RGP5 – Port Facilities Selection Phase Study

BENTHIC PRIMARY PRODUCER HABITAT ASSESSMENT

- Rev 1
- 30 June 2008
- Document Number: WV03418-MV-RP-0007
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<th>Date issued</th>
<th>Reviewed by</th>
<th>Approved by</th>
<th>Date approved</th>
<th>Revision type</th>
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<td>J. Sofonia</td>
<td>D. Murphy</td>
<td>22 Nov. 07</td>
<td>Draft for Client Review</td>
</tr>
<tr>
<td>Rev 0</td>
<td>01 Feb 08</td>
<td>R. Hanley</td>
<td>D. Murphy</td>
<td>01 Feb 08</td>
<td>Final Issue</td>
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<tr>
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Distribution of copies

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Printed: 7 August 2008
Last saved: 7 August 2008 11:50 AM
File name: I:\WVES\Projects\WV03418\Deliverables\700_EPA Referral\Harriet Point Environmental Referral Document\12. Appendices\Current Versions\Appendix A - Benthic Primary
Authors: R. Hanley, K. Peat, A. Tennyson, and J. Sofonia
Project manager: D. Murphy
Name of organisation: BHPBIO
Name of project: RGP5
Document version: 0
Project number: WV03418
Executive Summary

BHPBIO is seeking approval under Part IV of the *Environmental Protection Act 1986* for dredging at Harriet Point on Finucane Island. The proposal is a component of the RPG5 expansion to increase the throughput capacity of BHPBIO’s operations to 205 Mtpa.

The proposal involves the dredging of approximately 3.9 million cubic metres (Mm³) of material for two new berth pockets and extensions to the existing departure channel and swing basin at Harriet Point to accommodate vessels of approximately 250,000 dead weight tonnes (DWT).

The management of the dredged material to Dredged Material Management Areas (DMMA) will be dependent on its characteristics. Potentially Acid Sulphate Soils (PASS) material will be disposed offshore at the Port Hedland Port Authority (PHPA) Spoil Ground ‘I’. All other dredged material will be managed at DMMA B1 and B2, with excess fines managed at DMMA A.

To assess the potential impact on Benthic Primary Producer Habitat (BPPB) and objectively inform the evaluation and selection process nine potential DMMA were identified and assessed.

Both desktop and in-field surveys of these areas were performed by SKM in order to define boundaries of each of the potential disposal grounds and sensitive habitats to avoid and/or minimise potential environmental impacts. These surveys also characterised the vegetation present and ranked the areas relative to each other (locally and regionally) based on the quality, range and diversity present (*Table 1*).

Anthropogenic disturbances of varying degrees were observed at most locations. Moreover, no unique features were observed and these areas are considered representative of the intertidal zone along much of the Pilbara coastline.

An assessment of Benthic Primary Producer Habitats losses and impacts as required by EPA Guidance Statement No. 29 has been completed separately as part of ongoing DMMA selection and impact mitigation studies.
<table>
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<tr>
<th>DMMA</th>
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<th>Area (ha)</th>
<th>Summary Detail</th>
<th>Environmental &amp; aesthetic significance (Lowest - Highest)</th>
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<td>G</td>
<td>Within the harbour</td>
<td>14.1</td>
<td>Relatively undisturbed; High environmental and amenity values; Limited vehicle access – benefit to vegetation; and Minor disturbance from freshwater seepage and lower soil salinity</td>
<td>Highest</td>
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<tr>
<td>E</td>
<td>West of Pretty Pool</td>
<td>32.5</td>
<td>Typical of upper intertidal areas in region; No apparent alteration to local drainage; Disturbance to vegetation by indiscriminate vehicle access; and Fringing mangroves along creek channels in relatively good health</td>
<td>High</td>
</tr>
<tr>
<td>A</td>
<td>West of Finucane Island Causeway</td>
<td>123.2</td>
<td>Water flow highly modified from construction of Finucane Isl. Causeway; Moderate BPPH present although apparently modified in composition from alteration in tidal flow; Western side connected to relatively undisturbed habitat; and Remaining resources comparable with similar areas within undeveloped harbour and coastal areas</td>
<td>Medium</td>
</tr>
<tr>
<td>H</td>
<td>North of Wedgefield</td>
<td>152</td>
<td>Natural drainage modified by previous development; Significant disturbance to vegetation through unregulated 4WD and trail-bike use; Moderate BPPH present including health mangroves lining creek channels; and</td>
<td>Medium</td>
</tr>
<tr>
<td>C</td>
<td>On BHPBio lease</td>
<td>18.7</td>
<td>Natural drainage modified by previous development; Heavily influenced by storm water discharge through culverts Unstable – showing signs of erosion; and Limited BPPH present</td>
<td>Low</td>
</tr>
<tr>
<td>D</td>
<td></td>
<td>32.1</td>
<td>Substantial sub-tidal areas; Steep slope along shoreline; Little BPPH present; and Highly modified by existing development</td>
<td>Low</td>
</tr>
<tr>
<td>B</td>
<td>East Lewis Island</td>
<td>27.1</td>
<td>Artificially created in past; No intertidal areas; Nearly devoid of vegetation; and No apparent connection to undisturbed areas</td>
<td>Lowest</td>
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<td>I</td>
<td>Nelson Point Eastern end of southern stock pile</td>
<td>32.1</td>
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Table 1 Summary detail and ranking of significance for areas of proposed dredge material disposal.
1. Introduction

BHPBIO is seeking approval under Part IV of the Environmental Protection Act 1986 for dredging at Harriet Point on Finucane Island. The proposal is a component of the RPG5 expansion to increase the throughput capacity of BHPBIO’s operations to 205 Mtpa.

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The management of the dredged material to Dredged Material Management Areas (DMMA) will be dependent on its characteristics. Potentially Acid Sulphate Soils (PASS) material will be disposed offshore at the Port Hedland Port Authority (PHPA) Spoil Ground ‘I’. All other dredged material will be managed at DMMA B1 and B2, with excess fines managed at DMMA A.

1.1. Overview

Preliminary Site Investigations (PSI’s) conducted from 22-27 July and 28-29 August, 2007, followed by field data analysis utilising Geographical Information Systems (GIS) software, identified nine potential DMMA’s. These include two areas along the western side of the harbour, five areas on the eastern side of the harbour and two areas on the southern side of the harbour.

Benthic primary producer habitat (BPPH), in particular mangrove habitat, are recognised as being important habitats for feeding grounds and fish nurseries, as well as protecting coastal areas from erosion by stabilising sediments. Key considerations regarding the potential impacts on BPPH include:

- the direct loss of BPPH due to dredging and the construction of DMMA; and
- potential indirect impacts on mangroves as a result of dredging and construction activities.

The Environmental Protection Authority’s (EPA’s) objectives for the management of mangroves are:

- To limit the direct loss of mangroves associated with the dredging activities and construction;
- To ensure the protection of the mangrove ecosystem of the Port Hedland Harbour from indirect impacts associated with the project; and
- To maintain the abundance, diversity, geographic distribution and productivity of mangrove communities at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.
1.2. Objectives

The purpose of this report is to determine and describe the types of BPPH found in the area to be dredged and potential DMMA’s, and assess them in terms of ‘ecological values’ relative to each other and in a regional setting. It is not the purpose of this report to make recommendation on the selection of a preferred DMMA, or DMMA’s, for development but to objectively inform the evaluation and selection process which will be documented elsewhere.

Specifically this report provides an assessment of the areas surveyed in terms of the Benthic Primary Producer Habitat (BPPH) Guidance Statement 29 (EPA 2004), and Guidance Statement 1 for Protection of Tropical Arid Zone Mangroves Along the Pilbara Coastline (EPA 2001).

The areas selected for survey were:

1) **Area of mangroves, salt marsh and tidal flats which would be directly impacted by the footprint of any future development at Harriet Point:**

In Figure 1, the area at Harriet Point which could be removed and/or affected by the proposed development of berths at some time in the future is shown as lying inside the hatched black and white line on the west side of the main harbour channel.

Examination of aerial photography show that the mangroves on Harriet Point ranged from closed canopy stands fringing the channels on both sides of the point, to less dense coverage moving to landward. The aerial photography also shows an apparent change in species composition between the edge of the channel and the landward extent of mangroves (e.g. based upon different colours of canopy in (Figure 2).

2) **Areas of the upper intertidal zone that may be suitable for deposition of dredged material:**

In areas of the upper intertidal zone potentially utilised for the disposal of dredged material (Figure 1) two field surveys were undertaken to assess the biota (flora and fauna) present. The surveys were designed to assess the relative ecological and environmental value of the resources present and to also assess whether the proposed footprints at each potential DMMA could be altered to minimise impact on mangroves, salt marshes and other biota.

Inherent within the process of assessment was the development of a ranking system whereby each of the potential DMMA’s was ranked relative to each other, and to allow placement within a regional context.
Figure 1 Dredge volumes, reclamation areas and mangrove loss
2. Methods

Compared to other areas in the Pilbara region, the mangrove, salt marsh and tidal flats of Port Hedland are relatively well known and many elements of the ecology, distribution and classification of these habitats have been described in detail. Important references include:

- Flora (Semeniuk et al 1978; Paling et al 2003);
- The influence of geology and geomorphology on the different intertidal habitats (Semeniuk 1993, 1994, 1997);
- vegetation associations (Beard 1975; Craig 1983; Semeniuk 2007a; Paling et al 2003);
- Fauna (Jones 2004).

As a substantial level of information already exists, the field surveys undertaken to characterise the flora, fauna, and relative ‘ecological values’ of the areas where the potential impact areas were of limited scope and scale. Regardless, the field surveys are considered to be of sufficient detail to permit an assessment of what is present in each of the potential DMMA’s against the significant body of information already documented in previous studies.

2.1. Flora

The present survey comprised a single field visit to each site and was considered sufficient to characterise the mangrove and salt marsh flora in terms of the several habitat and landform classification systems already produced for this area of Port Hedland (see references above).

The flora present at sites is a key component of the assessment process as mangrove habitats are considered to be an important habitat in the context of the BPPH Guidance Statement 29 (EPA, 2004) and also the earlier Guidance Statement 1 on tropical arid zone mangroves of the Pilbara (EPA, 2001).

Key references used for the identification of flora were Duke (2006) for mangroves and Johns (2006) for salt marshes, supplemented with additional resources where available.

2.1.1. Mangroves on Harriet Point

Mangrove transects surveyed on Harriet Point are illustrated in Figure 2, the locations and direction of which, were governed by the need to assess different species associations and appraise the variation within these associations.

Specifically, to detect any variation in species assemblage, observations were recorded beginning with the height on the shore, followed by points along each transect where the surveyors considered the features of the vegetation changed substantially. Here, a GPS position was taken and digital
photographs of the vegetation were also captured. In addition, each time a GPS position was taken, the survey team noted the:

- Species of trees and or shrubs and herbs present and relative abundance of each species;
- Approximate height range of the trees present;
- Presence of surface water (ponded); and
- Presence and relative abundance of leaf litter, twigs, branches, logs on the substrate.

All data collected were stored in the field on a hand held Trimble GeoExplorer (2005 series; WGS84 Zone 50 South Datum) which allowed linkage of each GPS position with a data sheet.

2.1.2. Upper intertidal mangroves, salt marsh and tidal flats

From previous discussion with BHPBIO and examination of aerial photography a number of sites were identified that may be suitable for the disposal of dredged material. These areas consist mainly of large tidal pans (flats), devoid of vegetation and relatively close to the locations where dredging is proposed. The aim of the present study was to visit each of the potential sites and determine the boundaries of potential banded areas should be located (i.e. in order to minimise environmental impact in the intertidal zones), and to determine what biological attributes were present within that area.

Thus, the surveys were conducted by walking the margins of the potential disposal areas and avoiding the areas which, in the survey team’s opinion, constituted mangrove, salt marsh and tidal flat habitats of relatively high ecological value and sensitivity. The rationale behind this approach is discussed further in Section 3 (Results) of this report.

As is typical of mangroves habitats on arid coastlines, the dense stands of mangroves only occupy those areas of the intertidal zone where tidal inundation is frequent enough to keep soil salinities low enough for colonisation by mangroves. In addition, as distance from the waterline increases, the height and cover of vegetation decreases and mangroves usually disappear altogether, giving way to salt marsh and then bare tidal flats (Saenger, 2002). Some areas between the mangrove and samphire dominated zones of the upper intertidal and may support cyanobacterial mats under suitable conditions (Paling et al 1989, 2003). At the upper limit of the intertidal zone, wherever there is some hinterland relief (e.g. created by dunes, cheniers or limestone ridges) there is often a thin band of mangroves supported by groundwater discharge.

The distribution of mangroves, salt marsh plants and bare tidal flats in the upper intertidal areas of Port Hedland Harbour is a mosaic that reflects a variety of factors and these have been described in detail by Semeniuk (1994; 1996). Interspersed among the intertidal habitats are many ‘islands’ of...
supra tidal vegetation (Paling et al. 2003) where the elevation is high enough to allow colonisation by terrestrial plants and these are quite easily seen in images produced by aerial photography.

As noted previously, survey of those sites identified as potential DMMA’s were undertaken by walking the perimeters of the upper intertidal areas. This included both the landward edge where plants typically associated with marine habitats give way to the terrestrial flora as well as the edges of channels where frequent tidal inundation permits the development of mangroves. It should be noted that the vegetation at the interface between upper intertidal and terrestrial (e.g. supra tidal islands) is not always clearly demarcated and usually there is a gradient from one community type into the other.

Whenever different vegetation associations were encountered, or substantial differences in vegetation height and cover were obvious, a GPS position was recorded and photographs were taken and the following information recorded:

- Species of trees, shrubs and herbaceous plants present and relative abundance of each species;
- Approximate height range of any trees present;
- Characteristics of the substrate (mud, sand, wet, dry, cracked surface);
- Presence of cyanobacterial mats; and
- Presence of any surface water (ponding, drainage channels)

As the vegetation height at these levels on the shore is typically low, the survey team was afforded uninterrupted views across large areas of the tidal flats allowing the survey of large areas relatively quickly.

2.2. Fauna

While there have been a significant number of studies documenting the flora of mangroves and salt marshes in the Port Hedland region, the fauna of these habitats is, by comparison, less well known.

In part, the lack of investigation reflects the general lack of resources with which to undertake comprehensive surveys of fauna in these areas as well as a general lack of taxonomic expertise on the many invertebrates associated with these habitats. While the flora of mangroves in the region is easily identified in the field using a variety of field guides, the identification of fauna is more difficult and equivalent guides are currently not available. A useful general guide to the more common mangrove fauna likely to be encountered is provided by Jones (2004).

Therefore, it is important to state that the fauna surveys undertaken as part of the current assessment were performed by the senior author of this report, who also has considerable taxonomic expertise and experience in mollusces, crustaceans, polychaetes, sipunculans and insects.

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associated with the substrate in these types of habitats throughout the Australian tropics and the wider Indo-West Pacific region.

The fauna surveys undertaken were not quantitative and no representative collections of specimens were made. The records presented here are records of fauna either observed in-situ at sites, or in some cases, cast-off exoskeletons and dead shells, and also the presence or absence of burrows of particular species.

2.2.1. Fauna of habitats surveyed at Harriet Point

At each site where a GPS position was recorded at Harriet Point, the following was noted regarding fauna habitat:

- Presence, type and degree of bioturbation (e.g. mounds and burrows); and
- Benthic fauna species present

2.2.2. Fauna of habitats surveyed at potential DMMA’s

Within potential DMMA’s, data recorded regarding fauna habitat at GPS waypoints included the following:

- The presence, type and degree of bioturbation (mounds, burrows, pellets, etc); and
- Benthic fauna species present
- Figure 2 Location of two transect lines at Harriet Point
3. Results

3.1. Mangrove, Saltmarsh and tidal flat areas at Harriet Point

Field Survey of the mangrove, salt marshes and tidal flats (saltpans) of the Harriet Point area took place on 23rd July 2007.

The location of the proposed development area on Harriet Point is shown in Figure 2, which also shows the points located along each transect where data was collected.

1) Location HP-1: lat: 20° 18'53.95"S long: 118° 33'40.72"E

The transect began near the northern edge of the mangroves on Harriet Point that are constrained by a rock revetment wall which ran in an east-west orientation at the base of the peninsula. To the south west, the mangrove was well developed with a mixture of mature *Rhizophora stylosa* and *Avicennia marina*. Both species ranged in height from 2 to approximately 4m tall. The substrate here was wet muddy sand.

At point HP-1, the mangrove changed as the height on the shore increases with the tall closed canopy giving way to a open heath scrub of low *A.marina*. The substrate was drier and sandier.

2) Location HP-2: lat: 20° 19'0.78"S long: 118° 33'52.89"E

At point HP-2 there was a well developed limestone ridge that forms a low cliff on its northern side and the slope in front of this cliff is a mixture of muddy sand with low outcrops of limestone colonised by *Avicennia marina* of between 0.5 to 2m in height (Figure 3).

On the ridge itself were small patches of terrestrial vegetation and to landward, this sloped to a salt marsh area of muddy sand overlying limestone. There were numerous areas where the limestone was exposed suggesting only a surface veneer of muddy sand.

There was little evidence of benthic fauna in this area, although there were signs of a midden with shells of the bivalve *Anadara granosa* and the potamid gastropods *Terebralia semistriata* and *Telescopium telescopium*.

3) Location HP-3: lat: 20° 19'16.35"S long: 118° 33'58.79"E

Moving from HP-2 to HP-3, the salt flat gradually changed to the open heath scrub of *A.marina* and the mangrove trees increased in both height and density as the substrate became both wetter and muddier.
At HP-3 the *A.marina* were thicket like shrubs ranging from 0.5 to about 2m in height and there are numerous pneumatophores of this species covering the substrate (Figure 4). The muddy sand was quite wet, although there was little surface water present and not much leaf litter or debris.

![Image of limestone ridge at HP-2 with *A.marina* in foreground and *R.stylosa* behind](image1)

![View south from HP-2 with bare area, terrestrial vegetation to left and samphires to right](image2)

![View from HP-2 across ridge, salt marsh, to mangroves on south western side of peninsula](image3)

![View north from HP-2 showing edge of ridge and *A.marina*, bare salt pan to left](image4)

**Figure 3 Photographs from the limestone ridge, waypoint HP-2, Harriet Point**

The fauna was dominated by many burrows of the fiddler crab *Uca flammula*, and a few small sesarmid crabs that appeared to be predominantly a species of *Parasesarma* were also noted. There were several small mounds of mud, typical of the type of bioturbation produced by the mud lobster *Thalassina anomala*, but no other corroborative evidence of this species such as remains of cast off exoskeletons.

Some of the typical burrows of the large herbivorous sesarmid *Neosarmatium meinerti* were observed here and pieces of ecdysed exoskeletons of this species were also found.
Surprisingly, no molluscs were observed in this area despite the apparent suitability for a number of species including the two potamids whose shells were observed in the midden at HP-2.

Figure 4 Photographs A. marina and pneumatophores of this species taken from waypoint HP-3, Harriet Point

Figure 5 Photographs A. marina from waypoint HP-4, Harriet Point. Pneumatophores of this species are visible

4) Location HP-4: lat: 20° 19’18.63”S long: 118° 34’0.66”E

The vegetation at HP-4 was similar to that at point HP-3 with a thicket of shrub like A. marina but not as high (ranging from 0.5 to about 1.5m). A few small C. australis (approximately 0.3 to 0.5m) were also noted (Figure 5).
In addition, the substrate was not as heavily bioturbated and not as wet as was observed at HP-3. The pneumatophores of *A. marina* are abundant and present over most of the substrate. There was very little leaf litter or other debris on the substrate.

There are very few burrows here, with *U. flammula* and *N. meinerti* present. No other fauna was recorded here.

5) **Location HP-5: lat: 20°19’19.84”S long: 118°34’2.9”E**

Waypoint HP-5 indicates the point at which the transect enters a grove of much taller trees of *A. marina* ranging up to approximately 3m in height (**Figure 6**). Here, the beginning of a canopy and the trees was much larger and the substrate was sticky, mud with some sand, with
accumulations of both leaf litter (and larger debris from the trees) among the abundant pneumatophores. There was also an amount of flotsam in this area, brought in by the tide.

The fauna here comprised *Uca flammula* and *N.meinerti*. There were also many individuals of *Parasesarma* spp. No signs of any molluscs were evident in this area which is unusual in this type of mangrove setting where a range of species could be expected on the mud, bases of the trees and up in the canopy.

- **Figure 7 Photographs of mature *R. stylosa* and *A. marina* with more developed undergrowth, Waypoint HP-6, Harriet Point**

6) **Location HP-6: lat: 20° 19’20.45”S long: 118° 34’6.28”E**

At HP-6, the transect passes the southern edge of a strip of *Rhizophora stylosa* forest with some large trees of this species ranging from 2 up to 6m tall (*Figure 7*). The trees were mature with large trunks and exhibit extensive prop root development and the development of aerial roots from lower branches. The root system was almost impenetrable. This grove of *R. stylosa* was adjacent to woodland of large *Avicennia marina* also up to 6m tall.

The substrate here was heavily bioturbated muddy sand with small pools of surface water, and some leaf litter and debris.

At HP-6 *Uca flammula* are abundant and the *Parasesarma* species is also common. Mounds of *Thalassina anomala* are present and there are mudskippers of the genus *Periopthalmus* associated with the pools of surface water. There are some burrows of *Neosarmatium meinerti* here, but the species does not appear to be common.

No molluscs were observed in this area at all and that is unusual given the presence of suitable habitat for a range of well known molluscs typically associated with this type of mangrove setting.
7) Location HP-7: lat: 20°19’20.82”S long: 118°34’8.59”E

Waypoint HP-7 is where the transect enters the tallest forest of *Avicennia marina* and represents the most seaward development of mangroves. Here the trees were large and multi-stemmed ranging in height from 2 to 7m (Figure 8) and exhibit a growth form commonly found on the Pilbara coast at the seaward edge (Semeniuk et al. 1979).

![Image of A. marina woodland and typical large A. marina at HP-7]

- Adventitious roots on base of large A. marina at HP-7
- An emergent limestone ridge on the seawards edge of the mangrove between HP-7 and HP-8

*Figure 8 Photographs from waypoint HP-7, Harriet Point. Indication of the forest of *Avicennia marina* and represents the most seaward development of mangroves*

The multi-stemmed trees produce branches that lie almost horizontal to the substrate from which smaller branches rise, almost vertically, and are spindly in appearance. The canopy was effectively closed over most of this area.

The substrate was wet, unconsolidated mud with some sand and pools of water are abundant. Pneumatophores were very abundant, suggesting the substrate always remains waterlogged.
The fiddler crab *Uca flammula* and the sesarmid *Parasesarma spp.* were both abundant and were signs of the mud lobster *Thalassina anomala* were evident. Pools of water present also support the mudskipper *Periophthalmus spp.* as well as the sesarmid *N.meinerti* (uncommon).

No molluscs were recorded in this area, however, between this area (HP-7) and the next waypoint (HP-8) there numerous specimens of the pulmonate mollusc *Onchidium daemilli* were observed. These are largely associated with the emergent limestone ridge shown in Figure 8, but also wander into the seaward edge of the mangrove.

The field survey team continued along the seaward edge of the mangrove before starting a return transect at point HP-8 (Figure 2)

- **Figure 9** General photography at waypoint HP-8, Harriet Point. The narrow fringe of the mangrove *Aegiceras corniculatum*, and thick carpet of *A. marina* pneumatophores are evident

8) **Location HP-8: lat: 20o 19’25.74”S long: 118o 34’10.37”E**

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At the seaward edge of HP-8, an area with a narrow fringe of the mangrove *Aegiceras corniculatum* was observed with specimens of up to about 2.5m in height. This narrow fringe is backed by a grove of large *A.marina* similar to those observed at HP-7.

The trees, substrate and fauna present are similar to that recorded at point HP-7.

![HP-9 closed R.stylosa with well developed prop and aerial roots](image)

![Closed R.stylosa forest HP-9](image)

![Edge of taller forest with lower scrub in background](image)

![Scrub forest of R.stylosa between HP-9 and HP-10](image)

**Figure 10 Photographs from waypoint HP-9, Harriet Point. Tree height ranged from 2-6m and exhibited strong development of prop and aerial roots**

9) **Location HP-9: lat: 20o 19'26.66"S long: 118o 34’6.87”E**

The seaward grove of *A.marina* gave way to a closed forest of *R. stylosa* at waypoint HP-9, similar to that observed at point HP-6. The trees ranged in height from 2 to 6m and all exhibited strong development of prop roots. Aerial roots are also well developed. Between HP-9 and HP-10, the height of this closed *R.stylosa* forest declines to 1.5 to 2m and becomes a scrub like thicket through which movement was very difficult.
The substrate was wet, unconsolidated mud with pools of surface water and very little leaf litter. The crabs *U.flammula* and *Parasesarma* spp were abundant with mounds of *T.anomala* and burrows of *N.meinerti* evident. No molluscs recorded at this point.

10) Location HP-10: lat: 20° 19’27.51”S long: 118° 34’4.56”E

Waypoint HP-10 marks the location along the transect which passed through a densely packed scrub of *R.stylosa*. This area was particularly difficult to negotiate as there was extensive development of prop roots. Moreover, aerial roots were well developed in these small trees which were between 1 to 2m in height (Figure 10, lower right image).

The substrate was wet, but firm mud with some sand present, no pools of surface water and very little leaf litter which, given the close packed nature of the roots here, is surprising. There was less bioturbation of the substrate and the crabs *U.flammula*, *Uca capricornis* and *Parasesarma* spp were observed, but were not as common as at HP-9.

![Mixed transitional area between HP-11 and HP-12](image)

![Transitional area with *R.stylosa* and *A.marina*](image)

- **Figure 11 General photography showing the transitional area in vegetation between closed scrub of *R.stylosa* and the closed forest of *A.marina* between HP-11 and HP-12, Harriet Point**

11) Location HP-11: lat: 20° 19’27.51”S long: 118° 34’4.56”E

At HP-11, the transect passes through a transitional area between the closed scrub of *Rhizophora stylosa* and the closed forest/scrub where *A.marina* was dominant (Figure 11). The transect was run through this mosaic of mixed *R.stylosa* and *A.marina* to waypoint HP-12.

The substrate is much firmer, although still wet, with a few surface pools and there are now pneumatophores and some leaf litter and other debris.

The fauna is similar to that seen throughout, *U.flammula*, *Parasesarma* spp, *N.meinerti*. No molluscs.
12) **Location HP-12: lat: 20°19′28.89″S long: 118° 33′58.14″E**

As noted above, the area around HP-12 is a transitional area in the vegetation between closed scrub of *R. stylosa* and the closed forest of *A. marina* (Figure 11). The substrate and fauna present is also similar to that described for HP-11.

13) **Location HP-13: lat: 20°19′23.62″S long: 118° 33′57.55″E**

The transect emerges from *A. marina* scrub at HP-13 to an area where mangroves gradually give way to samphires. The trees here were composed primarily of *A. marina* at approximately 1.5m in height with some *C. australis* also present reaching approximately 1m.

The substrate was drier, with little leaf litter and burrows of *N. meinerti*. Between HP-13 and the point HP-2 the area consisted mostly *A. marina* scrub with some samphires around HP-2 (Figure 12).

![Edge of bare tidal flat with A. marina and C. australis at HP-13](image1)

![Typical samphires H. halocnemoides near HP-2](image2)

**Figure 12 General photography illustrating typical habitat near waypoints HP-13 and HP-2, Harriet Point**

### 3.2. Mangrove Salt marsh and tidal flat areas in and near potential DMMA’s

The following section provides a summary of the data recorded at each of the potential DMMA’s that were physically surveyed: Areas A to D and G to I (Figure 1).

Areas E and F were not physically surveyed, primarily because they lie at distances from proposed dredging that would be economically prohibitive. In addition they appeared to be similar to the areas adjacent areas assessed from a tour by vehicle and aerial photography.
Figure 13 Boundaries of Area A and corresponding data collection points

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3.2.1. Potential DMMA A

The boundaries of Area A are shown in Figure 13 and also included on the figure are the locations where information was recorded.

- Figure 14 Photographs taken from the pedestrian footbridge across the conveyor system
The area was surveyed on the morning of 24th July, 2007.

There is a pedestrian footbridge across the conveyor belt linking the roadway to the mangroves areas on the western side of the conveyor belt and this afforded a useful platform to photograph the general area. These are shown in Figure 14.

The view to the north is across a bare tidal pan and a fringe of samphires and the mangroves fringing the large channel that was blocked by construction of the causeway to Finucane Island. The area to the west shows an area occupied by the mangrove species *Avicennia marina* with an increasing density of these shrubs approaching the creek channel further to the west. There was some evidence of seepage of tidal water under the road and conveyor system here as the area is positioned on top of an anabranch of the tidal creek located east of the causeway.

The view to the southeast and south shows *A.marina* in the foreground and in the distance samphires, supratidal islands, the hinterland and the HBI plant in the distance.

1) **Location A-1: lat: 20° 20’10.87”S long: 118°32’ 59.19”E**

Moving to the north along side the conveyor belt, which is elevated at approximately 2m above the tidal pan, the substrate was quite wet, although there is no pooling surface water observed. The substrate was also heavily bioturbated with small mounds and several fiddler crab burrows (Figure 15). At this height on the shore, on these mostly bare tidal pans, the fiddler crab present was *Uca elegans* and examination of cast-off exoskeletons scattered across the pan supports that determination.

There was no evidence of any other burrowing infauna, and no evidence of any epifauna in this area.

The flora was dominated by a mixture of the mangrove *Avicennia marina* growing as shrubs of up to 2m in height interspersed with the samphires. The salt marsh here were dominated by the samphire species *Halosarcia halocnemoides* ssp. *tenuis* with *Halosarcia indica* present in areas where the substrate was drier.
Between this waypoint and the next station (Location A2) the substrate rose slightly in elevation and became drier, often cracking in places. This area had a heavier density of samphires, and among these were patches of cyanobacterial mats (Figure 16). Along side the base of the rock revetment for the conveyor system was sparse *A. marina* growing at the base (Figure 17).
2) Location A-2: lat: 20° 19’54.151"S long: 118° 33’ 03.52”E

On approach to Location A-2, the substrate fell lightly in elevation and became much wetter. The samphires gave way gradually to *Avicennia marina* and *Ceriops australis* forming a low, sparse, mangrove scrub (Figure 18). This gradually increased in density and height (up to 1.5m) toward the creek bank, well north of the boundary of the area surveyed.

The mud was bioturbated with many burrows of *Uca elegans* and the distinctive burrows of *Neosarmatium meinerti*. Comparitively, the large, sesarmid crabs tend to be clustered around the bases of the larger mangrove trees. These burrows were the only evidence of fauna here, and the substrate had no leaf litter or other detritus other than leaves and twigs that lie under the mangrove shrubs. The concentration of *N.meinerti* burrows under the trees in proximity to the available leaf litter is consistent with the ecology of this species (Emmerson 2001) which feed largely on fallen mangrove leaves (Dahdouh-Gebas 1999).

![View toward the east](image1.jpg)
![View to east](image2.jpg)
![View south](image3.jpg)

- **Figure 18 Photographs taken Location A-2**
3) **Location A-3: lat: 20° 19’ 51.26”S Long: 118° 32 57.97”E.**

Continuing northwest from Location A-2, the transect covered bare tidal flat with clumps of samphires before reaching the edge of a creek anabranch running south (approximately parallel to the conveyor belt). At this point the influence of tidal water produced a wetter substrate and the mangroves, *A.marina* and *C. australis* increased in height and density to the edge of the creek bank. This creek bank was not visited, however, *Rhizophora stylosa* was visible and identified.

*Avicennia marina* was estimated to reach approximately 1.5 m (max) height in this area with *C. australis* rarely more than 1m in height. The thick bases of the trees of both species suggest that they are not recent arrivals, although, much younger trees of both species were also present including recently established seedlings. There are a few samphires here, but scattered *A.marina* were the dominant species (**Figure 19**).

The mud is extensively bioturbated in this area by *Uca. elegans*, including the distinctive turreted burrows of the male of this fiddler crab.

**Figure 19 Photographs taken Location A-3**

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4) Location A-4: lat: 20°19' 55.39"S Long: 118°32' 55"S

Location A-4 is very similar to A-3, running further to the south-west, roughly parallel to the creek. There was a small channel here draining into the creek and the substrate, as a result, was marginally wetter with very heavy bioturbation by burrowing of *Uca elegans*. Patches of *Neosarmatium meinerti* burrows, typically associated with the bases of the larger *A.marina* were identified along with some scattered *C. australis* (approximately 0.5m in height). Between this point and the conveyor belt (eastward), the substrate was wet and bioturbated.

Largely bare of leaf litter and other detritus, this area was colonised by patches of *Halosarcia halocnemoides* spp. *tenuis* and the occasional *H. indica* on slightly drier patches of substrate (Figure 20).

![View South](image1.png) ![View South east](image2.png)

![View East](image3.png) ![View North north west](image4.png)

**Figure 20 Photographs taken from Location A-4**

5) Location A-5: lat: 20°20'06.8"S long: 118°32’ 53.41”E

At Location A-5, it was necessary to move slightly back to the south east in order to avoid a large channel of the creek and a dense stand of fringing mangroves. At this point, the conveyor is relatively close and the pedestrian footbridge can be seen to the south-east (Figure 21).
intervening area is largely comprised of scattered mangroves (*A.marina* dominant), a few samphires, large areas of bare tidal flat with scattered areas of bioturbation produced by *U. elegans*.

- **Figure 21 Photographs taken from Location A-5. The conveyor can be seen eastward and pedestrian footbridge visible in the distance to the south-east**

6) **Location A-6: lat: 20° 20'10.729" long: 118° 32’ 54.733”**

The need to avoid a very large channel lined with mangroves (*A.marina, C. australis* and a few *R. stylosa*) brought the survey team back to mark Location A-6 at a point very close to point A-1. Here, the channel sloped to the west to the mangrove creek and contained pools of water. The wetter substrate then extended back toward A-1, however, the vegetation became gradually thinner and tree height reduced with both drier substrate and higher in elevations (*Figure 22*).

A few mudskippers, *Periophthalmus* spp. were noted and several *Uca flammula* were present on the wetter margins of the channel. Towards the east are areas bioturbated by burrowing *U. elegans*.
7) Location A-7: lat: 20° 20’17.9”S long: 118° 32’ 45.09”E

A deeply cut channel was encountered at Location A-7 and the substrate was comprised only of a thin veneer of mud and sand over limestone (Figure 23). Patches of limestone were emergent and the flora was sparse, comprised of only a few *A.marina* to the east. To the south was a low scrub of mangrove and samphires with few, isolated and larger, *A.marina*.

Very little bioturbation was evident within the general area, however, dense aggregations of *U. elegans* burrows were noted within several small depressions where the overlying mud was thicker.
8) **Location A-8: lat: 20° 20’022”S long: 118° 32’ 40.354”E**

At Location A-8, the survey team crossed a bare pan with very little vegetation or bioturbation and then turned south upon meeting a shallow creek channel.

The substrate is sandy with a little mud and was wet on the day of survey. The vegetation here is very sparse with a few scattered mangroves of *A.marina* and *C. australis* (Figure 24). There is very little bioturbation and no fauna was noted in the dry bed of the channel.

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**Figure 23 Photographs taken from Location A-7. A deeply cut channel is evident at this location**

Substrate at Location A-9 was wet with *U. elegans* burrows present and scattered *A. marina* and samphires also observed (Figure 25). Moving further south the substrate became much wetter and heavily bioturbated with *U. elegans* burrows. Some *N. meinerti* burrows were also observed around the bases of the larger mangrove trees.

![Figure 24 Photographs taken from Location A-8](image-url)
Figure 25 Photographs taken from, and near to, Location A-9

10) Location A-10: lat: 20° 20'28.9"S long: 118° 32' 31.52"E

As illustrated in Figure 26, a small area of terrestrial vegetation atop a supratidal island at Location A-10. The area was really a mosaic of lower intertidal flat, salt marsh plants (mainly samphires), scattered mangroves and a few elevated areas with terrestrial vegetation.

These elevated areas contained occasional limestone outcroppings, however, much of the increase in elevation was apparently due to the presence of a low dune or chenier of sand. Upon further assessment, this chenier which contained the dead shells of the bivalve mollusc *Anadara granosa*. On first inspection the mounds looked like middens, however they covered too large an area and comprised of a homogenous mixture of both sand and shell suggesting they have been formed by winds and waves generated during cyclones.
11) Location A-11: lat: 20° 20’37.71”S long: 118° 32’ 34.75”E

At Location A-11, the tidal pan was adjacent to mixture of supratidal islands and broad channels that were sandy and dry. These areas appeared to be only periodically flooded.

Scattered mangroves were present, dominated by *A. marina* with a few small *C. australis* also present. There were few signs of fauna and the fiddler crab *U. elegans* was not common here (Figure 27).
12) Locations A12-A14

Locations A-12 to A-14 were positioned using a GPS reading marked from a vehicle and were not surveyed physically by the field team.

3.2.2. Potential DMMA B

Potential DMMA B is a small bay on the eastern end of Finucane Island and is already surrounded by the infrastructure built on the island by BHPBIO (Figure 1). The area has been identified as a potential DMMA and although relatively small in area, the bay is steeply sloping and therefore could utilise a large volume of fill in reclamation efforts. Specifically, deposition of dredged material in this area may be utilised to bring the level of the ground behind the rock revetment (lining the bay) further toward the existing ship loading facilities.

A more detailed view of the Bay and the boundaries of the proposed disposal ground are illustrated in Figure 28.
Figure 28 Boundaries of Area B and corresponding data collection points

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The bay, although small, is steeply sloping on the landward side and the upper part of the beach comprised of coarse sands and detritus that has been brought in by the tide. The highest tides may reach to the rock revetment at the back of the beach and the presence of a steep slope and coarse sand suggests that wave action is sufficient to prevent the settlement of any fine silts or mud.

A natural outcrop of rock was located at the northern end of the bay forming an intertidal reef, however, the position within the intertidal zone suggests that it frequently exposed and therefore contains no significant development of encrusting fauna (Figure 29). The type of fauna typically associated with this type of reef at this height on the shore has been reasonably described in general terms by Jones (2004) and apart from a few hardy organisms capable of tolerating extreme temperatures the majority of fauna was confined to the undersides of boulders and deep crevices where these exist.

To the East on the day of survey, the tidal flat at the foot of the beach was exposed and comprised sand with some patches of mud. The single mangrove shown in Figure 29 (top right picture) is an Avicennia marina and is likely sited very close to Mean Sea Level. Patches of mud and a considerable number of pieces of debris, mostly of anthropogenic origin, were also noted. No marine flora was evident on the tidal flat apart from those mangroves shown in Figure 29. The fauna of the tidal flat were species adapted to living on sandy substrates, with the majority of which concentrated on, and near, those areas where rivulets of sea water run out of the beach on the ebbing tide.

At the southern end of the Bay was a small grove of A.marina consisting of about a dozen, well developed trees. According to local sources, these have established themselves within in the last decade or so. On the back of the beach a small patch of Ipomea brasiliensis and Spinifex longifolus was also identified (Figure 29).

The proximity of the ship loading berth, the stockpiles and conveyor system suggest that it is unlikely this beach is utilised by marine turtles for nesting purposes. The rock revetment at the back of the beach effectively sits on the area that, historically, may have been used for nesting prior to the installation of these existing facilities.

No evidence of any turtle tracks was found during a cursory examination on the day of the survey.
3.2.3. Potential DMMA C and DMMA D

DMMA C and DMMA D are also illustrated in Figure 1 and the following is presented as a summary of these areas based upon a field survey at each location similar to that undertaken at DMMA A and DMMA H.

Initially the survey team was requested to treat the entire area of C and D as one combined area, including substantial and intertidal areas that lie between them. As the area is largely mangrove dominated, and the channels appear to provide an important drainage function, the area was not included in the area to be considered for a potential disposal site, thus splitting the potential areas into two, site C to the west, and site D to the east (Figure 1).
Closer examination of Figure 1 indicates that the area between DMMA C and DMMA D contains a series of mangrove lined tidal channels which traverse the entire area between the roadway and rail line and the larger arm of Stingray Creek to the south. These channels are unusual in that they are long, relatively straight and are also braided and therefore do not appear to readily conform to the typical meandering channels seen on the upper intertidal areas elsewhere in the Port Hedland tidal creek system.

The reasons for the different creek channel morphology are the consequence of modifications of the channels undertaken in the 1990’s to allow the entry of tidal water (Piggott pers. com) and this work has led to the establishment of some areas of mangroves along the channels. It is likely the channels act to periodically drain large volumes of water from the areas of the lease site, and in particular, the discharge of storm water that collects during cyclones and thunderstorms into the two large artificial lagoons created during the construction of the causeways supporting these transport corridors (i.e. north of the road and railways).

At the time of survey, the lagoon positioned immediately north of Area I held a substantial volume of water and appears to be a permanent wetland now as a consequence of a permanent inflow of water at its westernmost end. This assessment is based upon the presence of very well developed individual trees of *A. marina* to a height of 5m, exhibiting a growth form consistent with an abundance of freshwater.

More than 15 species of wetland birds were also observed in this relatively small area. This lagoon is connected through a narrow series of culverts and open channels with the second lagoon that lies immediately east of the road bounding Area I. This lagoon was mostly dry, but appears to periodically receive large volumes of storm water both from the lagoon to the west and run-off from surrounding areas. Apparently, all of this water discharges through culverts under the road and railways into the upper sections of the channels that dissect the intertidal flat between sites C and D.

The presence of a large stand of relatively tall (for this height on the shore) *A. marina* in the upper reaches of these braided channels is also suggestive of a substantial input of freshwater either through groundwater seepage from the lagoon on the other side of the causeway, and/or discharges through the culverts into the braided channels (Figure 30).
The braided nature of the channels suggests periodic and substantive inputs of both water and sediment into the channels through the culverts from the lagoon system. Signs of erosion and instability are observed in this area and it appears that these erosional event/s were sudden. The roots of many *Avicennia marina* have not been gradually exposed, but sediment to a depth of more than 20cm has been rapidly stripped away exposing pneumatophores and cable roots. The plants which have survived have re-grown their cable root system and pneumatophores just under the new surface. These erosional events appear to be infrequent, and the status of the cable root systems on most of the affected trees suggests there has been only one major event (*Figure 31*).
Erosion of *A. marina* on bank  
Infilled small channel with dead tree stumps

- **Figure 31** Photographs of channels through lagoon system between Area C and Area D. Signs of erosion and instability are evident with pneumatophores and cable roots of *A. marina* exposed to a depth of more than 20cm

It is possible that either episodic flood events (e.g. cyclones, thunderstorms) may cause a large volume of storm water to run off the site upstream, and/or storm surge generated waves are responsible for these rapid erosional events.

In addition to erosion there was also evidence of infilling of small channels in this same area, and the subsequent death of trees lining these channels. These areas, however, do not appear to be orientated in any relationship with the aforementioned areas where past erosion is evident.

Throughout the, apparently unstable, braided channel area are numerous seedlings of *A. marina* with *Ceriops australis* also present. The majority of the seedlings appeared healthy and reasonably well established with many estimated a > 1 year old (thickness of base and number of leaf pairs). The area is not densely colonised, however, and the density of seedlings does not appear to be restricted by lack of suitable habitat, but instead, is probably a function of recruitment rate (**Figure 32**).

**SINCLAIR KNIGHT MERZ**
Successful colonisation by mangroves of different ages

Figure 32 Photographs of *A. marina* and *C. australis* seedlings within the braided channel, between Area C and Area D

Finally, a layer of limestone was noted forming a bar across the largest creek channel and links a small ‘island’ of limestone outcrop with the larger limestone ridge that runs roughly east-west on the southern side of the channel.

3.2.4. Potential DMMA C

The boundaries of Area C where surveyed on foot and are shown in Figure 33. The northern boundary of the site is formed by the causeway and the southern boundary is defined by the substantial limestone ridge running east-west between this area and the main channel of Stingray Creek. The eastern boundary was defined by the survey team taking a route between the ridge to the south and the causeway and thereby avoiding the larger drainage channels which drain toward the large braided channels. The Team also turned to the west, near the causeway, in effort to avoid a large patch of well developed mangroves, apparently supported by freshwater inputs from the northern causeway lagoon. The area defined by these boundaries is roughly triangular in shape, and in general is almost devoid of vegetation.

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- Figure 33 Boundaries of Area C and corresponding data collection points
The substrate is wet over much of Area C, however, does not support much vegetation, and there is little evidence of fauna. Sparse *Uca elegans* burrows were encountered during the traverse along the eastern boundary, in close proximity to the mangroves further east, however, no evidence of any *Neosarmatium meinerti* was found.

Traverse of the eastern boundary of Area C revealed a number of dead mangroves along their eastern edge (*Figure 34*, top right image). Smothering appeared to be the most likely cause of death and the survey team noted that the substrate between the causeway and the limestone ridge to the south was of uneven height (slightly elevated to the west). Consequently, some sediment appears to have moved in an easterly direction and buried the bases of the mangroves along the braided channels. This is unsurprising as mangroves are typically found in areas where sediment is being deposited and their presence often enhances the rate of sedimentation. If, however, the rate of sedimentation is great enough to completely bury pneumatophores then species such as *A. marina* may often be killed.

The current difference in height does not appear to be substantial and the survey team concluded there is no clear evidence of a continuing problem of movement of material further eastward. It is not known whether the area inside Area C has been used to dump material in the past, but if some fill has been deposited there, it could explain the source of the unstable sediment that has moved eastward.

View north from limestone ridge at point C8  
View south from causeway point C1, note dead trees along edge of mangrove stand
3.2.5. Potential DMMA D

The boundaries of site D were surveyed on foot and are shown in Figure 35. Area D is roughly elliptical and is defined on the northern side by the road and rail causeway that curves in a south easterly direction.

The southern boundary of the site was determined by a traverse across the intertidal zone that avoided all major drainage channels and any of the smaller channels that had substantial stands of mangroves lining them. Between points D7 and D4 the survey team avoided the upper reaches of the meandering channels of Stingray Creek. The survey team walked from point D4 to point D1 roughly parallel to the easternmost channel that drains the northern causeway lagoons. This channel is unusually straight, and is lined with mangroves in varying densities.
Figure 35 Boundaries of Area D and corresponding data collection points
Area D is dominated by *A. marina*, but there are a few *C. australis* and *R. stylosa* right on the channel bank. Furthermore, from D4 to D1 between the transect and the creek bank several areas where identified where the substrate was wet with young trees and seedlings present. This suggests that the area is actively colonised by *A. marina* and to a lesser extent *C. australis*. The area, however, does not yet support a high density of these species but does appear suitable for further growth and maturity. Therefore, it is suggested that the apparently low density is only limited by the rate at which propagules are reaching the area.

It should be considered that the establishment of any disposal ground in this area would require the construction of bunds which require be sitting at a safe distance from the creek banks (i.e. reduce potential for erosion and undercutting of bunds). As there was some evidence that the channel configuration is not stable, then a buffer zone between the existing creek bank and the edge of any potential bunded areas would be highly recommended.

Very little flora was present inside the boundaries of the area defined as Area D. Some samphires, mostly *Halosarcia halocnemoides* and a few isolated small shrub-like *A. marina*, were noted, but for the most part the area consisted of bare tidal flat. There were some *A. marina* growing along the base of the causeway where they are apparently receiving some freshwater input (Figure 36).

Little evidence of fauna was encountered in the area. Typical patches of the burrows of *Uca elegans* was were observed, however, they were primarily confined between the creek banks and the southern boundaries as this is where the substrate is wet often enough by the tide. Similarly, the larger sesarmid herbivorous crab *Neosarmatium meinerti* was only present in locations where the mangroves were dense enough to provide sufficient leaf litter. These areas lie between the southern boundary and the creek banks.
3.2.6. Potential DMMA E and DMMA F

No detailed survey was undertaken for either area E or Area F as both areas could be easily observed from the roadways adjacent to them. The survey team, therefore, used the assessments from the other sites that were surveyed by foot and determined the best footprint for potential DMMA’s in each area from the aerial photography that was available.

The alignment of boundaries using the aerial photographs followed the same approach used in the field surveys, i.e. placing boundaries in areas where they did not cross the larger drainage channels draining the tidal flat. Care was also taken to place boundaries far enough from major channels to permit a buffer zone between the creek banks and any potential bund wall (Figure 27 a & b).

Examination of the flora through binoculars from the roadways and on the aerial photographs indicated that at both sites the flora had similar characteristics to those surveyed at areas C and D. Specifically, *A.marina* dominated close to the creeks where the substrate was wetter and declining in density and size with distance from the creeks. Few *C.australis* were present.

Samphires were located within area F as well as scattered mangroves. A relatively small area of bare tidal flat, compared to areas C and D, was also identified and delineated.

Observations of Area E, however, indicated a very large central area with very little vegetation, similar in aspect to Areas C and D where the vegetation is confined to a narrow margin along the creek channels (i.e. relatively frequent tidal inundation).

In the absence of in situ field data, no conclusions can be made regarding the fauna present within Areas E and F, however, it is assumed that the same species are be present and would be located in similar settings to those observed at the other intertidal sites.

**SINCLAIR KNIGHT MERZ**
Figure 37a and b: Boundaries of Area E, Area F and corresponding data collection points.
3.2.7. Survey of Potential Disposal Ground Area G

The boundaries of the proposed area G are illustrated in Figure 38 and were determined after walking this area, taking particular are to avoid areas considered to be sensitive. It apparent that the actual area proposed is quite small relative to the total area surveyed. This is due to the fact that the area represents the best assemblage of the mid-and upper intertidal flora and fauna yet encountered during the surveys of the harbour. Hence, avoidance of areas of significance greatly reduced the area where it might be possible to place a DMMA.
Figure 38 Boundaries of Area G and corresponding data collection points
The site is also somewhat unique as it has a relatively steep and high limestone ridge along the southern edge that is broken in two with the eastern end of the ridge forming a circular mound that is probably an island on very high tides (Figure 39). This ridge is more than 2.5m high on its western extremity and affords a good view of the surrounding area. Photographs taken from this ridge indicate that the mangrove assemblages and salt marsh assemblages are both well developed and extensive. From this vantage point the view to the west shows the main creek channel and the presence of thick stands of *A. marina*, *R. stylosa* and a fringe of *C. australis* at the landward edge. The relatively narrow zone occupied by these assemblages is not generally unusual, however, the area behind these dense stands is not locally common. Specifically, almost all of the tidal flat area is quite heavily vegetated, which is apparent from the corresponding photograph in Figure 39 (looking eastwards along the ridge).

It is not clear whether the relatively well-developed vegetation cover has anything to do with freshwater run-off and/or seepage from the limestone ridge, although the presence of well developed specimens of *A. marina* as a fringe along the base of the ridge suggests there is such an effect.

However, the salt marsh showed the presence of several different assemblages and these extend almost right across the tidal flat, gradually transitioning to an *A. marina* dominated mangrove stand that increases in height and density toward the creek on the northern side (Figure 39). It is unlikely that the almost continuous cover of vegetation across the tidal flat would be a consequence of the seepage of water from the limestone ridge. It is therefore suggested that there are other factors that lower soil salinities in the middle of the tidal pan here.

Another consideration is that this area is cut-off by most high tides through a low lying area to the east of the limestone ‘island’ and it is clear the area is very difficult to reach in a vehicle. There are virtually no vehicle tracks in this area and it is tempting to speculate that at least some of the differences between the extent of vegetation at this site when compared with all the other sites visited are due to an absence of damage from vehicles.

There was a narrow band of bare tidal pan in this area which ran roughly east-west and lying between the mangroves and the salt marshes. At least on the western edge of where the salt marshes give way to the bare flat there are well developed cyanobacterial mats present.

In addition, the area was well populated with fauna and the burrowing crabs *U. elegans* and *N.meinerti* were abundant over most of the vegetated intertidal zone. Several burrows among the heavily vegetated salt marsh patches was unusual indicating that there may be another species of sesarmid crab present in this area. The area is also frequented by euros and both tracks and individuals were sighted.
View from end of ridge

Salt marsh and mangroves

Very little bare tidal flat

Looking east along the ridge

Cliff face of ridge, supra tidal vegetation in foreground

Salt marsh foreground, mangroves in the distance
Samphires are still relatively dense

Looking toward limestone ridge from northern boundary

Relatively small bare tidal flat

Cyanobacterial mat present in this area

Figure 39 Photographs taken from various waypoints along the transect within Area G

While there is an unusually well vegetated intertidal zone at the western end of Area G, there is also a bare tidal flat present, however, it is not very wide (Figure 39, lower left image). This flat contracts in width near its eastern end and becomes so narrow that the use of the area as a potential DMMA is considered unpractical.

3.2.8. Potential DMMA H

On the southern side of the harbour between Wedgefield and Stingray Creek is a very large peninsula that is mostly intertidal, although there are substantial areas of supra tidal islands closer to Wedgefield. This area was surveyed on foot and the boundaries of the potential disposal ground are shown in Figure 1 and Figure 40.

The survey of boundaries by foot traversed the line between points H1 and H14 and then the boundaries were extended to point H15 after examination of the area by vehicle and from examination of the aerial photography.
Figure 40 Boundaries of Area H and corresponding data collection points
1) Location H-1: lat: 20° 21′13.32″S long: 118° 35′ 30.18″E

To the east the area was dominated by mangroves increasing in height and density. The mangroves are primarily A.marina, up to 1.5m in height with a few C.australis also present (Figure 41).

The area to the west was dominated by samphires, primarily Halosarcia halocnemoides, and the substrate at point H-1 is quite dry. Around the bases of some of the larger A.marina trees were burrows of Neosarmatium meinerti.

![A.marina and samphires at H1](image1)

![C.australis in foreground with samphires, A.marina in background and supra tidal islands in distance](image2)

- **Figure 41 Photographs from waypoint H1, Area H. A. marina, C. australis and samphires are evident**

2) Location H-2: lat: 20° 21′6.78″S long: 118° 35′ 30.36″E

Further north at waypoint H-2, the habitat remained a mixture of samphire (dominant) but with scattered A.marina and C.australis sufficient to class this as a mixed area of mangroves and samphires. The substrate was consistently dry and it was only to the east of the boundary where the substrate became wetter and the mangrove stands began to increase in density and height (Figure 42).

There were a few scattered N.meinerti burrows and no evidence of U.elegans.

A mangrove channel was observed north of waypoint H-2 and the boundary turns westward to avoid this area.
3) Location H-3: lat: 20° 21’ 11.7”S long: 118° 35’ 16.8”E

The immediate area at waypoint H-3 was a mixture of samphires and scattered mangroves of both *A.marina* and *C.australis*. The substrate was dry and there are very few burrows of *N. meinerti* with no evidence of *U. elegans*.

The area to the north of H-3 was bounded by a mangrove lined channel continuing to the south-west to avoid the denser stands of mangroves lining a smaller channel. The area to the south and south-west quickly transitioned into bare tidal flat.
4) Location H-4: lat: 20° 21’ 11.7”S long: 118° 35’ 16.8”E

At H-4, the vegetation had given way to bare tidal flat to the south, while on the northern side of the boundary there is a small channel that is lined with mangroves of both *A.marina* and *C.australis*.

The substrate is quite wet here and there are patches of substrate with numerous burrows of *Uca elegans*. There are also many patches with distinct cyanobacterial mats (Figure 44).

5) Location H-5: lat: 20° 21’ 14.64”S long: 118° 35’ 9.72”E

The survey team skirted the edge of the mangrove lined channel to the north at H-5. The edge of this channel was bare tidal flat with scattered, shrub-like *A.marina*. To the south the area was bare tidal flat with occasional patches of *A.marina* (Figure 45).
The wetter areas of the bare tidal flat are colonised by *U.elegans* and there were numerous burrows of *N.meinerti* around the bases of the *A.marina* on the northern side of the boundary.

![View to the south-west across bare tidal flat, supra tidal islands in distance](image1)

![View on north side of boundary showing *A.marina* along channel and extensive bioturbation of substrate](image2)

**Figure 45 Photographs from waypoint H-5, Area H. Supra-tidal islands can be observed distant from this position**

6) **Location H-6: lat: 20° 21' 10.26"S long: 118° 35' 7.74"E**

At site H-6, the field survey moved along the edge of the channel and could then turn back towards the north-east.

The area to the west is mangrove lining the upper reaches of the large channel, while to the south west and south the habitat is bare tidal flat (**Figure 46**).

The area was very similar to H-4 and H-5 in character.

![View from H-6 to the south west across tidal flat with supra tidal islands in distance](image3)

![View to the north from H-6 showing edge of mangrove lined channel and extensive bioturbation](image4)

**Figure 46 Photographs from waypoint H-6, Area H, illustrating the tidal flat and edge of the tidal mangrove lined channel at this position**
The bare tidal flat here does have well developed patches of cyanobacterial mats and examples of these are shown in Figure 47.

![Figure 47 Photographs from waypoint H-6, Area H, showing typical cyanobacterial mat](image)

7) Location H-7: lat: 20° 21’ 1.2”S long: 118° 35’ 13.08”E

The boundary at waypoint H-7 was extended to the north east from point H-6. From the aerial photograph ( ), it appeared the boundary could continue in this direction for some distance, however, the area immediately to the north of H-7 appeared to contain a stand of small mangroves. As a result, a decision was made to change direction to the north west in order to skirt around this area.

The areas surrounding waypoint H-7 was predominantly bare tidal flat to the west, north and south west. There was very little vegetation except for the mangroves lining the creek channel to the south and east (Figure 48). The tidal flat had some cyanobacterial mats present with patches of bioturbation created by the burrowing of *U. elegans*.
8) Location H-8: lat: 20° 20’ 54.42”S long: 118° 35’ 6.78”E

In order to avoid an area of scattered mangroves to the north of H7, the survey team at H-8, changed direction to the north west. The area at H-8 had scattered mangroves to the east of the boundary, and to the west there is a relatively narrow area of tidal flat with scattered samphires between this point and a large stand of mangroves to the west (Figure 49).

The substrate was wet, and with patches of the burrows of U. elegans present.

![View toward south west across tidal flat with scattered samphires](image1)

![View to the north west from H-8](image2)

Figure 49 Photographs from waypoint H-8, Area H, with relatively narrow area of tidal flat with scattered samphires

9) Location H-9: lat: 20° 20’ 47.16”S long: 118° 35’ 4.38”E

The transect boundary at waypoint H-9 transitioned the area to the eastern mangrove lined channel. The area was unusual in the context of the area surveyed previously in that the mangroves to the east of the boundary consisted of scattered C. australis. Specimens here were older and more abundant than observed elsewhere at this height on the shore (Figure 50).

A. marina was still the dominant species lining the upper reaches of this creek, however, the presence and distribution of the C. australis suggests that this area may have had a denser stand of this species at some time in the past.
Between waypoints H-9 and H-10, the field survey team avoided heading in a more north easterly direction to skirt the patch of *C. australis* (Figure 51).

10) **Location H-10: lat: 20° 20' 36.66”S long: 118° 35’ 9.42”E**

Location H-10 lies on the southern edge of a low limestone ridge that runs roughly south west to north east. Specifically, H-10 lies about mid way along the long axis of this ridge.

In addition to the presence of limestone outcrops there were also extensive deposits of the shells of the bivalve *Anadara granosa*. These could be evidence of a midden, but as they are mixed through a thick layer of quite coarse sand it is more likely they were deposited here during a cyclonic event and the structure would be more correctly termed a chenier.
The limestone ridge is vegetated with similar terrestrial vegetation to that found on other supra tidal islands, but due to the extra elevation also supports a few trees and larger shrubs (Figure 52).

Figure 52 Photographs from waypoint H-10, Area H. Mixed vegetation, samphires and supra-tidal vegetation are evident

The transect boundary turns again at H-10 and runs along the ridge in a south westerly direction to H-11. The area on intertidal zone to the north of the limestone ridge was not surveyed in any detail as it is quite well vegetated with A.marina and the survey team believed this area should be avoided.

11) Location H-11: lat: 20o 20’ 45.54"S long: 118o 34’ 56.58”E

The edge of the area influenced by the large drainage channel to the west was encountered at waypoint H-11. Here, the substrate was dry but samphires increased in number and scattered A.marina appear. The mangroves increased in density and height from this point westwards as the channel of the major creek is approached.

There was a well used track here running north-south along the edge between the samphire dominated tidal flat to the east. Wetter areas of mangrove dominated tidal flat were present to the west.

Evidence of cyanobacterial mats was noted in this area along with some burrows which appear to be occupied by the sesarmid crab N.meinerti (Figure 53).
12) Location H-12: lat: 20° 20’ 59.4”S long: 118° 35’ 1.14”E

At point H-12, the boundary followed a small channel leading into the large creek to the west. The mangroves to the west of here were shrub like *A.marina* to about 1.5m in height. The road here apparently acts as a boundary between this area and the tidal flat to the east of point H-12 which was mostly bare with a few scattered samphires (Figure 54).
West of H-12, *A.marina* on channel  
View north from H-12  
View to south east from H-12  
View south of H-12 along track

**Figure 54 Photographs from waypoint H12, Area H. The road apparently acting as a boundary between the mangrove area and tidal flat**

13) **Location H-13: lat: 20° 21' 21.78"S long: 118° 34’ 54.72"E**

H-13 was the last point surveyed by foot on this transect. The mangroves were well developed to the west side of the boundary and the eastern and southern areas were a mixture of intertidal flat and supra tidal islands between here and Wedgefield.

The area has evidently suffered from the effects of indiscriminate 4WD driving across all types of vegetation with literally dozens of different tracks criss-crossing the supra tidal and intertidal areas. Only those areas which are too wet below the surface have been avoided (**Figure 55**).

The area between here and Wedgefield may also characterised by a large array of debris and it was clear that many of the visitors dump both household and industrial refuse in this area.
3.2.9. Potential DMMA I

Area I (Figure 56) lies on the eastern end of the stockpile area. The area appears to be a former reclamation site, although it lies at a level of more than 1m below that of the surrounding rail loop and yards.

Figure 55 Photographs from waypoint H-13, Area H. The area has been impacted by indiscriminate 4WD driving across all types of vegetation
Figure 56 Boundaries of Area I and corresponding data collection points

Figure 56

Proposed BHP BiO RGP5 Spoil Location Area I

* Figure 56 Boundaries of Area I and corresponding data collection points*
Currently the site is mostly bare with a few patches of terrestrial colonising flora and there is no evidence of an intertidal area for use as a disposal ground (Figure 56). It does appear, however, that perhaps this did exist at some time in the past. This is supported by the fact there is a low lying area directly north (Figure 57) that appears to be occasionally reached by salt water. This area is now a permanent lagoon wetland supporting mangroves, reed beds, freshwater macrophytes and a large number and variety of waterbirds, some of which were nesting.

The mangroves (*A.marina*) were at the western end of the lagoon and appeared benefit from the constant discharge of freshwater as the trees here are up to 5m tall. Area I, which has been highly modified by the permanent inflow of freshwater had the highest diversity of fauna observed at any site during the survey and serves as a reminder of the impact on intertidal flora and fauna from low rainfall conditions in this region.

The apparent reclamation of Area I has created a dam which retains water in the lagoon to the north that otherwise would have drained through the former intertidal zone to the sea. The only path for water to leave the lagoon now is via a narrow channel and culvert at the eastern end, under the roadway and through a connection with a second lagoon that was almost dry. From this second lagoon, water then drains through a culvert under the road and rail causeway and into the area lying between areas C and D.
Figure 57 Photographs from waypoint Area I illustrating various areas of the lagoon system
4. Comparative Environmental Values of Proposed Disposal Sites

The field survey work has examined the areas proposed as potential disposal sites and in this section, an attempt is made to rate these areas in terms of the perceived environmental values of the areas and their surroundings.

The ratings include an assessment of the areas in a regional sense and how they compare to each other.

4.1. DMMA I

This area differs from all the other potential DMMA’s as there are no intertidal areas present and the area was created by infilling of the intertidal flat at some time in the past.

The area is almost devoid of vegetation and there are no significant environmental values within the boundaries of area I.

DMMA I has no apparent connection with any significant undisturbed environmental value nearby, although it does form the southern boundary of a highly artificial, and locally valuable wetland formed by the past reclamation works.

This area is rated the lowest in terms of environmental values and amenity values.

4.2. DMMA B

Another of the areas proposed for dredged material disposal, DMMA B, is also quite different from the others in that it includes substantial subtidal areas and a very large area below Mean Sea Level (MSL).

DMMA B is also unique in that it is a steeply sloping sandy shoreline with very little mangrove or other benthic primary producer habitats present.

The area is not typical of the inner harbour where the majority of the other potential disposal sites are located and is more typical of small sandy bays found along the coastline to the east and west of the harbour entrance.

This area does not appear to contain any unique features that are not found elsewhere along the coast. It has also been highly modified by the infrastructure development which includes a rock revetment wall behind the beach, and the infrastructure behind that, and also the presence of ship loading facilities that effectively create a barrier across the mouth of most of the bay.
The area is characterised by industrial activities that generate noise and light and while it may at one time in the past have provided some natural environmental features in the past and possibly some natural amenity values, it no longer does so and access to the area is restricted.

This area is therefore given a low rating in terms of environmental values.

4.3. DMMA’s C, D, and F

The two DMMA’s C and D show signs of modification as a consequence of anthropogenic influences, and this is primarily the presence of what appears to be an unstable drainage system across the intertidal zone between the eastern boundary of DMMA C and the western boundary of area D.

This unstable area shows signs of erosion and sedimentation and appears to be heavily influenced by periodic discharges of storm water through culverts linking the lagoons upstream of the causeway to the intertidal zone.

The area has been the site of engineering works in the mid 1990’s (Piggott pers.com.) designed to allow re-entry of tidal water to encourage re-colonisation by mangroves and the project has been successful in the reestablishment of some mangroves in the area.

Inside the boundaries of both DMMA C and D there is little vegetation and very evidence of cyanobacterial mats, although examination of the aerial photographs suggests that there may be times when cyanobacterial mats do develop on these flats. However in terms of mangrove or salt marsh vegetation, the areas do not appear to support the same amount of vegetation as some of the other intertidal flats surveyed during this study and for DMMA C. There is also evidence of recent deposition of fresh sediment into this area from unknown sources.

The northern boundaries of both DMMA’s join the highly modified environment of the rail and road causeways, however, the southern boundaries of both areas do join areas that have been identified as having some environmental value with stands of mangroves associated with Creek channels.

The southern boundary of DMMA C also abuts the limestone ridge, which appears to be relatively undisturbed on its eastern end, while the western end has some areas where material has been dumped.

DMMA F, which also lies between the causeway and the headwaters of Stingray Creek has also had drainage altered by the construction of the causeway and appears to be similar to DMMA C, and D with a large area of unvegetated tidal flat.
Comparisons of these DMM’s with others in the region is difficult as they have been heavily modified, but it appears that one conspicuous difference between these areas and equivalent areas to the west of the HBI plant site at Boodarrie for example is the apparent lack of samphire vegetation at similar heights on the shore at DMMA’s C,D and F.

The natural areas to the west of Boodarrie also have large bare tidal pans but these appear to be higher in elevation than those at DMMA’s C,D, and F. Presumably the equivalent height on the shore at north of DMMA’s C, D and F, now lies under the causeway, stockpiles and other infrastructure.

Thus, it appears that comparisons with similar heights on the shoreline of relatively undisturbed sites such as DMMA G, and some of the flats out to the west of the Finucane Island Causeway show there is much less vegetation at DMMA’s C,D and F.

In terms of the wider harbour, DMMA’s C, D and F show less widespread disturbance of vegetation due to unregulated vehicle traffic across the intertidal flats, but the other modifications wrought by alteration of drainage across the intertidal zone caused by the construction of the causeway gives these areas a relatively low rating in terms of environmental values. There is also very little amenity value on this lease area.

4.4. DMMA E

DMMA E was not surveyed by foot and the assessment was conducted by driving near the area and also by examination of aerial photographs. However, the senior author did walk extensively over this area in October 2006 and so is familiar with the area.

DMMA E is typical of many of the upper intertidal areas around Port Hedland in that it has not apparently suffered a major alteration of local drainage patterns, but it has suffered from indiscriminate and unregulated vehicle access that has apparently removed vegetation.

Closer to the creek the mangroves fringing the creek channels appear to be in relatively good health and exhibit the same types of vegetation associations and fauna seen elsewhere on similar heights on the shore on other creeks in the harbour and also elsewhere on the coastline.

4.5. DMMA H

The area of intertidal zone and supra tidal islands to the north of Wedgefield has been modified in two major ways. There has been some modification of drainage patterns from the hinterland due to the construction of Wedgefield itself, but this is likely to be a minor influence compared to the unregulated use of the area by 4WD vehicles and trail bikes and the dumping of both household and industrial rubbish. There are a significant number of tracks cut through this area by vehicles and trail bikes.
There are however some environmental values of habitats inside DMMA H where there are scattered samphires (and other salt marsh plants), mangroves and cyanobacterial mats present. These primary producers are not extensive within DMMA H, but are present and are more abundant in this area than they are inside DMMA’s C, D and F for example, but are far less abundant than that observed inside DMMA G.

The areas adjacent to the borders of DMMA H also have environmental values associated with the presence of samphires and there are healthy stands of mangroves lining many of the creek channels.

The area has better environmental values than DMMA’s C, D and F but these are in danger of being further degraded by uncontrolled vehicle access. Similarly as the area is readily accessible it does have some amenity value and it appears that fishing at the banks of the two major creeks either side of the peninsula is a popular pastime among locals.

4.6. DMMA A

DMMA A is also a highly modified area as a consequence of the construction of the Finucane Island Causeway across the upper area of the intertidal. The causeway has interrupted the flow of water across low points on the peninsula that linked tidal waters inside the harbour with tidal waters flooding west. The most severe modification is the complete blocking of the large creek to the south of Finucane Island, but examination of area on both sides of the causeway on a spring tide (Figure 58) illustrates that water flowed right across into and out of the harbour through this area before construction of the causeway.

Substantial alterations of tidal flow of this magnitude can alter the vegetation assemblages present and the vegetation present in DMMA A today is likely to be different to that present before the construction of the causeway. In particular, the presence of scattered, large, scrub-like $A. marina$
right across the middle of DMMA A between A-1 and A-6 appears to be relatively recent as all of
the trees are relatively young and quite large for their age.

The area does however have some areas of scattered mangroves, salt marsh (mostly samphires) and
cyanobacterial mats inside Area A and these compare favourably with similar habitats seen at Area
H, primarily because there is no evidence of vehicle damage over much of the northern end of the
Area. There is however, uncontrolled vehicle access along the southern and south-western ends of
the area and this has had some apparent impact on vegetation on the tidal flats and supra tidal
islands.

The area has an artificial boundary along its eastern side, but on the western side is connected to a
creek channel that is relatively undisturbed, although that creek channel is connected to the larger
channel system that was cut off by the construction of the causeway across to Finucane Island.

The area therefore has been significantly altered, but the value of its remaining environmental
resources such as mangroves and salt marsh is comparable with those of other similar areas within
the harbour and along the coastline nearby.

4.7. DMMA G

Of all the areas surveyed, DMMA G was in the best condition and appeared relatively undisturbed
and as a consequence was rated the best of the areas in terms of both environmental and amenity
values.

The only apparent protection this area has is the narrow neck of low lying land to the east which
floods at high tide making vehicle access virtually impossible. There is no information readily
available on what the other areas of the harbour were like before the advent of heavy recreational
vehicle traffic, but the recent coastal management plan for Port Hedland (Ecoscape 2004) identified
the proliferation of tracks as a major issue for damage to intertidal flats and supra tidal islands.

It is possible that some of the better extent and quality of vegetation throughout most of the
intertidal zone at DMMA G is due to protection from vehicle access. However, it appears there
may also be significant freshwater seepage in this area and lower soil salinities may explain some
of the vegetation distributions recorded.

4.8. General Observations

Although the areas surveyed mostly showed signs of disturbance, and some were more disturbed
than others in the harbour, there were no indications that any unique or significant environmental
values were observed during the survey.
The mangroves and other intertidal flora and fauna of the harbour and wider Pilbara region have been described in some detail by several authors (previously discussed in Section 2) of the harbour, and the characteristics of the areas surveyed showed broad general agreement with these descriptions.

The one exceptional outcome of the survey was the conclusion that all areas surveyed were remarkably poor in terms of the biodiversity of fauna supported.

Benthic invertebrate fauna in tropical Australian mangroves is typically comprised of four major groups, the Crustacea, Mollusca, Polychaeta, and in the wet tropics, Insecta. It is not surprising that insects were not common in, or on, the mud due to the arid conditions which produce low soil moisture content and high salinities. The lack of molluscs, however, was intriguing as many of the mollusc species that would normally be associated with some of the mangrove vegetation surveyed are known to be present both north and south of Port Hedland.

Whether the absence of species in these areas is a recent phenomenon or a more general trend is not clear at this point, but it is noteworthy that recent surveys of areas around the causeway to Finucane Island reveal that benthic invertebrate fauna are more diverse and abundant at several sites where alterations to drainage have apparently produced slightly wetter substrates with more organic material (Hanley pers. obs.)
5. Vegetation Classification

To assist the ongoing option evaluation and DMMA selection process elements of the ecology, distribution and classification of mangroves, salt marshes and other intertidal vegetation types such as cyanobacterial mats in the Port Hedland have been described in some detail for DMMA A, DMMA H and Harriet Point.

Important references include:

- Flora (Semeniuk et al. 1978; Paling et al. 2003);
- The influence of geology and geomorphology on the different intertidal habitats (Semeniuk, 1993, 1994, 1997);
- vegetation associations (Beard, 1975; Craig 1983; Semeniuk, 2007a; Paling et al. 2003); and
- Fauna (Jones, 2004)

5.1. Mangroves

The mangrove vegetation associations have been described in the most detail by Semeniuk in his series of papers (Semeniuk 1993, 1994, 1997, 2007a; Semeniuk et al. 1978) which include descriptions of the complex interactions of the physical, geological and geomorphological features that define the habitat types that a series of identified mangrove assemblages are found to occupy.

The most recent paper in this series (Semeniuk, 2007a) gives a comprehensive account of the development of his model of habitat classification for Port Hedland and identifies the following main assemblages and their habitats (note that Semeniuk used the species determination *Ceriops tagal* and that has been renamed *Ceriops australis* here following the determination of Duke (2006) that this is the only species of the genus Ceriops found on the coast of Western Australia):

14) *Avicennia marina* low forest to scrub on mid to high tidal flats;
15) Mixed *Avicennia marina* and *Rhizophora stylosa* low forest to scrub on mid to high tidal flats;
16) *Rhizophora stylosa* low forest to scrub on mid to high tidal flats;
17) *Avicennia marina* scrub to open heath, grading to low heath and low open heath on high tidal flats;
18) *Ceriops australis* scrub to closed heath to open heath on high tidal flats;
19) Mixed *Ceriops australis* and *Avicennia marina* scrub and heath on high tidal flats and high tidal beaches;
20) Scrub, to heath to open heath of mixed *Avicennia marina*, *Rhizophora stylosa*, *Bruguiera exaristata*, *Ceriops australis*, *Aegialitis annulata*, and locally *Osbornia octodonta*, on sandy spits and beaches in the high tidal zone; and
21) Mixed *Aegialitis annulata*, *Aegiceras corniculatum*, and *Avicennia marina* on point pars, mud channel shoals, and accreting soft mid-tidal flats in the mid tidal zone.

This description of 8 different floristic assemblages is based on a total pool of just 7 mangrove species, of which two, *Bruguiera exaristata* and *Osbornia octodonta* are extremely rare in Port Hedland and were not encountered during the present survey. A third species, *Aegiceras corniculatum*, is not common and was only encountered once during the survey of Harriet Point.

In the report on a recent survey of mangroves at Utah Point (Semeniuk, 2007a), the number of mangrove assemblages present was reduced for mapping purposes from an apparent 12 types (see Table 1 in Semeniuk 2007a) to the following four types:

1) *Avicennia marina* low forest to scrub (where *A. marina* formed closed formations with plants 3 m - 6 m high);

2) Mixed *Avicennia marina* and *Rhizophora stylosa* low forest to scrub (where *A. marina* and *R. stylosa* in a 50:50 mix, formed closed formations with plants 3 m - 6 m high);

3) *Rhizophora stylosa* low forest to scrub (where *R. stylosa* formed closed formations with plants 3 m - 6 m high); and

4) *Avicennia marina* scrub to open heath, (where *A. marina* formed closed formations with plants 3 m high, grading to open formation with 50% cover, with plants 1-2 m high)

Semeniuk (2007a) then defines four types of patterns of assemblages which are related to habitat:

1) Zoned sequence of species and structure across the limestone barrier, where muddy tidal flat deposits flank and bury the limestone ridge to form barrier-fringing muddy tidal flats, with mangrove floristic/structural banding (zonation) running parallel to the environmental gradients of groundwater salinity, soilwater salinity, and frequency of inundation across the tidal flat; this is the dominant pattern in Utah Point; the zones consist of a narrow seaward fringe of *Avicennia marina* low forest to scrub; followed by wide band of *Rhizophora stylosa* low forest to scrub, with local pockets of a mix of *Avicennia marina* and *Rhizophora stylosa* low forest to scrub, followed to landward by a wide zone of *Avicennia marina* scrub to open heath; this pattern dominates the Utah Point area;

2) Narrow fringe of *Ceriops australis*, with lesser *Bruguiera exaristata* and *Avicennia marina*, where the mangroves abut a limestone ridge; as such this assemblage commonly is linearly extensive, but narrow (one or two shrubs wide); this pattern occurs along the length of limestone ridges, and essentially is a limestone ridge assemblage of mangroves;

3) Patches of *Avicennia marina*, with lesser *Ceriops australis*, *Bruguiera exaristata*, *Aegialitis annulata*, and *Aegiceras corniculatum*, where the mangroves inhabit sandy
beaches or sand on limestone; this assemblage occurs locally on the areas of sand and on beaches; and

4) Narrow fringe of low open heath *Aegialitis annulata*, *Aegiceras corniculatum*, and *Avicennia marina*; this assemblage occurs in accreting soft sediment zones, adjoining and occurring just seaward of the main mangrove zones.

Paling et al. 2003, assessed the mangroves of Port Hedland and identified the following 8 community types which appear to be based upon the dominance of species present (note that Paling et al also used the species determination *Ceriops tagal*, but that has been changed here to *Ceriops australis* as Duke 2006 reports this is the only species of Ceriops found on the Western Australian coastline:

1) *Rhizophora stylosa*;
2) *R. stylosa*/*Avicennia marina*;
3) *A. marina* (seaward fringe);
4) *A. marina* (behind *R. stylosa*);
5) *A. marina* (scattered trees);
6) *Ceriops australis*;
7) *Aegiceras corniculatum*; and
8) *Aegialitis annulata*.

In this classification scheme, the 8 vegetation communities are based upon 5 different species of mangroves as the two rare species, *Bruguiera exaristata* and *Osbornia octodonta*, are not included.

5.2. Salt Marshes

The salt marshes of the Port Hedland Harbour area have not been described or mapped in the same detail as the mangroves.

Semeniuk does not provide any detailed descriptions of salt marsh habitats in his series of papers and Paling et al. (2003) use the broad category of ‘samphires’ for their assessment of the vegetation assemblages in the intertidal zone, in recognition that in most of the salt marsh areas around Port Hedland, the dominant components of the salt marshes are samphires such as *Halosarcia halocnemoides*.

Craig (1983) recognised four salt marsh zones:

1) Wet or periodically inundated heavy clay dominated by *Halosarcia halocnemoides* ssp. *tenuis*;
Mid to upper more sandy sites dominated by *Limonium salicorniaceum* and *Sporobolus virginicus*;

High well-drained sites of *Halosarcia indica*, *Frankenia ambita* and *Hemichroa dinandra*; and

Areas of high salinity but little waterlogging characterised by *Neobassia astrocarpa*, *Trianthema turgidifolia* and some *Triodia* species

Of these four only Category 1, dominated by the samphire *Halosarcia halocnemoides* is regularly inundated by monthly spring tide cycles. The remaining three categories are rarely reached by tidal water and comprise some of the vegetation on the “supra tidal islands” described by Paling et al. 2003.

Earlier Beard (1975) recognised that salt marshes often form three zones:

1) *Inner/lower zone* - dominated by *Arthrocnemum benthamii* (Red or Black Samphire), which thins out to expose bare ground at the lowest points;

2) *Central zone* - dominated by *Trianthema turgidifolia*, with *Neobassia astrocarpa* and *Atriplex elachophylla* also present. Occasional small thickets of *Acacia bivenosa* and *Acacia salicina* also occur; and

3) *Outer/upper zone* - dominated by *Sporobolus virginicus* (Salt Grass from) and colonies of *Trianthema turgidifolia* (Yellow Samphire), with *Trichinium exaltatum* and *Scaevola spinescens* (Currant Bush)

The name *Arthrocnemum benthamii* is synonymous with *Halosarcia halocnemoides* and so both Craig (1983) and Beard (1975) recognise a salt marsh zone dominated by this species of samphire lying at a level where it is frequently inundated.

The areas of salt marsh encountered on the current survey of Areas suitable for potential disposal grounds was dominated by *Halosarcia halocnemoides* and the other categories of salt marsh types appear to be relevant to the vegetation on, and fringing, the supra tidal islands.

### 5.3. Cyanobacterial (algal) mats

Paling et al. 2003 report the presence of cyanobacterial mats on the intertidal flats of Port Hedland and provide an estimate of the total area of this type of ‘vegetation’ in the harbour.

### 5.4. Vegetation classification for Harriet Point Survey

For the survey results from the Harriet Point area, the classification scheme developed by Semeniuk has been used as it included a comprehensive mapping exercise of this area (Semeniuk, 2007a).
The field survey work undertaken enabled a check of that mapping for the areas on and near Harriet Point and Stanley Point and the observations of the field team agree with the classification of vegetation proposed by Semeniuk (2007a).

The only caveat is to note that the dominant benthic fauna associated with mangrove habitats on and near Harriet Point did not show any correlations between the distributions of individual fauna and the dominance of a particular vegetation type.

The classification developed for Harriet Point and nearby areas developed by Semeniuk (2007a) and confirmed by this field survey is shown in Figure 59.
Figure 59 Vegetation Classification for Harriet Point and Nearby Areas
5.5. Vegetation classification for DMMA A and DMMA H

For the mapping exercise at DMMA A and H, the following vegetation associations and habitats were developed:

1) *Tidal flat* – comprising areas either devoid of vegetation altogether, or with very low densities and no evidence of the presence of cyanobacterial (algal) mats;

2) *Samphire dominated* – comprising areas predominantly of *Halosarcia halocnemoides* with some associated species such as *Halosarcia indica*, scattered individuals of the mangrove *A.marina* may also be present;

3) *Algal mat/samphires* – comprising a mixed association of scattered samphires (typically *Halosarcia halocnemoides* with bare areas of tidal flat with evidence of cyanobacterial (algal) mats;

4) *Sparse Avicennia marina* – comprising scattered individuals of the mangrove *A.marina*, often with scattered samphires, but without high densities;

5) *Supra tidal* – comprising the supra tidal islands described by Paling et al. (2003) and typically vegetated with the one or more of the vegetation types described by Craig (1983).

Vegetation maps for DMMA A and H have been produced using this vegetation classification system and are shown in Figure 60 and 61.
Figure 60 Area A vegetation classification
Figure 61 Area H vegetation classification

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6. References

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