropidae (Bee-eaters)	*Merops ornatus*	Rainbow Bee-eater	Mig	
Hirundinidae (swallows)	*Hirundo rustica*	Barn Swallow	Mig	
Maluridae (fairy-wrens)	*Malurus leucopterus*	White-winged Fairy-wren		
Acanthizidae (thornbills)	*Gerygone tenebrosa*	Dusky Gerygone		Man
Meliphagidae (honeyeaters)	*Lichenostomus virescens*	Singing Honeyeater		
	Lichenostomus penicillatus	White-plumed Honeyeater		
	Lichmera indistincta	Brown Honeyeater		
Campephagidae (cuckoo-shrikes)	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike		
Pachycephalidae (whistlers)	*Pachycephala melanura*	Mangrove Golden Whistler		Man
	Pachycephala lanioides	White-breasted Whistler		Man
Artamidae (woodswallows)	*Artamus superciliosus*	White-breasted Woodswallow		
Rhipiduridae (fantails)	*Rhipidura phasiana*	Mangrove Grey Fantail		Man
	Rhipidura leucophrys	Willie Wagtail		
Monarchidae (flycatchers)	*Grallina cyanoleuca*	Magpie-lark		
Petroicidae (Australian robins)	*Peneonanthe pulverulenta*	Mangrove Robin		Man
Alaudiae (larks)	*Mirafra javanica*	Horsfield's Bushlark		
Timaliidae (white-eyes)	*Zosterops luteus*	Yellow White-eye		Man
Estrildidae (finches)	*Taeniopygia guttata*	Zebra Finch		
Motacillidae (pipits)	*Anthus novaehollandiae*	Australasian Pipit		

Appendix 2 Population estimates for waterbirds recorded in the Pretty Pool area.

Estimates are global (for the East Asian-Australasian Flyway, from Delaney and Scott 2002 and Bamford *et al.* 2008), Australian and for the Pilbara and Gascoyne (from Bamford *et al.* 2008). Note that estimates are not available for all species, as Bamford *et al.* (2008) considered only migratory species with adequate data for population estimation. Where a population range is given (as by Delaney and Scott 2002), the lower limit only is provided.

Species	EAA Flyway	Australia	Pilbara and Gascoyne coast
Plumed Whistling-Duck	100,000	100,000	NA
Pacific Black Duck	200,000	100,000	NA
Grey Teal	50,000	25,000	NA
Hardhead	100,000	100,000	NA
Australasian Grebe	500,000	500,000	NA
Hoary-headed Grebe	500,000	500,000	NA
Pied Cormorant	NA	NA	NA
Little Pied Cormorant	NA	NA	NA
Lesser Frigatebird	NA	NA	NA
Australian Pelican	100,000	100,000	NA
Black-necked Stork	31,000	30,000	NA
Great Egret	NA	NA	NA
Eastern Reef Egret	100,000	NA	NA
White-faced Heron	1,000,000	1,000,000	NA
Little Egret	NA	NA	NA
Striated Heron	NA	NA	NA
Glossy Ibis	35,000	25,000	NA
Straw-necked Ibis	500,000	500,000	NA
Australian White Ibis	90,000	70,000	NA
Royal Spoonbill	100,000	100,000	NA
Eurasian Coot	100,000	NA	NA
Eastern Osprey	NA	NA	NA
White-bellied Sea-Eagle	NA	NA	NA
Brahminy Kite	NA	NA	NA
Bar-tailed Godwit	325,000	185,000	5,000
Eastern Curlew	38,000	38,000	200
Whimbrel	100,000	28,000	350
Little Curlew	180,000	180,000	NA
Marsh Sandpiper	100,000	100,000	NA
Common Greenshank	60,000	19,000	1,000
Common Sandpiper	25,000	NA	1,000
Grey-tailed Tattler	50,000	45,000	5,000
Ruddy Turnstone	35,000	35,000	2,500

Great Knot	375,000	360,000	5,000
Sanderling	22,000	10,000	200
Terek Sandpiper	60,000	60,000	1,000
Curlew Sandpiper	180,000	180,000	30,000
Sharp-tailed Sandpiper	160,000	160,000	NA
Broad-billed Sandpiper	25,000	25,000	7,000
Red-necked Stint	325,000	270,000	25,000
Pied Oystercatcher	11,000	11,000	NA
Sooty Oystercatcher	11,500	11,500	NA
Black-winged Stilt	300,000	300,000	NA
Grey Plover	125,000	NA	500
Pacific Golden Plover	100,000	100,000	100
Black-fronted Dotterel	17,000	16,000	NA
Red-capped Plover	95,000	95,000	NA
Lesser Sand Plover	140,000	25,000	2,000
Greater Sand Plover	110,000	73,000	2,000
Masked Lapwing	300,000	NA	NA
Silver Gull	1,000,000	1,000,000	NA
Caspian Tern	1,000	1,000	NA
Lesser Crested Tern	NA	NA	NA
Crested Tern	NA	NA	NA
Common Tern	25,000	25,000	NA
Whiskered Tern	100,000	100,000	NA
Fairy Tern	9,000	9,000	NA

Appendix E
NatureMap and Protected Matters database searches

NatureMap Species Report 5km Search

Created By Guest user on 05/06/2020

Current Names Only Yes
Core Datasets Only Yes
Method 'By Circle'
Centre 118° 37' 59'' E,20° 18' 47'' S
Buffer 5km
Group By Conservation Status

Conservation Status	Species	Records
Non-conservation taxon	372	1525
Priority 2	1	2
Priority 3	2	7
Priority 4	1	29
Protected under international agreement	32	364
Rare or likely to become extinct	7	2270
TOTAL	**415**	**4197**

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Rare or likely to become extinct					
1.	24784	*Calidris ferruginea (Curlew Sandpiper)*		T	
2.	24790	*Calidris tenuirostris (Great Knot)*		T	
3.	25575	*Charadrius leschenaultii (Greater Sand Plover)*		T	
4.	25576	*Charadrius mongolus (Lesser Sand Plover)*		T	
5.	24796	*Limosa lapponica subsp. menzbieri (Bar-tailed Godwit (northern Siberian))*		T	
6.	25344	*Natator depressus (Flatback Turtle)*		T	
7.	24798	*Numenius madagascariensis (Eastern Curlew)*		T	
Protected under international agreement					
8.	41323	*Actitis hypoleucos (Common Sandpiper)*		IA	
9.	25736	*Arenaria interpres (Ruddy Turnstone)*		IA	
10.	24779	*Calidris acuminata (Sharp-tailed Sandpiper)*		IA	
11.	24780	*Calidris alba (Sanderling)*		IA	
12.	25738	*Calidris canutus (Red Knot, knot)*		IA	
13.	24788	*Calidris ruficollis (Red-necked Stint)*		IA	
14.	24789	*Calidris subminuta (Long-toed Stint)*		IA	
15.	24378	*Charadrius veredus (Oriental Plover)*		IA	
16.	41332	*Chlidonias leucopterus (White-winged Black Tern, white-winged tern)*		IA	
17.	24478	*Fregata ariel (Lesser Frigatebird)*		IA	
18.	47954	*Gelochelidon nilotica (Gull-billed Tern)*		IA	
19.	24481	*Glareola maldivarum (Oriental Pratincole)*		IA	
20.	25630	*Hirundo rustica (Barn Swallow)*		IA	
21.	48587	*Hydroprogne caspia (Caspian Tern)*		IA	
22.	25739	*Limicola falcinellus (Broad-billed Sandpiper)*		IA	
23.	24795	*Limnodromus semipalmatus (Asian Dowitcher)*		IA	
24.	30932	*Limosa lapponica (Bar-tailed Godwit)*		IA	
25.	25741	*Limosa limosa (Black-tailed Godwit)*		IA	
26.	24799	*Numenius minutus (Little Curlew, Little Whimbrel)*		IA	
27.	25742	*Numenius phaeopus (Whimbrel)*		IA	
28.	24497	*Oceanites oceanicus (Wilson's Storm-petrel)*		IA	
29.	48591	*Pandion cristatus (Osprey, Eastern Osprey)*		IA	
30.	24843	*Plegadis falcinellus (Glossy Ibis)*		IA	
31.	24382	*Pluvialis fulva (Pacific Golden Plover)*		IA	
32.	24383	*Pluvialis squatarola (Grey Plover)*		IA	
33.	25642	*Sterna hirundo (Common Tern)*		IA	
34.	48593	*Sternula albifrons (Little Tern)*		IA	
35.	48597	*Thalasseus bergii (Crested Tern)*		IA	
36.	24806	*Tringa glareola (Wood Sandpiper)*		IA	
37.	24808	*Tringa nebularia (Common Greenshank, greenshank)*		IA	
38.	24809	*Tringa stagnatilis (Marsh Sandpiper, little greenshank)*		IA	
39.	41351	*Xenus cinereus (Terek Sandpiper)*		IA	

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Priority 2					
40.	2686	*Gomphrena pusilla*		P2	
Priority 3					
41.	25024	*Ctenotus angusticeps (Airlie Island Ctenotus, Northwestern coastal Ctenotus)*		P3	
42.	12832	*Gymnanthera cunninghamii*		P3	
Priority 4					
43.	24803	*Tringa brevipes (Grey-tailed Tattler)*		P4	
Non-conservation taxon					
44.	4895	*Abutilon lepidum*			
45.	3198	*Acacia acradenia*			
46.	3214	*Acacia ancistrocarpa (Fitzroy Wattle)*			
47.	3241	*Acacia bivenosa*			
48.	44588	*Acacia bivenosa x sclerosperma subsp. sclerosperma*			
49.	17013	*Acacia colei var. colei*			
50.	3377	*Acacia inaequilatera (Baderi)*			
51.	3434	*Acacia maitlandii (Maitland's Wattle)*			
52.	29015	*Acacia pyrifolia var. pyrifolia*			
53.	13078	*Acacia sclerosperma subsp. sclerosperma*			
54.		*Acacia sp.*			
55.	19456	*Acacia stellaticeps*			
56.	3579	*Acacia trachycarpa (Minni Ritchi, Balgali)*			
57.	20319	*Acacia tumida var. pilbarensis*			
58.	25243	*Acanthophis pyrrhus (Desert Death Adder)*			
59.	26441	*Acanthophora spicifera*			
60.	25535	*Accipiter cirrocephalus (Collared Sparrowhawk)*			
61.	17422	*Adriana tomentosa var. tomentosa*			
62.	2646	*Aerva javanica (Kapok Bush)*	Y		
63.	17147	*Alysicarpus muelleri*			
64.		*Amphiprion clarkii*			
65.	2383	*Amyema preissii (Wireleaf Mistletoe)*			
66.	35872	*Anadyomene plicata*			
67.	24312	*Anas gracilis (Grey Teal)*			
68.	24316	*Anas superciliosa (Pacific Black Duck)*			
69.	17651	*Andropogon gayanus*	Y		
70.	47414	*Anhinga novaehollandiae (Australasian Darter)*			
71.	25318	*Antaresia perthensis (Pygmy Python)*			
72.	24285	*Aquila audax (Wedge-tailed Eagle)*			
73.	25559	*Ardea intermedia (Intermediate Egret)*			
74.	41324	*Ardea modesta (great egret, white egret)*			
75.	24341	*Ardea pacifica (White-necked Heron)*			
76.	17797	*Argemone ochroleuca subsp. ochroleuca*	Y		
77.	211	*Aristida hygrometrica (Northern Kerosene Grass)*			
78.	25566	*Artamus cinereus (Black-faced Woodswallow)*			
79.	25567	*Artamus leucorynchus (White-breasted Woodswallow)*			
80.	24354	*Artamus leucorynchus subsp. leucopygialis (White-breasted Woodswallow)*			
81.	24356	*Artamus personatus (Masked Woodswallow)*			
82.	26486	*Asparagopsis taxiformis*			
83.	25320	*Aspidites melanocephalus (Black-headed Python)*			
84.	25236	*Aspidites ramsayi (Woma)*			
85.	2476	*Atriplex semilunaris (Annual Saltbush)*			
86.	6828	*Avicennia marina (White Mangrove)*			
87.	24318	*Aythya australis (Hardhead)*			
88.	2770	*Boerhavia coccinea (Tar Vine, Wituka)*			
89.	11167	*Bonamia erecta*			
90.	6606	*Bonamia media*			
91.	240	*Bothriochloa ewartiana (Desert Bluegrass)*			
92.	5291	*Bruguiera exaristata (Ribbed Mangrove)*			
93.	750	*Bulbostylis barbata*			
94.	47897	*Butorides striata (Striated Heron, Mangrove Heron)*			
95.	25716	*Cacatua sanguinea (Little Corella)*			
96.	42307	*Cacomantis pallidus (Pallid Cuckoo)*			
97.	11055	*Cajanus cinereus*			
98.	10972	*Cajanus marmoratus*			
99.	40825	*Calandrinia pentavalvis*			
100.	2872	*Calandrinia tepperiana*			
101.	7903	*Calotis hispidula (Bindy Eye)*			
102.	3749	*Canavalia rosea (Wild Jack Bean)*			
103.	48291	*Capparis spinosa subsp. nummularia*			
104.	42620	*Caulerpa chemnitzia*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
105.	44539	*Caulerpa cylindracea*			
106.	258	*Cenchrus ciliaris (Buffel Grass)*	Y		
107.	41568	*Cenchrus setaceus (Fountain Grass)*	Y		
108.	29721	*Cenchrus setiger (Birdwood Grass)*	Y		
109.	39680	*Ceriops australis*			
110.	24377	*Charadrius ruficapillus (Red-capped Plover)*			
111.	266	*Chloris barbata (Purpletop Chloris)*	Y		
112.	272	*Chloris virgata (Feathertop Rhodes Grass)*	Y		
113.		*Chroicocephalus novaehollandiae*			
114.	47174	*Chrysocephalum apiculatum subsp. pilbarense*			
115.	24288	*Circus approximans (Swamp Harrier)*			
116.	24774	*Cladorhynchus leucocephalus (Banded Stilt)*			
117.	29101	*Cleome uncifera subsp. uncifera*			
118.	2988	*Cleome viscosa (Tickweed, Tjinduwadhu)*			
119.	3769	*Clitoria ternatea*	Y		
120.	15036	*Coccinia grandis*	Y		
121.	2778	*Codonocarpus cotinifolius (Native Poplar, Kundurangu)*			
122.	25675	*Colluricincla harmonica (Grey Shrike-thrush)*			
123.	26694	*Colpomenia sinuosa*			
124.	24399	*Columba livia (Domestic Pigeon)*	Y		
125.	7939	*Conyza bonariensis (Flaxleaf Fleabane)*	Y		
126.	25568	*Coracina novaehollandiae (Black-faced Cuckoo-shrike)*			
127.	18410	*Corchorus carnarvonensis*			
128.	4857	*Corchorus elachocarpus*			
129.	17339	*Corchorus incanus*			
130.	25847	*Corchorus incanus subsp. incanus*			
131.	4867	*Corchorus walcottii (Woolly Corchorus)*			
132.	25593	*Corvus orru (Torresian Crow)*			
133.	17073	*Corymbia aspera*			
134.	14650	*Corymbia flavescens*			
135.	25701	*Coturnix ypsilophora (Brown Quail)*			
136.	24420	*Cracticus nigrogularis (Pied Butcherbird)*			
137.	3774	*Crotalaria cunninghamii (Green Birdflower, Bilbun)*			
138.	19378	*Crotalaria dissitiflora subsp. benthamiana*			
139.	24865	*Ctenophorus caudicinctus subsp. caudicinctus (Ring-tailed Dragon)*			
140.	24876	*Ctenophorus isolepis subsp. isolepis (Crested Dragon, Military Dragon)*			
141.	25073	*Ctenotus saxatilis (Rock Ctenotus)*			
142.	17118	*Cullen leucanthum*			
143.	15714	*Cullen stipulaceum*			
144.	45972	*Cyanthillium cinereum var. cinereum*	Y		
145.	25371	*Cyclorana australis (Giant Frog)*			
146.	25375	*Cyclorana maini (Sheep Frog)*			
147.	24322	*Cygnus atratus (Black Swan)*			
148.	280	*Cymbopogon bombycinus (Silky Oilgrass)*			
149.		*Cynodon radiatus*			
150.	777	*Cyperus bulbosus (Bush Onion, Tjanmata)*			
151.	806	*Cyperus polystachyos (Bunchy Sedge)*			
152.	290	*Dactyloctenium radulans (Button Grass)*			
153.	25297	*Demansia rufescens (Rufous Whipsnake)*			
154.	24324	*Dendrocygna arcuata (Wandering Whistling Duck, Chestnut Whistling Duck)*			
155.	24325	*Dendrocygna eytoni (Plumed Whistling Duck)*			
156.	19333	*Desmodium scorpiurus*	Y		
157.	29615	*Dichotomaria obtusata*			
158.	26764	*Dictyopteris australis*			
159.	26769	*Dictyosphaeria cavernosa*			
160.	26775	*Dictyota ciliolata*			
161.	311	*Digitaria ciliaris (Summer Grass)*	Y		
162.	48378	*Diplachne fusca subsp. fusca*			
163.	24926	*Diplodactylus conspicillatus (Fat-tailed Gecko)*			
164.	2499	*Dissocarpus paradoxus (Curious Saltbush)*			
165.	4759	*Dodonaea coriacea*			
166.	2504	*Dysphania plantaginella*			
167.	11890	*Dysphania rhadinostachya subsp. rhadinostachya*			
168.		*Egretta garzetta*			
169.		*Egretta novaehollandiae*			
170.		*Elanus axillaris*			
171.	47937	*Elseyornis melanops (Black-fronted Dotterel)*			
172.	24631	*Emblema pictum (Painted Finch)*			
173.	12064	*Enchylaena tomentosa var. tomentosa (Barrier Saltbush)*			
174.	360	*Enneapogon lindleyanus (Wiry Nineawn, Purple-head Nineawn)*			

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175.	365	*Enneapogon polyphyllus (Leafy Nineawn)*			
176.	12749	*Enneapogon purpurascens (Purple Nineawn)*			
177.	368	*Enteropogon ramosus (Windmill Grass, Curly Windmill Grass)*			
178.	25578	*Ephippiorhynchus asiaticus (Black-necked Stork)*			
179.	375	*Eragrostis cumingii (Cuming's Love Grass)*			
180.	378	*Eragrostis dielsii (Mallee Lovegrass)*			
181.	380	*Eragrostis eriopoda (Woollybutt Grass, Wangurnu)*			
182.	381	*Eragrostis falcata (Sickle Lovegrass)*			
183.	400	*Eriachne aristidea*			
184.	411	*Eriachne helmsii (Buck Wanderrie Grass)*			
185.	414	*Eriachne obtusa (Northern Wandarrie Grass)*			
186.	24379	*Erythrogonys cinctus (Red-kneed Dotterel)*			
187.	47938	*Esacus magnirostris (Beach Stone-curlew, Beach Thick-knee)*			
188.	35303	*Euphorbia australis var. subtomentosa*			
189.	4619	*Euphorbia biconvexa*			
190.	4635	*Euphorbia myrtoides*			
191.	12097	*Euphorbia tannensis subsp. eremophila (Desert Spurge)*			
192.	42879	*Euphorbia trigonosperma*			
193.	11200	*Evolvulus alsinoides var. villosicalyx*			
194.	25621	*Falco berigora (Brown Falcon)*			
195.	25622	*Falco cenchroides (Australian Kestrel, Nankeen Kestrel)*			
196.	31578	*Ficus aculeata var. indecora (Ranji)*			
197.	35558	*Flaveria trinervia (Speedy Weed)*	Y		
198.	25327	*Fordonia leucobalia (White-bellied Mangrove Snake)*			
199.	5188	*Frankenia ambita*			
200.	25727	*Fulica atra (Eurasian Coot)*			
201.	26835	*Galaxaura rugosa*			
202.	25730	*Gallirallus philippensis (Buff-banded Rail)*			
203.	41902	*Ganoderma steyaertanum*			
204.	24956	*Gehyra pilbara*			
205.	24958	*Gehyra punctata*			
206.	26842	*Gelidiella acerosa*			
207.	24401	*Geopelia cuneata (Diamond Dove)*			
208.	24402	*Geopelia humeralis (Bar-shouldered Dove)*			
209.	25585	*Geopelia striata (Zebra Dove)*			
210.	24276	*Gerygone tenebrosa (Dusky Gerygone)*			
211.	18363	*Gomphrena canescens subsp. canescens*			
212.	2677	*Gomphrena celosioides (Gomphrena Weed)*	Y		
213.	2680	*Gomphrena cunninghamii*			
214.	7509	*Goodenia forrestii*			
215.	7526	*Goodenia microptera*			
216.	4910	*Gossypium australe (Native Cotton)*			
217.	4913	*Gossypium hirsutum (Upland Cotton)*	Y		
218.	24443	*Grallina cyanoleuca (Magpie-lark)*			
219.	2079	*Grevillea pyramidalis (Caustic Bush, Tjungu)*			
220.	24484	*Grus rubicunda (Brolga)*			
221.	25627	*Haematopus fuliginosus (Sooty Oystercatcher)*			
222.	24487	*Haematopus longirostris (Pied Oystercatcher)*			
223.	24293	*Haliaeetus leucogaster (White-bellied Sea-Eagle)*			
224.	25541	*Haliastur indus (Brahminy Kite)*			
225.	24295	*Haliastur sphenurus (Whistling Kite)*			
226.	131	*Halodule uninervis*			
227.	6174	*Haloragis gossei*			
228.	6705	*Heliotropium crispatum*			
229.	25232	*Hemidactylus frenatus (Asian House Gecko)*	Y		
230.	26930	*Heterosiphonia crassipes*			
231.	29317	*Hibiscus austrinus var. austrinus*			
232.	4922	*Hibiscus brachychlaenus*			
233.	4930	*Hibiscus goldsworthii*			
234.	4933	*Hibiscus leptocladus*			
235.	25734	*Himantopus himantopus (Black-winged Stilt)*			
236.	24491	*Hirundo neoxena (Welcome Swallow)*			
237.	26946	*Hormophysa cuneiformis*			
238.	5215	*Hybanthus aurantiacus*			
239.	25363	*Hydrelaps darwiniensis*			
240.	25366	*Hydrophis elegans (Elegant Seasnake, Bar-bellied Seasnake)*			
241.	43385	*Hydrophis stokesii (Stoke’s Seasnake, Sea Snake)*			
242.	48203	*Hypertelis cerviana*			
243.	14587	*Indigastrum parviflorum*			
244.	3973	*Indigofera colutea (Sticky Indigo)*			

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245.	3981	*Indigofera linnaei (Birdsville Indigo)*			
246.	16061	*Indigofera oblongifolia*	Y		
247.	16062	*Indigofera sessiliflora*	Y		
248.	6635	*Ipomoea pes-caprae*			
249.	11312	*Ipomoea pes-caprae subsp. brasiliensis*			
250.	6637	*Ipomoea polymorpha*			
251.	464	*Iseilema membranaceum (Small Flinders Grass)*			
252.	468	*Lamarckia aurea (Goldentop)*	Y		
253.	30928	*Lerista clara*			
254.	3613	*Leucaena leucocephala (Leucaena)*	Y		
255.	25005	*Lialis burtonis*			
256.	25661	*Lichmera indistincta (Brown Honeyeater)*			
257.	27043	*Lobophora variegata*			
258.	45854	*Macalpinomyces eriachnes*			
259.	24326	*Malacorhynchus membranaceus (Pink-eared Duck)*			
260.	25652	*Malurus leucopterus (White-winged Fairy-wren)*			
261.	24583	*Manorina flavigula (Yellow-throated Miner)*			
262.	5923	*Melaleuca lasiandra*			
263.	5051	*Melhania oblongifolia*			
264.	24736	*Melopsittacus undulatus (Budgerigar)*			
265.	25184	*Menetia greyii*			
266.	24598	*Merops ornatus (Rainbow Bee-eater)*			
267.		*Microcarbo melanoleucos*			
268.	25542	*Milvus migrans (Black Kite)*			
269.	25545	*Mirafra javanica (Horsfield's Bushlark, Singing Bushlark)*			
270.		*Morebilus diversus*			
271.	6490	*Muellerolimon salicorniaceum*			
272.	17158	*Myoporum montanum (Native Myrtle)*			
273.	2573	*Neobassia astrocarpa*			
274.	25422	*Neobatrachus aquilonius (Northern Burrowing Frog)*			
275.	25685	*Neochmia ruficauda (Star Finch)*			
276.	44548	*Neomeris bilimbata*			
277.	27099	*Neomeris van-bosseae*			
278.	3614	*Neptunia dimorphantha (Sensitive Plant)*			
279.	6971	*Nicotiana benthamiana (Tjuntiwari)*			
280.	11856	*Nicotiana occidentalis subsp. occidentalis*			
281.	25430	*Notaden nichollsi (Desert Spadefoot)*			
282.	24742	*Nymphicus hollandicus (Cockatiel)*			
283.	24407	*Ocyphaps lophotes (Crested Pigeon)*			
284.	6651	*Operculina aequisepala*			
285.	6005	*Osbornia octodonta (Myrtle Mangrove)*			
286.	24620	*Pachycephala lanioides (White-breasted Whistler)*			
287.	25678	*Pachycephala melanura (Mangrove Golden Whistler)*			
288.	503	*Panicum decompositum (Native Millet, Kaltu-kaltu)*			
289.		*Paraplotosus albilabris*			
290.		*Parascorpaena picta*			
291.	3673	*Parkinsonia aculeata (Parkinsonia)*	Y		
292.	518	*Paspalidium clementii (Clements Paspalidium)*			
293.	529	*Paspalum fasciculatum*	Y		
294.	24648	*Pelecanus conspicillatus (Australian Pelican)*			
295.	3675	*Petalostylis labicheoides (Slender Petalostylis)*			
296.	48060	*Petrochelidon ariel (Fairy Martin)*			
297.	48061	*Petrochelidon nigricans (Tree Martin)*			
298.	25697	*Phalacrocorax carbo (Great Cormorant)*			
299.	24667	*Phalacrocorax sulcirostris (Little Black Cormorant)*			
300.	25699	*Phalacrocorax varius (Pied Cormorant)*			
301.	4680	*Phyllanthus maderaspatensis*			
302.	20652	*Physalis angulata*	Y		
303.	5230	*Pimelea ammocharis*			
304.	19744	*Pittosporum angustifolium*			
305.	24842	*Platalea regia (Royal Spoonbill)*			
306.	42306	*Platyplectrum spenceri (Centralian Burrowing Frog)*			
307.	8168	*Pluchea rubelliflora*			
308.	8170	*Pluchea tetranthera*			
309.	24908	*Pogona minor subsp. mitchelli (Dwarf Bearded Dragon)*			
310.	24681	*Poliocephalus poliocephalus (Hoary-headed Grebe)*			
311.	2902	*Polycarpaea involucrata*			
312.	2903	*Polycarpaea longiflora*			
313.	25731	*Porphyrio porphyrio (Purple Swamphen)*			
314.	2875	*Portulaca australis*			

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315.	2884	*Portulaca oleracea (Purslane, Wakati)*			
316.	25261	*Pseudechis australis (Mulga Snake)*			
317.	8189	*Pseudognaphalium luteoalbum (Jersey Cudweed)*			
318.	42416	*Pseudonaja mengdeni (Western Brown Snake)*			
319.	25263	*Pseudonaja modesta (Ringed Brown Snake)*			
320.	8192	*Pterocaulon sphacelatum (Apple Bush, Fruit Salad Plant)*			
321.	2695	*Ptilotus arthrolasius*			
322.	2696	*Ptilotus astrolasius*			
323.	2699	*Ptilotus axillaris (Mat Mulla Mulla)*			
324.	2704	*Ptilotus calostachyus (Weeping Mulla Mulla)*			
325.	2717	*Ptilotus divaricatus (Climbing Mulla Mulla)*			
326.	2725	*Ptilotus fusiformis*			
327.	2766	*Ptilotus villosiflorus*			
328.	2768	*Pupalia lappacea*	Y		
329.	25009	*Pygopus nigriceps*			
330.	24776	*Recurvirostra novaehollandiae (Red-necked Avocet)*			
331.	2582	*Rhagodia eremaea (Thorny Saltbush)*			
332.	48096	*Rhipidura albiscapa (Grey Fantail)*			
333.	25614	*Rhipidura leucophrys (Willie Wagtail)*			
334.	24457	*Rhipidura phasiana (Mangrove Grey Fantail)*			
335.	5295	*Rhizophora stylosa (Spotted-leaved Red Mangrove)*			
336.	30434	*Salsola australis*			
337.	12723	*Scaevola amblyanthera*			
338.	11650	*Sclerolaena bicornis var. bicornis (Goathead Burr)*			
339.	2616	*Sclerolaena glabra*			
340.	2617	*Sclerolaena hostilis*			
341.	27274	*Sebdenia flabellata*			
342.	12307	*Senna glutinosa subsp. glutinosa*			
343.	12312	*Senna notabilis*			
344.	10848	*Senna occidentalis*	Y		
345.	18445	*Senna stricta*			
346.	46816	*Seringia elliptica (Showy fire-bush)*			
347.	46821	*Seringia nephrosperma (Free carpel fire-bush)*			
348.	4196	*Sesbania cannabina (Sesbania Pea)*			
349.	4198	*Sesbania formosa (White Dragon Tree)*			
350.	606	*Setaria dielsii (Diels' Pigeon Grass)*			
351.	611	*Setaria sphacelata (South African Pigeon Grass)*	Y		
352.	4972	*Sida clementii*			
353.		*Sillago analis*			
354.		*Sillago schomburgkii*			
355.	7002	*Solanum diversiflorum*			
356.	7029	*Solanum phlomoides*			
357.	619	*Sorghum plumosum (Plume Canegrass)*			
358.	27282	*Spatoglossum macrodontum*			
359.	625	*Spinifex longifolius (Beach Spinifex)*			
360.	12489	*Stemodia lathraia*			
361.	24482	*Stiltia isabella (Australian Pratincole)*			
362.	27317	*Stoechospermum polypodioides*			
363.	8236	*Streptoglossa cylindriceps*			
364.	8240	*Streptoglossa odora*			
365.	24932	*Strophurus jeanae*			
366.	7711	*Stylidium desertorum*			
367.	43320	*Stylosanthes guianensis var. guianensis*	Y		
368.	12353	*Stylosanthes hamata (Verano Stylo)*	Y		
369.	4242	*Swainsona pterostylis*			
370.	13339	*Synaptantha tillaeacea var. tillaeacea*			
371.	25705	*Tachybaptus novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
372.	30870	*Taeniopygia guttata (Zebra Finch)*			
373.	31616	*Tecticornia auriculata*			
374.	33236	*Tecticornia halocnemoides (Shrubby Samphire)*			
375.	33319	*Tecticornia indica subsp. bidens*			
376.	33318	*Tecticornia indica subsp. leiostachya (Samphire)*			
377.	33220	*Tecticornia pterygosperma subsp. denticulata*			
378.	4280	*Tephrosia rosea (Flinders River Poison, Bungoo'dah)*			
379.	41825	*Tephrosia rosea var. Fortescue creeks (M.I.H. Brooker 2186)*			
380.	19531	*Tephrosia rosea var. clementii*			
381.	19529	*Tephrosia rosea var. rosea*			
382.	15947	*Tephrosia sp. B Kimberley Flora (C.A. Gardner 7300)*			
383.	17768	*Tephrosia sp. Bungaroo Creek (M.E. Trudgen 11601)*			
384.	40060	*Tephrosia sp. clay soils (S. van Leeuwen et al. PBS 0273)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
385.		*Thalasseus bengalensis*			
386.	169	*Thalassia hemprichii*			
387.	672	*Themeda avenacea (Native Oatgrass)*			
388.	24845	*Threskiornis spinicollis (Straw-necked Ibis)*			
389.	2942	*Tinospora smilacina (Snakevine, Oondala)*			
390.	42351	*Todiramphus pyrrhopygius (Red-backed Kingfisher)*			
391.	25549	*Todiramphus sanctus (Sacred Kingfisher)*			
392.	44240	*Trianthema cusackianum*			
393.	2830	*Trianthema portulacastrum (Giant Pigweed)*	Y		
394.	44362	*Trianthema triquetrum*			
395.	44360	*Trianthema turgidifolium*			
396.	4380	*Tribulus occidentalis (Perennial Caltrop)*			
397.	6727	*Trichodesma zeylanicum (Camel Bush, Kumbalin)*			
398.	12032	*Trichosanthes cucumerina var. cucumerina*			
399.	8252	*Tridax procumbens (Tridax, Tridax Daisy)*	Y		
400.	48201	*Trigastrotheca molluginea*			
401.	13131	*Triodia epactia*			
402.	700	*Triodia secunda*			
403.	46616	*Triodiomyces altilis*			
404.	46624	*Triodiomyces lituanus*			Y
405.	706	*Triraphis mollis (Needle Grass)*			
406.	13481	*Triumfetta ramosa*			
407.	27348	*Udotea argentea*			
408.	35302	*Udotea glaucescens*			
409.		*Urodacus hoplurus*			
410.	25577	*Vanellus miles (Masked Lapwing)*			
411.	7393	*Wahlenbergia tumidifructa*			
412.	5106	*Waltheria indica*			
413.	728	*Whiteochloa cymbiformis*			
414.	730	*Xerochloa imberbis (Rice Grass)*			
415.	24857	*Zosterops luteus (Yellow White-eye)*			

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement
S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3
4 - Priority 4
5 - Priority 5

[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report 5km Search

Printed by Guest user on 5/6/2020

Query details : Current Names Only=Yes; Core Datasets Only=Yes; Method='By Circle'; Centre=118° 37' 59'' E,20° 18' 47'' S; Buffer=5km;

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Search Results

Selected

- ● Selected Species

All Results

- ● Non-conservation taxon
- ● Priority 2
- ● Priority 3
- ● Priority 4
- ● Protected under international agreement
- ● Rare or likely to become extinct

Reference Layers

Major WA Towns
•

Major WA Towns
•

Major WA Towns
•

State Borders
—

Department of Biodiversity, Conservation and Attractions
WESTERN AUSTRALIAN MUSEUM

NatureMap is a collaborative project of the Department of Biodiversity, Conservation and Attractions, Western Australia, and the Western Australian Museum.

Australian Government
Department of the Environment and Energy

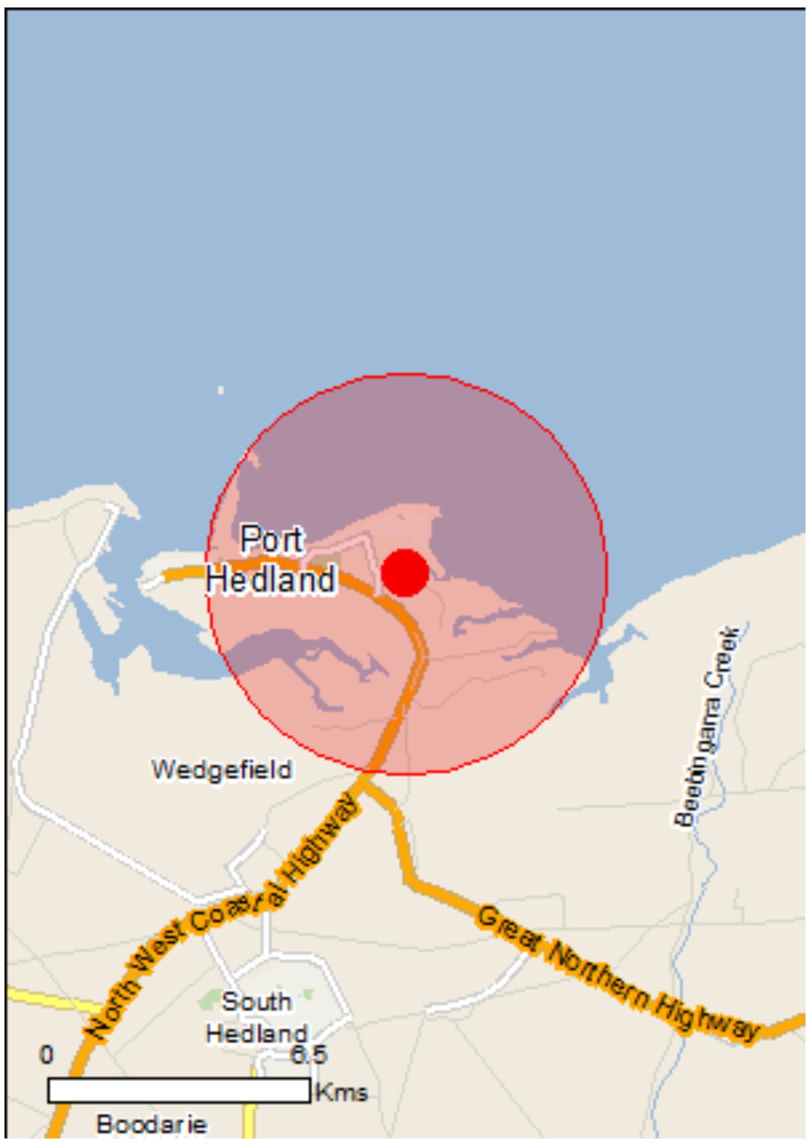
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

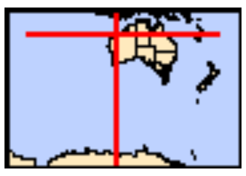
Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 05/06/20 12:17:17



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 5.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	25
Listed Migratory Species:	49

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	89
Whales and Other Cetaceans:	12
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	13
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species

[Resource Information]

Name	Status	Type of Presence
Birds		
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat likely to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat likely to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Reptiles		
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat likely to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Liasis olivaceus barroni Olive Python (Pilbara subspecies) [66699]	Vulnerable	Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Sharks		
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding likely to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding likely to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Migratory Terrestrial Species		
Hirundo rustica Barn Swallow [662]		Species or species habitat known to occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris alba Sanderling [875]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat likely to occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Calidris subminuta Long-toed Stint [861]		Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat known to occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur

Name	Threatened	Type of Presence
		within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Species or species habitat known to occur within area
Numenius phaeopus Whimbrel [849]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Species or species habitat known to occur within area
Tringa brevipes Grey-tailed Tattler [851]		Species or species habitat known to occur within area
Tringa glareola Wood Sandpiper [829]		Species or species habitat known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres Ruddy Turnstone [872]		Species or species

Name	Threatened	Type of Presence
		habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris alba Sanderling [875]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat likely to occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Calidris subminuta Long-toed Stint [861]		Species or species habitat known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat may occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Species or species habitat known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat known to occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Species or species habitat known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Species or species habitat known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat known to occur

Name	Threatened	Type of Presence
		within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Species or species habitat known to occur within area
Numenius phaeopus Whimbrel [849]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Species or species habitat known to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Stiltia isabella Australian Pratincole [818]		Species or species habitat known to occur within area
Tringa glareola Wood Sandpiper [829]		Species or species habitat known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area
Fish		
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within area
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within area
Festucalex scalaris Ladder Pipefish [66216]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat likely to occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Aipysurus tenuis Brown-lined Seasnake [1121]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis czeblukovi Fine-spined Seasnake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans

[Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species

Name	Status	Type of Presence
		habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Mammals		
Camelus dromedarius Dromedary, Camel [7]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		

Name	Status	Type of Presence
Andropogon gayanus		
Gamba Grass [66895]		Species or species habitat likely to occur within area
Cenchrus ciliaris		
Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Jatropha gossypifolia		
Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus		
Asian House Gecko [1708]		Species or species habitat likely to occur within area
Ramphotyphlops braminus		
Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat may occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-20.31304 118.63307

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

Appendix F
Aboriginal Heritage Inquiry System search

Aboriginal Heritage Inquiry System

List of Other Heritage Places

Search Criteria

Other Heritage Place ID 28249

Disclaimer

The *Aboriginal Heritage Act 1972* preserves all Aboriginal sites in Western Australia whether or not they are registered. Aboriginal sites exist that are not recorded on the Register of Aboriginal Sites, and some registered sites may no longer exist.

The information provided is made available in good faith and is predominately based on the information provided to the Department of Planning, Lands and Heritage by third parties. The information is provided solely on the basis that readers will be responsible for making their own assessment as to the accuracy of the information. If you find any errors or omissions in our records, including our maps, it would be appreciated if you email the details to the Department at AboriginalHeritage@dplh.wa.gov.au and we will make every effort to rectify it as soon as possible.

Copyright

Coordinate Accuracy

Coordinates (Easting/Northing metres) are based on the GDA 94 Datum. Accuracy is shown as a code in brackets following the coordinates.

Terminology (NB that some terminology has varied over the life of the legislation)

Place ID/Site ID: This a unique ID assigned by the Department of Planning, Lands and Heritage to the place.

Status:

- **Registered Site**: The place has been assessed as meeting Section 5 of the *Aboriginal Heritage Act 1972.*
- **Other Heritage Place which includes:**
  - **Stored Data / Not a Site:** The place has been assessed as not meeting Section 5 of the *Aboriginal Heritage Act 1972.*
  - **Lodged:** Information has been received in relation to the place, but an assessment has not been completed at this *stage* to determine if it meets Section 5 of the *Aboriginal Heritage Act 1972.*

Access and Restrictions:

- **File Restricted = No:** Availability of information that the Department of Planning, Lands and Heritage holds in relation to the place is not restricted in any way.
- **File Restricted = Yes:** Some of the information that the Department of Planning, Lands and Heritage holds in relation to the place is restricted if it is considered culturally sensitive. This information will only be made available if the Department of Planning, Lands and Heritage receives written approval from the informants who provided the information. To request access please contact AboriginalHeritage@dplh.wa.gov.au.
- **Boundary Restricted = No:** Place location is shown as accurately as the information lodged with the Registrar allows.
- **Boundary Restricted = Yes:** To preserve confidentiality the exact location and extent of the place is not displayed on the map. However, the shaded region (generally with an area of at least 4km²) provides a general indication of where the place is located. If you are a landowner and wish to find out more about the exact location of the place, please contact the Department of Planning, Lands and Heritage.
- **Restrictions:**
  - **No Restrictions:** *Anyone* can view the information.
  - **Male Access Only:** Only *males* can view restricted information.
  - **Female Access Only:** *Only* females can view restricted information.

Legacy ID: This is the former unique number that the former Department of Aboriginal Sites assigned to the place. This has been replaced by the Place ID / Site ID.

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Aboriginal Heritage Inquiry System

List of Other Heritage Places

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
28249	Pretty Pool	No	No	No Gender Restrictions	Lodged	Artefacts / Scatter, Midden / Scatter, Mythological, Camp	*Registered Knowledge Holder names available from DAA	671070mE 7753036mN Zone 50 [Reliable]	

Department of Planning, Lands and Heritage

GOVERNMENT OF WESTERN AUSTRALIA

Aboriginal Heritage Inquiry System

Map of Other Heritage Places

For further important information on using this information please see the Department of Planning, Lands and Heritage's Disclaimer statement at https://www.dplh.wa.gov.au/about-this-website

Legend

- ▢ Other Heritage Place
- ● Town
- — Road
- — River
- ▢ Local Government Authority

0.60 kilometres

Map Scale 1 : 18,200

MGA Zone 50 (GDA94)

Map created: 05/06/2020 10:25:05 AM by: GIS_NET_USER

Identifier: 455011

Appendix 2 – Engineering Servicing Report

THE STABLES (STAGE 3)
EAST PORT HEDLAND, WESTERN AUSTRALIA

PRELIMINARY ENGINEERING SERVICING REPORT
LANDCORP

May 2015 Revision E
Project Number: JDS14762

JDSi Consulting Engineers
Level 1, 59 Parry St
Perth WA 6000

Telephone (08) 9227 0595
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TABLE OF CONTENTS

DOCUMENT REVIEW				
Revision	**Date Issued**	**Written By**	**Reviewed By**	**Approved By**
Rev A	15/05/15	GPC	OS	
Rev B	18/05/15	GPC	OS	
Rev C	21/05/15	OS	GPC	
Rev D	26/05/15	GPC	GPC	
Rev E	28/05/15	GPC	GPC	GPC

1.0 Key Objectives

This report has been prepared by JDSi Consulting Engineers (JDSi) to assist LandCorp with the preliminary due diligence study of the potential residential and commercial development of the eastern end of the Port Hedland locality being an area of Pretty Pool colloquially known as “The Stables”. This area includes Lots 300 (Pt), 340 (Pt), 556 (Pt), 5770, 5755 and 5966 300 Styles Road, Port Hedland (the development).

The key objectives of this report are to:

- Gain an understanding of the existing assets in the vicinity of the development and its potential to support the development.
- Advise on likely infrastructure requirements for the planned development.
- Advise on the implementation of key infrastructure requirements.

This report is based on the civil engineering aspects of an assumed land use and covers the engineering infrastructure requirements to service the study area, and specifically cover earthworks, roads, stormwater drainage and utility services.

The investigations and preparation of the report are largely based on preliminary desktop advice. The information is current as of May 2015 and is subject to a development layout being derived so that actual capacity requirements can be discussed with authorities.

2.0 Introduction

This report focuses on a study area (Figure 2-1) covering an approximate area of 27 hectares. The study area is made up of Land Tenures consisting of;

- Town of Port Hedland - Crown Land parcels with Power to Lease
- Horizon Power - for the purpose of “Electricity Sub Station & Weather Station

This report provides an overview of the existing and future servicing requirements to support a proposed residential and commercial development. It has been based on JDSi’s site observations, experience gained from similar projects that have been undertaken and also advice received from the various infrastructure stakeholders.

Figure 2-1: Study Area

3.0 The Study Area

3.1 Location

The study area site is located in the 'Eastern End' of the Port Hedland Locality, and is approximately 6.0km east of the Port Hedland Town Centre. The study area is bound by Styles Road, Pretty Pool Creek, Cooke Point Drive and existing residential housing.

3.2 Vegetation

The study area is predominantly made up of low lying shrubs, small trees, grass and mangroves. It is anticipated that the development area can be cleared and earthworked to create final levels suitable for the development.

3.3 Existing structures

There is currently a Pony Club located within the development site. It is anticipated that Preliminary Site Investigation (PSI) and a hazardous material survey will be required to understand the environmental impacts and associated demolitions and remediation requirements.

3.4 Aboriginal Heritage

Landcorp has commissioned an Aboriginal Heritage Survey for the study area by Anthropos Australis.

4.0 Site Characteristics

4.1 Topography

The site has a topography ranging from RL8.0m Australian Height Datum (AHD) along Styles Road to Pretty Pool Creak of RL2.5m. There is also a localized high point located to the east with a levels ranging from RL8.0-RL5.0m.

4.2 Groundwater

Coffey Geotechnics completed testing in July 2014 which indicated that groundwater within the area was at RL2.50 – RL3.0m. It is anticipated that the groundwater levels will fluctuate and thus it is recommended to commission a study at the commencement of the design phase to determine suitable groundwater levels for the development.

4.3 Geology

The geological map provided by Geo Survey of WA indicates the subject site is overlain with predominantly coastal dunes, tidal flat deposits, silts and mud as shown in Figure 4-1.

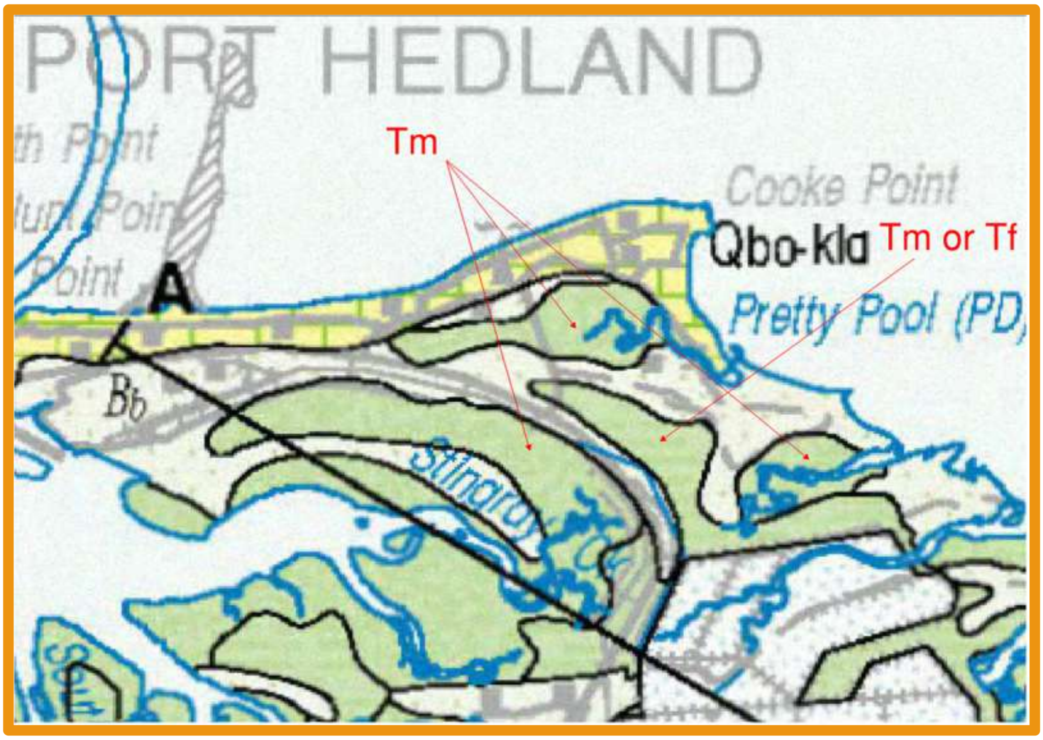

Figure 4-1 : Geological Mapping

Coffey Geotechnics completed a geotechnical investigation report on the study area "Ref: GEOTPERT10160AA-AC-Rev 0" The geological characteristics of the portions is summarized as follows;

- Area A - Dunal Sands – fine to coarse grained sand.
- Area B - Estuarine Deposits – Sandy Clay/ Clay with low to high plasticity.
- Area C - Limestone – well to very well cemented, low to high strength.

The preliminary area analysis boundaries is shown in Figure 4.2

Figure 4-2 : Geological Boundaries (Coffey Geotechnics 2014)

A typical geological cross section through the development running north-south is shown in Figure 4-3

Figure 4-3 : Typical Geological Cross Section

4.4 Acid Sulphate Soils

Acid Sulphate Soils (ASS) are soils containing naturally-occurring, fine-grained metal sulfides typically pyrite (FeS_2), formed under saturated, anoxic/reducing conditions. They generally occur in Quaternary (1.8 Ma – Present) marine or estuarine sediments, predominantly confined to coastal lowlands (elevations generally below 5 m AHD). Within these sediments, the majority of soils that present an environmental risk are generally confined to Holocene aged material (<10 000 years). Where these materials have oxidised, they commonly have a mottled appearance (orange and yellow discolouration) due to the presence of oxidised iron minerals. Although soils described represent typical conditions where ASS occur, in Western Australia these materials have been identified in other soil types such as leached sands and silts.

The iron sulfides in ASS react with oxygen when the soil is exposed to air through excavations or via lowering of the water table. Iron compounds and sulfuric acid are then created along with other substances, including heavy metals. All excavation works and dewatering in ASS must be carefully managed to avoid any potential damage to surrounding land and water ways.

Acid Sulfate Soil mapping compiled by the DEC indicates that the subject site has two categories of anticipated ASS, this being high to moderate risk and moderate to low risks of Acid Sulfate Soils within 3m of the natural soil surface as shown in Figure 4-1. Coffey Geotechnics completed testing and confirmed that the site ranges from high to low risk on encountering ASS.

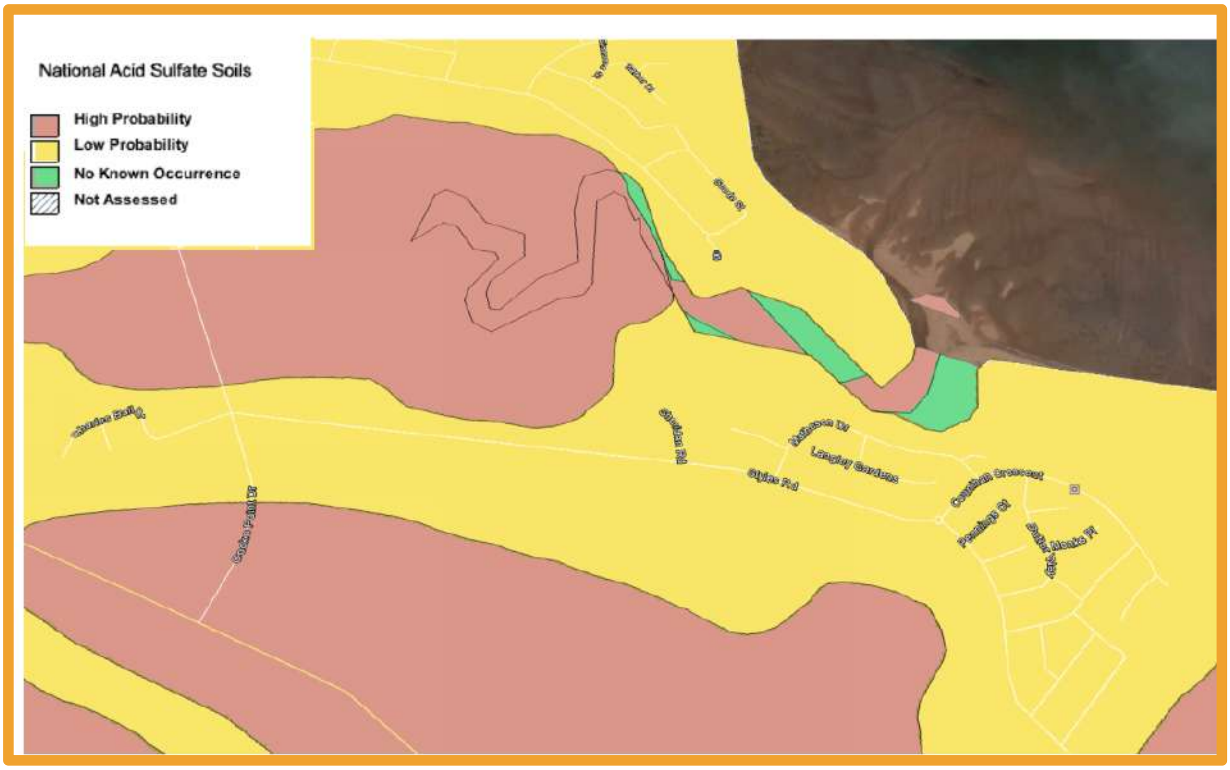

Figure 4-1 : Acid Sulphate Mapping

5.0 Earthworks

5.1 Earthworks

Earthworks levels will be based on the Port Hedland Coastal Vulnerability Study (PHCVS) completed by Cardno which prescribes development setbacks and permissible building heights. The study area is situated within the "East Port Hedland – No Setup" as shown in Figure 5-1.

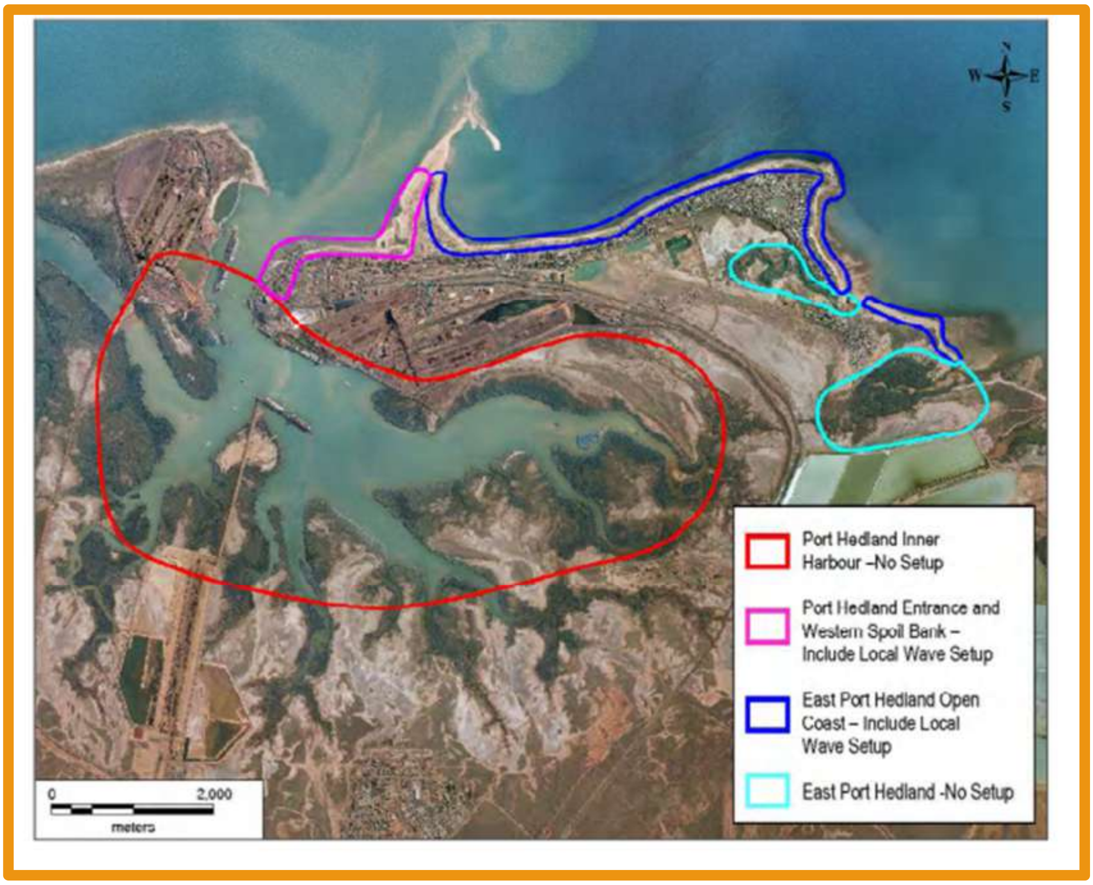

Figure 5-1 : Extras from Port Hedland CVS - Design Level Locations

Based on the PHCVS it is anticipated that the minimum habitable floor level for the development will be RL6.60m, refer to Figure 5-2. It is recommended that when designing the earthworks with respect to residential lot levels that consideration is given to the likely ground slab thicknesses to minimize any unnecessary filling on the site.

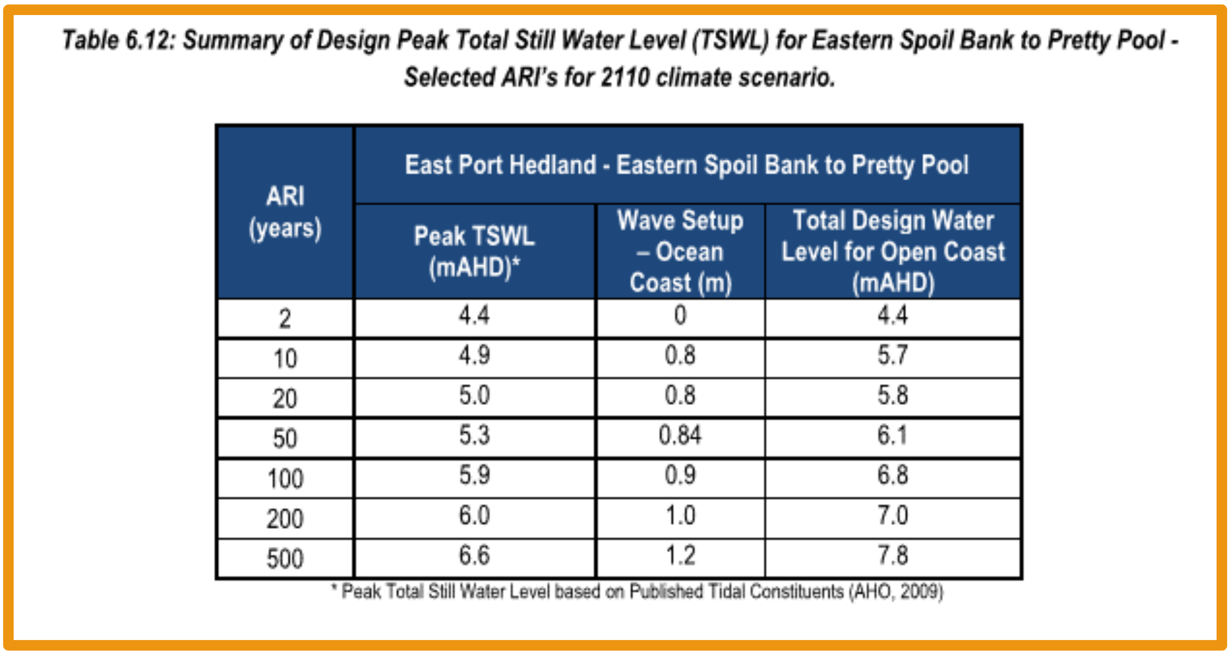

Table 6.12: Summary of Design Peak Total Still Water Level (TSWL) for Eastern Spoil Bank to Pretty Pool - Selected ARI's for 2110 climate scenario.

ARI (years)	East Port Hedland - Eastern Spoil Bank to Pretty Pool		
	Peak TSWL (mAHD)*	Wave Setup – Ocean Coast (m)	Total Design Water Level for Open Coast (mAHD)
2	4.4	0	4.4
10	4.9	0.8	5.7
20	5.0	0.8	5.8
50	5.3	0.84	6.1
100	5.9	0.9	6.8
200	6.0	1.0	7.0
500	6.6	1.2	7.8

* Peak Total Still Water Level based on Published Tidal Constituents (AHO, 2009)

Figure 5-2 : Design Peak Still Water Levels

Cardno completed modelling analysis and confirmed that the following finished surface levels are acceptable;

1) Long-term accommodation FFL = RL6.6m.
2) Roads and Carparks FFL = can be less than RL6.60m but needs to be engineered.
3) Short-term accommodation FFL = can be less than RL6.60m but needs to be engineered.

Due to the relatively low levels of the study area there will be minimal opportunities to source fill within the site. It is anticipated that fill can be generated from the following sources;

1) Import fill from quarries.
2) Potential synergies with other development sites needing to export material (such as Spoilbank Marina).

It is anticipated that rock breaking will be required where limestone is present.

The bulk earthworks will need to be undertaken in accordance with recommendations from a detailed geotechnical investigation and Australian Standard AS3978-1996 "Earthworks for Residential and Commercial Developments".

Coffey Geotechnics considered that the areas requiring ground improvements would be the areas which have Estuarine muds present (Area B Figure 4-2). The methods that would be suitable for ground improvement would be;

1) Preload the site.
2) Preload the site with wick drains.
3) Vibro-replacement columns.
4) Controlled modulus columns.

It is anticipated that the area would need approximately 2m surcharge filling above finished surface levels. It is anticipated that settlement would be approximately 100mm.

6.0 Sewer

Water Corporation owns and operates the wastewater infrastructure in Port Hedland has completed a major capital works contract which comprised of the decommissioning of the Port Hedland Wastewater Treatment Ponds located to the west of Cooke Point Drive and the construction of a type 180 pump station to the east which diverts Port Hedland's wastewater to the South Hedland Wastewater Treatment Plant.

At the location of Styles Road, there is an existing gravity network that services the residential lots to the east which discharges wastewater to a pump station located near the intersection of Sharman Mews and Styles Road. This pump station diverts wastewater to the newly completed Cooke Point type 180 pump station.

Water Corporation has confirmed that the subject site has received planning allowances and it is envisaged that the development will be divided into two separate catchment boundaries, that being;

1) West Catchment – construction of gravity main which discharges to an existing pump station located at Charles Ball Drive.
2) Eastern Catchment - construction of gravity mains with a discharge to a proposed type 90 pump station located to the south of Styles Road.

Refer to Figure 6-1 to understand the current wastewater planning for the locality;

Figure 6-1: Initial Water Corporation Planning

As Water Corporation has not been privileged to the proposed development layout and its intended purposes, it is expected that the catchment boundaries may change in which all the site will gravitate to proposed pump station south of Styles Road.

It is also anticipated that if this development proceeds ahead of the construction of the proposed type 90 pump station located south of Styles Road that interim measures should be considered. Some anticipated interim measures that should be considered are;

1) Construction of a permanent pump station located within the development site which discharges to the gravity network to the east.
2) Construction of a permanent pump station located within the development site which discharges to the pump station located at Sharmac Mews/Styles Road.
3) Construction of a temporary pump station with possible discharge options discussed above.

7.0 Water Supply

Water Corporation owns and operates the potable water infrastructure in Port Hedland

The site has a solid water infrastructure backbone with a 250mm diameter AC water main running along Styles Road which is supplied from 300mm diameter water mains along Cooke Point Drive.

Ultimate planning indicated that a 300P-12 water main is planned to be constructed along Cooke Point Drive, Water Corporation has advised this will not effect this development. Also Water Corporation has confirmed that there is a planned duplicate DN250 water main along Styles Road in 2035 (subject to review).

Refer to Figure 6-1 to understand the current water assets for the locality;

Figure 7-1: Initial Water Corporation Planning

It is important to discuss the development infrastructure pressures with Water Corporation closer to development realization to ensure up to date information is received and any upgrade requirement understood.

8.0 Power Supply

Electricity supplies to the development would originate from the Horizon Power Anderson Street Zone Substation. Anderson Street is a 132kV/22kV bulk distribution point with an electricity capacity rating of 30 MVA. All distribution feeders to the development area are 22 kV high voltage underground with a rating of 14 MVA and are operated for security and contingency reasons at 10 MVA.

The estimated power load for the new development is approximately 3.5MVA. There was a study undertaken back in 2010 which indicated the capacity at the Anderson zone substation to be 10 MVA. One would consider the capacity has reduced over the past five years due to its dynamic nature. Horizon Power may require a new feeder from Anderson zone substation to the development site, but again this will need to be confirmed via the feasibility study. Horizon Power levy $11k for the feasibility study will apply and it is recommended that for validity reasons, this study is completed during the acquisition phase of the development.

9.0 Telecommunications

As a result of the Australian Government’s decision to roll out a National Broadband Network (NBN) the ownership issues of delivering the wholesale fibre to the home system have been transferred to the Government with a number of retail service providers likely to offer services over the network. However, should the subject site create less than 100 residential lots, the development will ultimately be serviced by Telstra.

NBN’s rollout database indicated the study area is not part of any immediate rollout. The subject site is bounded by existing telecommunications infrastructure owned and operated by Telstra.

It is anticipated however that due to the size and diversity of development that NBN will be the communication provider for this development in the future, however, if the rollout does not occur before development, Telstra will be required to provide communication assets as a minimum.

10.0 Gas

Gas is not a reticulated asset within Port Hedland and is not an option for supply.

11.0 Roads

Styles Road is owned and maintained by the Town of Port Hedland. Any new roads within the subject site are required to be designed in accordance with the Town of Port Hedland guidelines.

It is important that in early concept layout development that consideration be given for any potential hierarchy upgrades of Styles Road.

The current road hierarchy information for the development locality is;

- Wilson Street - Primary Distributer.
- Cooke Point Drive – Local Distributer.

This is shown in Figure 11-1.

Figure 11-1: Road Herachy Information

Due to the large importation of fill requirements to develop the site, careful consideration needs to be given into the proposed haulage routes into the development. Currently only single trailer trucks are allowed to enter Cooke Point Drive which does place large import cost rates for fill material. It is recommended to look at permanent or temporary road geometry upgrades that would allow the larger trucks (such as triples and quads) to enter the site and thus reduce the import rate significantly.

12.0 Drainage

Urban Water Management (UWM) is now a key part of any development process incorporating principles of integrating water and land use planning, considering all water sources in water planning, integrating water use and natural water processes and a total catchment integration of natural resource use and management (Ref. Stormwater Management Manual for Western Australia, DOW, April 2004 the State Water Strategy 2003 and the State Water Plan 2007).

Stormwater drainage management is a major component of an overall UWM strategy for which achievement of the principals of the plan may be facilitated through the application of Water Sensitive Urban Design (WSUD) techniques during planning, design and construction of urban development projects.

It is important when considering the UWM principals that the Pilbara conditions are considered. Cardno has prepared a Local Water Management Strategy which details a stormwater management framework which should be considered when designing and constructing stormwater assets.

It is expected that stormwater management for the site will predominately focus on conveyance in the form of inverted roadways, public open space and roadside swales. Pit and pipe conveyance in the Pilbara is generally not encouraged and is only considered to manage trapped low points and flow widths within road pavements.

Coffey Geotechnics completed permeability testing in the development which suggested that soakage systems are not suitable for the development site. If any form of soakage is considered, then it is recommended that further permeability testing is completed at the specific locations where soakage is proposed.

Due to the vicinity of the mangroves and creek it is recommended that a sediment management plan be completed to minimize any impacts to the environmental sensitive areas. It is considered that temporary sediment basins be constructed while the development is built out and drainage swales are fully stabilized.

13.0 Disclaimer

JDSi have undertaken this assessment based on supplied information and subsequently assumptions have been made which, if incorrect, have the potential to change costs. Major cost implications exist through factors which cannot be assured at this time including upgrading and provision of utility services, WAPC conditions of development, Local Authority Scheme Requirements, ground conditions, timing of adjacent developments, etc.

While JDSi has taken all care in the preparation of the likely development requirements and has noted key assumptions, JDSi accepts no responsibility for the accuracy of this report and provides it only as an indicative summary of engineering requirements.

If any further information is required or should you wish to clarify any issue, please contact our office.

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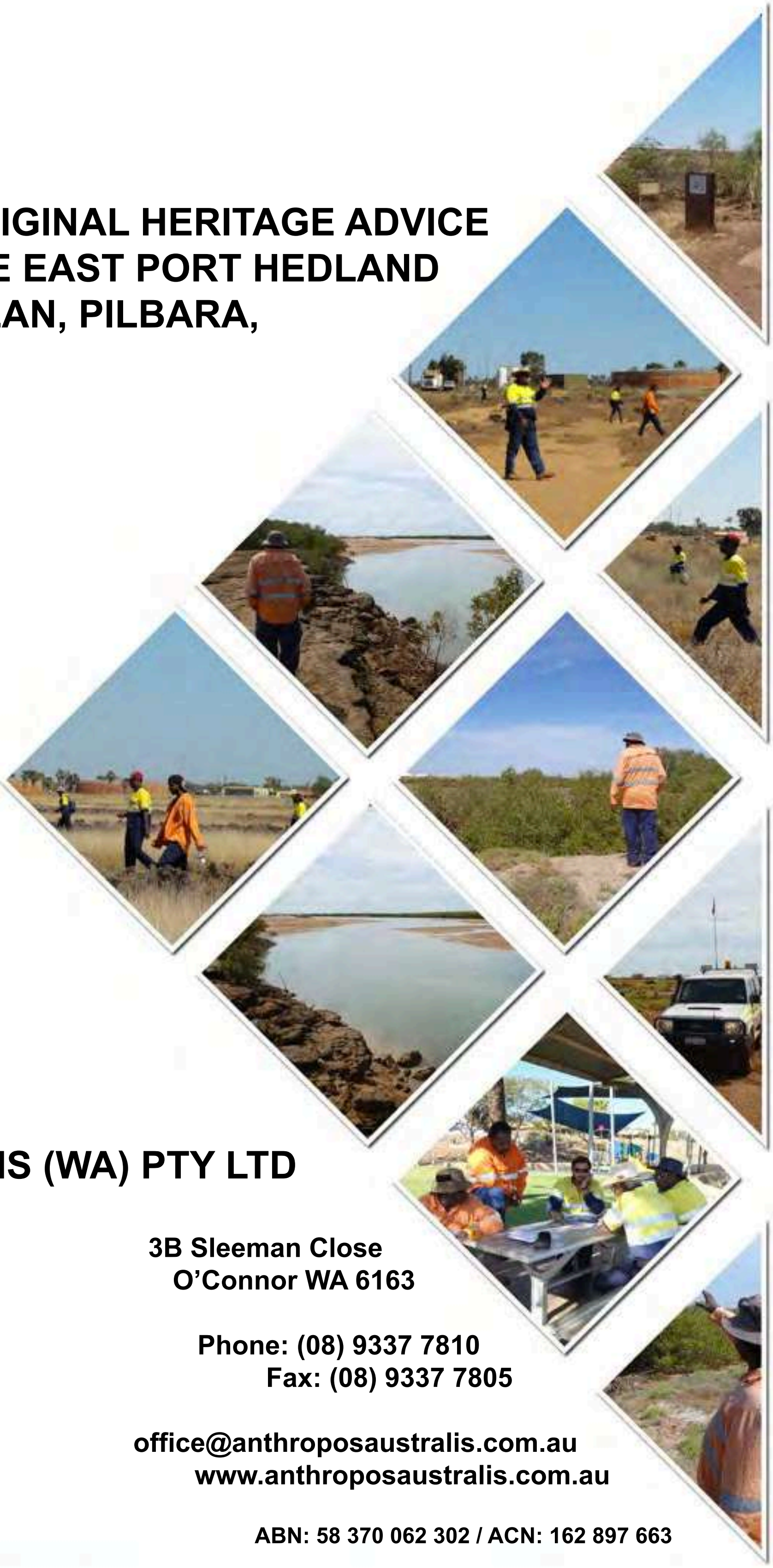
Appendix 3 – Aboriginal Heritage Report

THE REPORT ON ABORIGINAL HERITAGE ADVICE FOR THE STAGE THREE EAST PORT HEDLAND PROJECT CONCEPT PLAN, PILBARA, WESTERN AUSTRALIA

MAY 2015



For LandCorp

By

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DISCLAIMER

Whilst every effort has been made to ensure that all relevant data has been presented, the Author is not accountable for omissions and inconsistencies that may result from information which may come to light in the future but which was not forthcoming at the time of the provision of the Services.

The advice including the conclusions and recommendations within this Report are based on information available at the time of its preparation.

ACKNOWLEDGEMENTS

The Author would like to acknowledge and thank the following people in this Report:

- LandCorp: Brad Pawlenko and Olivia Abrugiato who commissioned the Author to undertake provide the Services; and
- Anthropos Australis (WA) Pty Ltd: Nicholas Green and Emily Ashby who drafted the Report.

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SECTION ONE – INTRODUCTION

INTRODUCTION

LandCorp is undertaking concept planning, a full Environmental Assessment and initiating a Scheme Amendment request to rezone an area of developable land from "Rural" to "Urban Development" within East Port Hedland, in the Pilbara region of Western Australia (the Project).

The area of land that is the subject of the Project is located in East Port Hedland, and is bound by Styles Road, Cooke Point Drive, Pretty Pool and existing residential development along Matherson Drive (the Study Area). The Study Area has been identified as Stage 3 within the East Port Hedland Concept Plan (August 2012) and is commonly referred to as "The Stables" area (see Figure 1).

LandCorp has engaged Anthropos Australis (WA) Pty Ltd to provide the Services which is comprised of three deliverables in regards to the Project:

- Part A: a brief Report on the European and Aboriginal historical research about the Study Area in the context of the broader Port Hedland Area (see Anthropos Australis (WA) Pty Ltd: 2014a);
- Part B: A brief Memorandum summarising comments on the proposed concepts from a heritage constraints and approvals perspective and recommendations for improvement/changes and provision of inputs into the Scheme Amendment documentation (see letter from Nicholas Green to Olivia Abrugiato dated 3rd February 2015); and
- Part C: A concise Report/Memorandum which includes a summary of issues and required approvals to deliver the Final Concept as part of the Scheme Amendment process, recommendations for the retention/integration of important heritage features into the urban development of the land, and details of all further heritage investigations/studies required to be completed to permit urban development of the Study Area inclusive of potential timeframes and costs.

This Report details the results of Part C above. The advice provided in this Report is designed to assist LandCorp to guide any future land developer that is interested in developing the land in the Study Area in the mid-term, say 15 plus years, to address the Aboriginal heritage issues/constraints that affect the Study Area as well as suggestions for engagement with *Marapikurrinya* people and the *Kariyarra* native title claimant group.

This advice is based upon current "Best Practice" standards and well as the existing procedures under the *Aboriginal Heritage Act* 1972 (Western Australia) and the *Aboriginal and Torres Strait Islander Heritage Act* 1984 (Commonwealth) and does not second guess what those standards and procedures may look like 15 years into the future. In addition, the views and desires of the Aboriginal parties with an interest in the land may also change, as culture is not static.

REPORT FORMAT

This Report is divided into two sections:

Section One contains this Introduction, providing details of the Study Area including Figure 1; and

Section Two provides advice on the Aboriginal Heritage Issues/Constraints in the Study Area, advice on the ongoing engagement with *Marapikurrinya* Pty Ltd, Figure 2 and Figure 3 as well as the Conclusions and the References cited.

Figure 1: Location of the Study Area

SECTION TWO – ABORIGINAL HERITAGE ISSUES/CONSTRAINTS AND ONGOING ENGAGEMENT WITH *MARAPIKURRINYA*

PREVIOUS ABORIGINAL HERITAGE SURVEYS OF THE STUDY AREA

The land within the Study Area has been the subject of an Aboriginal heritage survey (ethnographic and archaeological), undertaken by Anthropos Australis (WA) Pty Ltd in September 2011 (see Anthropos Australis Pty Ltd: 2012a).

That survey was undertaken under the terms of a Memorandum of Understanding (MoU) dated February 2010 between the Western Australian Land Authority (LandCorp), and the Representative Body, in this case *Marapikurrinya* Nominees Pty Ltd as Trustee for the *Marapikurrinya* Charitable Trust (referred to in this Report as *Marapikurrinya* Pty Ltd), which manages the conduct of Aboriginal heritage surveys in the Port Hedland area on behalf of and by agreement with the broader *Kariyarra* native title claimant group.

That survey was undertaken over 450 ha of land, which includes the Study Area and the generic recommendations in the subsequent report are valid here for any future land developer (see Anthropos Australis Pty Ltd: 2012a), which are as follows:

- *It is recommended that, should LandCorp wish to use the land containing any of the above mentioned Aboriginal sites, then they will need to be recorded to Site Identification standard to enable a Section 18 Notice under the Aboriginal heritage Act 1972 to be lodged with the Department of Indigenous Affairs. Any proposed Section 18 Notice will need to be discussed with Marapikurrinya Pty Ltd.*

- *It is* ***recommended*** *that, as there exist unrecorded engravings in close proximity to the eastern boundary of the Survey Area, along Gray Street, and if LandCorp wishes to gain access through Gray Street, this area will need to be the subject of an additional Aboriginal Heritage Survey undertaken by Marapikurrinya Pty Ltd prior to any ground disturbing activity.*

- *It is* ***recommended*** *that the LandCorp ensure continual land and water access for Marapikurrinya people to the Pretty Pool Creek system in order for the Marapikurrinya people to maintain their cultural connection with the area.*

- *It is* ***recommended*** *that, given the potential for Aboriginal cultural material, including skeletal, to be disturbed within* ***sand dune areas****, two Marapikurrinya Pty Ltd nominated Marapikurrinya Heritage Monitors be engaged by LandCorp through Marapikurrinya Pty Ltd during initial ground disturbing activity associated with the proposed works.*

- *It is **recommended** that LandCorp implements the following Stop Work Procedure should any sub-surface skeletal material and other cultural material be uncovered during the proposed ground disturbing activity:*

    1. *Should any sub-surface skeletal material (or any other cultural material) be uncovered during excavation work associated with the proposed construction, contractors are to cease **all work immediately** and the area cordoned off;*

    2. *Contractors are to formally notify the South Hedland Detectives (in the case of skeletal material), Marapikurrinya Pty Ltd and the Department of Aboriginal Affairs;*

    3. *LandCorp appoints a Bio-Archaeologist via Anthropos Australis (WA) Pty Ltd to document and record the skeletal material (or any other cultural material); and*

    4. *Further mitigation strategies and consultation with Marapikurrinya Pty Ltd and Anthropos Australis (WA) Pty Ltd will need to be instigated by LandCorp in response to this Stop Work Procedure.*

- *It is **recommended** that where possible, LandCorp provide employment opportunities for the Marapikurrinya people.*

- *Finally, it is **recommended** that LandCorp keep Marapikurrinya Pty Ltd informed of the proposed development, through regular meetings.*

What is significant about the MoU is that the parties that entered into it did so to ensure that the proposed development of the land, including the Study Area, will occur in a manner where the works:

- Are not likely to interfere directly with the community life of the local Indigenous people;

- Where practicable and in accordance with the law, avoid damage, disturbance or undue interference with areas or sites of particular significance to the local Indigenous representatives; and

- Are in compliance with the provisions of the *Aboriginal Heritage Act* 1972 (Western Australia) and the *Aboriginal and Torres Strait Islander Heritage Act* 1984 (Commonwealth).

Additionally, the processes in the MoU are intended to:

- Allow the local Indigenous representatives to maintain their cultural obligations over country in accordance with traditional law and custom;

- Provide a basis for a mutually beneficial future relationship; and

- Be transparent, timely, certain and cost effective for all parties in protecting Aboriginal heritage in areas where the works take place.

The subsequent survey identified four Aboriginal sites (LAN22-11-09 through to and including LAN22-11-12) and Other Heritage Place ID 28249 (Pretty Pool), which are all located within the Study Area. The Department of Aboriginal Affairs (the DAA) has provided the four Aboriginal sites with an interim label of Lodged but have not assigned them an ID number nor have they been mapped. Until the DAA formally considers the status of these Aboriginal sites under the *Aboriginal Heritage Act* 1972 (Western Australia), LandCorp and any future land developer needs to assume that they are Aboriginal sites within the meaning of the *Aboriginal Heritage Act* 1972 (Western Australia) and should therefore be protected.

It should be noted that the four Aboriginal sites and one Other Heritage Place have been recorded to Site Avoidance standard only as advised in the recommendations above (see Anthropos Australis Pty Ltd: 2012a), Should LandCorp or any future developer wish to use the land containing all or any of these Aboriginal sites/Place, then the Aboriginal sites/Place will need to be recorded to a Site Identification standard to enable the DAA to determine whether they are in fact Aboriginal sites within the meaning of Sections 5 and 39 of the *Aboriginal Heritage Act* 1972 (Western Australia) or not. If they are, then a notice under Section 18 of the *Aboriginal Heritage Act* 1972 (Western Australia) would need to be lodged by the land owner or agent with the DAA to enable the Aboriginal Cultural Material Committee (ACMC) to consider the notice and to provide their formal advice to the Minister for Aboriginal Affairs.

ABORIGINAL SITES RECORDED WITHIN THE STUDY AREA

The Final Concept Plan Option 1 and Option 2 has the four Aboriginal sites and Other Heritage Place located and therefore protected in the proposed Public Open Space (see Figure 2 and Figure 3). While this approach reflects “Best Practice” in the protection of Aboriginal cultural heritage as suggested by the *Australia ICOMOS Burra Charter* 2013, it does mean that there will be an ongoing commitment by the landowner to ensure that the Aboriginal sites/Place have an agreed Cultural Heritage Management Plan to ensure their protection and potential enhancement.

It should also be noted that there is the possibility of additional Aboriginal sites and or objects being uncovered by the mobile landscape within which they occur due to rain, wind and human activity on the land. Therefore, additional Aboriginal heritage survey work may be required in the future.

From a cultural heritage management point of view, either Concept Plan option is acceptable as both have the same outcome, which is to protect the Aboriginal sites/Other Heritage Place, and both Concept Plan options imply the same level of commitment from any future land developer.

Figure 2: Final Concept Plan Option 1

Figure 3: Final Concept Plan Option 2

Aboriginal Site LAN22-11-09 (Shell Midden/Scatter)

Grid Reference

50K	670260mE	7752982mN
	670261mE	7752974mN
	670254mE	7752977mN
	670255mE	7752985mN

Location

Aboriginal site LAN22-11-09 is located in the centre of the Survey Area, 10 m north west of LAN22-11-10 and 30 m north west of LAN22-11-11. The site is located to the north of Styles Road.

Site Environment

The site is located on a limestone outcrop. Vegetation at the site includes Spinifex, Butterfly Bush (*Petalostylis* spp.) and Buffel Grass *(Cenchrus ciliaris*). Ground surface visibility at the time of recording was approximately 80% (see Plate 1).

Archaeological Site Description

The site, which covers an area 10 m N/S by 10 m E/W, and 45 m^2, consists of a discrete shell scatter. Shell types noted include *Anadara granosa* and Baler (*Melo amphora*)(see Plate 2 and Plate 3). No artefacts were noted within the site.

Plate 1: View north of Aboriginal site LAN22-11-09 (scale = 2 m)

Plate 2: Close up of *Anadara granosa* within Aboriginal site LAN22-11-09 (scale = 10 cm)

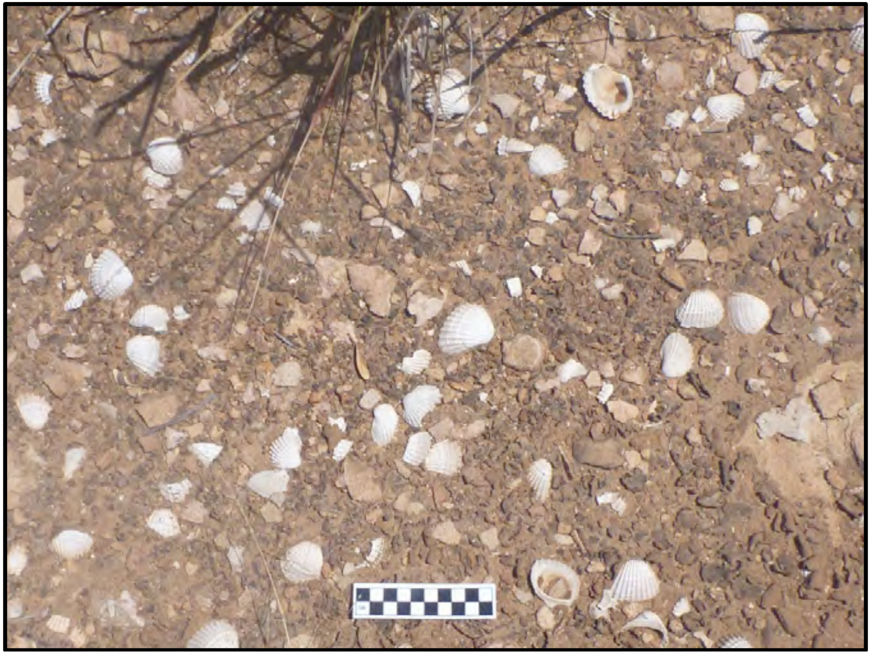


Plate 3: Close up of Baler fragment within Aboriginal site LAN22-11-09 (scale = 10 cm)

Aboriginal Site LAN22-11-10 (ENGRAVING)

Grid Reference

50K	670262mE	7752973mN
	670265mE	7752974mN
	670267mE	7752974mN
	670266mE	7752970mN

Location

Aboriginal site LAN22-11-10 is located in the centre of the Survey Area, 10 m south east of LAN22-11-09 and 20 m west of LAN22-11-11. The site is located to the north of Styles Road.

Site Environment

The site is located on a limestone outcrop south of mangroves and the associated creek line. Vegetation at the site includes Buffel Grass *(Cenchrus ciliaris*), Spinifex (*Triodia* spp.) and Butterfly Bush (*Petalostylis* spp.). Ground surface visibility at the time of recording was approximately 95% (see Plate 4).

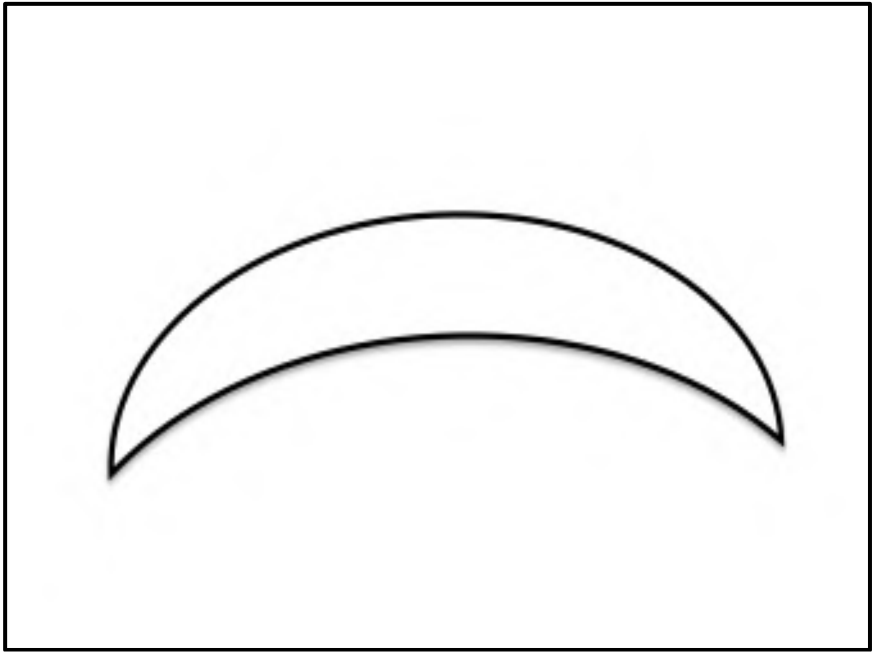
Archaeological Site Description

The site, which covers an area 5m N/S by 5 m E/W, and 10 m^2, consists of a single engraved enigmatic motif (see Plate 5 and Plate 6). No other archaeological material was noted within the site.

Plate 4: View south of Aboriginal site LAN22-11-10 (scale = 2 m)

Plate 5: Close up of the engraving within Aboriginal site LAN22-11-10 (scale = 10 cm)

Plate 6: Line drawing of the engraving within Aboriginal site LAN22-11-10 (not to scale)



Aboriginal Site ID LAN22-11-11 (ENGRAVING)

Grid Reference

50K	670285mE	7752962mN
	670288mE	7752960mN
	670290mE	7752962mN
	670285mE	7752965mN

Location

Aboriginal site LAN22-11-11 is located in the centre of the Survey Area, 20 m east of LAN22-11-10 and 70 m north west of LAN22-11-12. The site is located to the north of Styles Road.

Site Environment

The site is located on a limestone outcrop south of mangroves and the associated creek line. Vegetation at the site includes Spinifex (*Triodia* spp.) and Buffel Grass *(Cenchrus ciliaris*). Ground surface visibility at the time of recording was approximately 95% (see Plate 7).

Archaeological Site Description

The site, which covers an area 5 m by 5 m, and 10 m^2, consists of two engraved motifs, both enigmatic (see Plate 8, Plate 9, Plate 10 and Plate 11). No other archaeological material was noted within the site.

Plate 7: View south of Aboriginal site LAN22-11-11 (scale = 2 m)

Plate 8: Close up of an engraving within Aboriginal site LAN22-11-11 (scale = 10 cm)

Plate 9: Line drawing of an engraving within Aboriginal site LAN22-11-11 (not to scale)

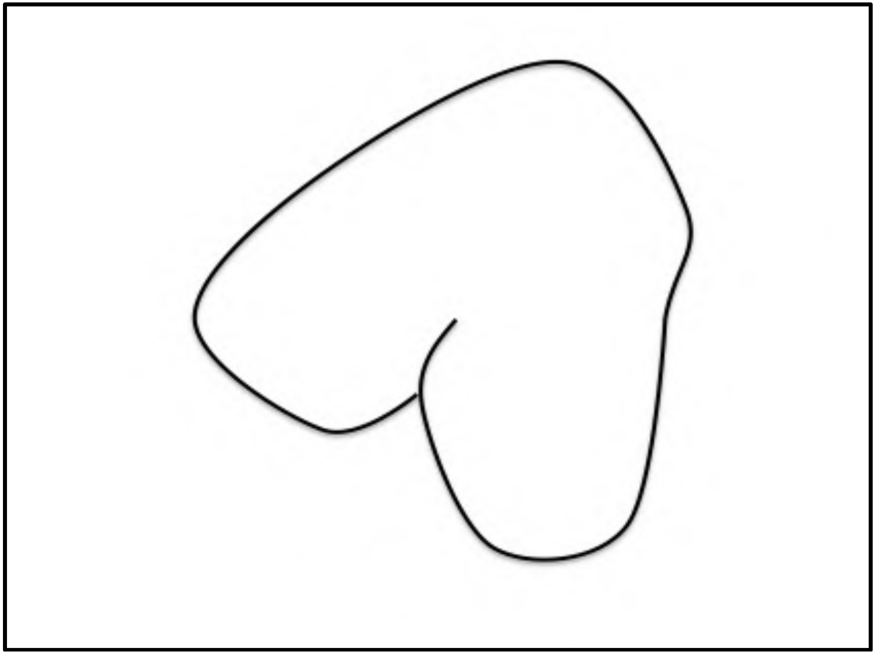


Plate 10: Close up of an engraving within Aboriginal site LAN22-11-11 (scale = 2 m)

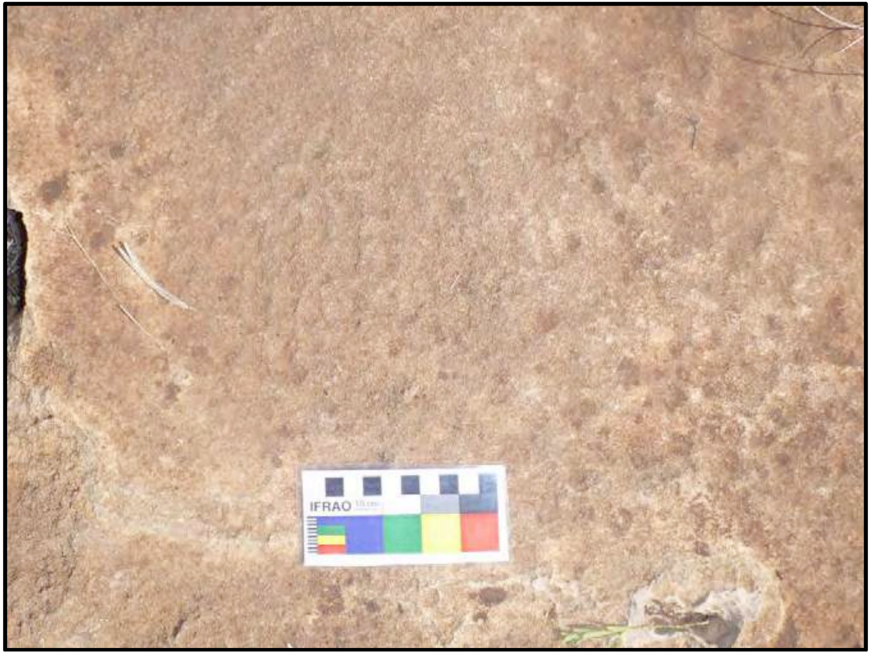
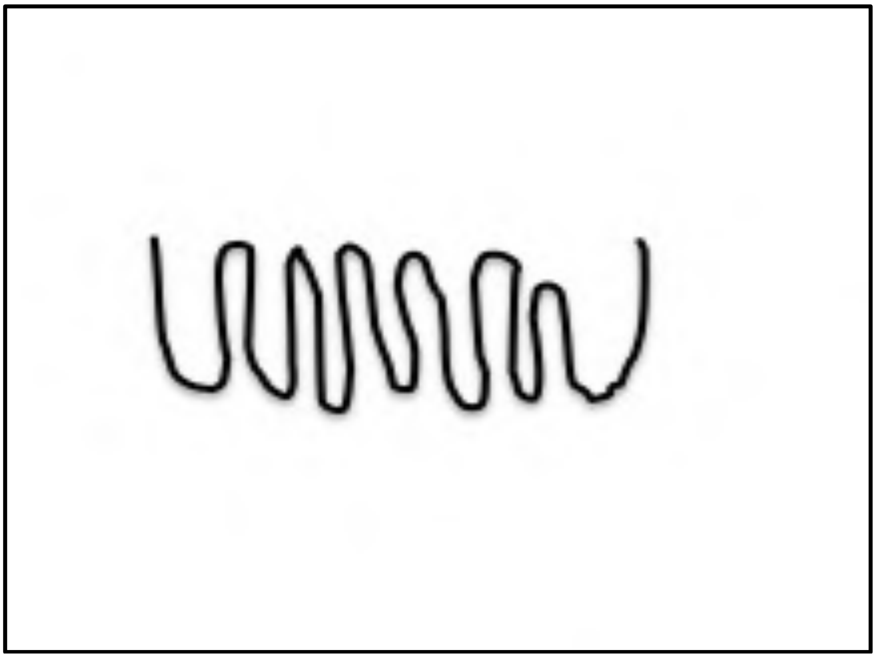


Plate 11: Line drawing of an engraving within Aboriginal site LAN22-11-11 (not to scale)



Aboriginal Site LAN22-11-12 (ENGRAVING)

Grid Reference

50K	670349mE	7752925mN
	670353mE	7752926mN
	670350mE	7752923mN
	670349mE	7752924mN

Location

Aboriginal site LAN22-11-12 is located in the centre of the Survey Area, 70 m south east of LAN22-11-11. The site is located to the north of Styles Road.

Site Environment

The site is located on a limestone outcrop south of mangroves and the associated creek line. Vegetation within the site includes Spinifex (*Triodia* spp.) and Buffel Grass *(Cenchrus ciliaris*). Ground surface visibility at the time of recording was approximately 95% (see Plate 12).

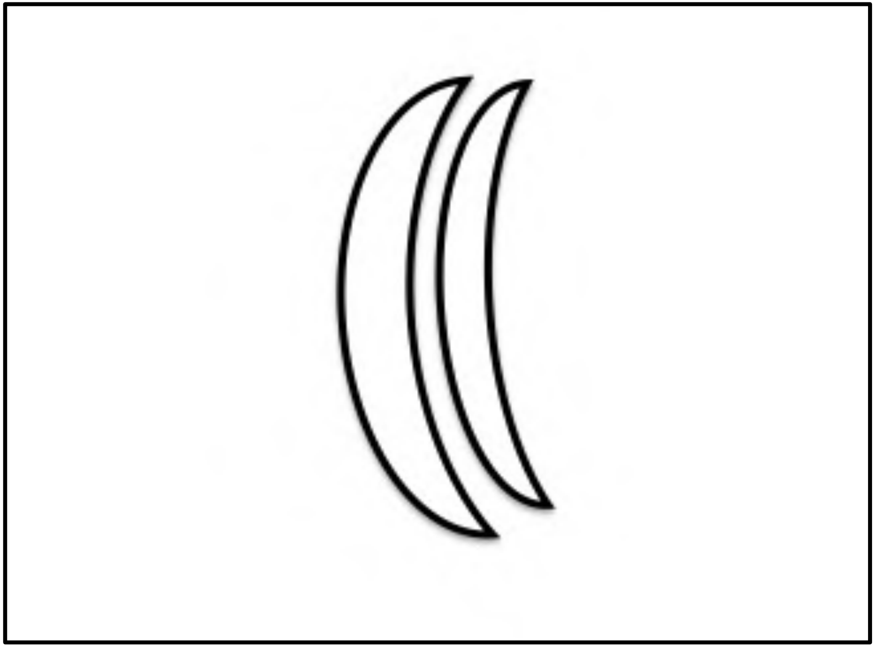
Archaeological Site Description

The site, which covers an area 5 m N/S by 5 m E/W, and 10 m^2, consists of a single enigmatic engraved motif (see Plate 13 and Plate 14). No other archaeological material was found at the site, however it is considered possible that additional engravings may occur further along the ridge, under the dense vegetation that grows there.

Plate 12: View south of Aboriginal site ID LAN22-11-12 (scale = 2 m)

Plate 13: Close up of the engraving within Aboriginal site LAN22-11-12 (scale = 10 cm)

Plate 14: Line drawing of the engraving within Aboriginal site LAN22-11-12 (scale = 10 cm)



ADDRESSING THE ABORIGINAL HERITAGE ISSUES / CONSTRAINTS AND ENSURING ONGOING ENGAGEMENT WITH *MARAPIKURRINYA*

In order to ensure that the four Aboriginal sites/Other Heritage Place within the Study Area as detailed in Concept Plans Option 1 and Option 2 are protected and potentially enhanced given their location in the proposed Public Open Space, it is important to benchmark any proposed cultural heritage management strategies against the agreed processes captured within the 2010 MoU between LandCorp and *Marapikurrinya* Pty Ltd.

First and foremost is the need to maintain the communication and engagement with the Aboriginal stakeholders concerned with the future development of the Study Area. There are two immediate Aboriginal stakeholders concerned with the future development of the Study Area. Consultation to date has included a properly constituted Aboriginal heritage survey of the Study Area, and going forward, engagement exercises with the Aboriginal stakeholders is required.

In relation to Aboriginal heritage, the Aboriginal stakeholders are:

- The *Marapikurrinya* people or family group, represented by *Marapikurrinya* Pty Ltd; and
- The *Kariyarra* native title claimant group, of which the *Marapikurrinya* family group forms a sub-set.

The people who comprise *Marapikurrinya* Pty Ltd are *Kariyarra*, and they are the clan estate for the Port Hedland area and are accepted as such by the broader *Kariyarra* native title claimant group and the broader public and private sectors.

The *Kariyarra* people that form *Marapikurrinya* Pty Ltd, want to ensure that the cultural heritage values of Port Hedland, including the Port Hedland Harbour, are recognised, accepted and preferably preserved in perpetuity. This desire of theirs has often met with conflict where land users, particularly mining companies wishing to construct on shore storage and loading and port facilities, have had to impact Aboriginal sites against the wishes of and without the informed consent of the *Marapikurrinya* people.

There may well be suggestions from people that other Aboriginal entities should be consulted about Aboriginal heritage in regard to the Study Area, which can be the case in certain situations.

Historically, and certainly before the *Native Title Act* 1993 (Commonwealth) was promulgated, some Aboriginal people asserted "custodianship " of sites and of country by historical occupancy. This has been the case in Port Hedland, largely due to the closeness of the relationship between the *Kariyarra*, *Nyamal* and *Ngarla* people, all being linguistic neighbours who have lived historically in Port Hedland and its surrounds pre and post the pastoral era.

There are historical Aboriginal sites in Port Hedland, some in close proximity to the Study Area including *Puriyakannya* (4 Mile Well) to the immediate south, which has a significant place in Western Australia's pastoral history as the strike camp when the Aboriginal stockmen initially planned and held the first Aboriginal labour strike in Australia (see Anthropos Australis (WA) Pty Ltd: 2014a). Aboriginal people throughout the Pilbara consider this location to be highly significant as one of the outcomes for them was the 1967 referendum, which resulted in equal wages for Aboriginal people in Australia. In this example, the location or place is significant to the broader Aboriginal community, however the actual responsibility for the protection of the location rests with the *Marapikurrinya* people as the Traditional Owners of the land.

The relationship between the *Marapikurrinya* people and the *Kariyarra* native title claimant group can be tense due to the conflicting interests over who speaks for what country, particularly as the broader *Kariyarra* group is still in the process of determining their native title claim with the State of Western Australia. The bottom line is that the *Marapikurrinya* people consider themselves to be a part of the broader *Kariyarra* linguistic group and they participate in native title claimant group meetings because they are *Kariyarra*.

For some years now, the *Marapikurrinya* people, through their entity *Marapikurrinya* Pty Ltd and by agreement with the broader *Kariyarra* native title claimant group have managed the cultural heritage values of the Port Hedland area. The native title claim process will run its course and will result in an outcome that should be inclusive of the *Marapikurrinya* people.

The proposed development of the Study Area by a future land developer has all of the elements of a mutually agreeable outcome, which in this instance is the development of much needed land with no adverse impact on the Aboriginal sites/Other Heritage Place and their associated cultural heritage values. To achieve this outcome, a number of steps will need to be carefully considered and ascribed with the full support of LandCorp, which should be enforced as a caveat on any future land development. These steps, which can and should be part of a substantial Cultural Heritage Management Plan include:

- Establishing set of work procedures within the Study Area, which are consistent with the requirements for the protection of Aboriginal sites as set out in the Guidelines issued by the DAA, pursuant to the *Aboriginal Heritage Act* 1972 (Western Australia) and the aspirations of the *Marapikurrinya* people;

- Ensuring that construction is undertaken in a manner that protects the Aboriginal sites in the Public Open Space;

- Liaising with *Marapikurrinya* Pty Ltd regarding Aboriginal heritage management during the pre-construction, construction and post-construction and post-development stages of the Project;
- Ensuring that discoveries of previously unidentified Aboriginal sites or objects are culturally and legally dealt with in the appropriate manner including the implementation of a Stop Work Procedure; and
- Creating opportunities for the enhancement of the four Aboriginal sites and Other Heritage Place in the Study Area with the active engagement and participation of the *Marapikurrinya* people at all times.

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Appendix 4 – Bushfire Management Plan

Bushfire management plan/Statement addressing the Bushfire Protection Criteria coversheet

Site address: Lot 5755, Pt Lot 556, Pt Lot 340, Lot 5770, Lot 5966 and Pt Lot 300 Styles Road, Port Hedland.

Site visit: Yes ☐ No ☑

Date of site visit (if applicable): Day Month Year

Report author or reviewer: Ian Macleod

WA BPAD accreditation level (please circle):

Not accredited ☐ Level 1 BAL assessor ☐ Level 2 practitioner ☑ Level 3 practitioner ☐

If accredited please provide the following.

BPAD accreditation number: 39131 Accreditation expiry: Month November Year 2020

Bushfire management plan version number: 1.0

Bushfire management plan date: Day 29th Month May Year 2020

Client/business name: RPS Australia West Pty Ltd

	Yes	No
Has the BAL been calculated by a method other than method 1 as outlined in AS3959 (tick no if AS3959 method 1 has been used to calculate the BAL)?		✓
Have any of the bushfire protection criteria elements been addressed through the use of a performance principle (tick no if only acceptable solutions have been used to address all of the bushfire protection criteria elements)?		✓

Is the proposal any of the following (see SPP 3.7 for definitions)?	Yes	No
Unavoidable development (in BAL-40 or BAL-FZ)		✓
Strategic planning proposal (including rezoning applications)	✓	
High risk land-use		✓
Vulnerable land-use		✓

None of the above ☐

Note: Only if one (or more) of the above answers in the tables is yes should the decision maker (e.g. local government or the WAPC) refer the proposal to DFES for comment.

Why has it been given one of the above listed classifications (E.g. Considered vulnerable land-use as the development is for accommodation of the elderly, etc.)?

The proposal is for a Scheme Amendment for the land within Lot 5755, Pt Lot 556, Pt Lot 340, Lot 5770, Lot 5966 and Pt Lot 300 Styles Road, Port Hedland.

The information provided within this bushfire management plan to the best of my knowledge is true and correct:

Signature of report author or reviewer: Ian Macleod

Date: 29th May 2020

Bushfire Management Plan

(Strategic Level Proposal)

"The Stables", Styles Road, Port Hedland

Town of Port Hedland

Job Number:	190685
Report Date:	2 June 2020

BPP Group Pty Ltd t/a Bushfire Prone Planning
ABN: 39 166 551 784

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Guildford WA 6055

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Guildford WA 6935

Ph: 08 6477 1144
Email: admin@bushfireprone.com.au

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Disclaimer

The measures contained in this Bushfire Management Plan are considered to be minimum standards and they do not guarantee that a building will not be damaged in a bushfire, persons injured, or fatalities occur either on the subject site or off the site while evacuating. This is substantially due to the unpredictable nature and behaviour of fire and extreme weather conditions. Additionally, the correct implementation of the required bushfire protection measures (and any associated response/evacuation plan if applicable) will depend, among other things, on the actions of the landowners or occupiers over which Bushfire Prone Planning has no control.

All surveys, forecasts, projections and recommendations made in this report associated with the project are made in good faith based on information available to Bushfire Prone Planning at the time.

All maps included herein are indicative in nature and are not to be used for accurate calculations.

Notwithstanding anything contained therein, Bushfire Prone Planning will not, except as the law may require, be liable for any loss or other consequences whether or not due to the negligence of their consultants, their servants or agents – arising out of the services provided by their consultants.

Document Control

Version	Version Details	Date Submitted
1.0	Original Document Issue	2-Jun-20

Author	Accreditation	Signature
Ian Macleod	BPAD Level 2 - No. 39131	Ian Macleod
Co-author		
Reviewed/Approved		
Kathy Nastov	BPAD Level 3 - No. 27794	K. Nastov

Document Content Compliance Statement
This Bushfire Management Plan (the Plan) provides the required information to address State Planning Policy No. 3.7: Planning in Bushfire Prone Areas - December 2015 (SPP 3.7), the associated Guidelines for Planning in Bushfire Prone Areas - WAPC 2017 v1.3 (Guidelines), and any additional information as directed by the WA Planning Commission (WA Department of Planning, Lands and Heritage). It is fit for accompanying a planning application.

Structure Plan / Subdivision BMP Template v7.3

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List of Figures

Executive Summary

This Bushfire Management Plan is to accompany a proposed Scheme Amendment to rezone "The Stables" land, as shown in Figure 1.1, from its current zonings of "Rural", "Parks and Recreation" and "Other Public Purposes" to "Urban Development".

It is envisaged that the site will be developed into a housing estate with low and medium density residential lots created. This proposed urban development site is located outside the local governments IP50 Improvement Plan area, which is affected by dust from the iron ore stockpile and ship loading facilities.

The bushfire assessment and management strategies contained in the BMP, assume that environmental approval will be achieved for the site or clearing permit exemptions will apply.

The subject site is assessed as having a Moderate Bushfire Hazard Level (BHL) with two small areas having a Low BHL. It is expected that development of the subject site will reduce the BHL for a large portion of the onsite land to Low. Once the area is developed, remaining vegetation external to the subject site will continue to generate a Moderate BHL for portions of the subject site.

Where re-vegetation of riparian zones and/or wetland buffers are proposed, the future subdivision design must take this into consideration to ensure that no lot will be subject to a BAL rating greater than BAL-29.

Any planned areas of landscaping or Public Open Space (POS) should be designed and managed so that the vegetation within these areas does not increase the BAL rating of adjoining lots to above BAL-29.

Cooke Point Road provides safe access and egress to two different destinations. Styles Road provides a single access/egress route only to or from future lots in the development area. That is, west to Cooke Point Road.

Consideration should be given to a northern perimeter internal road having direct access onto Cooke Point Road. A northern perimeter road will provide access/egress through a predominantly low bushfire threat area as an alternative to the use of Styles Road.

Alternatively, where direct access to Cooke Point Road is not feasible, the perimeter road should access Styles Road at a distance of no greater than 200 metres from the Cooke Point Road intersection. This will create two different routes to that point allowing a redundancy should one route be blocked.

A reticulated water supply is available to the subject site and hydrants will be installed in locations throughout the proposed development as required by the relevant authorities. The nearest existing hydrant is located approximately 85 metres to the east of the subject site on Styles Road.

It is considered that with the appropriate management measures for location, siting and design of the development, vehicular access and firefighting water supply, compliance with the bushfire protection criteria can be achieved on the subject site.

1 The Proposal and Purpose of the Plan

1.1 Details

Proponent:	RPS Australia West Pty Ltd
Site Address:	Lot 5755, Pt Lot 556, Pt Lot 340, Lot 5770, Lot 5966 and Pt Lot 300 Styles Road, Port Hedland.
Local Government:	Town of Port Hedland
Site Area:	27.1 hectares (approximately)
No. of Proposed Lots:	N/A
Planning Stage:	Strategic - local planning scheme amendment
Subdivision Type:	N/A

Overview of the Proposal:

This Bushfire Management Plan is to accompany a proposed Scheme Amendment to rezone "The Stables" land, as noted above and shown in Figure 1.1, from its current zonings of "Rural", "Parks and Recreation" and "Other Public Purposes" to "Urban Development".

It is envisaged that the site will be developed into a housing estate with low and medium density residential lots created.

This proposed urban development site is located outside the local governments IP50 Improvement Plan area, which is affected by dust from the iron ore stockpile and ship loading facilities.

Bushfire Prone Planning Commissioned to Produce the Plan by:	RPS Australia West Pty Ltd
Purpose of the Plan:	To support a strategic planning assessment
For Submission to:	Town of Port Hedland

Figure 1.1

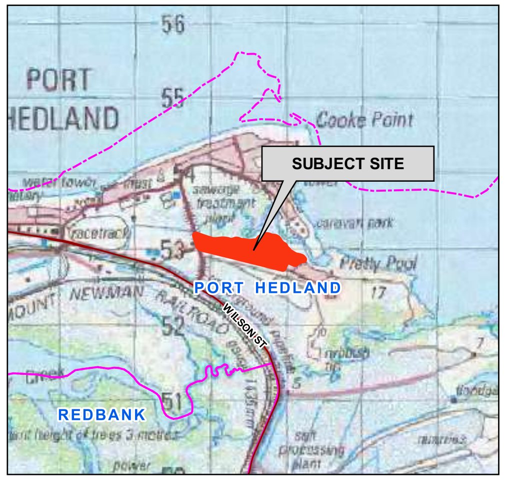
Proposed Scheme Amendment Site Plan

Lot 5755 on Plan 216870, Pt Lot 556 on Plan 74214, Pt Lot 340 on Plan 72895, Lots 5770 and 5966 on Plan 188290 & Pt Lot 300 on Plan 53035
Styles Road
PORT HEDLAND
TOWN OF PORT HEDLAND

------ LEGEND ------

- H Hydrants
- ▭ Subject Site
- ▭ Cadastre

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: Ian Macleod 20-05-2020
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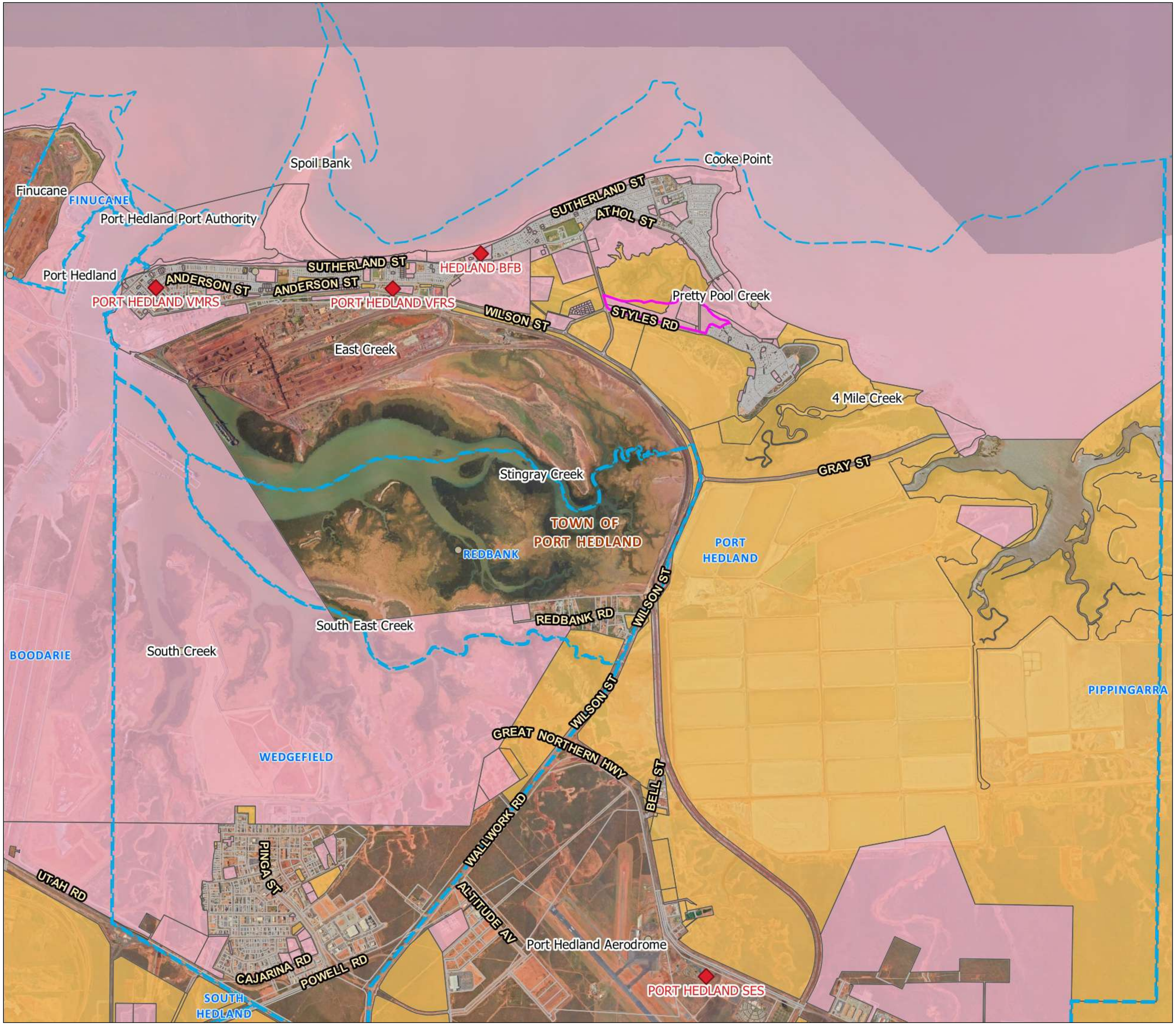


Figure 1.2

Proposed Scheme Amendment Spatial Context Plan

Lot 5755 on Plan 216870, Pt Lot 556 on Plan 74214, Pt Lot 340 on Plan 72895, Lots 5770 and 5966 on Plan 188290 & Pt Lot 300 on Plan 53035
Styles Road
PORT HEDLAND
TOWN OF PORT HEDLAND

------ LEGEND ------

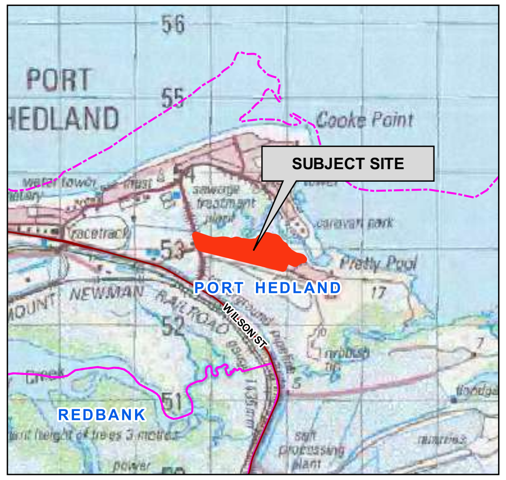
◆ DFES Stations
▭ Subject Site
▭ Localities_Suburb
▭ Cadastre

Reserves_UCL

🟪 Reserve
🟧 Unallocated Crown Land

0 500 1000 1500 2000 2500
Metres

------ LOCALITY ------



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AERIAL IMAGERY: Landgate/SLIP

BUSHFIRE PRONE PLANNING

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Mercator Units: Metre
Map by: Ian Macleod 20-05-2020
SCALE (A3): 1 : 40000

Figure 1.3

Proposed Scheme Amendment Bushfire Prone Areas Map

Lot 5755 on Plan 216870, Pt Lot 556 on Plan 74214, Pt Lot 340 on Plan 72895, Lots 5770 and 5966 on Plan 188290 & Pt Lot 300 on Plan 53035
Styles Road
PORT HEDLAND
TOWN OF PORT HEDLAND

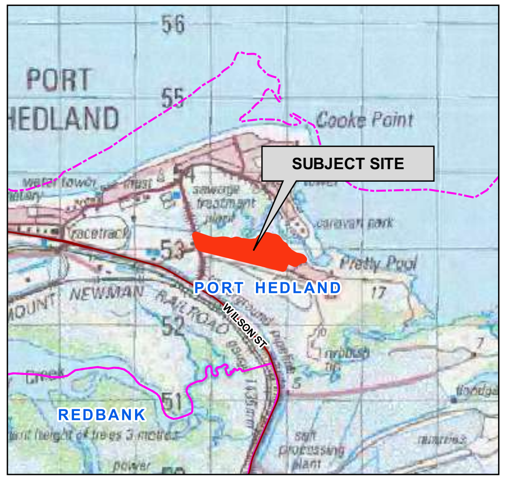
------ LEGEND ------

◆	DFES Stations
🟪	Bush Fire Prone Areas 2019
▭	Subject Site
▭	Localities_Suburb
☐	Cadastre

0 500 1000 1500 2000 2500

Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: Ian Macleod 20-05-2020
SCALE (A3): 1 : 40000

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190685 The Stables Development, Port Hedland BPA.qgz

1.2 Existing Documentation Relevant to the Construction of this Plan

This section acknowledges any known reports or plans that have been prepared for previous planning stages, that refer to the subject area and that may or will impact upon the assessment of bushfire risk and/or the implementation of bushfire protection measures and will be referenced in this Bushfire Management Plan.

Relevant Documents

Existing Document	Copy Provided by Client	Title
Structure Plan	No	
Environmental Report	No	
Landscaping (Revegetation) Plan	No	
Bushfire Risk Assessments	Yes	Bushfire Hazard Level (BHL) Assessment - RFF

A Bushfire Hazard Level Assessment (BHL) for the proposed development site has been completed in July 2016. This Bushfire Management Plan will update the BHL Assessment to the requirements of the Guidelines for Planning in Bushfire Prone Areas v1.3, and address the Bushfire Protection Criteria for the site.

2 Environmental Considerations

2.1 Native Vegetation – Modification and Clearing

'Guidelines' s2.3: "Many bushfire prone areas also have high biodiversity values. SPP 3.7 policy objective 5.4 recognises the need to consider bushfire risk management measures alongside environmental, biodiversity and conservation values."

Existing conservation areas that are potentially affected by the development proposal are required to be identified. This may result in vegetation removal/modification prohibition or limitations. These areas include National Parks, Nature Reserves, Wetlands and Bush Forever sites.

Environmental Protection Act 1986: "Clearing of native vegetation in Western Australia requires a clearing permit under Part V, Division 2 of the Act unless clearing is for an exempt purpose. Exemptions from requiring a clearing permit are contained in Schedule 6 of the Act or are prescribed in the Environmental Protection Regulations" ('Guidelines' s2.3).

The Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act): This Act administered by the Australian Government Department of the Environment and Energy, provides a national scheme of environment and heritage protection and biodiversity conservation. Nationally threatened species and ecological communities are a specific matter of significance. Areas of vegetation can be classified as a Threatened Ecological Community (TEC) under the EPBC Act and consequently may have removal restrictions imposed.

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Vegetation Modification and Clearing Assessment	
Will on-site clearing of native vegetation be required?	Yes
Does this have the potential to trigger environmental impact/referral requirements under State and Federal environmental legislation?	Yes
Identified environmental legislation applicable to the Proposal site - No.1:	Conservation Category Wetlands and Buffer
Identified environmental legislation applicable to the Proposal site - No.2:	N/A
For the proposed development site, have any areas of native vegetation been identified as species that might result in the classification of the area as a Threatened Ecological Community (TEC)?	Unaware
Potential TEC species identified:	N/A

The bushfire assessment and management strategies contained in the BMP, assume that environmental approval will be achieved for the site or clearing permit exemptions will apply.

Recommendation: It is advised that the proponent seek further advice from an Environmental Consultant or the WA Department of Biodiversity, Conservation and Attractions for further information on the condition and species contained within the proposed development area and the requirement for referral of the proposal.

Development Design Options

Establishing development in bushfire prone areas can adversely affect the retention of native vegetation through clearing associated with the creation of Lots and/or Asset Protection Zones. Where loss of vegetation is not acceptable or causes conflict with landscape or environmental objectives, it will be necessary to consider available design options to minimise the removal of native vegetation.

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Minimising the Removal of Native Vegetation		
Design Option	Identified	Adopted
Reduction of lot yield	N/A	N/A
Cluster development	N/A	N/A
Construct building to a standard corresponding to a higher BAL rating as per BCA (AS 3959-2018 and/or NASH Standard)	N/A	N/A
Modify the development location	N/A	N/A

The future creation of residential lots and construction of buildings on the proposed development site will allow for the development of asset protection zones without the clearing of large areas of significant vegetation.

Impact on Adjoining Land

Is this planning proposal able to implement the required bushfire measures within the boundaries of the land being developed so as not to impact on the bushfire and environmental management of neighbouring reserves, properties or conservation covenants?	Yes

The proposed development abuts areas of intertidal mudflats and mangroves which run along the Pretty Pool Creek. Planning for the proposed development will take into consideration the recommendations of the "Port Hedland Townsite CHRMAP Coastal Hazard Risk Management and Adaptation Plan to mitigate any consequences of the proposal.

2.2 Re-vegetation / Retained Vegetation / Landscape Plans

Riparian zones, wetland/foreshore buffers, road verges and public open space may have plans to re-vegetate or retain vegetation as part of the Proposal.

Vegetation corridors may join offsite vegetation and provide a route for fire to enter a development area.

When applicable, any such area will be identified in this Bushfire Management Plan and their impact on the assessment and future management accounted for.

Is re-vegetation of riparian zones and/or wetland or foreshore buffers and/or public open space a part of this Proposal?	Unaware
Is the requirement for ongoing maintenance of existing vegetation in riparian zones and/or wetland or foreshore buffers and/or public open space a part of this Proposal?	unaware

Where re-vegetation of riparian zones and/or wetland buffers are proposed, the future subdivision design must take this into consideration to ensure that no lot will be subject to a BAL rating greater than BAL-29.

3 Potential Bushfire Impact Assessment

3.1 Assessment Input

3.1.1 Fire Danger Index (FDI) Applied

AS 3959-2018 specifies the fire danger index values to apply for different regions as per Table 2.1. The values used in the model calculations are for the Forest Fire Danger Index (FFDI) and for which equivalent representative values of the Grassland Fire Danger Index (GFDI) are applied as per Appendix B. The values can be refined if appropriately justified.

Table 3.1: Applied FDI Value

FDI Value			
Vegetation Area	As per AS 3959 - 2018 Table 2.1	As per DFES for the Location	Value Applied
All Areas	80	N/A	80

3.1.2 Existing Vegetation Identification, Classification and Effective Slope

Vegetation identification and classification has been conducted in accordance with AS 3959-2018 s2.2.3 and the Visual Guide for Bushfire Risk Assessment in WA (DoP February 2016).

When more than one vegetation type is present, each type is identified separately with the worst-case scenario being applied as the classification. The predominant vegetation is not necessarily the worst-case scenario.

The vegetation structure has been assessed as it will be in its mature state (rather than what might be observed on the day). Areas of modified vegetation are assessed as they will be in their natural unmodified state (unless maintained in a permanently low threat, minimal fuel condition, satisfying AS 3959-2018 s2.2.3.2-f and asset protection zone standards). Vegetation destroyed or damaged by a bushfire or other natural disaster has been assessed on its revegetated mature state.

Effective Slope: Is the ground slope under the classified vegetation and is determined for each area of classified vegetation. It is the measured or determined slope which will most significantly influence the bushfire behaviour in that vegetation as it approaches a building or site. Where there is a significant change in effective ground slope under an area of classified vegetation, that will cause a change in fire behaviour, separate vegetation areas will be identified, based on the change in effective slope, to enable the correct assessment.

Table 3.2: Vegetation identification and classification

All Vegetation Within 150 metres of the Proposed Development				
Vegetation Area	Identified Classification Types [1] or Description if 'Excluded'	Applied Classification[2]	Effective Slope Under Classified Vegetation	
			degrees	description
1	Hummock Grassland G-20 Tussock Grassland G-22	Class G Grassland	>0-5	Downslope
2	Open Heath C-11	Class C Shrubland	>0-5	Downslope
-	Mangroves, intertidal mudflats, managed grasses and gardens	Excluded AS 3959-2018 2.2.3.2 (f)	N/A	N/A

Representative photos of each vegetation area, descriptions and classification justification, are presented on the following pages. The areas of classified vegetation are defined, and the photo locations identified on the topography and classified vegetation map, Figure 3.1.

Note[1]: As per AS 3959-2018 Table 2.3 and Figures 2.3 and 2.4 a-h
Note[2]: As per AS 3959-2018 Table 2.3.

Vegetation Area 1 | **Classification Applied or Exclusion Clause:** Class G Grassland

Vegetation Type Present: Tussock grassland G-22

Description / Classification Justification: Open areas of grassland vegetation, isolated areas of low shrubs.

Photo ID: 1a

Photo ID: 1b

Vegetation Area 1 | **Classification Applied or Exclusion Clause:** Class G Grassland

Vegetation Type Present: Tussock grassland G-22

Description / Classification Justification: Open areas of grassland vegetation, isolated areas of low shrubs.

Photo ID: 1c

Photo ID: 1d

Vegetation Area 1	**Classification Applied or Exclusion Clause:** Class G Grassland
Vegetation Type Present: Tussock grassland G-22	
Description / Classification Justification: Tussock grassland bordering low wetland areas.	
 Photo ID: 1e	 Photo ID: 1f
Vegetation Area 1	**Classification Applied or Exclusion Clause:** Class G Grassland
Vegetation Type Present: Tussock grassland G-22 ; Hummock grassland G-20	
Description / Classification Justification: Tussock grasses and spinifex.	
 Photo ID: 1g	 Photo ID: 1h

Vegetation Area 1	**Classification Applied or Exclusion Clause:** Class G Grassland
Vegetation Type Present: Tussock grassland G-22	
Description / Classification Justification: Open areas of grassland vegetation, isolated shrubs.	
 Photo ID: 1i	 Photo ID: 1j
Vegetation Area 2	**Classification Applied or Exclusion Clause:** Class C Shrubland
Vegetation Type Present: Open heath C-11	
Description / Classification Justification: Shrubs to 1 metre high, tussock grasses.	
 Photo ID: 2a	 Photo ID: 2b

Vegetation Area 2 | **Classification Applied or Exclusion Clause:** Class C Shrubland

Vegetation Type Present: Open heath C-11; Tussock grassland G-22

Description / Classification Justification: Open area of shrubs and tussock grasses.

Photo ID: 2c

Vegetation Area | **Classification Applied or Exclusion Clause:** Excluded AS3959-2018 2.2.3.2 (f) Low Threat Vegetation

Vegetation Type Present: Low threat vegetation.

Description / Classification Justification: Intertidal mudflats and saline wetlands.

Photo ID: 3a

Photo ID: 3b

Vegetation Area	**Classification Applied or Exclusion Clause:** Excluded AS3959-2018 2.2.3.2 (f) Low Threat Vegetation
Vegetation Type Present: Low threat vegetation.	
Description / Classification Justification: Intertidal mudflats and saline wetlands.	


Photo ID: 3c


Photo ID: 3d

Vegetation Area	**Classification Applied or Exclusion Clause:** Excluded AS3959-2018 2.2.3.2 (f) Low Threat Vegetation
Vegetation Type Present: Low threat vegetation.	
Description / Classification Justification: Saline wetlands, mangroves.	


Photo ID: 3e


Photo ID: 3f

Vegetation Area

Classification Applied or Exclusion Clause: Excluded AS3959-2018 2.2.3.2 (f) Low Threat Vegetation

Vegetation Type Present: Low threat vegetation.

Description / Classification Justification: Saline wetlands, mangroves.

Photo ID: 3g

Photo ID: 3h

Vegetation Area

Classification Applied or Exclusion Clause: Excluded AS3959-2018 2.2.3.2 (f) Low Threat Vegetation

Vegetation Type Present: Low threat vegetation.

Description / Classification Justification: Managed private gardens, grasses and road verges.

Photo ID: 3i

Photo ID: 3j

Vegetation Area	**Classification Applied or Exclusion Clause:** Excluded AS3959-2018 2.2.3.2 (f) Low Threat Vegetation
Vegetation Type Present: Low threat vegetation.	
Description / Classification Justification: Port Hedland Pony Club paddocks, mostly managed grassland areas.	
 Photo ID: 3k	

Figure 3.1

Existing Topography & Classified Vegetation Map

Lot 5755 on Plan 216870, Pt Lot 556 on Plan 74214, Pt Lot 340 on Plan 72895, Lots 5770 and 5966 on Plan 188290 & Pt Lot 300 on Plan 53035
Styles Road
PORT HEDLAND
TOWN OF PORT HEDLAND

------ LEGEND ------

- Photos
- Elevation (m)
- Subject Site
- 150m_Assessment_Area
- Cadastre

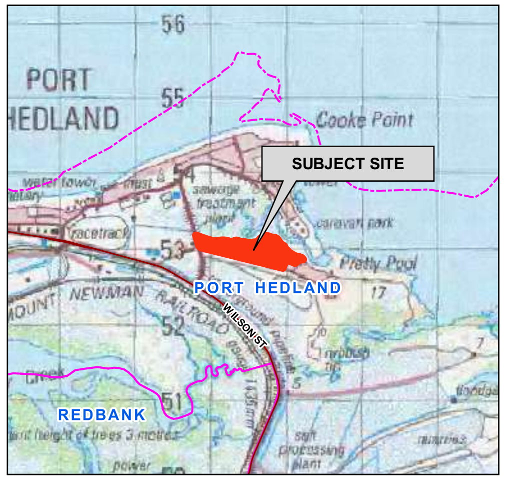
Classified Vegetation Slope Range

- Class C - Shrubland
- Class G - Grassland
- Exclusion 2.2.3.2

0 50 100 150 200 250 300

Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Merctaor Units: Metre
Map by: Ian Macleod 27-05-2020
SCALE (A3): 1 : 6000

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190685 The Stables Development, Port Hedland VEG.qgz

3.2 Assessment Output

3.2.1 Bushfire Hazard Level (BHL) Assessment

"A Bushfire Hazard Level assessment provides a 'broad-brush' means of determining the potential intensity of a bushfire for a particular area. The Bushfire Hazard Level assessment assists in informing the suitability of land contained within strategic planning proposals for future subdivision and development.

The Bushfire Hazard Level assessment categorises land within a designated bushfire prone area as having a low, moderate or extreme bushfire hazard level. Different hazard levels may be assigned to different parts of individual lots.

Bushfire Hazard Level assessments allow for early strategic consideration of bushfire risk which can then be used to inform the more detailed stages that follow, ensuring all issues are considered, identified and properly addressed at the earliest possible time ('Guidelines' s4.1)".

For a summary of the assessment methodology refer to Appendix 2. BHL assessments are required to accompany all strategic planning proposals unless the future lot layout of the Proposal is known in which case a BAL Contour Map is more appropriate (SPP 3.7 s6.3).

Rationale for the Inclusion/Exclusion of a Bushfire Hazard Level Assessment in this BMP	
An earlier BHL assessment for the subject site is known to exist.	Yes Requires Updating
The existing BHL assessment is included in this BMP as additional information.	N/A
A BHL assessment has been included in this BMP as the Proposal is at a strategic planning stage with the location of future lots unknown.	Yes
A BHL assessment has been requested by the relevant decision maker (WAPC, DFES or LGA).	Yes
A BHL assessment has been conducted for this BMP due to the terrain of the development site resulting in it not being possible (or practical) to calculate the Bushfire Attack Level (as per the Planning and Development (Local Planning Schemes) Amendment Regulations 2015).	N/A
A BHL assessment has not been conducted for this BMP as the lot layout is known and/or the Proposal is for a subdivision or development application. A Bushfire Attack Level assessment can provide more appropriate and detailed information.	N/A

Assessment Results

The results of the Bushfire Hazard Level assessment detailing the vegetation type, class and the hazard levels assigned, are presented in Tables 3.3 & 3.4, and visually in Figure 3.2 as a Bushfire Hazard Level Map.

Table 3.3: Vegetation Classification and Applied Bushfire Hazard Level.

Area	Identified Vegetation Types or Description if 'Excluded'	Applied Vegetation Classification	Effective Slope Under Vegetation	Assessed Bushfire Hazard Level
1	Hummock Grassland G-20 Tussock Grassland G-22	Class G Grassland	>0-5	Moderate
2	Open Heath C-11	Class C Shrubland	>0-5	Moderate
-	Saline wetlands, mangroves, managed areas	Excluded AS3959-2018 2.2.3.2 (f)	N/A	Low

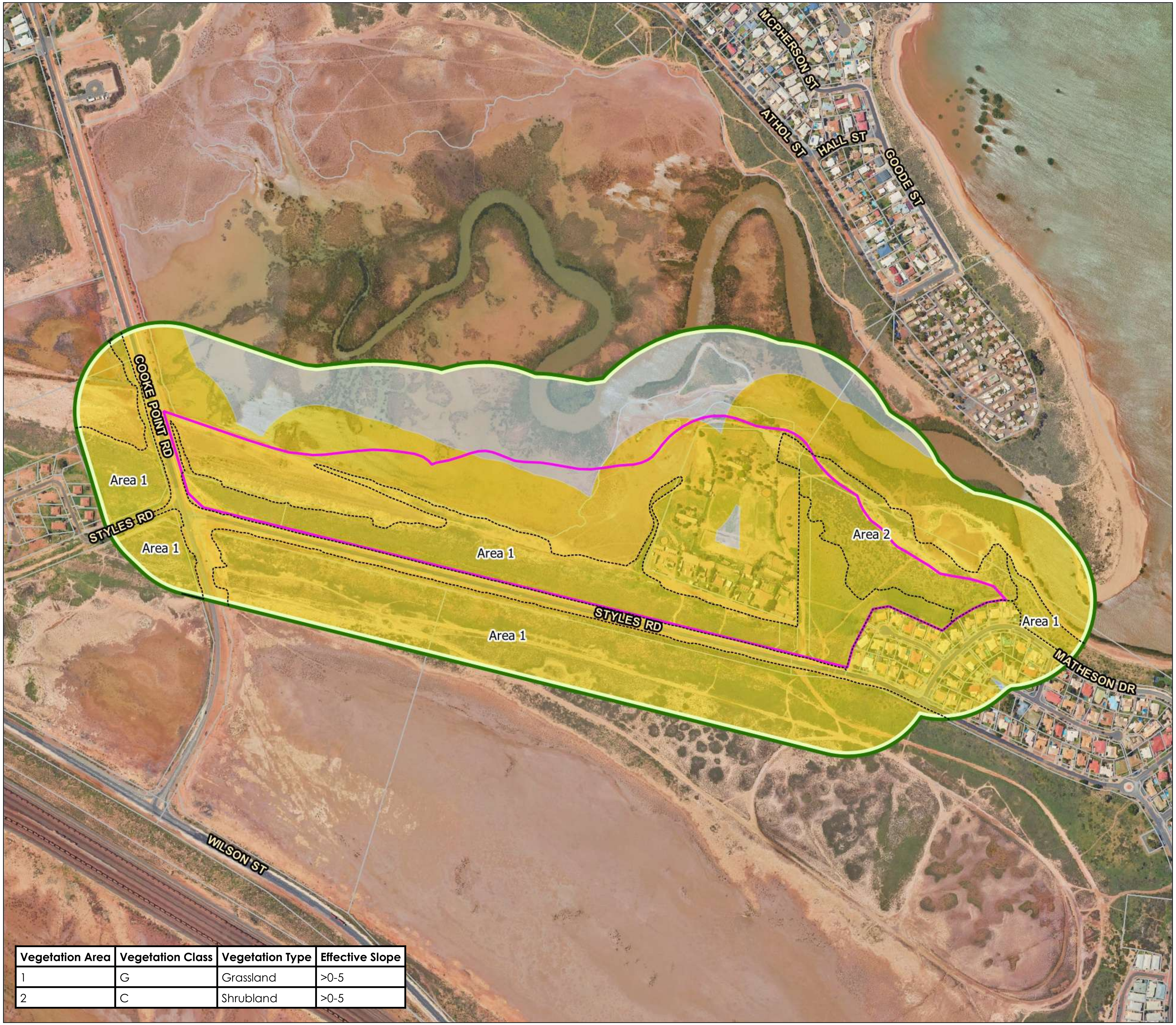
Table 3.4: Bushfire Hazard Level Assessment

Bushfire Hazard Level Assessment	
Data Used (methodology as per the 'Guidelines' Appendix 2):	Site photos and aerial photography data
Assessed Area	**Bushfire Hazard Level**
Land inside the external boundary of the subject site:	Low + Moderate
Land within 150 metres of external boundary of the subject site:	Low + Moderate

Figure 3.2

Proposed Scheme Amendment Bushfire Hazard Level Map

Lot 5755 on Plan 216870, Pt Lot 556 on Plan 74214, Pt Lot 340 on Plan 72895, Lots 5770 and 5966 on Plan 188290 & Pt Lot 300 on Plan 53035
Styles Road
PORT HEDLAND
TOWN OF PORT HEDLAND



Vegetation Area	Vegetation Class	Vegetation Type	Effective Slope
1	G	Grassland	>0-5
2	C	Shrubland	>0-5

------ LEGEND ------

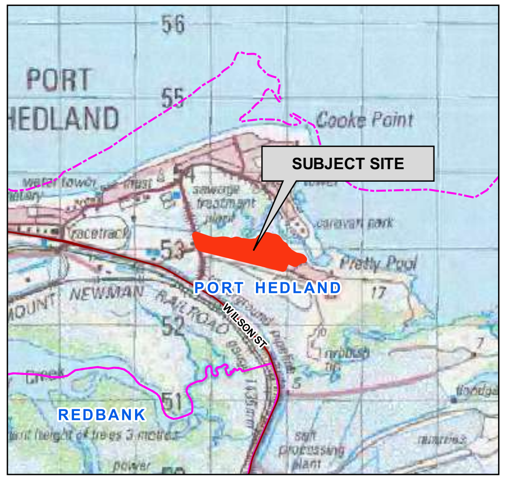
- ▭ Subject Site
- 🟩 150m Assessment Area
- ▭ Cadastre
- -------- Vegetation Outline

Bushfire Hazard Levels

- 🟥 Extreme
- 🟨 Moderate
- ⬜ Low

0 50 100 150 200 250 300
Metres

------ LOCALITY ------



AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
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4 Identification of Bushfire Hazard Issues

The subject site is assessed from aerial photography and recent site photos. The precautionary principle has been adopted in assessing any vegetation from aerial photography.

The subject site contains vegetation areas classified as grassland, shrubland, saline wetlands and mangroves.

Land to the north of the subject site is assessed as low bushfire threat saline wetlands and mangroves which border Pretty Pool Creek. To the west are generally areas of open grassland with some low sections of saline wetlands. To the east sits the Pretty Pool residential estate and further east is an area of coastal shrubs and grasses and then the Indian Ocean. To the south is a corridor of grassland vegetation running parallel to the development and then low saline wetlands and mangroves.

In the western portion of the subject site the land is generally flat and rises up towards Styles Road at the south. To the east the land rises out of the low wetland areas to a height of approximately 8 metres above sea level. Onsite slopes are generally between zero to five degrees.

The subject site is assessed as having a Moderate Bushfire Hazard Level (BHL) with two small areas having a Low BHL. It is expected that development of the subject site will reduce the BHL for a large portion of the onsite land to Low. Once the area is developed, remaining vegetation external to the subject site will continue to generate a Moderate BHL for portions of the subject site.

It is considered that with the appropriate management measures for location, siting and design of the development, vehicular access and firefighting water supply, compliance with the bushfire protection criteria can be achieved on the subject site.

5 Assessment Against the Bushfire Protection Criteria (BPC)

5.1 Bushfire Protection Criteria - Assessment Summary

Summarised Outcome of the Assessment Against the Bushfire Protection Criteria (BPC)

Element	Basis for Achieving Compliance with the Intent of the Element			The Proposal Cannot Achieve Compliance with the Intent of the Element	The Element is Not Applicable to the Proposal	Not a Strategic Planning Proposal therefore Location Options Do Not Apply
	All Relevant Acceptable Solutions Are or Can be Met	The Performance Principle is Addressed (one or more solutions cannot be fully met, or it is inappropriate to do so –				
		Argument Justifying Compliance with the Intent is Presented	A Performance Principle-Based Solution is Applied	Progressed as Minor or Unavoidable Development	Different bushfire protection measures are to be applied to specified development types and land uses (as per a WAPC Position Statement or guidance)	
1. Location	✓					
2. Siting and Design of Development	✓					
3. Vehicular Access	✓					
4. Water	✓					

The Proposal has been assessed against:

1. The requirements established in Appendix 4 of the Guidelines for Planning in Bushfire Prone Areas, WAPC 2017 v1.3 (the 'Guidelines'). The detail, including the technical requirements, are found at https://www.planning.wa.gov.au/8194.aspx; and
2. Any endorsed variations to the Guideline's acceptable solutions and associated technical requirements that have been established by the relevant local government. If known and applicable these have been stated in Section 5.2 of this Plan (with the detail included as an appendix if required by the relevant local government).

5.2 Local Government Variations to Apply

Local governments may add to or modify the acceptable solutions of the Bushfire Protection Criteria (BPC) and/or apply technical requirements that vary from those specified in the Guidelines for Planning in Bushfire Prone Areas (WAPC). In such instances, this Proposal will be assessed against these variations and/or any specific local government technical requirements for emergency access and water. Refer to Appendices 2 and 3 for relevant technical requirements.

Will local or regional variations to the acceptable solutions (endorsed by WAPC / DFES) and/or the technical requirements contained in the Guidelines, apply to this Proposal.	N/A

5.3 Bushfire Protection Criteria – Acceptable Solutions Assessment Detail

5.3.1 Element 1: Location

Bushfire Protection Criteria Element 1: Location
Assessment Statements and Bushfire Protection Measures to be Applied

Intent: To ensure that strategic planning proposals, subdivision and development applications are located in areas with the least possible risk of bushfire to facilitate the protection of people, property and infrastructure.

Acceptable Solution:	A1.1: Development Location	Method of achieving Element compliance and/or the Intent of the Element:	The acceptable solution is fully met.

The proposed development achieves compliance by:

- Being located in an area where the bushfire hazard level assessment of the subject site is or will on completion, be moderate or low; and
- Managing the remaining bushfire risk to an acceptable level by the existence/implementation and ongoing maintenance of all required bushfire protection measures, as identified within this Plan. These measures include the requirements for vegetation management, vehicular access and firefighting water supply.

For the proposed development the highest Bushfire Hazard Level affecting the site, from internal or external classifiable vegetation is Moderate.

5.3.2 Element 2: Siting and Design of Development

Bushfire Protection Criteria Element 2: Siting and Design of Development
Assessment Statements and Bushfire Protection Measures to be Applied

Intent: To ensure that the siting and design of development (note: not building/construction design) minimises the level of bushfire impact.

Acceptable Solution:	A2.1: Asset Protection Zone	Method of achieving Element compliance and/or the Intent of the Element:	The acceptable solution can be fully met in the future (at a later planning stage).

The proposed development can achieve compliance by:

- Ensuring future building work on the lot/s can have established around it an APZ of the required dimensions - to ensure that the potential radiant heat from a bushfire to impact future building/s, does not exceed 29 kW/m^2 (i.e. a BAL rating of BAL-29 or less will apply to determine building construction standards);
- Ensuring the APZ/s can be established fully within each future lots boundaries; or
- The APZ/s can be partially established within each future lots boundaries. The balance of the APZ's required dimensions are being contributed by an area on adjoining land that is either non-vegetated or assessed as being managed in a low-fuel state and which can most reasonably be expected to be managed this way in perpetuity; and
- The landowner/s having the responsibility of continuing to manage the required APZ as low threat vegetation in a minimal fuel state, by maintaining the APZ to the required dimensions and standard, including compliance with the local government's annual firebreak notice.

The required APZ dimensions are set out in Section 5.4.1. The APZ technical requirements (Standards) are detailed in Appendix 1.

5.3.3 Element 3: Vehicular Access

Bushfire Protection Criteria Element 3: Vehicular Access
Assessment Statements and Bushfire Protection Measures to be Applied

Intent: To ensure that the vehicular access serving a subdivision/development is available and safe during a bushfire event.

Acceptable Solution:	A3.1: Two access routes	Method of achieving Element compliance and/or the Intent of the Element:	The acceptable solution can be fully met in the future (at a later planning stage).

Cooke Point Road provides safe access and egress to two different destinations.

Styles Road provides a single access/egress route only to or from future lots in the development area. That is, west to Cooke Point Road.

Consideration should be given to a northern perimeter internal road having direct access onto Cooke Point Road. A northern perimeter road will provide access/egress through a predominantly low bushfire threat area as an alternative to the use of Styles Road.

Alternatively, where direct access to Cooke Point Road is not feasible, the perimeter road should access Styles Road at a distance of no greater than 200 metres from the Cooke Point Road intersection. This will create two different routes to that point allowing a redundancy should one route be blocked.

Acceptable Solution:	A3.2 Public Road	Method of achieving Element compliance and/or the Intent of the Element:	The acceptable solution can be fully met in the future (at a later planning stage).

Future roads are planned to be constructed on the subject site. The construction technical requirements established by the Guidelines and/or the local government can and will be complied with. These requirements are set out in Appendix 2.

Acceptable Solution:	A3.3 Cul-de-sacs (including a dead-end road)	Method of achieving Element compliance and/or the Intent of the Element:	The acceptable solution can be fully met in the future (at a later planning stage).

Cul-de-sacs are not preferred in bushfire prone areas and should be avoided unless no alternative exists. The construction technical requirements established by the Guidelines and/or the local government can and will be complied with. These requirements are set out in Appendix 2.

Acceptable Solution:	A3.4: Battle-axe	Method of achieving Element compliance and/or the Intent of the Element:	The acceptable solution can be fully met in the future (at a later planning stage).

Cul-de-sacs are not preferred in bushfire prone areas and should be avoided unless no alternative exists. The construction technical requirements established by the Guidelines and/or the local government can and will be complied with. These requirements are set out in Appendix 2.

Bushfire Protection Criteria Element 3: Vehicular Access (continued)
Assessment Statements and Bushfire Protection Measures to be Applied

Acceptable Solution:	A3.5: Private Driveways	Method of achieving Element compliance and/or the Intent of the Element:	The acceptable solution can be fully met in the future (at a later planning stage).

Where a house site is greater than 50 metres from a public road, the construction technical requirements established by the Guidelines and/or the local government can and will be complied with. These requirements are set out in Appendix 2.

Acceptable Solution:	A3.6 Emergency Access Way	Method of achieving Element compliance and/or the Intent of the Element:	The acceptable solution can be fully met in the future (at a later planning stage).

The construction technical requirements established by the Guidelines and/or the local government can and will be complied with. These requirements are set out in Appendix 2.

Acceptable Solution:	A3.7 Fire Service Access Routes	Method of achieving Element compliance and/or the Intent of the Element:	The acceptable solution can be fully met in the future (at a later planning stage).

The construction technical requirements established by the Guidelines and/or the local government can and will be complied with. These requirements are set out in Appendix 2.

Acceptable Solution:	A3.8 Firebreak Width	Method of achieving Element compliance and/or the Intent of the Element:	The acceptable solution can be fully met in the future (at a later planning stage).

The proposed lots will comply with the requirements of the local government annual firebreak notice issued under s33 of the Bush Fires Act 1954.

5.3.4 Element 4: Water

Bushfire Protection Criteria Element 4: Water
Assessment Statements and Bushfire Protection Measures to be Applied

Intent: To ensure water is available to the subdivision, development or land use to enable people, property and infrastructure to be defended from bushfire.

Acceptable Solution:	A4.1 Reticulated Areas	Method of achieving Element compliance and/or the Intent of the Element:	The acceptable solution can be fully met in the future (at a later planning stage).

A reticulated water supply is available to the subject site and hydrants will be installed in locations throughout the proposed development as required by the relevant authorities. The nearest existing hydrant is located approximately 85 metres to the east of the subject site on Styles Road.

The construction technical requirements established by the Guidelines and/or the local government can and will be complied with. These requirements are set out in Appendix 3.

Acceptable Solution:	A4.2 Non-Reticulated Areas	Method of achieving Element compliance and/or the Intent of the Element:	N/A
Acceptable Solution:	A4.3 Non-reticulated Areas (Individual Lots)	Method of achieving Element compliance and/or the Intent of the Element:	N/A

5.4 Additional Information for Required Bushfire Protection Measures

The purpose of this section of the Plan is:

- As necessary, to provide additional detail (to that provided in the tables of Section 5.3) regarding the implementation of the acceptable solutions for those persons who will have the responsibility to apply the stated requirements;

- As necessary, to detail specific onsite vegetation management requirements such as the APZ dimensions, management of Public Open Space or application of landscaping plans for onsite vegetation;

- To discuss how staged development will be handled, if applicable; and

- As relevant, for future planning stages, consider and discuss the requirements that may apply to future planning applications and the content of the associated BMP. In particular:
    - Any potential Vulnerable or High-Risk Land Uses.
    - Any additional content that will be required in the future BMP.

5.4.1 Vegetation Management

Asset Protection Zone (APZ) Dimensions that are to Apply

The required dimensions of the APZ will vary dependent upon the purpose for which the APZ has been defined. There are effectively three APZ dimensions that can apply:

1. An application for planning approval will be required to show that an APZ can be created which is of sufficient size to ensure the potential radiant heat impact of a fire does not exceed 29kW/m² (BAL-29); and
2. If the assessment has determined a BAL rating for an existing or future building is less than BAL-29, the APZ must be of sufficient size to ensure the potential radiant heat impact of a fire does not exceed the kW/m² corresponding to the lower assessed BAL rating; or
3. Complying with the relevant local government’s annual firebreak notice may require an APZ of greater size than that defined by the two previous parameters.

The dimensions (vegetation separation distances) that are to apply to the APZs for this Proposal are presented in the tables below.

Table 5.1: Planning Minimum Required Separation Distances for the Proposed Development

The 'Planning (WAPC) BAL-29' APZ Minimum Required Vegetation Separation Distances for the Proposed Development				
Requirement Set By	Guidelines for Planning in Bushfire Prone Areas (WAPC 2017 v1.3)			
Relevant Fire Danger Index (AS3959-2018 Table 2.1)				80
BAL Determination Method	Method 1 (as per AS 3959-2018 s2.2.6 and Table 2.5)			
Vegetation Area	Applied Vegetation Classification	Effective Slope (degrees)	Maximum Acceptable 'Planning' BAL	Required Separation Distance (metres)
1	Class G Grassland	>0-5	**BAL-29**	9
2	Class C Shrubland	>0-5		10
-	Excluded AS 3959-2018 2.2.3.2 (f)	N/A		N/A
This requirement has been established through the State bushfire provisions, SPP 3.7 and the associated Guidelines, as being a key compliance requirement for development proposals in WA.				

Table 5.2: Local Government Firebreak Notice Minimum Requirements.

'Local Government Firebreak Notice APZ' Required Minimum Dimensions for the Subject Site	
Requirement Set By:	Town of Port Hedland
Minimum Dimensions:	See Town of Port Hedland Firebreak Notice
Other Conditions:	If Asset Protection Zone technical requirements are defined in the Notice, the standards and dimensions may differ from the Guideline's APZ Standards, with the intent to better satisfy local conditions. When these are more stringent than those created by the Guidelines, or less stringent and endorsed by the WAPC and DFES, they must be complied with. Refer to Appendix 1.
This requirement has been established through the stated local government's annual fire break notice issued under the Bushfires Act 1954 s33.	

Consideration/Implementation of Public Open Space Management

Any planned areas of Public Open Space (POS) should be designed and managed so that the vegetation within the POS does not increase the BAL rating of adjoining lots to above BAL-29.

Consideration/Implementation of Proposed Landscape Plans

Any future landscape plans should be designed and managed so that the vegetation within the landscaped areas does not increase the BAL rating of adjoining lots to above BAL-29.

Consideration/Implementation of Staged Development

Where the proposed development is staged each stage must comply with the requirements of this Bushfire Management Plan. This may require the creation of roads or management of land or installation of water supply lines outside that particular stage to achieve compliance.

5.4.2 Future Stage Planning Application – Additional Information Required

Tourism Land Uses proposed with the development site must demonstrate that they comply with the DPLH Position Statement: Tourism Land Uses in Bushfire Prone Areas.

High Risk or Vulnerable land uses must comply with the requirements of the Guidelines for Planning in Bushfire Prone Areas.

6 Responsibilities for Implementation and Management of the Bushfire Protection Measures

Table 6.1: BMP Implementation responsibilities prior to the issue of titles for the Developer (Landowner).

DEVELOPER (LANDOWNER) - PRIOR TO ISSUE OF TITLES		
No.	Implementation Actions	Subdivision Clearance
1	Planning approval may be conditioned with the requirement to make appropriate notifications (on the certificates of title and the deposited plan), of the existence of this Bushfire Management Plan. The WAPC may condition a subdivision application approval with a requirement for the landowner / proponent to place a notification onto the certificate(s) of title and a notice of the notification onto the diagram or plan of survey (deposited plan). This will be done pursuant to Section 165 of the Planning and Development Act 2005 ('Hazard etc. affecting land, notating titles as to:') and applies to lots with a determined BAL rating of BAL-12.5 or above. The notification will be required to state: *'This land is within a bushfire prone area as designated by an Order made by the Fire and Emergency Services Commissioner and may be subject to a Bushfire Management Plan. Additional planning and building requirements may apply to development on this land'.*	☐
2	Construct the public roads and cul-de-sacs to the standards stated in the BMP.	☐
3	Construct the emergency access ways, fire service access routes and associated signs and gates to the standards stated in the BMP.	☐
4	Construct the private driveways and battle axes to the standards stated in the BMP.	☐
5	Install the reticulated water supply (hydrants) to the standards stated in the BMP.	☐

Table 6.2: BMP Implementation responsibilities prior to lot sale, occupancy or building for the Landowner (Developer).

LANDOWNER (DEVELOPER) - PRIOR TO LOT SALE, OCCUPANCY OR BUILDING	
No.	Implementation Actions
1	Prior to sale of future lots, each individual lot is to be compliant with the relevant local government's annual firebreak notice issued under s33 of the Bushfires Act 1954.
2	Prior to occupation of future lots, establish the Asset Protection Zone (APZ) on the lot to the dimensions and standard stated in the BMP. This is the responsibility of the landowner.
3	Prior to occupancy, install the private driveways and battle axes to the standards stated in the BMP, where required.
4	Prior to any building work, inform the builder of the existence of this Bushfire Management Plan and the responsibilities it contains, regarding the required construction standards. This will be: • The standard corresponding to the determined BAL rating, as per the bushfire provisions of the Building Code of Australia (BCA); and/or • A higher standard as a result of the BMP establishing that construction is required at a standard corresponding to a higher BAL rating.

Table 6.3: Ongoing management responsibilities for the Landowner/Occupier.

LANDOWNER/OCCUPIER - ONGOING	
No.	Ongoing Management Actions
1	Maintain the Asset Protection Zone (APZ) to the dimensions and standard stated in the BMP.
2	Comply with the Town of Port Hedland Firebreak Notice issued under s33 of the Bush Fires Act 1954.
3	Maintain vehicular access routes within the lot to the required surface condition and clearances as stated in the BMP.
4	Ensure that any builders (of future structures on the lot) are aware of the existence of this Bushfire Management Plan and the responsibilities it contains regarding the application of construction standards corresponding to a determined BAL rating.
5	Ensure all future buildings the landowner has responsibility for, are designed and constructed in full compliance with: 1. the requirements of the WA Building Act 2011 and the bushfire provisions of the Building Code of Australia (BCA); and 2. with any identified additional requirements established by this BMP or the relevant local government.

Table 6.4: Ongoing management responsibilities for the Local Government.

LOCAL GOVERNMENT - ONGOING	
No.	Ongoing Management Actions
1	Monitor landowner compliance with the Bushfire Management Plan and the annual Firebreak Notice.
2	Where control of an area of vegetated land is vested in the control of the local government and that area of land has influenced the assessed BAL rating/s of the subject site/s there is an obligation to consider the impact of any changes to future vegetation management and/or revegetation plans with respect to that area.

Appendix 1 - Onsite Vegetation Management Technical Requirements

It is the responsibility of the landowner to maintain the established bushfire protection measures on their property. Not complying with these responsibilities can result in buildings being subject to a greater potential impact from bushfire than that determined by the assessed BAL rating presented in this Bushfire Management Plan.

For the management of vegetation within a lot (i.e. onsite) the following technical requirements exist:

1. **The APZ:** Installing and maintaining an asset protection zone (APZ) of the required dimensions to the standard established by the Guidelines for Planning in Bushfire Prone Areas (WA Planning Commission, as amended). When, due to the planning stage of the proposal to which this Bushfire Management Plan applies, defined APZ dimensions are known and are to be applied to existing or future buildings – then these dimensions are stated in Section 5.4.1 of this Plan.

2. **The Firebreak/Fuel Load Notice:** Complying with the requirements established by the relevant local government's annual firebreak notice issued under s33 of the Bushfires Act 1954. Note: If an APZ requirement is included in the Notice, the standards and dimensions may differ from the Guideline's APZ Standard – the larger dimension must be complied with.

3. **Changes to Vegetated/Non-Vegetated Areas:**

    a. If applicable to this Plan, the minimum separation distance from any classified vegetation, that corresponds to the determined BAL for a proposed building, must be maintained as either a non-vegetated area or as low threat vegetation managed to a minimal fuel condition as per AS 3959-2018 s2.2.3.2 (e) and (f). Refer to Part 4 of this Appendix 1.

    b. Must not alter the composition of onsite areas of classified vegetation (as assessed and presented in Section 3.1.2) to the extent that would require their classification to be changed to a higher bushfire threat classification (as per AS 3959-2018); and

    c. Must not allow areas within a lot (i.e. onsite) that have been:
        i. excluded from classification by being low threat vegetation or non-vegetated; and
        ii. form part of the assessed separation distance that is determining a BAL rating -

    …to become vegetated to the extent they no longer represent a low threat (refer to Part 4 of Appendix 1). Note: The vegetation classification exclusion specifications as established by AS 3959-2018 s2.2.3.2, are included at A1.4 below for reference.

1. Requirements Established by the Guidelines – the Asset Protection Zone (APZ) Standards

(Source: Guidelines for Planning in Bushfire Prone Areas - WAPC 2017 v1.3 Appendix 4, Element 2, Schedule 1 and Explanatory Note E2.1)

Defining the Asset Protection Zone (APZ)

Description: An APZ is an area surrounding a building that is managed to reduce the bushfire hazard to an acceptable level (by reducing fuel loads). The width of the required APZ varies with slope and vegetation. For planning applications, the minimum sized acceptable APZ is that which is of sufficient size to ensure the potential radiant heat impact of a fire does not exceed 29kW/m² (BAL-29). It will be site specific.

The APZ may include public roads, waterways, footpaths, buildings, rocky outcrops, golf courses, maintained parkland as well as cultivated gardens in an urban context, but does not include grassland or vegetation on a neighbouring rural lot, farmland, wetland reserves and unmanaged public reserves.

For subdivision planning, design elements and excluded/low threat vegetation adjacent to the lot can be utilised to achieve the required vegetation separation distances and therefore reduce the required dimensions of the APZ within the lot.

Defendable Space: The APZ includes a defendable space which is an area adjoining the asset within which firefighting operations can be undertaken to defend the structure. Vegetation within the defendable space should be kept at an absolute minimum and the area should be free from combustible items and obstructions. The width of the defendable space is dependent on the space which is available on the property, but as a minimum should be 3 metres.

Establishment: The APZ should be contained solely within the boundaries of the lot on which the building is situated, except in instances where the neighbouring lot or lots will be managed in a low-fuel state on an ongoing basis, in perpetuity.

Note: Regardless of whether an Asset Protection Zone exists in accordance with the acceptable solutions and is appropriately maintained, fire fighters are not obliged to protect an asset if they think the separation distance between the dwelling and vegetation that can be involved in a bushfire, is unsafe.

Schedule 1: Standards for APZ

Fences: within the APZ are constructed from non-combustible materials (e.g. iron, brick, limestone, metal post and wire). It is recommended that solid or slatted non-combustible perimeter fences are used.

Objects: within 10 metres of a building, combustible objects must not be located close to the vulnerable parts of the building i.e. windows and doors.

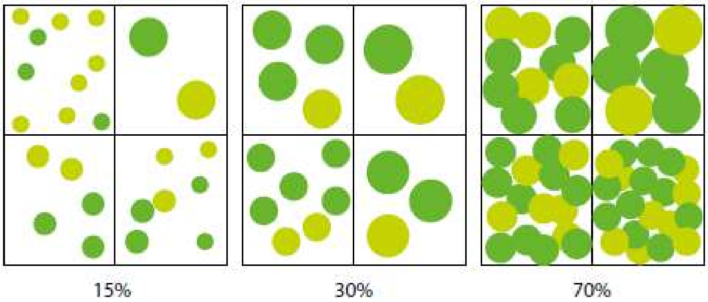
Fine Fuel Load: combustible dead vegetation matter less than 6 mm in thickness reduced to and maintained at an average of two tonnes per hectare (example below).

Example Fine Fuel Load of Two Tonnes per Hectare

(Image source: Shire of Augusta Margaret River's Firebreak and Fuel Reduction Hazard Notice)

Trees (> 5 metres in height): trunks at maturity should be a minimum distance of 6 metres from all elevations of the building, branches at maturity should not touch or overhang the building, lower branches should be removed to a height of 2 metres above the ground and or surface vegetation, canopy cover should be less than 15% with tree canopies at maturity well spread to at least 5 metres apart as to not form a continuous canopy. Diagram below represents tree canopy cover at maturity.

Tree canopy cover – ranging from 15 to 70 per cent at maturity



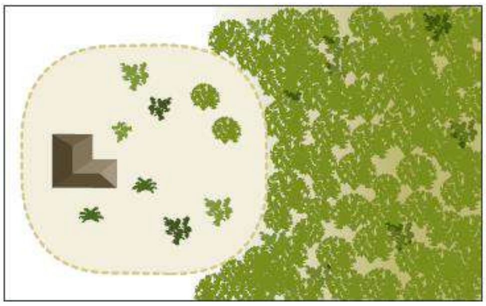
(Source: Guidelines for Planning in Bushfire Prone Areas 2017, Appendix 4)

Shrubs (0.5 metres to 5 metres in height): should not be located under trees or within 3 metres of buildings, should not be planted in clumps greater than 5m2 in area, clumps of shrubs should be separated from each other and any exposed window or door by at least 10 metres. Shrubs greater than 5 metres in height are to be treated as trees.

Ground covers (<0.5 metres in height): can be planted under trees but must be properly maintained to remove dead plant material and any parts within 2 metres of a structure, but 3 metres from windows or doors if greater than 100 mm in height. Ground covers greater than 0.5 metres in height are to be treated as shrubs.

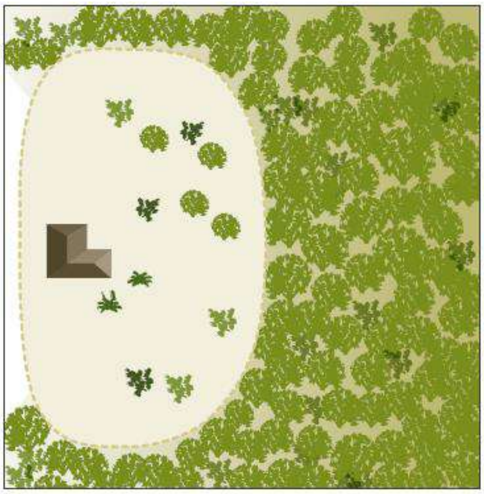
Grass: should be managed to maintain a height of 100 mm or less.

The following example diagrams illustrate how the required dimensions of the APZ will be determined by the type and location of the vegetation.



Hazard on one side

▢ APZ



Hazard on three sides

▢ APZ

2. Requirements Established by the Local Government – the Firebreak Notice

These requirements are established by the relevant local government's Firebreak Notice created under s33 of the Bushfires Act 1954 and issued annually (potentially with revisions). The Notice may include additional components directed at managing fuel loads, accessibility and general property management with respect to limiting potential bushfire impact.

> The relevant local government's current Firebreak Notice is available on their website, at their offices and is distributed as ratepayer's information. It must be complied with.

If Asset Protection Zone technical requirements are defined in the Notice, the standards and dimensions may differ from the Guideline's APZ Standards, with the intent to better satisfy local conditions. When these are more stringent than those created by the Guidelines, or less stringent and endorsed by the WAPC and DFES, they must be complied with.

When, due to the planning stage of the proposal to which this Bushfire Management Plan applies, defined APZ dimensions are known and are to be applied to existing or future buildings – then these dimensions are stated in Section 5.4.1 of this Plan.

3. Requirements Recommended by DFES – Property Protection Checklists

> Further guidance regarding ongoing/lasting property protection (from potential bushfire impact) is presented in the publication 'DFES – Fire Chat – Your Bushfire Protection Toolkit'. It is available from the Department of Fire and Emergency Services (DFES) website.

4. Requirements Established by AS 3959-2018 - Maintaining Areas within your Lot as 'Low Threat'

This information is provided for reference purposes. This knowledge will assist the landowner to comply with Management Requirement No. 3 set out in the Guidance Panel at the start of this Appendix. It identifies what is required for an area of land to be excluded from classification as a potential bushfire threat.

"Australian Standard - AS 3959-2018 Section 2.2.3.2: Exclusions - Low threat vegetation and non-vegetated areas:

The Bushfire Attack Level shall be classified BAL-LOW where the vegetation is one or a combination of the following:

a) Vegetation of any type that is more than 100m from the site.
b) Single areas of vegetation less than 1ha in area and not within 100m of other areas of vegetation being classified.
c) Multiple area of vegetation less than 0.25ha in area and not within 20m of the site or each other.
d) Strips of vegetation less than 20m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20m of the site or each other, or other areas of vegetation being classified.
e) Non-vegetated areas, including waterways, roads, footpaths, buildings and rocky outcrops.
f) Low threat vegetation, including grassland managed in a ***minimal fuel condition*** *(i.e. insufficient fuel available to significantly increase the severity of a bushfire attack – recognisable as short cropped grass to a nominal height of 100mm for example), maintained lawns, golf courses, maintained public reserves and parklands, vineyards, orchards, cultivated gardens, commercial nurseries, nature strips and windbreaks."*

Appendix 2 - Vehicular Access Technical Requirements

Each local government may have their own standard technical requirements for emergency vehicular access and they may vary from those stated in the Guidelines.

Contact the relevant local government for the requirements that are to apply in addition to the requirements set out as an acceptable solution in the Guidelines. If the relevant local government requires that these are included in the Bushfire Management Plan, they will be included in this appendix and referenced.

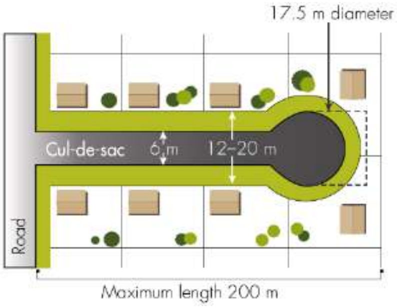
Requirements Established by the Guidelines – The Acceptable Solutions

(Source: Guidelines for Planning in Bushfire Prone Areas WAPC 2017 v1.3, Appendix 4)

Vehicular Access Technical Requirements - Part 1

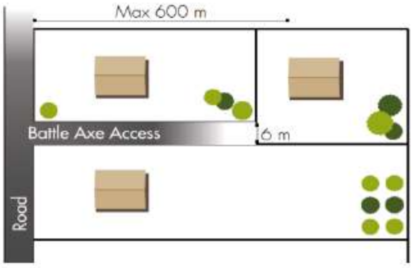
Acceptable Solution 3.3: Cul-de-sacs (including a dead-end road)
Their use in bushfire prone areas should be avoided. Where no alternative exists then the following requirements are to be achieved:

- Maximum length is 200m. If public emergency access is provided between cul-de-sac heads (as a right of way or public access easement in gross), the maximum length can be increased to 600m provided no more than 8 lots are serviced and the emergency access way is less than 600m in length;
- Turnaround area requirements, including a minimum 17.5m diameter head to allow type 3.4 fire appliances to turn around safely;
- The cul-de-sac connects to a public road that allows for travel in two directions; and
- Meet the additional design requirements set out in Part 2 of this appendix.



Acceptable Solution 3.4: Battle-axe
Their use in bushfire prone areas should be avoided. Where no alternative exists then the following requirements are to be achieved:

- Maximum length 600m and minimum width 6m; and
- Comply with minimum standards for private driveways.



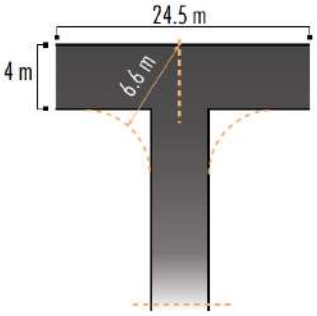
Acceptable Solution 3.5: Private Driveways

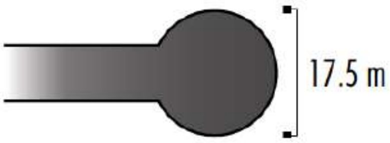
The following requirements are to be achieved:

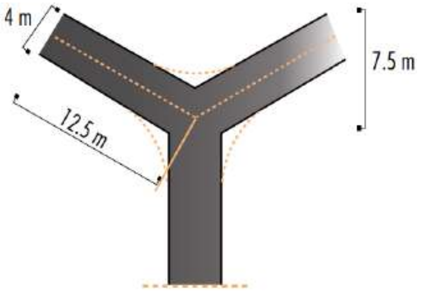
- The design requirements set out in Part 2 of this appendix; and

Where the house site is more than 50 metres from a public road:

- Passing bays every 200 metres with a minimum length of 20 metres and a minimum width of two metres (ie combined width of the passing bay and constructed private driveway to be a minimum six metres);
- Turn-around areas every 500 metres and within 50 metres of a house, designed to accommodate type 3.4 fire appliances to turn around safely (ie kerb to kerb 17.5 metres);
- Any bridges or culverts are able to support a minimum weight capacity of 15 tonnes; and
- All weather surface (i.e. compacted gravel, limestone or sealed).



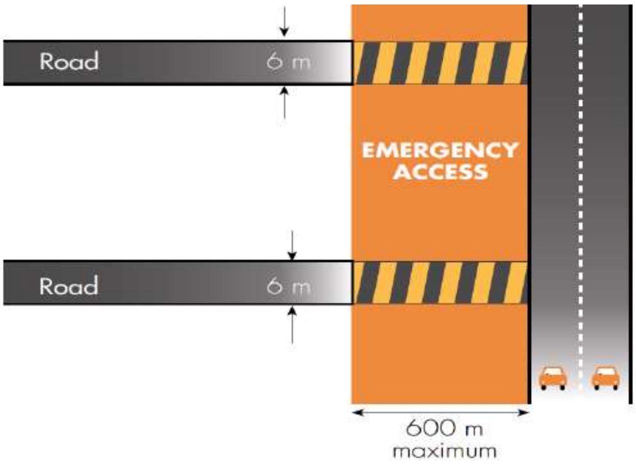




Acceptable Solution 3.6: Emergency Access Way

An access way that does not provide through access to a public road is to be avoided bushfire prone areas. Where no alternative exists, an emergency access way is to be provided as an alternative link to a public road during emergencies. The following requirements are to be achieved:

- No further than 600 metres from a public road;
- Must be signposted including where they ajoin public roads;
- Provided as a right of way or public access easement in gross;
- Where gates are used they must not be locked and they must be a minimum width of 3.6 metres with design and construction approved by local government (refer to the example in this appendix); and
- Meet the additional design requirements set out in Part 2 of this appendix.



Acceptable Solution 3.7: Fire Service Access Routes (Perimeter Roads)
Are to be established to provide access within and around the edge of subdivision and related development and to provide direct access to bushfire prone areas for firefighters and link between public road networks for firefighting purposes. Fire service access is used during bushfire suppression activities but can also be used for fire prevention work. The following requirements are to be achieved:

- No further than 600 metres from a public road (driveways may be used as part of the designated fire service access;
- Dead end roads not permitted;
- Allow for two-way traffic (i.e. two 3.4 fire appliances);
- Provide turn-around areas designed to accommodate 3.4 fire appliances and to enable them to turn around safely every 500m (i.e. kerb to kerb 17.5 metres);
- All weather surface (i.e. compacted gravel, limestone or sealed) and have erosion control measures in place;
- Must be adequately sign posted;
- Where gates are used they must be a minimum width of 3.6 metres with design and construction approved by local government (refer to the example in this appendix) and may be locked (use a common key system);
- Meet the additional design requirements set out in Part 2 of this appendix;
- Provided as right of ways or public access easements in gross; and
- Management and access arrangements to be documented and in place.

Acceptable Solution 3.8: Firebreak Width

Lots greater than 0.5 hectares must have an internal perimeter firebreak of a minimum width of three meters or to the level as prescribed in the local firebreak notice issued by the local government.

Vehicular Access Technical Requirements - Part 2

Technical Component	Vehicular Access Types				
	Public Roads	Cul-de-sacs	Private Driveways	Emergency Access Ways	Fire Service Access Routes
Minimum trafficable surface (m)	6*	6	4	6*	6*
Horizontal clearance (m)	6	6	6	6	6
Vertical clearance (m)	4.5	4.5	4.5	4.5	4.5
Maximum grade <50 metres	1 in 10	1 in 10	1 in 10	1 in 10	1 in 10
Minimum weight capacity (t)	15	15	15	15	15
Maximum cross-fall	1 in 33	1 in 33	1 in 33	1 in 33	1 in 33
Curves minimum inner radius (m)	8.5	8.5	8.5	8.5	8.5

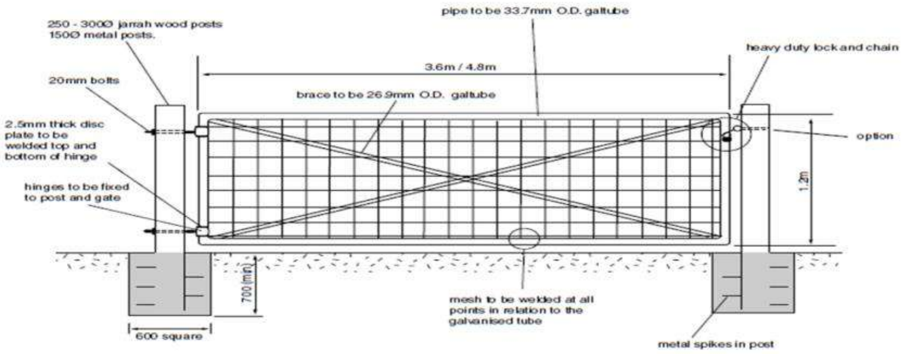
* A six metre trafficable surface does not necessarily mean paving width. It could, for example, include four metres of paving and one metre of constructed road shoulders. In special circumstances, where 8 lots or less are being serviced, a public road with a minimum trafficable surface of four metres for a maximum distance of ninety metres may be provided subject to the approval of both the local government and DFES.

Vehicular Access Technical Requirements – Gates and Signs Examples

Gates

Design and construction to be approved by relevant local government.

- Minimum width 3.6m
- Emergency access way gates must not be locked.
- Fire service access route gates may be locked but only with a common key that is available to local fire service personnel.
- Bollards will be to the relevant local government specifications



Note: Mesh to be metric mesh 46G5 and galvanised finish complete with fittings.

Signs

Design and construction to be approved by the relevant local government.

Minimum height above ground of 0.9m.

Lettering height to be 100mm.

To display the words (as appropriate) “Emergency Access Only” or “Fire Service Access – No Public Access”.

Size 600mm x 400mm.

Sign colour red, base (white) area is reflective background.

Rounded corners, radius 20mm.

White key-line 3mm wide, 3mm from outside edge.

Suggested mounting hole six 6mm diameter.

Appendix 3 - Water Technical Requirements

Requirements Established by the Guidelines - Acceptable Solution A4.1: Reticulated Areas

(Source: Guidelines for Planning in Bushfire Prone Areas WAPC 2017 v1.3, Appendix 4, Element 4)

The requirement is to supply a reticulated water supply and fire hydrants, in accordance with the technical requirements of the relevant water supply authority and DFES.

The Water Corporation's 'No 63 Water Reticulation Standard' is deemed to be the baseline criteria for developments and should be applied unless local water supply authority's conditions apply.

Key specifications in the most recent version/revision of the design standard include:

- ***Residential Standard*** – hydrants are to be located so that the maximum distance between the hydrants shall be no more than 200 metres.
- ***Commercial Standard*** – hydrants are to be located with a maximum of 100 metre spacing in Industrial and Commercial areas.
- ***Rural Residential Standard*** – where minimum site areas per dwelling is 10,000 m^2 (1ha), hydrants are to be located with a maximum 400m spacing. If the area is further subdivided to land parcels less than 1ha, then the residential standard (200m) is to be applied.

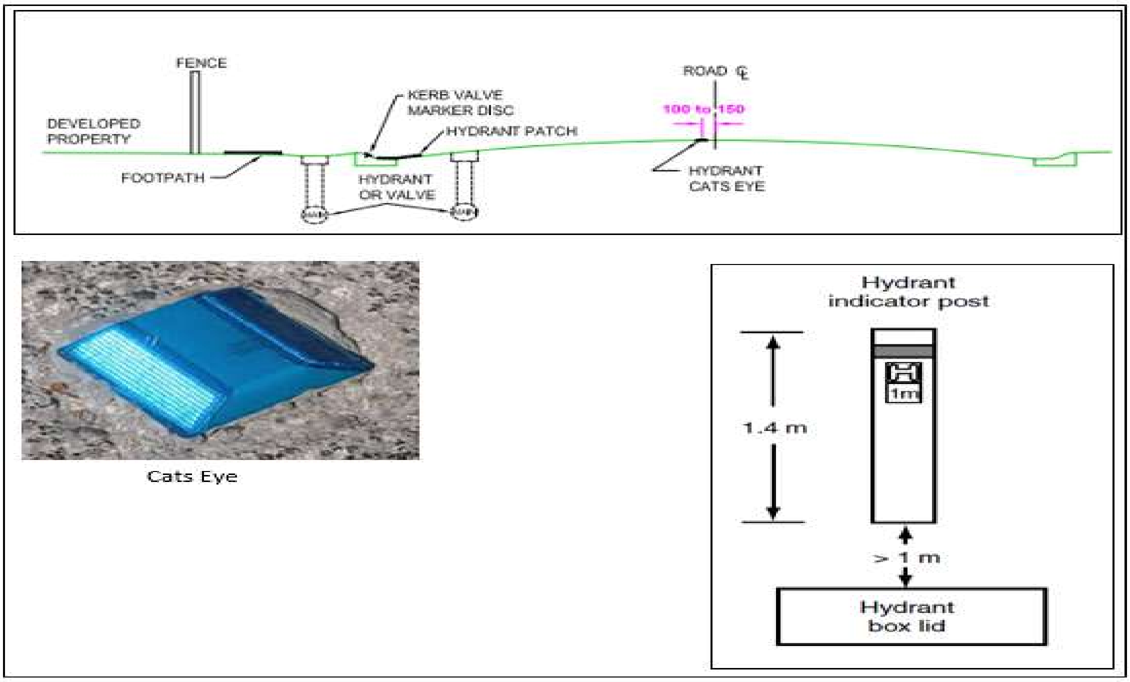


Figure A4.1: Hydrant Location and Identification Specifications

Contact the relevant water supply authority to confirm the technical requirements that are to be applied. They may differ from the minimum requirements of the 'baseline' Water Corporation's No. 63 Water Reticulation Standard.

Appendix 5 – Acoustic Assesement

STABLES
STYLES ROAD
PORT HEDLAND

STATE PLANNING POLICY 5.4
NOISE MANAGEMENT PLAN

JUNE 2020

OUR REFERENCE: 25919-1-20146

Rochdale Holdings Pty Ltd A.B.N. 85 009 049 067 trading as:
HERRING STORER ACOUSTICS
P.O. Box 219, Como, W.A. 6952
(08) 9367 6200
hsa@hsacoustics.com.au

DOCUMENT CONTROL PAGE

SPP 5.4 NOISE MANAGEMEN PLAN
STABLES – PORT HEDLAND

Job No: 20146

Document Reference: 25919-1-20146

FOR

RPS GROUP

DOCUMENT INFORMATION			
Author:	Tim Reynolds	**Checked By:**	George Watts
Date of Issue:	17 June 2020		

REVISION HISTORY				
Revision	**Description**	**Date**	**Author**	**Checked**

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1	1	RPS Group Attn : John Halleen Email : John.Halleen@rpsgroup.com.au		✓

CONTENTS

APPENDICIES

1. INTRODUCTION

Herring Storer Acoustics was commissioned by RPS Group to undertake an acoustical assessment of noise received within the proposed Stables Structure Plan, located north of Styles Road, Port Hedland.

As part of the study, the following was carried out:

- Determine by noise modelling the noise levels that would be received at residences within the development from vehicles travelling on Styles and Cooke Point Roads.
- Assess the predicted noise levels received at residence for compliance with the requirements of the WAPC State Planning Policy 5.4 *"Road and Rail Noise"* - 2019 (SPP 5.4).
- If exceedances are predicted, comment on possible noise amelioration options for compliance with the appropriate criteria.

For information, the concept structure plan is attached in Appendix A.

2. SUMMARY

Under the WAPC State Planning Policy 5.4, for this development, the appropriate "Noise Targets" to be achieved under SPP 5.4, external to a residence are:

External

Day	Maximum of 55 dB(A) L_{Aeq}
Night	Maximum of 50 dB(A) L_{Aeq}

The policy states that the "outdoor targets are to be met at all outdoor areas as far as reasonable and practical to do so using the various noise mitigation measures outlined in the guidelines". The Policy also states, under Section 6 – Policy Measures that "a reasonable degree of acoustic amenity for living areas on each residential lot". The policy recognises that "it may not be practicable to meet the outdoor noise targets".

The Policy states the following acceptable internal noise levels:

Internal

Living and Work Areas	$L_{Aeq(Day)}$ of 40 dB(A)
Bedrooms	$L_{Aeq(Night)}$ of 35 dB(A)

For this development, it is noted that under the policy, an assessment is not required, as neither Styles or Cooke Point Roads carry sufficient traffic to trigger the requirement for an assessment. Additionally, the distance to Wilson Street, which is considered a Strategic Freight route, is sufficient that it also does not trigger the requirement for an assessment. Even so, we have undertaken an assessment as outlined in the Implementation Guidelines.

The results of the noise modelling indicated that noise received within the proposed development would exceed the "Target" noise level. Thus, we provide the following information with regards to possible noise mitigation. To reduce noise received within the development.

To mitigate the noise received within the development, the following options are provided :

- Install barriers as shown on Figure D1 and Appendix D and apply "Quiet House" design is required for some residences, as shown on Figure D2 in Appendix D.

- Install barriers as shown on Figure D1, modify road speed and upgrade surface and apply "Quiet House" design as shown on Figure D3 in Appendix D.

It is noted that under the policy, that for those residences where noise would exceed the "Noise Target", notification of vehicle noise will need to be stated on the titles. These residences are also indicated on Figures D2 and D3, attached in Appendix D. Information on "Quiet House" design packages are attached in Appendix E.

With the current road conditions, noise reduction could be achieved by in the future, reducing the posted speeds of both Styles and Cooke Point Roads to 60km/hr and upgrading the road surface to Dense Grade Asphalt. However, it is unclear whether these would be considered achievable.

3. CRITERIA

The Western Australian Planning Commission (WAPC) released on 6th September 2019 State Planning Policy 5.4 *"Road and Rail Noise"*. The requirements of State Planning Policy 5.4 are outlined below.

POLICY APPLICATION (Section 4)

When and where it applies (Section 4.1)

SPP 5.4 applies to the preparation and assessment of planning instruments, including region and local planning schemes; planning strategies, structure plans; subdivision and development proposals in Western Australia, where there is proposed:

*a) noise-sensitive land-use within the policy's trigger distance of a transport corridor as specified in **Table 1**;*

*b) New or major upgrades of roads as specified in **Table 1** and maps **(Schedule 1,2 and 3);** or*

*c) New railways or major upgrades of railways as specified in maps (**Schedule 1, 2 and 3);** or any other works that increase capacity for rail vehicle storage or movement and will result in an increased level of noise.*

Policy trigger distances (Section 4.1.2)

***Table 1** identifies the State's transport corridors and the trigger distances to which the policy applies.*

*The designation of land within the trigger distances outlined in **Table 1** should not be interpreted to imply that land is affected by noise and/or that areas outside the trigger distances are un-affected by noise.*
*Where any part of the lot is within the specified trigger distance, an assessment against the policy is required to determine the likely level of transport noise and management/ mitigation required. An initial screening assessment (**guidelines: Table 2: noise exposure forecast**) will determine if the lot is affected and to what extent."*

TABLE 1: TRANSPORT CORRIDOR CLASSIFICATION AND TRIGGER DISTANCES

Transport corridor classification	*Trigger distance*	*Distance measured from*
Roads		
Strategic freight and major traffic routes *Roads as defined by Perth and Peel Planning Frameworks and/or roads with either 500 or more Class 7 to 12 Austroads vehicles per day, and/or 50,000 per day traffic volume*	*300 metres*	*Road carriageway edge*
Other significant freight/traffic routes *These are generally any State administered road and/or local government road identified as being a future State administered road (red road) and other roads that meet the criteria of either >=23,000 daily traffic count (averaged equivalent to 25,000 vehicles passenger car units under region schemes)*	*200 metres*	*Road carriageway edge*
Passenger railways		
	100 metres	*Centreline of the closest track*
Freight railways		
	200 metres	*Centreline of the closest track*

Proponents are advised to consult with the decision making authority as site specific conditions (significant differences in ground levels, extreme noise levels) may influence the noise mitigation measures required, that may extend beyond the trigger distance.

POLICY MEASURES (Section 6)

The policy applies a performance-based approach to the management and mitigation of transport noise. The policy measures and resultant noise mitigation will be influenced by the function of the transport corridor and the type and intensity of the land-use proposed. Where there is risk of future land-use conflict in close proximity to strategic freight routes, a precautionary approach should be applied. Planning should also consider other broader planning policies. This is to ensure a balanced approach takes into consideration reasonable and practical considerations.

Noise Targets (Section 6.1)

***Table 2** sets out noise targets that are to be achieved by proposals under which the policy applies. Where exceeded, an assessment is required to determine the likely level of transport noise and management/mitigation required.*

In the application of the noise targets the objective is to achieve:

- *indoor noise levels as specified in **Table 2** in noise sensitive areas (for example, bedrooms and living rooms of houses, and school classrooms); and*
- *a reasonable degree of acoustic amenity for outdoor living areas on each residential lot. For non-residential noise-sensitive developments, for example schools and child care centres the design of outdoor areas should take into consideration the noise target.*

It is recognised that in some instances, it may not be reasonable and/or practicable to meet the outdoor noise targets. Where transport noise is above the noise targets, measures are expected to be implemented that balance reasonable and practicable considerations with the need to achieve acceptable noise protection outcomes.

TABLE 2: NOISE TARGETS

Proposals	***New/Upgrade***	***Noise Targets***		
		Outdoor		***Indoor***
		Day (L_{Aeq}(Day) dB) (6 am-10 pm)	***Night (L_{Aeq}(Night)dB) (10 pm-6 am)***	***(L_{Aeq} dB)***
Noise-sensitive land-use and/or development	*New noise sensitive land use and/or development within the trigger distance of an existing/proposed transport corridor*	*55*	*50*	*L_{Aeq} (Day) 40(Living and work areas)* *L_{Aeq} (Night) 35 (bedrooms)*
Roads	*New*	*55*	*50*	*N/A*
	Upgrade	*60*	*55*	*N/A*
Railways	*New*	*55*	*50*	*N/A*
	Upgrade	*60*	*55*	*N/A*

Notes:

- *The noise target is to be measured at one metre from the most exposed, habitable façade of the proposed building, which has the greatest exposure to the noise-source. A habitable room has the same meaning as defined in State Planning Policy 3.1 Residential Design Codes.*

- *For all noise-sensitive land-use and/or development, indoor noise targets for other room usages may be reasonably drawn from Table 1 of Australian Standard/New Zealand Standard AS/NZS 2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors (as amended) for each relevant time period.*

- *The 5dB difference in the criteria between new and upgrade infrastructure proposals acknowledges the challenges in achieving noise level reduction where existing infrastructure is surrounded by existing noise-sensitive development.*

- *Outdoor targets are to be met at all outdoor areas as far as is reasonable and practical to do so using the various noise mitigation measures outlined in the guidelines. For example, it is likely unreasonable for a transport infrastructure provider to achieve the outdoor targets at more than 1 or 2 floors of an adjacent development with direct line of sight to the traffic.*

Noise Exposure Forecast (Section 6.2)

*When it is determined that SPP 5.4 applies to a planning proposal as outlined in Section 4, proponents and/or decision makers are required to undertake a preliminary assessment using **Table 2**: noise exposure forecast in the guidelines. This will provide an estimate of the potential noise impacts on noise-sensitive land-use and/ or development within the trigger distance of a specified transport corridor. The outcomes of the initial assessment will determine whether:*

- *no further measures is required;*

- *noise-sensitive land-use and/or development is acceptable subject to deemed-to- comply mitigation measures; or*

- *noise-sensitive land-use and/or development is not recommended. Any noise-sensitive land-use and/ or development is subject to mitigation measures outlined in a noise management plan.”*

4. MODELLING

To determine the noise levels from traffic on both Styles and Cooke Point Roads, acoustic modelling was carried out using SoundPlan, using the Calculation of Road Traffic Noise (CoRTN)[1] algorithms.

The input data for the model included:

- Structure plan, as supplied by client (Shown in Appendix A);
- Traffic data as per Table 4.1 (And Sourced in Appendix B);
- Adjustments as listed in Table 4.1.

TABLE 4.1 - NOISE MODELLING INPUT DATA

Parameter	Styles Road	Cooke Point Road
Current Traffic flows (year)	1836 vpd (2013)	4673 vpd (2018/19)
Future Traffic Flow (2041)	3200 vpd	7224 vpd
Heavy Vehicles (%)	2.6%	4.0%
Traffic Speed km/hr	80	80
Road Surface	Chip Seal (+1.5 dB)	
Façade Correction	+2.5 dB	

Other input data for the model included:

- Noise source heights for the three road source strings (Passenger Vehicles, Heavy Vehicles Engine and Heavy Vehicle Exhausts) are +0.5, +1.5 and +3.6m, with a noise correction of -0.8 and -8.0 applied to the heavy vehicle engines and exhaust noise sources.
- Traffic data from MRWA (https://mrapps.mainroads.wa.gov.au/TrafficMap/). Data attached in Appendix B.
- Future traffic flows were based on an 2% increase per year, to the year 2041.
- Topographical data, with the ground level within the development based on natural ground levels as the survey data provided by the client.
- Development receiver heights at 1.4m above ground level.
- Future buildings located on the Lots (assumed to be present for future road traffic volumes).

To determine the noise that would be received within the development from the surrounding road network, acoustic modelling was carried out using the computer program 'SoundPlan'.

---

[1] *Calculation of Road Traffic Noise* UK Department of Transport 1987

The following scenarios were modelled:

1. Future traffic volumes, without any noise mitigation (ie base model).
2. Future traffic volumes, with barriers, as detailed in Appendix D.
3. Future Traffic volumes, with barriers, as detailed in Appendix D and first row of residences (excluding caravan park).

Given the adjustments / correction factors for road surface (as per guidelines) and speed (calculated within noise model), as additional modelling scenario was run for scenario 2 (ie with barriers), with the road speed reduced to 60 km/hr and the road surface upgraded to dense graded asphalt

The resultant noise contour plots are attached in Appendix C.

5. DISCUSSION / RECOMMENDATION

Under the WAPC State Planning Policy 5.4, for this development, the appropriate "Noise Targets" to be achieved under SPP 5.4, external to a residence are:

External

Day	Maximum of 55 dB(A) L_{Aeq}
Night	Maximum of 50 dB(A) L_{Aeq}

The policy states that the "outdoor targets are to be met at all outdoor areas as far as reasonable and practical to do so using the various noise mitigation measures outlined in the guidelines". The Policy also states, under Section 6 – Policy Measures that "a reasonable degree of acoustic amenity for living areas on each residential lot". The policy recognises that "it may not be practicable to meet the outdoor noise targets".

To mitigate the noise received within the development, the following options are provided :

- Install barriers as shown on Figure D1 and Appendix D and apply "Quiet House" design is required for some residences, as shown on Figure D2 in Appendix D.
- Install barriers as shown on Figure D1, modify road speed and upgrade surface and apply "Quiet House" design as shown on Figure D3 in Appendix D.

It is noted that under the policy, that for those residences where noise would exceed the "Noise Target", notification of vehicle noise will need to be stated on the titles. These residences are also indicated on Figures D2 and D3, attached in Appendix D. Information on "Quiet House" design packages are attached in Appendix E.

Notes :

1 Barriers fencing to be a minimum surface density of 15 kg/m^2.

2 The stated Quiet House design packages attached in Appendix E are deemed to satisfy requirements. Alternative constructions are acceptable, provided they are supported by an acoustic assessment report, prepared by a suitably qualified acoustic consultant.

APPENDIX A

SUBDIVISION PLAN

LEGEND

🟨	LOW DENSITY RESIDENTIAL (R20)
🟫	MEDIUM DENSITY RESIDENTIAL (R40)
🟩	PUBLIC OPEN SPACE
▭	30 METRE BUFFER TO HORSE STABLES SUBJECT TO FURTHER INVESTIGATION
●	ABORIGINAL HERITAGE SITES
- - - -	INDICATIVE DEVELOPMENT BO UNDARY
🟩	MANGROVES
—	DUAL USE PATH
- - - -	GEOLOGICAL AREAS
A	DUNE SAND
B	ESTUARINE DEPOSIT
C	LIMESTONE

LAND USE / LOT YIELD ANALYSIS

GROSS DEVELOPABLE AREA	27.16HA
CARAVAN PARK	4.3HA
GROSS RESIDENTIAL AREA	22.86HA
PUBLIC OPEN SPACE	2.36HA (10%)
LOW DENSITY R20	9.66HA
MEDIUM DENSITY R40	4.12HA
ROADS	6.72HA
R20 138 LOTS @ 700SQM	
R40 137 LOTS @ 300SQM	
TOTAL LOT YIELD	**275**

Concept Plan - Option 01

Stables Structure Plan, Port Hedland

Date: 12 May 2020 Scale: 1:4000 @ A3 1:2000 @ A1 File: **20-213 SA-1** Staff: JP GW Checked: JP

element.

APPENDIX B

TRAFFIC FLOWS

MetroCount Traffic Executive
Weekly Vehicle Counts

WeeklyVehicle-135 -- English (ENA)

Datasets:

Site:	**[Port hedland] Styles Raod mathison Drive - Counihan Cres**
Direction:	8 - East bound A>B, West bound B>A., **Lane:** 0
Survey Duration:	16:00 Thursday, 1 March 2013 => 11:12 Friday, 9 March 2013
File:	C:\Users\eto\Desktop\Styles Rd 2013.EC0 (PlusB)
Identifier:	BA024H4S MC56-L5 [MC55] (c)Microcom 19Oct04
Algorithm:	Factory default
Data type:	Axle sensors - Paired (Class/Speed/Count)

Profile:

Filter time:	**16:00 Thursday, 1 March 2013 => 11:12 Friday, 9 March 2013**
Included classes:	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
Speed range:	10 - 160 km/h.
Direction:	North, East, South, West (bound)
Separation:	All - (Headway)
Name:	Factory default profile
Scheme:	Vehicle classification (ARX)
Units:	Metric (meter, kilometer, m/s, km/h, kg, tonne)
In profile:	Vehicles = 13415 / 13435 (99.85%)

Weekly Vehicle Counts

WeeklyVehicle-135

Site:	Port hedland.0WE
Description:	**Styles Raod mathison Drive - Counihan Cres**
Filter time:	**16:00 Thursday, 1 March 2013 => 11:12 Friday, 9 March 2013**
Scheme:	Vehicle classification (ARX)
Filter:	Cls(1 2 3 4 5 6 7 8 9 10 11 12) Dir(NESW) Sp(10,160) Headway(>0)

	Mon	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**	**Sun**	**Averages**	
Hour	**27 Feb**	**28 Feb**	**29 Feb**	**01 Mar**	**02 Mar**	**03 Mar**	**04 Mar**	**1 - 5**	**1 - 7**
0000-0100	*	*	*	*	4	13	10	4.0	9.0
0100-0200	*	*	*	*	1	8	7	1.0	5.3
0200-0300	*	*	*	*	2	3	4	2.0	3.0
0300-0400	*	*	*	*	0	3	5	0.0	2.7
0400-0500	*	*	*	*	12	8	5	12.0	8.3
0500-0600	*	*	*	*	37	22	15	37.0	24.7
0600-0700	*	*	*	*	146	93	21	146.0	86.7
0700-0800	*	*	*	*	**174<**	81	42	**174.0<**	99.0
0800-0900	*	*	*	*	124	93	74	124.0	97.0
0900-1000	*	*	*	*	112	118	89	112.0	106.3
1000-1100	*	*	*	*	82	**140<**	92	82.0	104.7
1100-1200	*	*	*	*	97	133	**98<**	97.0	**109.3<**
1200-1300	*	*	*	*	102	**135<**	96	102.0	111.0
1300-1400	*	*	*	*	123	122	**104<**	123.0	116.3
1400-1500	*	*	*	*	142	99	96	142.0	112.3
1500-1600	*	*	*	*	131	119	92	131.0	114.0
1600-1700	*	*	*	168	150	104	93	159.0	128.8
1700-1800	*	*	*	217	**166<**	102	103	**191.5<**	**147.0<**
1800-1900	*	*	*	131	111	84	71	121.0	99.3
1900-2000	*	*	*	89	68	94	47	78.5	74.5
2000-2100	*	*	*	47	42	32	27	44.5	37.0
2100-2200	*	*	*	32	34	23	21	33.0	27.5
2200-2300	*	*	*	17	32	23	14	24.5	21.5

```
2300-2400         *        *        *        7       11       17        5 |    9.0
10.0
                                                                        |
Totals
_______________________________________________________________|________________
                                                                        |
0700-1900         *        *        *        *     1514     1330     1050 | 1558.5
1345.0
0600-2200         *        *        *        *     1804     1572     1166 | 1860.5
1570.7
0600-0000         *        *        *        *     1847     1612     1185 | 1894.0
1602.2
0000-0000         *        *        *        *     1903     1669     1231 | 1950.0
1655.2
                                                                        |
AM Peak           *        *        *        *     0700     1000     1100 |
                  *        *        *        *      174      140       98 |
                                                                        |
PM Peak           *        *        *        *     1700     1200     1300 |
                  *        *        *        *      166      135      104 |

* - No data.
```

Weekly Vehicle Counts

WeeklyVehicle-135
Site: Port hedland.0WE
Description: **Styles Raod mathison Drive - Counihan Cres**
Filter time: **16:00 Thursday, 1 March 2013 => 11:12 Friday, 9 March 2013**
Scheme: Vehicle classification (ARX)
Filter: Cls(1 2 3 4 5 6 7 8 9 10 11 12) Dir(NESW) Sp(10,160) Headway(>0)

Hour	Mon 05 Mar	Tue 06 Mar	Wed 07 Mar	Thu 08 Mar	Fri 09 Mar	Sat 10 Mar	Sun 11 Mar	Averages 1 - 5	Averages 1 - 7
0000-0100	4	1	1	1	6	*	*	2.6	2.6
0100-0200	0	0	4	0	0	*	*	0.8	0.8
0200-0300	0	1	0	4	1	*	*	1.2	1.2
0300-0400	1	1	0	2	0	*	*	0.8	0.8
0400-0500	5	6	7	8	8	*	*	6.8	6.8
0500-0600	26	51	56	51	56	*	*	48.0	48.0
0600-0700	61	**164<**	161	**162<**	**160<**	*	*	**141.6<**	**141.6<**
0700-0800	54	159	**164<**	156	159	*	*	138.4	138.4
0800-0900	81	115	123	118	135	*	*	114.4	114.4
0900-1000	93	108	99	110	98	*	*	101.6	101.6
1000-1100	**116<**	115	99	122	4	*	*	91.2	91.2
1100-1200	113	96	97	108	0	*	*	82.8	82.8
1200-1300	111	98	119	118	*	*	*	111.5	111.5
1300-1400	93	114	107	130	*	*	*	111.0	111.0
1400-1500	88	138	145	138	*	*	*	127.3	127.3
1500-1600	91	133	128	117	*	*	*	117.3	117.3
1600-1700	120	170	170	**186<**	*	*	*	161.5	161.5
1700-1800	**120<**	**187<**	**207<**	180	*	*	*	**173.5<**	**173.5<**
1800-1900	71	141	107	131	*	*	*	112.5	112.5
1900-2000	59	65	59	83	*	*	*	66.5	66.5
2000-2100	41	44	36	39	*	*	*	40.0	40.0
2100-2200	12	22	24	37	*	*	*	23.8	23.8
2200-2300	7	12	12	23	*	*	*	13.5	13.5

```
2300-2400        4        4        5        7        *        *        * |    5.0
5.0
                                                                         |
Totals
_______________________________________________________________|________________
                                                                         |
0700-1900     1151     1574     1565     1614        *        *        * | 1442.9
1442.9
0600-2200     1324     1869     1845     1935        *        *        * | 1714.8
1714.8
0600-0000     1335     1885     1862     1965        *        *        * | 1733.3
1733.3
0000-0000     1371     1945     1930     2031        *        *        * | 1793.5
1793.5
                                                                         |
AM Peak       1000     0600     0700     0600     0600        *        * |
               116      164      164      162      160        *        * |
                                                                         |
PM Peak       1700     1700     1700     1600        *        *        * |
               120      187      207      186        *        *        * |

* - No data.
```

SITE 16457

Hourly Volume

2018/19
Monday to Friday

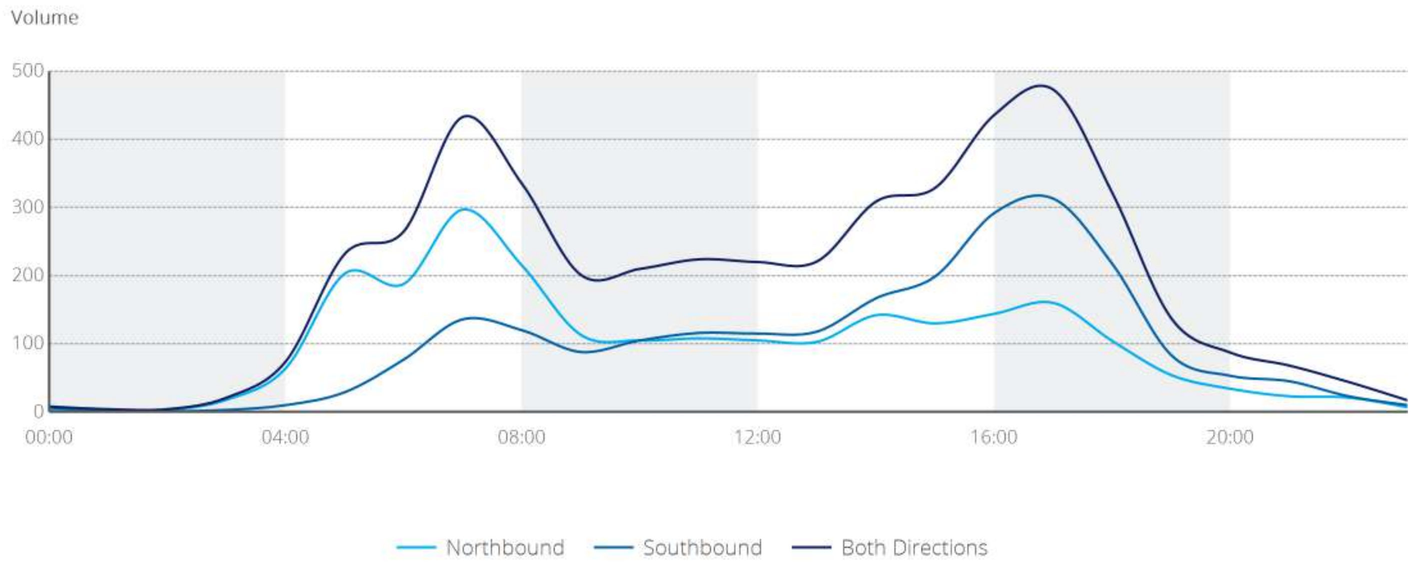
Cooke Point Rd (8130140)

North of Wilson St (SLK 0.13)

	All Vehicles			Heavy Vehicles			
	NB	SB	Both	NB	SB	Both	%
00:00	2	6	8	0	0	0	0.0
01:00	2	2	4	0	0	0	0.0
02:00	3	1	4	0	0	0	0.0
03:00	18	3	21	0	0	0	0.0
04:00	64	10	74	1	0	1	1.4
05:00	203	29	232	9	0	9	3.9
06:00	188	77	265	8	8	16	6.0
07:00	297	136	433	13	6	19	4.4
08:00	215	120	335	10	6	16	4.8
09:00	113	88	201	10	3	13	6.5
10:00	105	105	210	9	6	15	7.1
11:00	108	116	224	6	4	10	4.5
12:00	105	115	220	8	3	11	5.0
13:00	103	118	221	9	6	15	6.8
14:00	142	167	309	10	7	17	5.5
15:00	130	199	329	5	4	9	2.7
16:00	144	292	436	7	4	11	2.5
17:00	160	313	473	8	2	10	2.1
18:00	104	217	321	5	3	8	2.5
19:00	54	83	137	2	2	4	2.9
20:00	34	53	87	1	0	1	1.1
21:00	23	45	68	1	0	1	1.5
22:00	21	23	44	2	1	3	6.8
23:00	7	10	17	0	0	0	0.0
TOTAL	2345	2328	4673	124	65	189	4.0

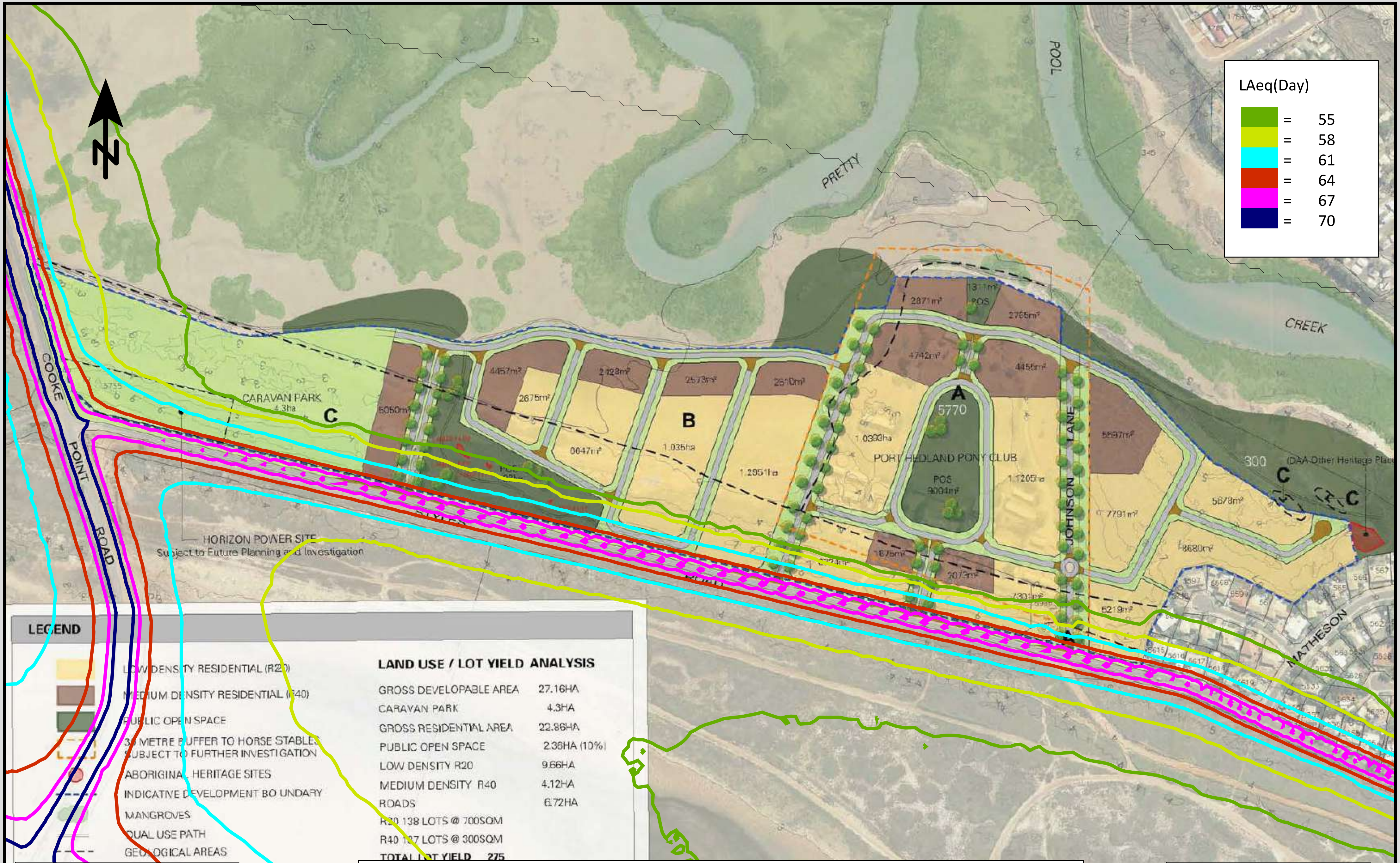
Peak Statistics

AM	TIME	07:15	07:15	07:15	07:00	06:15	06:30
	VOL	320	151	471	13	11	21
PM	TIME	16:45	16:30	16:30	12:30	14:15	14:15
	VOL	170	321	490	11	8	17



APPENDIX C

$L_{Aeq(16hr)}$ DAY NOISE CONTOURS

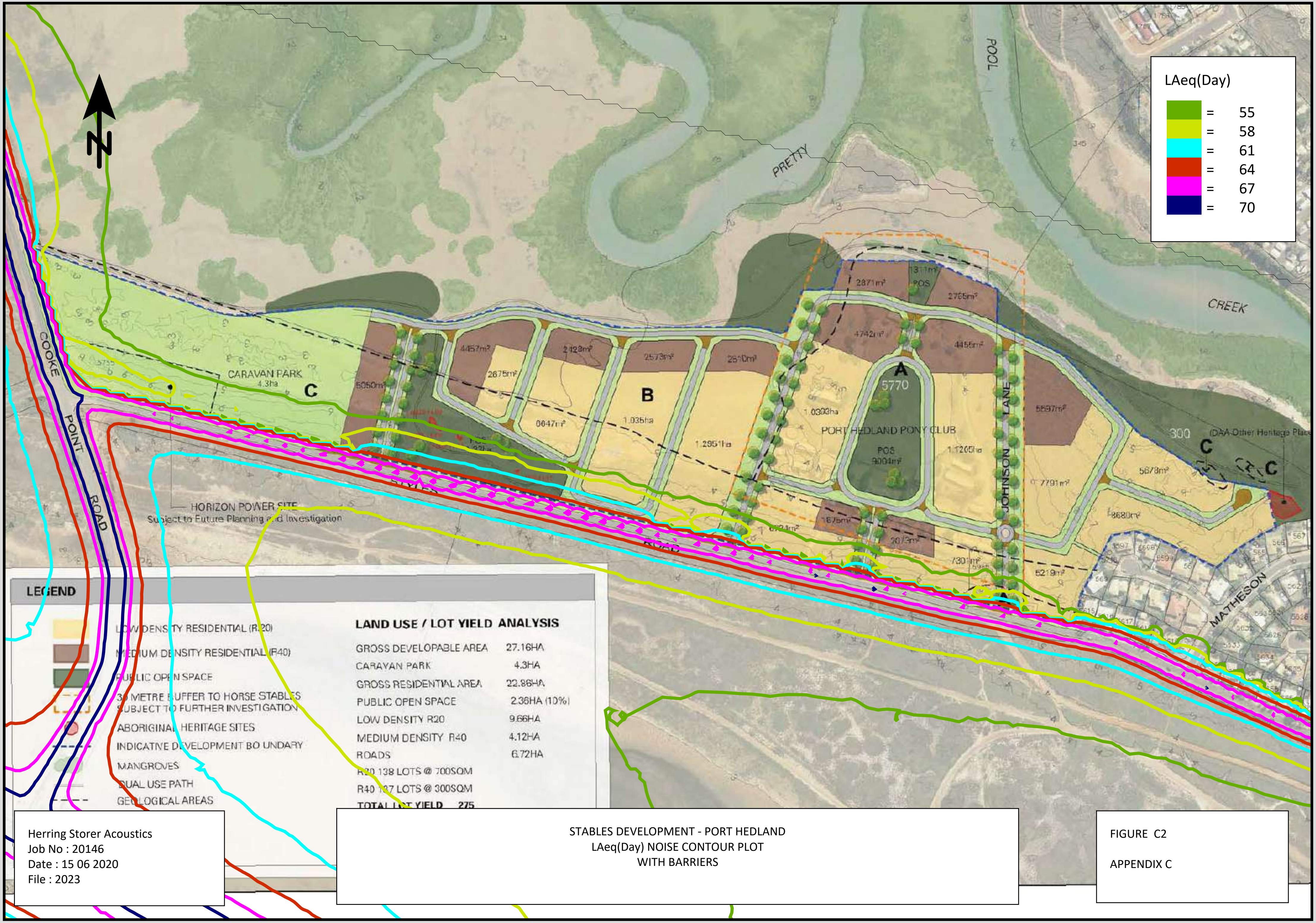


Herring Storer Acoustics
Job No : 20146
Date : 15 06 2020
File : 2022

STABLES DEVELOPMENT - PORT HEDLAND
LAeq(Day) NOISE CONTOUR PLOT
BASE SCENARIO

FIGURE C1

APPENDIX C

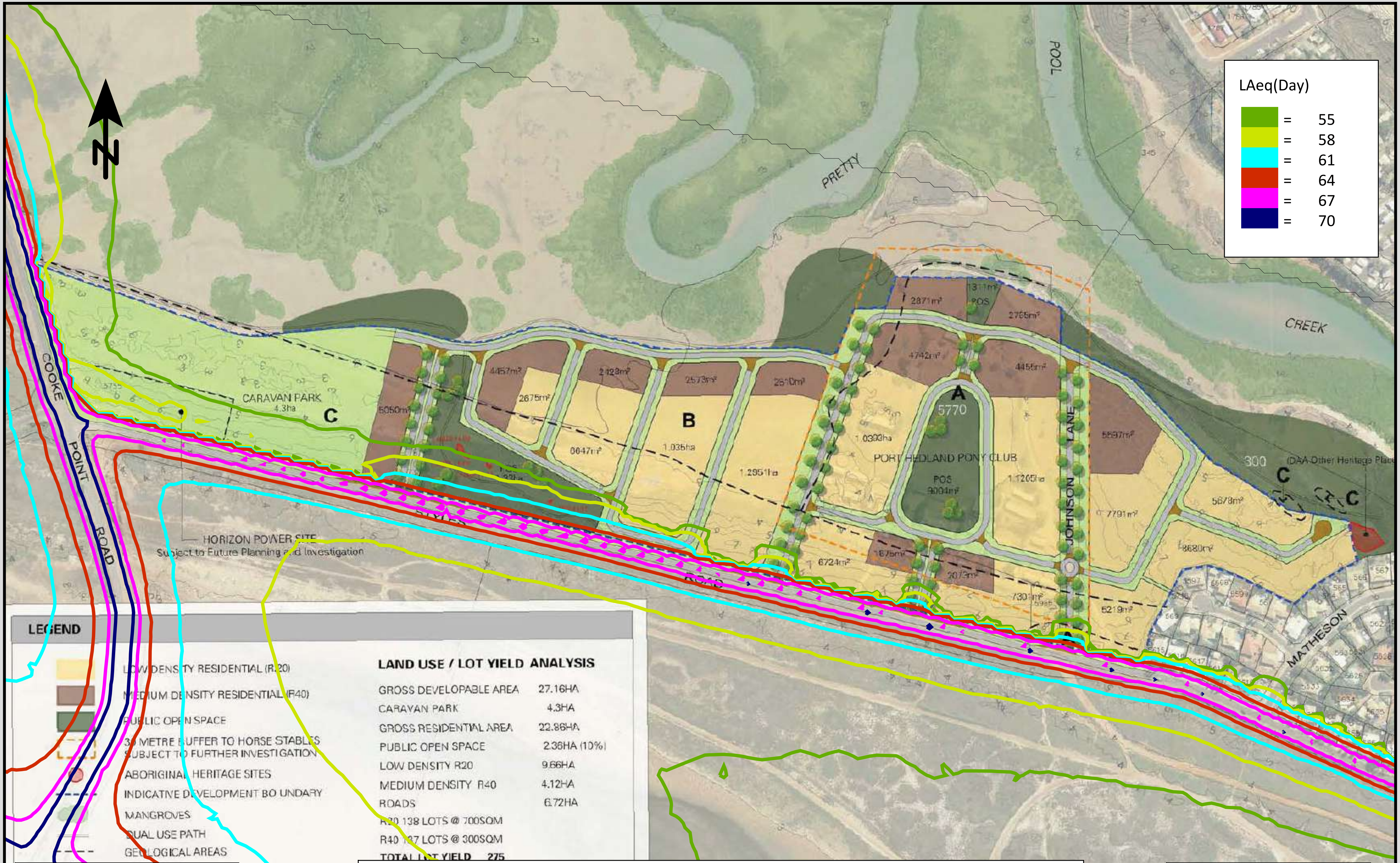


Herring Storer Acoustics
Job No : 20146
Date : 15 06 2020
File : 2023

STABLES DEVELOPMENT - PORT HEDLAND
LAeq(Day) NOISE CONTOUR PLOT
WITH BARRIERS

FIGURE C2

APPENDIX C

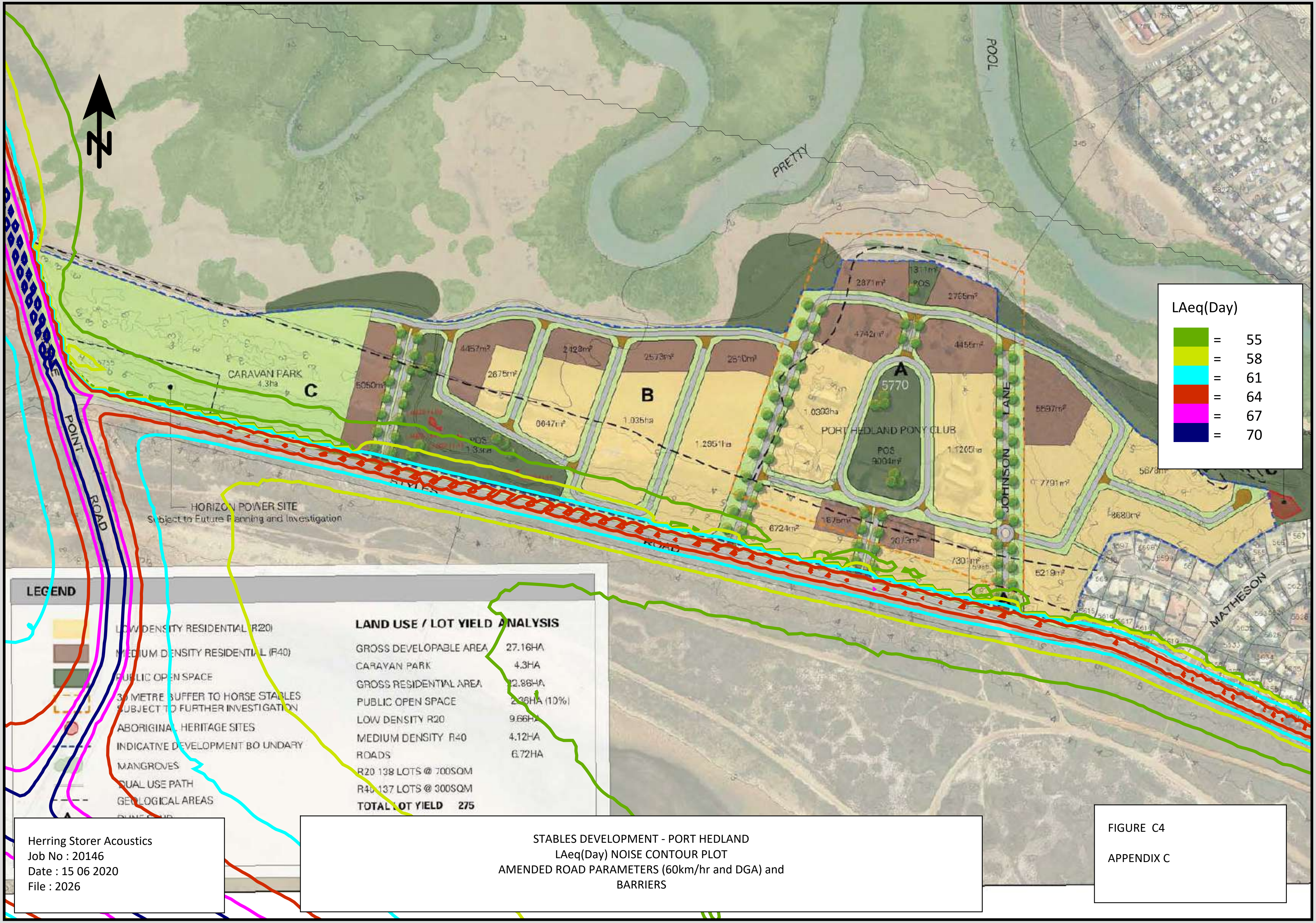


Herring Storer Acoustics
Job No : 20146
Date : 15 06 2020
File : 2024

STABLES DEVELOPMENT - PORT HEDLAND
LAeq(Day) NOISE CONTOUR PLOT
WITH BARRIERS and FIRST ROW OF RESIDENCES

FIGURE C3

APPENDIX C



Herring Storer Acoustics
Job No : 20146
Date : 15 06 2020
File : 2026

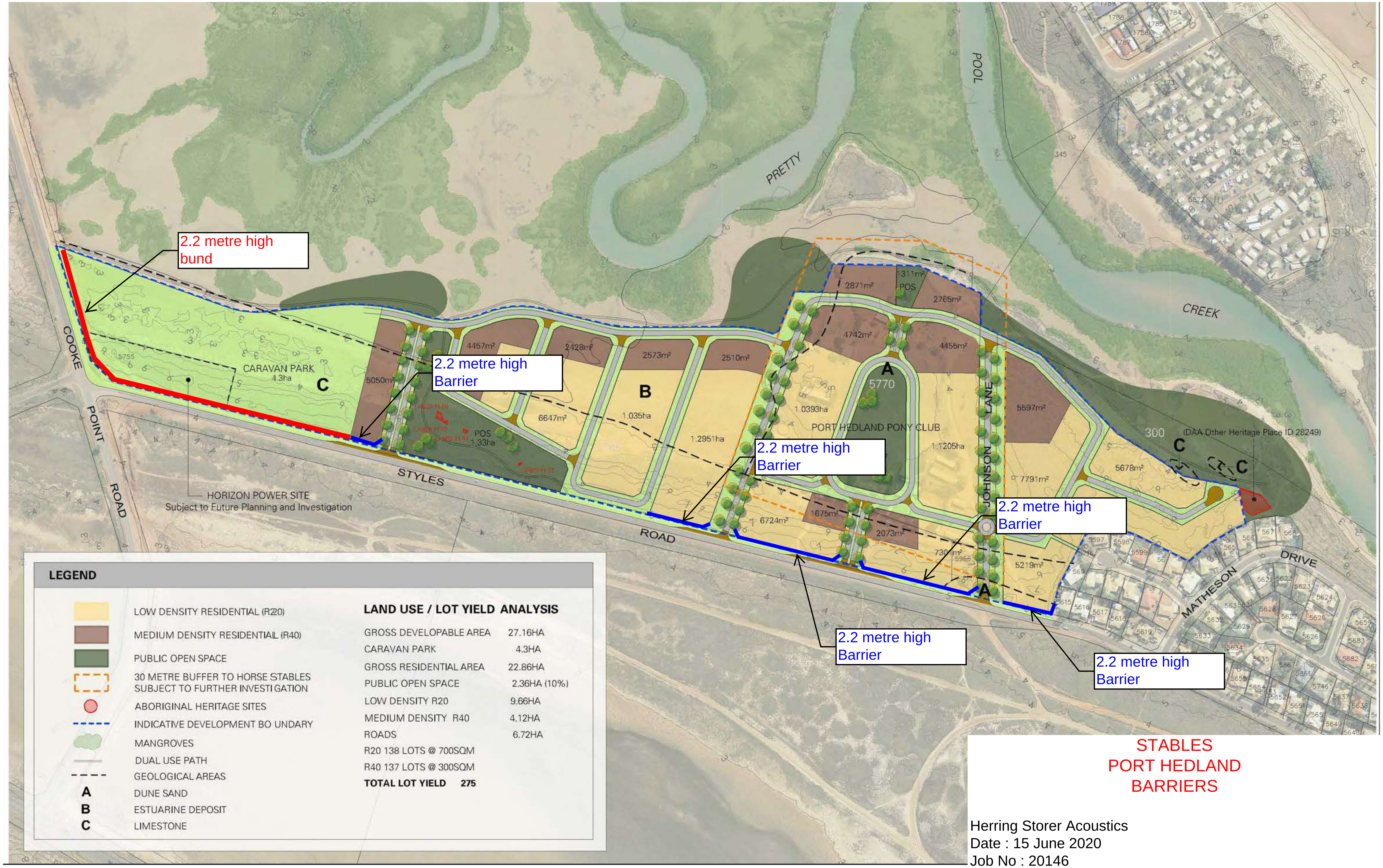
STABLES DEVELOPMENT - PORT HEDLAND
LAeq(Day) NOISE CONTOUR PLOT
AMENDED ROAD PARAMETERS (60km/hr and DGA) and
BARRIERS

FIGURE C4

APPENDIX C

APPENDIX D

RECOMMENDED BARRIERS, “QUIET HOUSE” DESIGN AND NOTIFICATION REQUIREMENTS



LEGEND

🟨	LOW DENSITY RESIDENTIAL (R20)
🟫	MEDIUM DENSITY RESIDENTIAL (R40)
🟩	PUBLIC OPEN SPACE
▭	30 METRE BUFFER TO HORSE STABLES SUBJECT TO FURTHER INVESTIGATION
●	ABORIGINAL HERITAGE SITES
- - -	INDICATIVE DEVELOPMENT BOUNDARY
☁	MANGROVES
—	DUAL USE PATH
- - -	GEOLOGICAL AREAS
A	DUNE SAND
B	ESTUARINE DEPOSIT
C	LIMESTONE

LAND USE / LOT YIELD ANALYSIS

GROSS DEVELOPABLE AREA	27.16HA
CARAVAN PARK	4.3HA
GROSS RESIDENTIAL AREA	22.86HA
PUBLIC OPEN SPACE	2.36HA (10%)
LOW DENSITY R20	9.66HA
MEDIUM DENSITY R40	4.12HA
ROADS	6.72HA
R20 138 LOTS @ 700SQM	
R40 137 LOTS @ 300SQM	
TOTAL LOT YIELD	**275**

STABLES
PORT HEDLAND
BARRIERS

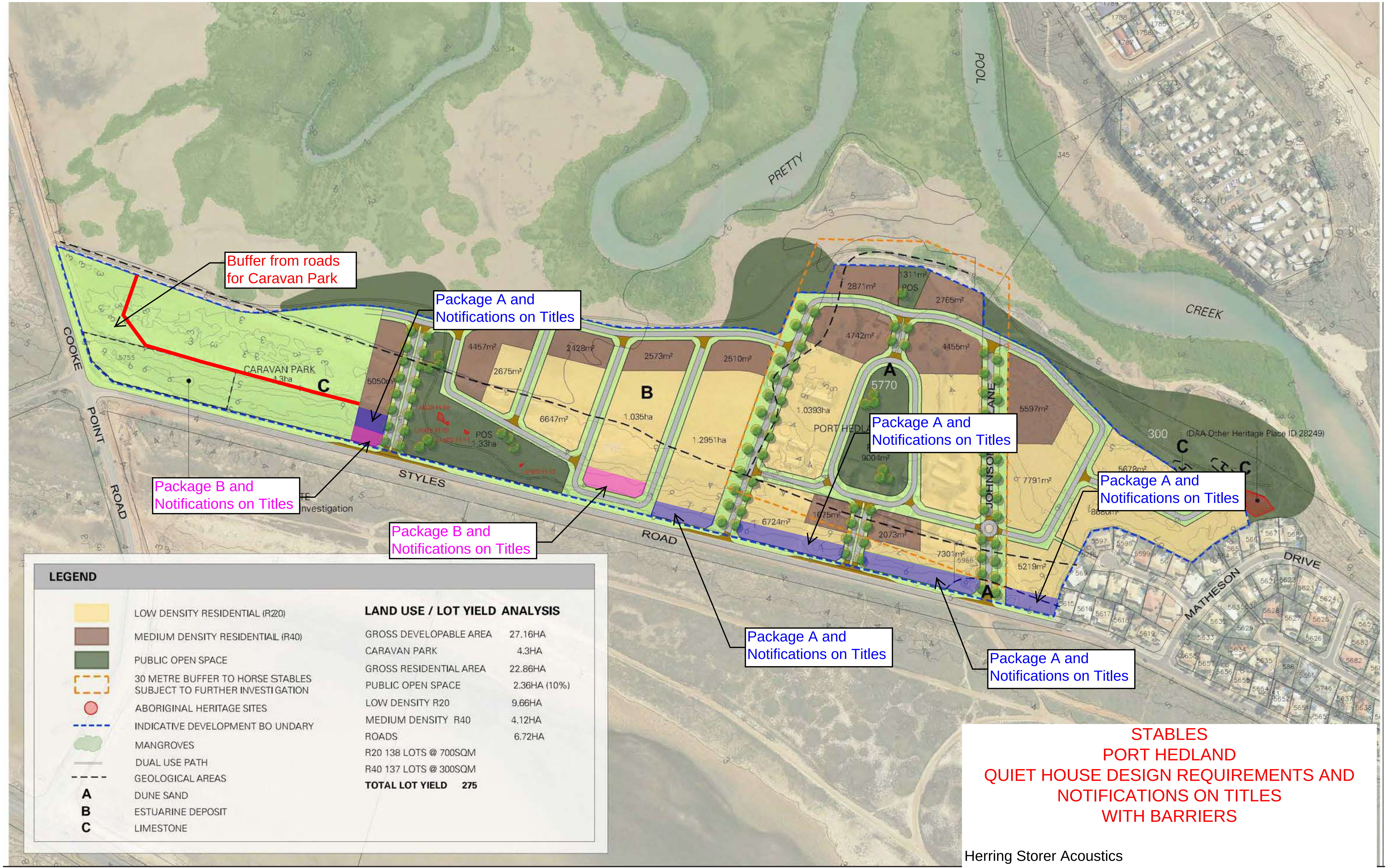
Herring Storer Acoustics
Date : 15 June 2020
Job No : 20146

Figure D1
Appendix D

Concept Plan - Option 01

Stables Structure Plan, Port Hedland

Date: 12 May 2020 Scale: 1:4000 @ A3 1:2000 @ A1



Buffer from roads for Caravan Park

Package A and Notifications on Titles

Package A and Notifications on Titles

Package A and Notifications on Titles

Package B and Notifications on Titles

Package B and Notifications on Titles

Package A and Notifications on Titles

Package A and Notifications on Titles

LEGEND

🟨	LOW DENSITY RESIDENTIAL (R20)
🟫	MEDIUM DENSITY RESIDENTIAL (R40)
🟩	PUBLIC OPEN SPACE
▭	30 METRE BUFFER TO HORSE STABLES SUBJECT TO FURTHER INVESTIGATION
●	ABORIGINAL HERITAGE SITES
- - -	INDICATIVE DEVELOPMENT BOUNDARY
▨	MANGROVES
—	DUAL USE PATH
- - -	GEOLOGICAL AREAS
A	DUNE SAND
B	ESTUARINE DEPOSIT
C	LIMESTONE

LAND USE / LOT YIELD ANALYSIS

GROSS DEVELOPABLE AREA	27.16HA
CARAVAN PARK	4.3HA
GROSS RESIDENTIAL AREA	22.86HA
PUBLIC OPEN SPACE	2.36HA (10%)
LOW DENSITY R20	9.66HA
MEDIUM DENSITY R40	4.12HA
ROADS	6.72HA
R20 138 LOTS @ 700SQM	
R40 137 LOTS @ 300SQM	
TOTAL LOT YIELD	**275**

STABLES
PORT HEDLAND
QUIET HOUSE DESIGN REQUIREMENTS AND
NOTIFICATIONS ON TITLES
WITH BARRIERS

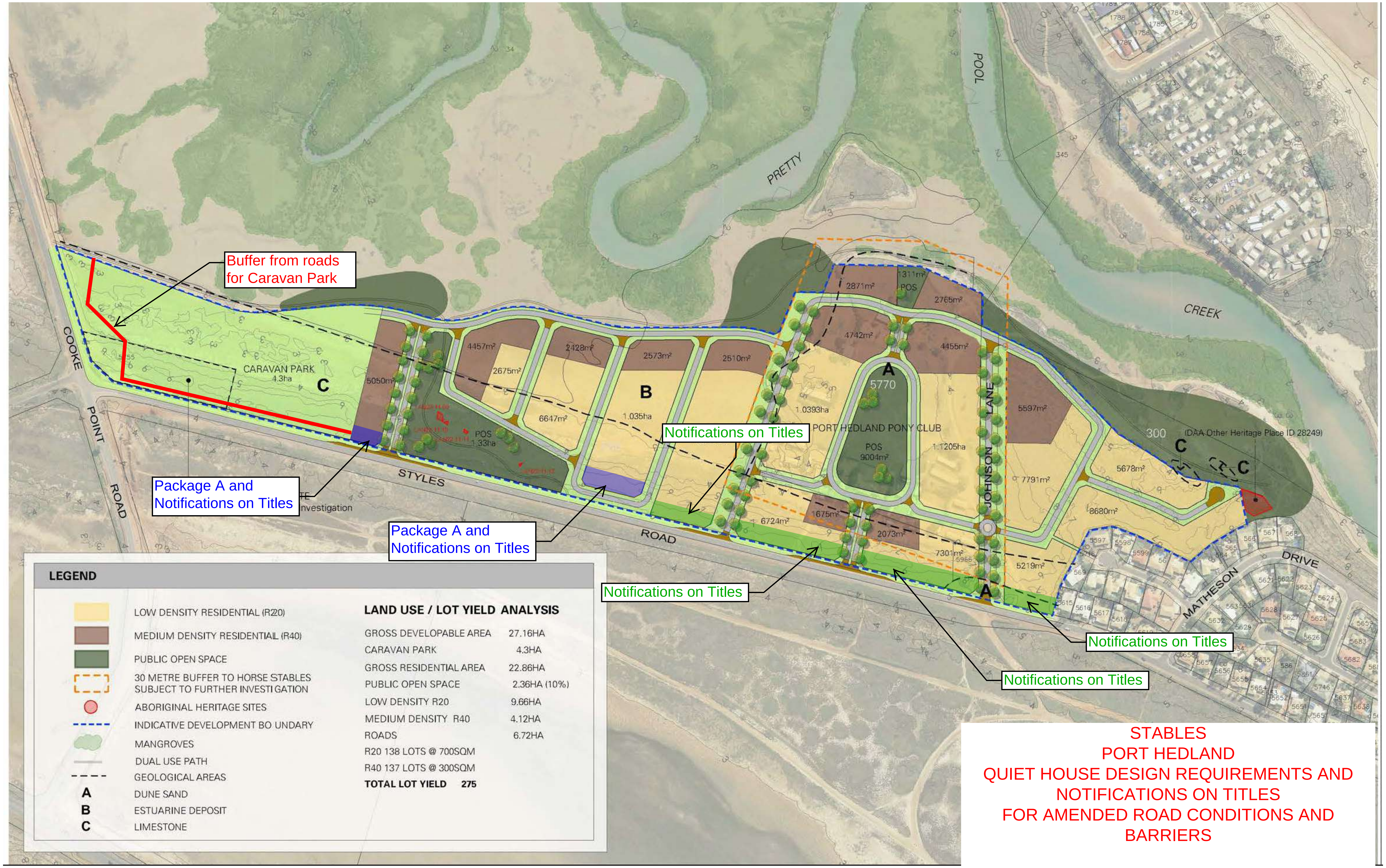
Herring Storer Acoustics
Date : 15 June 2020
Job No : 20146

Concept Plan - Option 01

Stables Structure Plan, Port Hedland

Date: 12 May 2020 Scale: 1:4000 @ A3 1:2000 @

Figure D2
Appendix D



LAND USE / LOT YIELD ANALYSIS

GROSS DEVELOPABLE AREA	27.16HA
CARAVAN PARK	4.3HA
GROSS RESIDENTIAL AREA	22.86HA
PUBLIC OPEN SPACE	2.36HA (10%)
LOW DENSITY R20	9.66HA
MEDIUM DENSITY R40	4.12HA
ROADS	6.72HA
R20 138 LOTS @ 700SQM	
R40 137 LOTS @ 300SQM	
TOTAL LOT YIELD	**275**

STABLES
PORT HEDLAND
QUIET HOUSE DESIGN REQUIREMENTS AND NOTIFICATIONS ON TITLES
FOR AMENDED ROAD CONDITIONS AND BARRIERS

Herring Storer Acoustics
Date : 15 June 2020
Job No : 20146

Concept Plan - Option 01

Stables Structure Plan, Port Hedland

Date: 12 May 2020 Scale: 1:4000 @ A3 1:2000 @

Figure D3
Appendix D

APPENDIX E

“QUIET HOUSE” DESIGN – GENERAL INFORMATION

Road Traffic and Passenger Rail - Quiet House Requirements
(*Based on Table 3 of State Planning Policy 5.4 2019*)

Exposure Category	Orientation to corridor	Acoustic ratings					Mechanical ventilation/air conditioning considerations
		Walls	External doors	Windows	Roofs and ceilings of highest floors	Outdoor Living areas	
A **Quiet House A**	**Facing**	**Bedroom and Indoor Living and work areas** ➢ Rw + Ctr 45dB	**Bedrooms**: ➢ R_w+C_{tr} 28dB **Indoor Living and work areas:** ➢ R_w+C_{tr} 25dB	**Bedrooms**: Window size dependant ➢ **Minimum** R_w+C_{tr} 28 dB **Indoor Living and work areas** Window size dependant ➢ **Minimum** R_w+C_{tr} 25 dB	➢ R_w+C_{tr} 35dB	➢ At least one outdoor living area located on the opposite side of the building from the transport corridor and/or at least one ground level outdoor living area screened using a solid continuous fence or other structure of minimum **2 metres** height above ground level	➢ Acoustically rated openings and ductwork to provide a minimum sound reduction performance of **Rw 40dB** into sensitive spaces
	Side On		**Bedrooms**: ➢ R_w+C_{tr} 25dB **Indoor Living and work areas:** ➢ R_w+C_{tr} 22dB	**Bedrooms**: Window size dependant ➢ **Minimum** R_w+C_{tr} 25 dB **Indoor Living and work areas** Window size dependant ➢ **Minimum** R_w+C_{tr} 22 dB			
	Opposite		No specific requirements	No specific requirements			
B **Quiet House B**	**Facing**	**Bedroom and indoor living and work areas** ➢ R_w+C_{tr} 50dB	**Bedrooms** ➢ R_w+C_{tr} 31dB **Indoor Living and work areas:** ➢ R_w+C_{tr} 28dB	**Bedrooms**: Window size dependant ➢ **Minimum** R_w+C_{tr} 31 dB **Indoor Living and work areas** Window size dependant ➢ **Minimum** R_w+C_{tr} 28 dB	➢ **R_w+C_{tr} 35dB**	➢ At least one outdoor living area located on the opposite side of the building from the corridor and/or at least one ground level outdoor living area screened using a solid continuous fence or other structure of minimum **2.4 metres** height above ground level	➢ Acoustically rated openings and ductwork to provide a minimum sound reduction performance of **Rw 40dB** into sensitive spaces
	Side-On		**Bedrooms** ➢ R_w+C_{tr} 28dB **Indoor Living and work areas:** ➢ R_w+C_{tr} 28dB	**Bedrooms**: Window size dependant ➢ **Minimum** R_w+C_{tr} 28 dB **Indoor Living and work areas** Window size dependant ➢ **Minimum** R_w+C_{tr} 25 dB			
	Opposite		**Bedrooms** ➢ R_w+C_{tr} 25dB **Indoor Living and work areas:** ➢ R_w+C_{tr} 25dB	**Bedrooms**: Window size dependant ➢ **Minimum** R_w+C_{tr} 25 dB **Indoor Living and work areas** Window size dependant ➢ **Minimum** R_w+C_{tr} 22 dB			
C **Quiet House C**	**Facing**	**Bedroom and indoor living and work areas** ➢ R_w+C_{tr} 50dB	**Bedrooms** ➢ No External doors to bedrooms facing the corridor **Indoor Living and work areas** ➢ Rw+Ctr 31dB	**Bedrooms**: Window size dependant ➢ **Minimum** R_w+C_{tr} 31dB) **Indoor Living and work areas** Window size dependant ➢ **Minimum** R_w+C_{tr} 31dB	➢ **R_w+C_{tr} 40dB**	➢ At least one outdoor living area located on the opposite side of the building from the corridor and/or at least one ground level outdoor living area screened using a solid continuous fence or other structure of minimum **2.4 metres** height above ground level	➢ Acoustically rated openings and ductwork to provide a minimum sound reduction performance of Rw 40dB into sensitive spaces.
	Side-on		**Bedrooms** ➢ R_w+C_{tr} 31dB **Indoor Living and work areas** ➢ R_w+C_{tr} 28dB	**Bedrooms**: Window size dependant ➢ **Minimum** R_w+C_{tr} 31 dB **Indoor Living and work areas** Window size dependant ➢ **Minimum** R_w+C_{tr} 28 dB			
	Opposite		**Bedrooms**: ➢ R_w+C_{tr} 28dB **Indoor Living and work areas:** ➢ R_w+C_{tr} 28dB	**Bedrooms**: Window size dependant ➢ **Minimum** R_w+C_{tr} 28 dB **Indoor Living and work areas** Window size dependant ➢ **Minimum** R_w+C_{tr} 25 dB			

Note: The above treatments are a deemed to satisfy construction. Alternative designs are acceptable, provided they are certified by a suitable qualified acoustic consultant

element.
the art and science of place

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