Outer Harbour Development and Goldsworthy Rail Duplication: Subterranean Fauna Risk Assessment

Prepared for
Sinclair Knight Merz
by Bennelongia Pty Ltd

September 2009

Report 2008/41

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Client – Sinclair Knight Merz Pty Ltd

Report	Version	Prepared by	Checked by	Submitted to Client	
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[1] SKM, [2] BHP Billiton Iron Ore

Executive Summary

This report provides a desktop review of the risks to subterranean fauna associated with the proposed Outer Harbour Development and Goldsworthy Rail Duplication projects at Port Hedland, in the Pilbara region of Western Australia. Impacts of construction were evaluated for six elements of the development: stockyards, car dumpers, conveyor tunnels, infrastructure corridor to Finucane Island, transfer pad on Finucane Island, and railway lines. The review is based on a description of the proposed Outer Harbour Development and Goldsworthy Rail Duplication supplied by SKM.

There are two types of subterranean fauna. Stygofauna are aquatic and live in groundwater whereas troglofauna are air-breathing and live in deep subterranean spaces above the watertable. Risks to each group were considered separately. Evaluation of risks focussed on elements within the proposed developments where potentially significant impacts (principally de-watering or excavation) will occur and where subterranean fauna are likely to be present. Less likely, and probably less significant, impacts of pollution of groundwater and soil were also considered.

Results of previous regional stygofauna survey showed almost 50 species of stygofauna occur within 100 km of Port Hedland, suggesting that stygofauna are present within the Outer Harbour Development and Goldsworthy Rail Duplication project areas. De-watering, and thus potentially adverse impacts on any stygofauna present, will occur at the proposed car dumpers and conveyor tunnels. However, most groundwater in the vicinity of those elements has salinities of 10-60 g L^{-1} Total Dissolved Solids (TDS). There are almost no records of known athalassicstygofauna species (i.e. those found in groundwater that is not of marine origin) at such high salinities in the Pilbara and, therefore, it is unlikely stygofauna occur within the area of the proposed car dumpers and conveyor tunnels unless they are marine species. Any marines tygofauna species present are likely to distributed elsewhere on the Pilbara coast and, because the spatial scale of any de-watering will be very small, the likelihood of any significant impact on these stygofauna from de-watering is very small.

De-watering will not be required during construction of the proposed infrastructure corridor, transfer pad or rail lines and any stygofauna present in these areas are unlikely to be impacted by development. Construction of the rail lines may utilise water from shallow bores nearby, which if located within sands or alluvium, may possibly result in very localised loss of athalssic stygofauna. However, nearly all species recorded from the coastal plain are wide-ranging and the area likely to be impacted by water abstraction will be very small in relation to species' ranges. Extracting only small water volumes from shallow bores will minimize change to aquifer habitat and eliminate any small risk.

Groundwater pollution caused by spillages of hydrocarbons, waste or hazardous materials can potentially result in reduced health of any stygofauna communities present under, or downstream of, project facilities. However, adoption of adequate threat management, including spill management plans, should prevent any significant impacts on stygofauna.

There are no sampling results available in the public domain for troglofauna in sandy soils or alluvium in the vicinity of in Outer Harbour Development and Goldsworthy Rail Duplication. However, troglofauna are considered unlikely to occur in significant numbers within about 5 m of the surface because they require high humidity and relatively constant environmental conditions. Furthermore, at shallow depths they are likely to be outcompeted by surface animals. Given that the depth to groundwater under the stockyards, car dumpers and conveyor tunnels is only 3-4 m, occasionally much less after heavy rain, and that watertables are even shallower close to the coast where the infrastructure corridor and transfer pad lie, troglofauna appear unlikely to be present under any component of the proposed Outer Harbour

Development and Goldsworthy Rail Duplication other than rail lines in southern parts of the project areas. The spatial scale of any impact from rail construction will be very small because excavation will mostly be less than 3 m, which is above the zone thought to constitute core troglofauna habitat. Thus, the development is not considered to pose a risk to troglofauna habitat or troglofauna themselves. Given that troglofauna are unlikely to occur within the northern part of the proposed Outer Harbour Development project area, where most potential sources of pollution are located, it is considered very unlikely that soil pollution will cause loss of troglofauna, especially if spillages of hydrocarbons, waste or hazardous materials are managed.

This desktop study has shown there is very low probability of either stygofauna or troglofauna being impacted upon by de-watering, groundwater abstraction, soil excavation or soil leveling for the proposed Outer Harbour Development and Goldsworthy Rail Duplication projects. The afore-mentioned activities, together with soil and groundwater pollution, are considered to be the only potential impacts to subterranean fauna. No significant pollution is expected and best practice management should prevent any pollution threat to any subterranean fauna.

It is considered that the desktop review accurately reflects the risks to subterranean fauna from the the proposed Outer Harbour Development and Goldsworthy Rail Duplication projects within the constraints of current knowledge. No further work on subterranean fauna is recommended as a result of this review.

Contents

1.0 Introduction

1.1 Background and Objectives

This report provides a desktop review of the risks to subterranean fauna associated with the construction of BHP Billiton Iron Ore's proposed Outer Harbour Development and Goldsworthy Rail Duplication projects at Port Hedland, in the Pilbara region of Western Australia. This subterranean fauna risk assessment forms part of the environmental impact assessment that BHP Billiton Iron Ore is conducting under Part IV of the *Environmental Protection Act 1986*.

The objectives of the review were to:

- collate and review existing subterranean fauna information;
- collate and review existing hydrogeological and geological information that is relevant to the occurrence of subterranean fauna;
- identify the potential occurrence of subterranean fauna communities within the project area based on biological and habitat information;
- provide species lists of potentially occurring subterranean fauna and highlight those of conservation significance;
- consider likely direct and indirect impacts to subterranean fauna from the proposed projects; and
- recommend further work, if necessary, where a high risk of impact on subterranean fauna is identified.

Maps of subterranean fauna occurrence and suitable habitat are not provided within this report because of the substantial small-scale variability that is likely to exist in the habitat suitability for subterranean fauna and the lack of information on habitat preferences of subterranean fauna that would enable meaningful prediction of the distributions of subterranean fauna species that may occur within the project areas. Distributions are expected to be variable because of large spatial and temporal variation in groundwater salinity, which is likely one of the major factors controlling stygofauna distribution (e.g. Masciopinto et al. 2006).

1.2 Subterranean Fauna

'Subterranean fauna' is a term used to describe animals that spend all, or most of, their life cycle underground and possess morphological adaptations to an underground existence (Gibert & Deharveng 2002). Most commonly, these are loss of eyes and skin pigmentation although some subterranean species retain eyes.

There are two kinds of subterranean animals: stygofauna and troglofauna. Stygofauna are aquatic invertebrates and occur in groundwater. Troglofauna are air-breathing invertebrates and occur in underground cavities and small fissures above the water table. Nearly all subterranean fauna are invertebrates, although both stygofaunal fish and troglofaunal reptiles have been recorded in Western Australia (Aplin 1998, Whitely 1945).

In this report, a distinction is made between athalassic and marine stygofauna. The former are species occurring in groundwater that is not of direct marine origin (for further description see Bayly 1972), even if most of the salts present are marine, whereas the latter occur in groundwater directly connected to the sea.

1.3 Project Location

The Outer Harbour Development project area lies west and south-west of the towns of Port Hedland and South Hedland and covers an area from Finucane Island to the decommissioned Boodarie Hot

Briquette Iron (HBI) Plant and inland to the Newman to Port Hedland rail line in the south-east (Figure 1.1).

The proposed Goldsworthy Rail Duplication project area lies to the south and south-west of Port Hedland and covers areas immediately adjacent to the existing Goldsworthy rail line and Newman to Port Hedland rail line from (Figure 1.1).

1.4 Project Description

The proposed Outer Harbour Development will provide an export capacity of approximately 240 million tonnes per annum (Mtpa) of iron ore. The proposed Outer Harbour Development will involve the construction and operation of terrestrial and marine infrastructure for the handling and export of iron ore, of which the terrestrial infrastructure is considered to be relevant to this subterranean fauna risk assessment. Terrestrial infrastructure under consideration in the project design includes:

- two rail options, Rail Options A and B (the latter is the preferred rail option otherwise known as the proposed Western Spur Railway), which originate from the area of the decommissioned Boodarie HBI Plant and connect with the existing Newman to Port Hedland rail line;
- stockyards to the north of the decommissioned Boodarie HBI Plant;
- four car dumpers and associated conveyor tunnels within the area of the decommissioned Boodarie HBI Plant;
- a transfer pad on Finucane Island; and
- an infrastructure corridor (including conveyors, access roadway and utilities) from the stockyards to the transfer pad.

The proposed Goldsworthy Rail Duplication project will include the addition of rail infrastructure to sections of the existing Goldsworthy rail line. The exact location of this rail infrastructure is still under consideration.

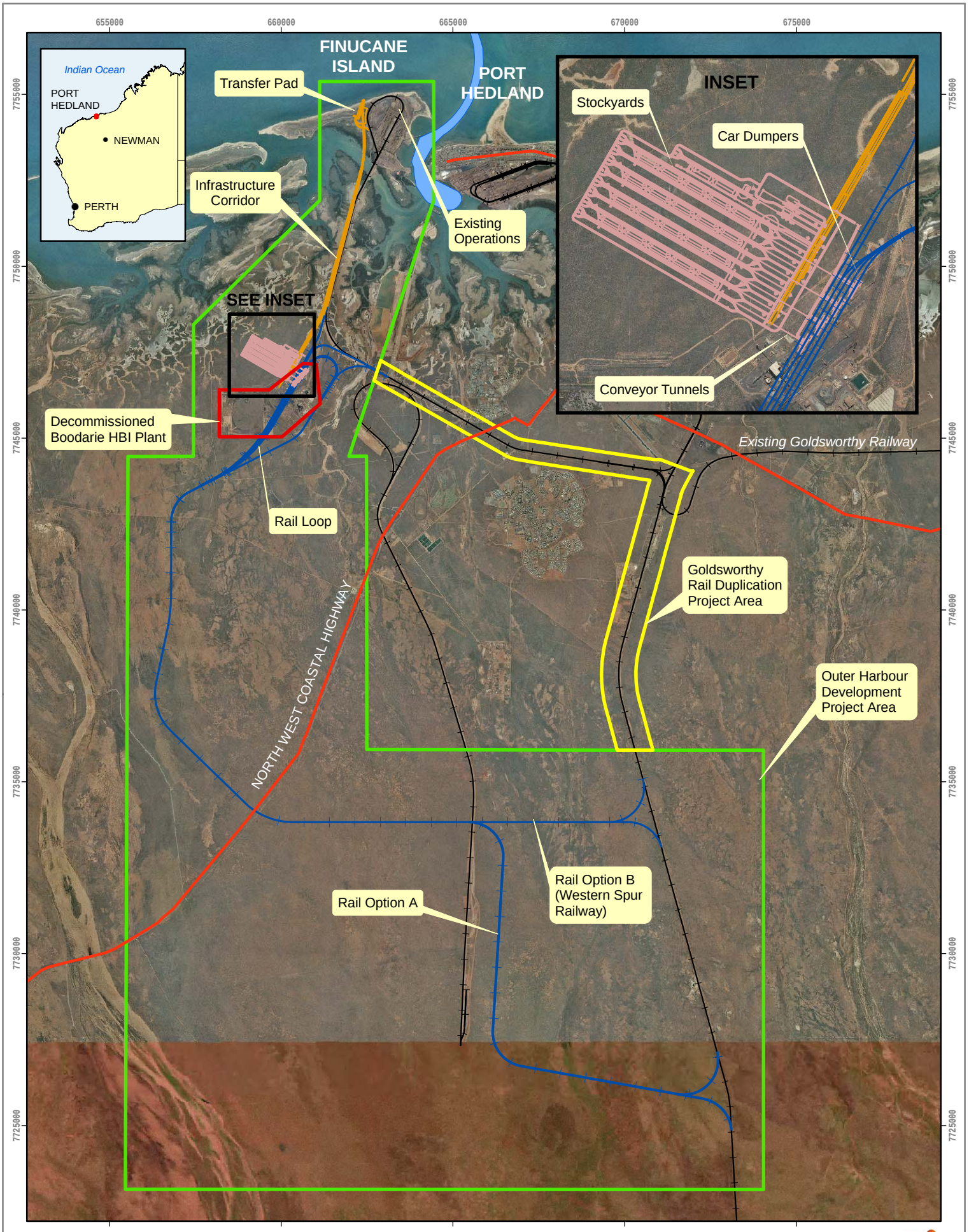
2.0 Methods

2.1 Sources of Information

This desktop review is based on the project descriptions for the proposed Outer Harbour Development and Goldsworthy Rail Duplication provided in Section 1.4. The following sources of information were used to compile a review of the risks to subterranean fauna associated with the projects:

Hydrogeology - Information on geology of the site was taken from the HBI plant CER (BHP Direct Reduced Iron 1994) and a recent review of various aspects of the geology and hydrology of the Port Hedland Outer Harbour Development (SKM 2009a).

Information of groundwater levels and salinity within the development area was obtained from the former Boodarie HBI plant CER, annual environmental monitoring for the plant (BHP Billiton Iron Ore 2005, 2008; Boodarie Iron 2006; Ecowise Environmental unpubl. data) and studies at Finucane Island (Coffey 2007; SKM 2009b). Information about groundwater levels and salinity on the plain around Port Hedland was obtained from water quality data collected during previous biological surveys (Halse et al. in prep.).



Legend

- Goldsworthy Rail Duplication Project Area
- OHD Project Area
- Principal Road
- Proposed Infrastructure
- Proposed Stockyards
- Existing Railway
- Proposed Railway Options
- Existing Shipping Channel

0 1 2 3 4
kilometres

Scale @ A4: 1:140,000

Horizontal Datum: GDA94
Map Grid: MGA94 Zone 50

Source:
Orthorectified Aerial Photograph: June 2008 (BHPBIO)
Topography: GEODATA Topo 250K V3
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Figure 1.1 Location of Outer Harbour Development and Goldsworthy Rail Duplication Project Areas

Subterranean Fauna - Information on stygofauna distributions was collated from a recent Pilbara-wide biological survey (Halse et al. in prep.). No information on relevant troglofauna distributions was available. Inferences about the habitats occupied by stygofauna and troglofauna were based on a range of scientific publications (e.g. Biota 2005; EPA 2008; Edward & Harvey 2008) and results of the Pilbara survey.

2.2 Risk to Subterranean Fauna

The assessment of risk to subterranean fauna from the proposed projects was based on the species of subterranean fauna likely to be present, their likely habitat requirements and environmental tolerances, and the likely changes to subterranean fauna habitat resulting from development.

The principal criterion for assessing whether subterranean fauna are likely to occur within the development was the likelihood of the area containing voids and other underground spaces for animals to inhabit. Groundwater salinity in relation to known tolerances of Pilbara stygofauna species (Halse et al. unpubl.; see also Eberhard et al. 2008) was also an important element in assessing likely occurrence.

The recent conclusion of the Environmental Protection Authority (EPA) that troglofauna are unlikely to occur on the eastern side of Exmouth Gulf because of the shallow depth to groundwater and saline environment (EPA 2008) provided context for evaluating the likelihood of occurrence of troglofauna in the development area.

3.0 Results

3.1 Physical Description

The proposed Outer Harbour Development and Goldsworthy Rail Duplication project areas lie within the broad, flat coastal plain, up to 20 km wide, that runs the length of the Pilbara coast and cover areas of 34,450 ha and 1384 ha, respectively. The project areas are located in the South West Creek and South Creek catchments within the Port Hedland Coastal river basin (Figure 3.1). All significant construction activity for the proposed Outer Harbour Development, other than railway construction, will be restricted to the northern part of the project area between Finucane Island and BHP Billiton Iron Ore's decommissioned Boodarie HBI plant, which are areas showing varying signs of previous disturbance. The construction of new rail for the proposed Goldsworthy Rail Duplication project is likely to be confined to areas adjacent to the existing Goldsworthy rail line, which predominantly traverses sandplain with occasional areas of samphire.

Finucane Island is a small island that encloses the bay into which South West Creek discharges when it flows after cyclonic rain. It is substantially modified, with the eastern part of the island mostly covered by existing port operations, while tracks and roads occur elsewhere on the island. However, the northern side of Finucane Island has retained comparatively undisturbed dunes (Plate 3.1). The mainland opposite Finucane Island, where the Outer Harbour Development infrastructure corridor is proposed to occur, has extensive intertidal and supratidal mudflats. The latter support samphire and mangroves grow along the margin of the intertidal flats in more sheltered areas. Inland of the mudflats, where the proposed Outer Harbour Development rail loops, stockyards and car dumpers will be located the area is predominantly sandplain covered by open grassland (Plate 3.2).

3.2 Climate

The climate of Port Hedland is warm to hot and semi-arid, with mean maximum temperatures of 35°C in January and 26°C in July. Maximum temperatures in summer are usually moderated by a

humid sea breeze. Most rainfall results from cyclones and monsoonal depressions. Average annual rainfall is about 330 mm (http://www.bom.gov.au/climate/averages/tables/cw_004002.shtml) but this is highly variable between years.

3.3 Geology

Soils consist of silty red brown sand, with patches of clayey sand and bands of high level sand (Figure 3.2). The river courses themselves contain alluvium. Towards the coast there is a band of silty sand grading into mangrove areas and mudflats, with patches of dune limestone emerging from the mudflats (GSWA 1983). On the northern side of the adjacent Finucane Island, there is a ridge of dune limestone and lime cemented beach conglomerate. South of this ridge, the island consists of mudflats and mangrove areas.

3.3.1 Subterranean Fauna Habitat

The lithologies underlying the proposed Outer Harbour Development and Goldsworthy Rail Duplication project areas are summarized in Table 3.1.

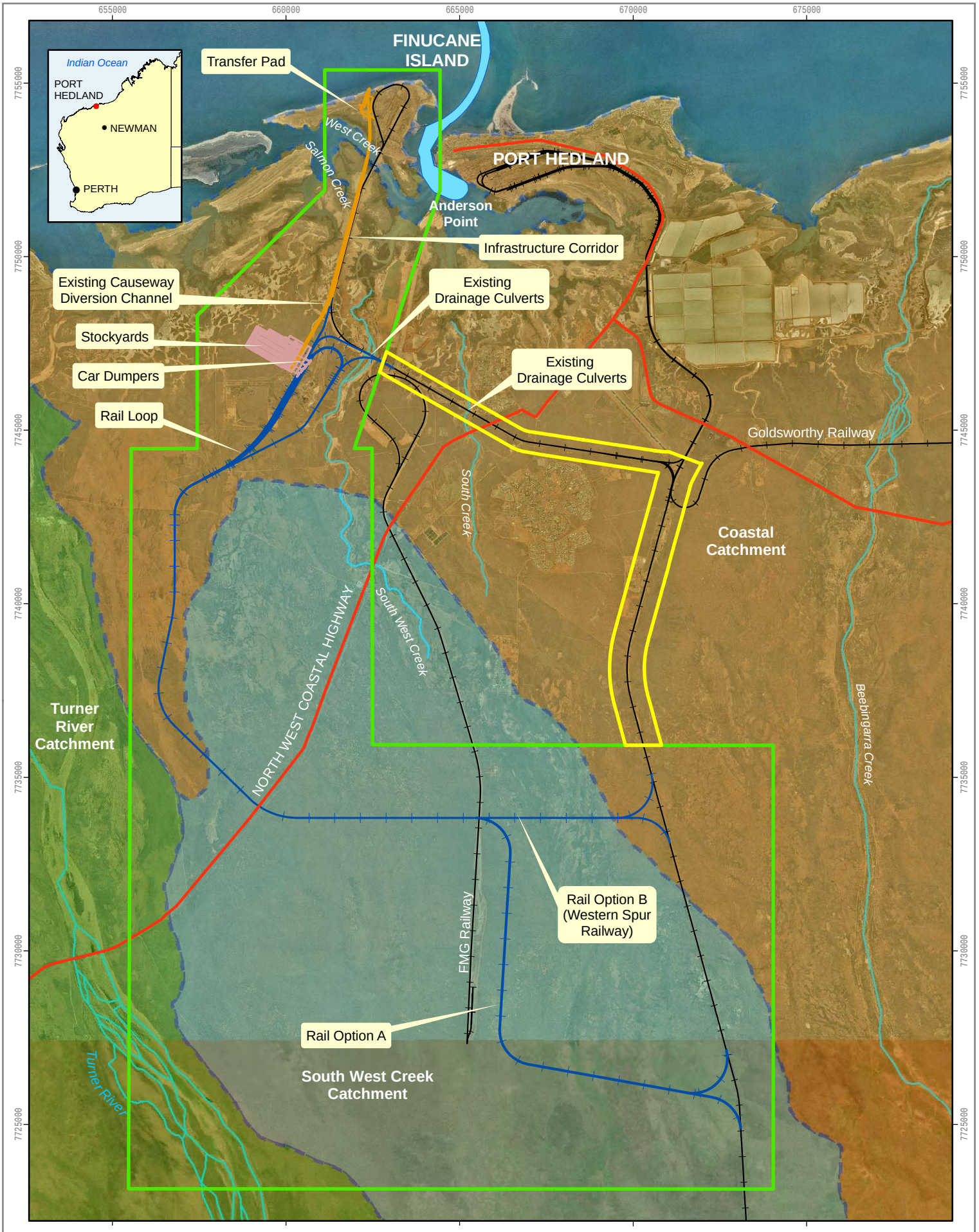
In terms of providing physical space for subterranean fauna habitat, dune limestone, lime cemented beach conglomerate and areas of sand within any geological formation are likely to contain large enough interstitial spaces and voids to support most types of subterranean fauna (Gibert et al. 1994;

Plate 3.1. Finucane Island Loading Facilities in the Right Hand Side of Photo, Dunes Behind. Note the mangroves on Finucane Island in the foreground.

Plate 3.2. Environment around the HBI Plant at Boodarie. The stockyards are planned to be located north (to the left and towards viewer) of the now decommissioned plant. The route to be used approximately by the conveyor to Finucane Island is visible.

Table 3.1 Geologies Present in the Proposed Outer Harbour Development and Goldsworthy Rail Duplication Project Areas. Data provided by BHP Billiton Iron Ore.

Project area / Project element	Geologies
Outer Harbour Development	
Rail loop	Silty sand, clayey sand, high level sand
Rail Options A & B	Silty sand, clayey sand, high level sand, mudflat
Stockyards	Silty sand
Car dumpers	Silty sand
Conveyor tunnels	Silty sand
Infrastructure corridor	Mudflat and mangrove, silty sand
Transfer pad	Lime cemented beach conglomerate, dune limestone, mudflat
Goldsworthy Rail Duplication	
Northern project area	Mangrove, alluvium
Southern project area	Sand, claypans



Legend

- Principal Road
- Watercourse (DoW, 2008)
- Proposed Infrastructure Corridor
- Proposed Stockyards
- Goldsworthy Rail Duplication Project Area
- OHD Project Area
- Proposed Railway Options
- Existing Railways
- Existing Shipping Channel

Catchments (DoW, 2008)

- South West Creek
- Turner River
- Coastal

0 2 4 kilometres

Scale = 1:140,000 at A4

Datum: GDA94
Map Grid: MGA94 Zone 50

bhpbilliton

Source:
Orthorectified Aerial Photograph: 08/06/2008 (BHPBIO)
Topography: GEODATA Topo 250K V3
© Commonwealth of Australia (GA), 2006

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Figure 3.1 Surface Water Hydrology of the Project Areas

Reference

- Qhm — Mangrove flats (tidal); Mud and silt
- Qhym — Mobile dunes
- Qhy — Younger beach and dune shelly sands
- Qho — Older dune shelly sand
- Qhs — Silty sand, red brown
- Qr — Residual sand
- Qp — Dune limestone
- Ql — Lime-cemented beach conglomerate
- Qfl — Levees
- Qf — Flood-plain sediments
- Qa — Alluvium, gravel, sand and silt
- Qk — Colluvium, quartz scree
- Qc — Clayey sand, abundant claypans
- Qps — Silty sand, red brown
- Qs — High-level sands
- Tp — POONDANOO FORMATION : laterite
- q — Quartz; milky-white to grey

Qw Qc Qrg

- Qw — Sheetwash deposits - silt, sand and pebbles on distal outwash fans; no defined drainage
- Qc — Colluvium - sand, silt and gravel in outwash fans; scree and talus; proximal mass wasting deposits
- Qrg — Quartzofeldspathic eluvial sand with quartz and rock fragments; overlaying and drevied from granitoid rock

Qaa Qac Qao Qaoc Qab

- Qaa — Alluvial sand and gravel in rivers and creeks; clay, silt, and sand in channels on floodplains
- Qac — Clay and silt in claypans on floodplains
- Qao — Alluvial sand, silt, and on clay floodplains
- Qaoc — Mixed floodplain deposits with numerous small claypans
- Qab — Alluvial sand, silt, and clay in floodplains, with gilgai surface in areas of expansive clay

AgLpe AgLko AgLpo AgLmb AgLmi AgLmw AgLmf AgLmm AgLmp AgLdmf

CARLINDI GRANITOID COMPLEX

- AgLpe — Pegmatite; metamorphosed
- AgLkd — **KADGEWARRINA MONZOGRANITE:** muscovite-biotite(-garnet) monzogranite; equigranite to weakly porphyritic; massive to weakly foilated; metamorphosed
- AgLpo — **POOCATCHE MONZOGRANITE:** muscovite-biotite monzogranite; seriate to porphyritic, massive to weakly foliated; locally abundant pegmatite; metamorphosed
- AgLmb — Fine- to coarse grained muscovite-biotite monzogranite; massive to weakly foliated; metamorphosed
- AgLmi — **MINNAMONICA MONZOGRANITE:** porphyritic biotite(-muscovite) monzogranite; fine- to coarse-grained; quartz and K-feldspar phenocryst; massive to weakly foliated; metamorphosed
- AgLmw — Biotite(-muscovite) monzogranite, equigranular to weakly K-feldspar porphyritic; locally highly leucocratic and ghost-banded; massive to weakly foliated; metamorphosed
- AgLmf — Biotite monzogranite; strongly foliated; seriate to K-feldspar porphyritic; related to AgLmp; metamorphosed
- AgLmm — Mylonitized monzogranite; related to AgLmp; metamorphosed
- AgLmp — Biotite monzogranite, porphyritic (K-feldspar) to seriate; massive to weakly foliated; locally strong flow alignment; metamorphosed
- AgLdmf — Diorite, grandodiorite, monzogranite, and abundant felsic to mafic inclusions and dykes, strongly foliated; metamorphosed

AGlc AGlcw AGli AGls

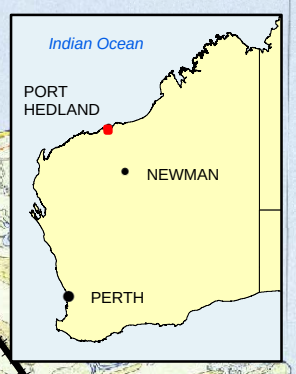
CLEAVERVILLE FORMATION

- AGlc — Chert; metamorphosed
- AGlcw — Chert; weakly banded, grey white; metamorphosed
- AGli — Banded iron-formation; locally includes banded quartz-magnetite-grunerite rock; metamorphosed
- AGls — Metamorphosed, fine- to medium-grained wacke, locally interleaved with serpentine- and tremolite-rich schist and metamorphosed iron-formation and ferruginous siltstone

As Aci Acil Acq Anp

- As — Sedimentary rock, undivided; metamorphosed
- Aci — Banded iron-formation; locally includes banded quartz-magnetite-grunerite rock; metamorphosed
- Acil — Banded iron-formation; strongly recrystallized and limonitized
- Acq — Banded white and grey chert, and quartzite; local minor jaspilite and iron formation; locally includes banded quartz-grunerite rock; metamorphosed
- Anp — Paragneiss; medium-grained, strongly recrystallized rock

Transfer Pad
Existing Shipping Channel
Infrastructure Corridor
Stockyards
Rail Loop
Car Dumpers
Rail Option B (Western Spur Railway)
Rail Option A
Port Hedland
Wedgefield
South Hedland



650000 655000 660000 665000 670000
7755000 7750000 7745000 7740000 7735000 7730000 7725000 7720000

Legend

- Proposed Jetty
- Proposed Infrastructure Corridor
- Proposed Stockyards
- Existing Railways
- Proposed Railway Options
- Existing Shipping Channel
- Goldsworthy Rail Duplication Project Area
- OHD Project Area

0 1 2 kilometres

Scale = 1:100,000 at A3

Datum: GDA94
Map Grid: MGA94 Zone 50

Source:
Topography: Geoscience Australia, GEODATA Topo 250K V3. Spoil Ground I: PHPA, 29/10/2007
H: F112-C-00155_C 14/10/2008 (FAST)
Nelson Point: PHE-V-210-A301.dwg 25/08/2008 (MPD JV)
50k Urban Geology: 2557-II (1983), 2657-III (1983) (GSWA)

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Figure 3.2 Geology of the Project Areas

Wilkens et al. 2000). Silty and clayey components of the formations are likely to support smaller subterranean species, such as stygal micro- and meiofauna (animals not easily visible to the naked eyes), together with species capable of burrowing. Burrowing species are likely to be surface animals rather than troglofauna or stygofauna.

This review suggests the proposed Outer Harbour Development and Goldsworthy Rail Duplication project areas occur in habitats that are likely to have the physical structure to support at least some subterranean fauna.

3.4 Groundwater

3.4.1 Hydrogeology

The majority of the recharge into the alluvial aquifer in the Port Hedland area is likely a result of infiltration during storm events (SKM 2009a). Some localised recharge to the alluvial aquifer may also occur from creeks when they contain surface water in creeks. Groundwater levels are expected to be affected in a dampened and delayed way by tidal fluctuations in areas close to the coastline.

Modelling of groundwater flow in the Port Hedland area shows an overall movement of groundwater north towards the coast (Figure 3.3).

3.4.2 Depth

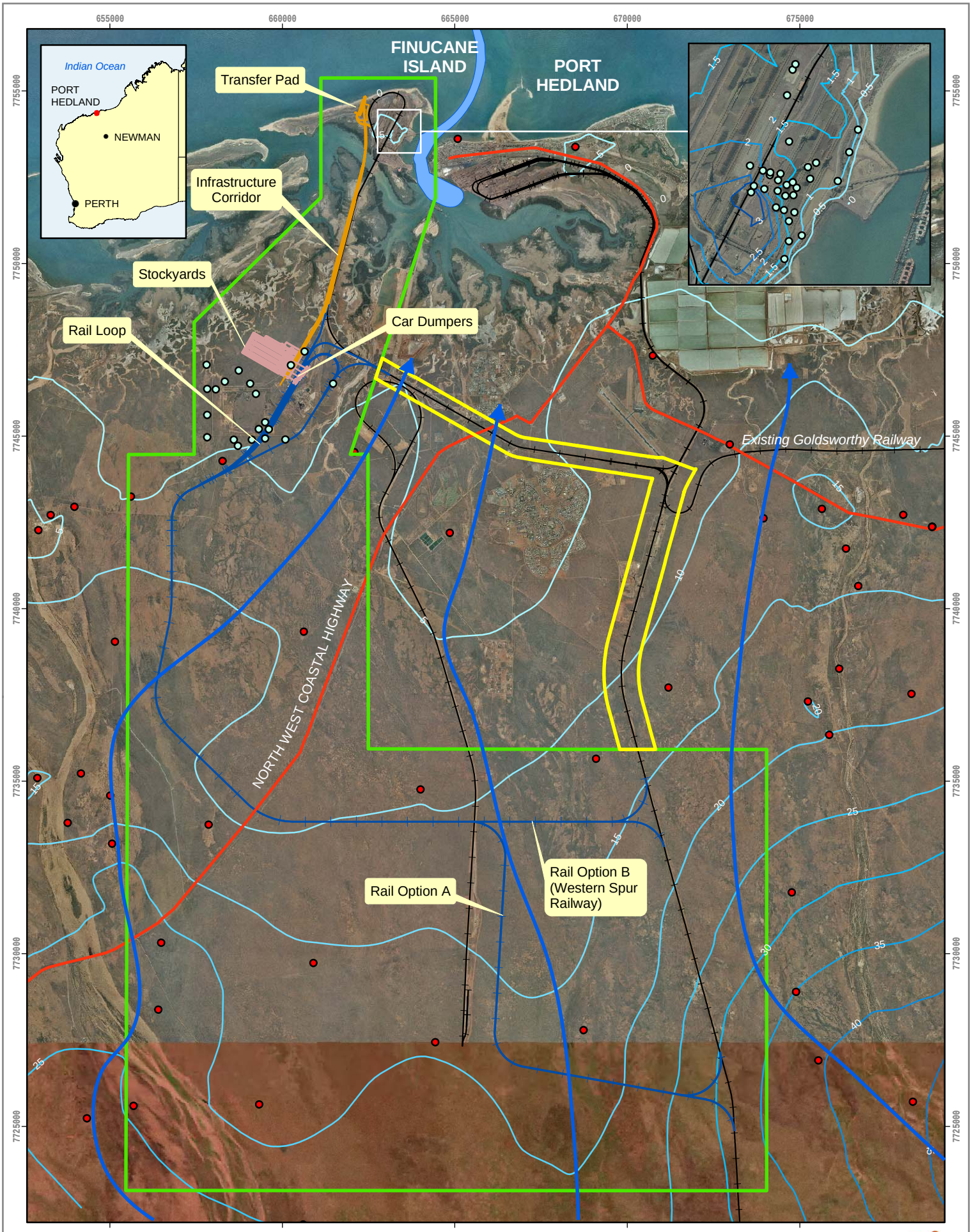
Groundwater conditions within the area proposed for construction of the Outer Harbour Development's stockyards, car dumpers and conveyor tunnels were described in the former Boodarie HBI plant CER (BHP Direct Reduced Iron 1994). It can be inferred from the CER, and subsequent monitoring of bores north of the plant (Figure 3.4), that groundwater depth under the proposed stockyards and associated infrastructure is mostly 3-4 m below ground level (Table 3.2). However, in some areas groundwater is only 1-2 m below ground level (Figure 3.5). Depth to groundwater below the proposed Outer Harbour Development rail options is variable according to location but increases with distance from the coast.

Groundwater on Finucane Island lies between about 7 m below ground in the centre of the island and 1 m below ground in the south-east. There is evidence of limited groundwater mounding in the eastern part of the island (around the wharf area) associated with leakage from wet processing of iron ore (SKM 2009b).

Seasonal fluctuations in groundwater level are about 2 m during years of high rainfall (BHP Billiton Iron Ore 2008; Bennelongia unpublished data).

3.4.3 Chemistry

Monitoring around the HBI plant suggests salinities are mostly 10-60 g L^{-1} Total Dissolved Solids (TDS), which is similar to of the values of 13-52 g L^{-1} TDS given for groundwater under the plant by BHP Direct Reduced Iron (1994). However, salinity exhibits considerable spatial and temporal variability with some salinity at some bores varying by at least 30 g L^{-1} during the year and modal salinities between bores varying almost two ranges of magnitude. Thus, while most of the groundwater around the stockyards and car dumpers is likely to have salinities roughly similar to seawater, some pockets of consistently fresh water occur and many sites are either more saline than seawater or experience spikes of salinity (see Table 3.2, Figure 3.5). Recorded salinities during about 10 years of monitoring at bore 456 in the south-west part of HBI plant were 0.8-1.6 g L^{-1} TDS, while bore BH421 on the north-east corner of the former residue storage pond had salinities of 20-30 g L^{-1} TDS until 1999 when groundwater level rose



Legend

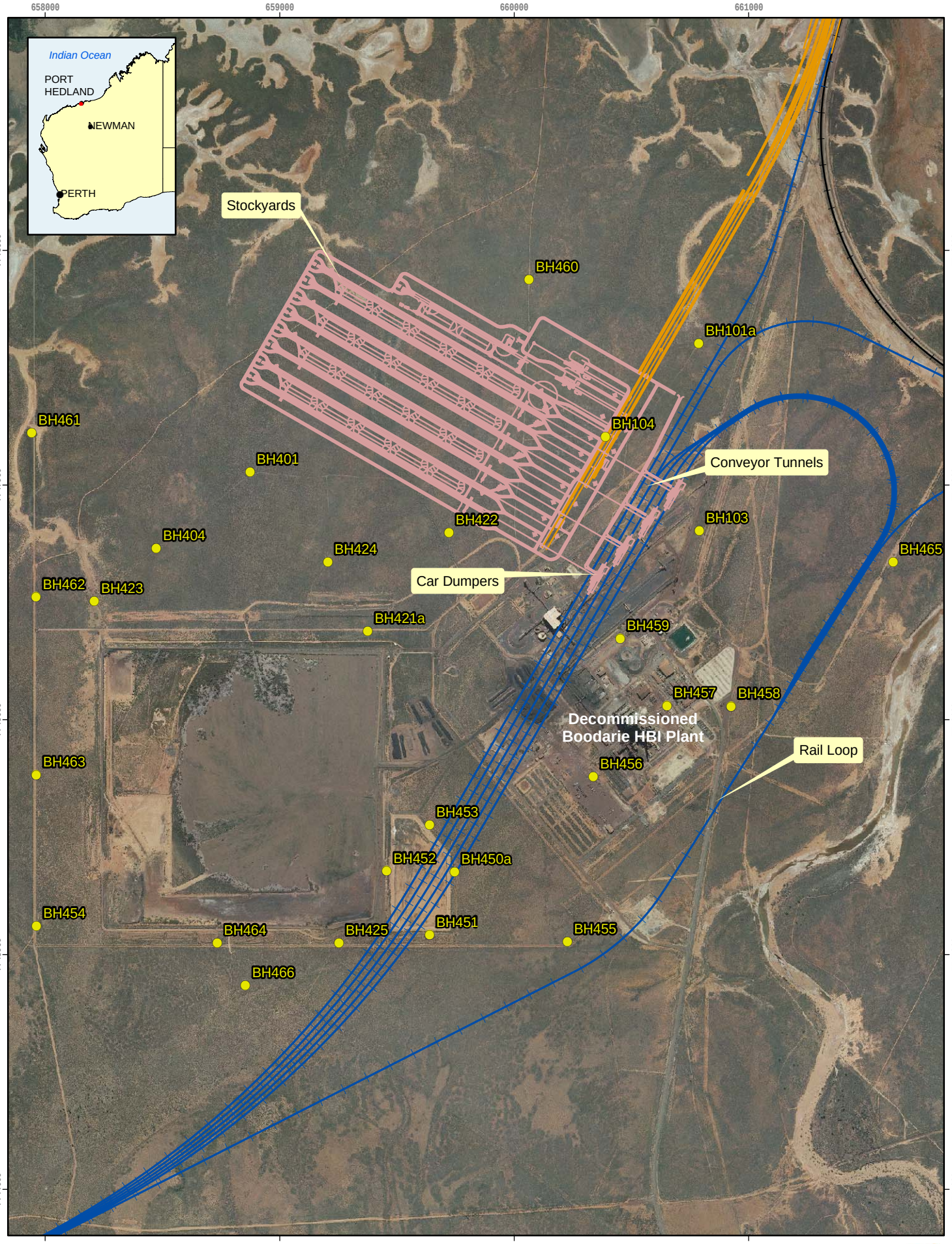
- Rationalised Subset of WIN Sites used for Modelling (DoW, 2008)
- Rationalised Subset of BHPBIO Monitoring Bores used for Modelling (BHPBIO, 2008)
- Principal Road
- Proposed Infrastructure
- Proposed Stockyards
- Existing Railway
- Proposed Railway Options
- Groundwater Contour (m AHD)
- Groundwater Flow
- Goldsworthy Rail Duplication Project Area
- OHD Project Area

0 1 2 3 4 kilometres

Scale @ A4: 1:140,000
Vertical Datum: AHD71
Horizontal Datum: GDA94
Map Grid: MGA94 Zone 50

Source:
Groundwater Contours: 2008 (SKM)
Orthorectified Aerial Photograph: June 2008 (BHPBIO)
Topography: GEODATA Topo 250K V3

Figure 3.3 Hydrogeological Hradient for the Project Areas



Legend

- Existing Monitoring Boreholes
- Proposed Infrastructure Corridor
- Proposed Stockyards
- Proposed Railway Loop

0 0.5 1
kilometres

Scale =1:21,000 at A4

Datum: GDA94
Projection: MGA94 Zone 50

Source:
Orthorectified Aerial Photograph: 08/06/2008 (BHPBIO)
Topography: Geoscience Australia, GEODATA Topo 250K V3
(Copyright Commonwealth of Australia, 2006)

Figure 3.4 Groundwater Bores Monitored at Decommissioned Boodarie HBI Plant

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and salinities dropped to 1-3 g L^{-1} TDS and then fresh conditions persisted despite groundwater level returning to previous levels (Ecowise Environmental unpublished data converted from mS). Even fresher water was present (and persisted) in some bores, such as BH101, after rain in autumn and winter of 2001 (Figure 3.7). On the other hand, bores BH101a (43-78 g L^{-1}) and BH461 (59-87 g L^{-1}) and other slightly less saline bores are probably more representative of overall conditions between the former HBI plant and the coast.

Groundwater under Finucane Island appears to be less saline than in the plant area with salinities (based on conductivity readings) of about 4-28 g L^{-1}. It is considered likely, however, that a lens of fresher water forms seasonally over the more saline 'regional' groundwater (SKM 2009a) and the lower salinity recordings were probably collected from this layer.

When data on groundwater salinities were examined for bores farther south, and elsewhere on the coastal plain as illustrated in Figure 3.6, there was little evidence of saline water and, therefore, it is expected that salinities under southern parts of the railway line will be low (Table 3.2). It is likely that high salinities close to the coast in the development area are a product of the shallow water table, marine influences and relatively high clay content of soils. The extent of the influences of historical inundation by seawater, the seawater wedge underlying fresh groundwater and high levels of marine salt deposition are unclear, given that not all groundwater close to the sea is saline (e.g. bores PSS261-263, Table 3.2).

A preliminary site investigation that was undertaken for the proposed Outer Harbour Development and Goldsworthy Rail Duplication projects concluded that there is a low risk of encountering groundwater contamination within the project areas (SKM 2009b). An exception to this, however, is the Boodarie HBI Plant inside the proposed Outer Harbour Development project area, where site remediation is currently occurring.

Table 3.2. Groundwater Depth and Salinity on the Coastal Plain. Bores BH101-460 around HBI plant, data from Boodarie Iron (2006), and BHP Billiton Iron Ore (2008) and Ecowise Environmental (unpublished); bores PSS024-263 and POL091 on coastal plain around Port Hedland (see Figure 43.7), data from Halse et al. (unpublished) and Bennelongia (unpublished).

Development area/HBI plant bores				Coastal plain sub-region stygofauna bores			
Bore	Depth (m)	TDS (g L^{-1})	Geology	Bore	Depth (m)	TDS (g L^{-1})	Geology
North of HBI plant				PSS024	5	0.5	alluvium
BH101	0.6-1.7	30-60[1]	clayey sand	PSS025	7.2	0.55	alluvium
BH104	0.9-3.7	19-56[2]	clayey sand	PSS027	11.5	0.5	colluvium
BH401	1.6-3.4	26-43	silty sand	PSS132	7.1	0.05	alluvium
BH422	1.4-4.4	10-55[3]	clayey sand	PSS133	6.8	0.07	alluvium
BH460	1.7-4.2	44-69	clayey sand	PSS134	10	0.23	alluvium
Fresher sites				PSS261	2.4	0.63	conglomerate[5]
BH421	1.3-4.9	1.1-22	silty sand	PSS262	6.3	0.74	conglomerate[5]
BH450	2.7-5.5	5-18[4]	clayey sand	PSS263	2.5	2.8	conglomerate[5]
BH456	2.7-4.6	0.4-1.6	silty sand	POL091	3.8	7.2	alluvium
				POL100	5.7	7.2	alluvium

[1] Value of 0.03 g L^{-1} recorded in February 2001; [2] outlying upper value 80 g L^{-1}; [3] fresher period in 1997 and values 30 g L^{-1} only in 1998-99; [4] 0.04 g L^{-1} in April 1999; [5] lime cemented beach conglomerate.

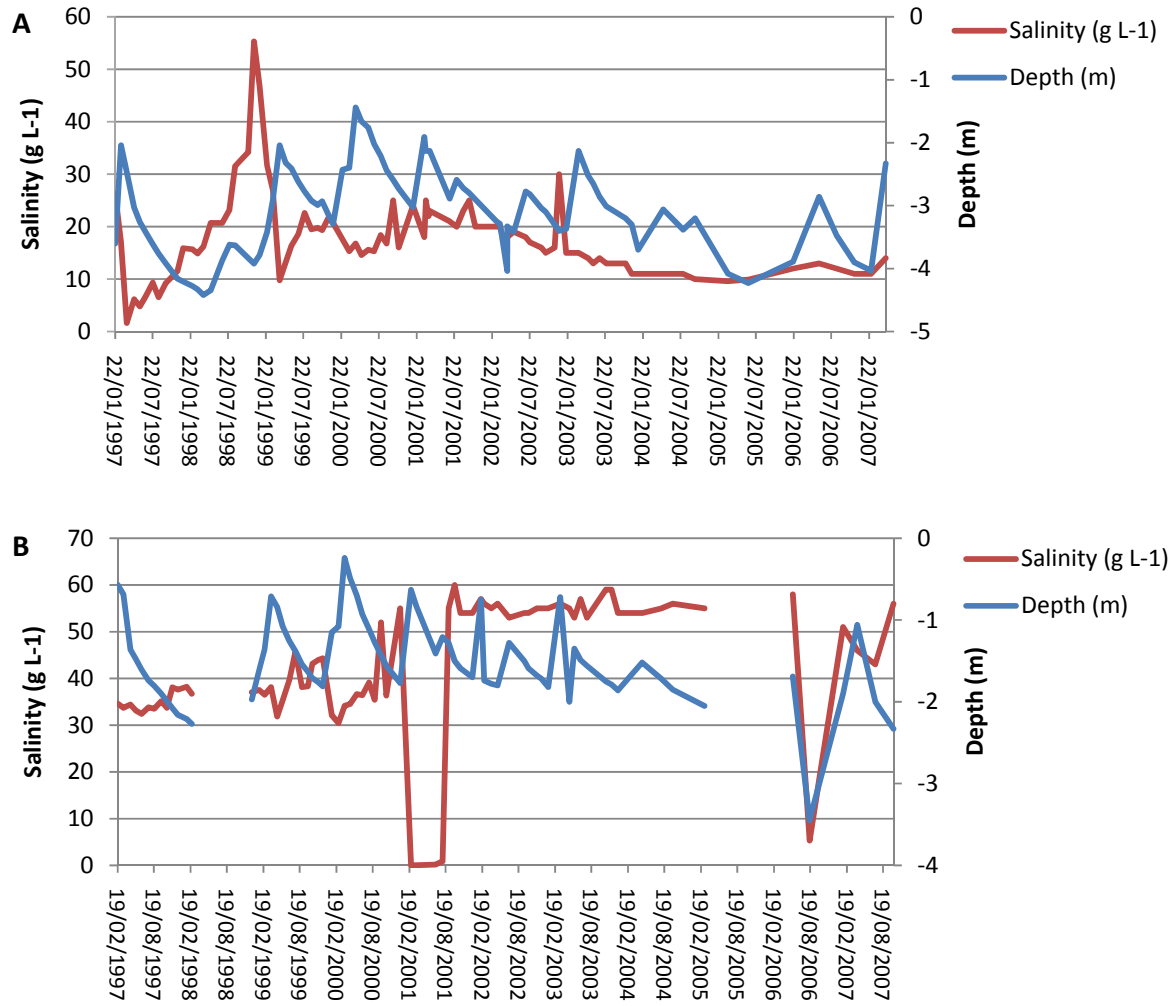

Figure 3.5. Temporal Variation in Depth and Salinity of Groundwater. Bores from the vicinity of the former HBI plant, monitored from 1997 to early 2008. A, Bore BH422; B, Bore BH101 (see Figure 3.4 for locations). Data provided BHP Billiton Iron Ore from annual monitoring program associated with the HBI plant (see Table 3.2).

3.5 Anchialine Habitat

Karstic anchialine systems constitute a habitat with potentially high conservation significance for stygofauna (Humphreys 2000). Anchialine systems are based on the Ghyben-Herzberg relationship, where a lens of fresh water overlying sea water is able to displace the sea water to considerable depth, thus creating fresh water habitat in a marine environment. Anchialine systems occur on the Exmouth Peninsula, where the habitat and stygofaunal community are listed as a Threatened Ecological Community under the *Environment Protection and Biodiversity Conservation Act* 1999 and several of the component species are listed as rare under the *Wildlife Conservation Act* 1950. Anchialine systems can potentially occur in many coastal limestones but the high salinities and absence of fresh groundwater at the former HBI plant suggest there is no suitable freshwater lens to form anchialine conditions in much of the area planned for the proposed Outer Harbour Development.

It has been suggested, however, that a freshwater lens overlays more saline groundwater at Finucane Island (SKM 2008). This is likely to be principally a seasonal phenomenon supplemented by some groundwater mounding associated with wet processing of iron ore and leakage from tailings ponds (Coffey 2007). It is unlikely to form an anchialine habitat of the type used by stygofauna (e.g. Iliffe et al. 1984), which requires more permanence to enable animals to complete many life cycles in a stable environment.

3.6 Subterranean Fauna

3.6.1 Known records in the Local Area

The recent stygofauna survey of the Pilbara region, completed as part of the Department of Environment and Conservation's Pilbara Biological Survey, has provided broadscale information about stygofauna occurrence on the coastal plain around Port Hedland and in the hinterland of the Turner River catchment (Halse et al. in prep.) (Figure 3.6). A total of 39 athalassic stygofauna species have been recorded from 16 bores in the catchment within 100 km of the proposed Outer Harbour Development and Goldsworthy Rail Duplication project areas, and 34 stygofauna species have been recorded on the coastal side of the North West Coastal Highway (Table 3.3). On the basis of the relatively rich stygofauna community in the local area, the proposed Outer Harbour Development and Goldsworthy Rail Duplication project areas would be expected to contain stygofauna where suitable groundwater salinity and geology exist (e.g. small interstitial spaces and fresh water may support syncarids while small interstitial species and saline water may support marine stygofaunal harpacticoids, if such species exist).

There are no troglofauna trapping data in the public domain from areas closer to Port Hedland than the Ord Ranges.

3.6.2 Potential Occurrence of Stygofauna based on Habitat Assessment

Stygofauna are expected to occur within the proposed Outer Harbour Development and Goldsworthy Rail Duplication project areas, based on sampling records from the Port Hedland sub-region and the geology of the project areas, although results of groundwater monitoring suggest salinities in some coastal parts of the project areas may be sufficiently high to preclude the occurrence of athalassic stygofauna (see below). The species listed in Table 3.3 were found in alluvium, silty sand, clayey sand and related habitats (and to a lesser extent lime cemented beach conglomerate and dune limestone), which are all prospective habitat for stygofauna (Halse et al. in prep.).

Athalassic stygofauna are likely to occur in fresher water to the south in the broad vicinity of the stockyards and under all railway options. It is unlikely that these stygofauna, which occupy alluvium, silty sand and clayey sand, will have highly restricted distributions, because of the predominance of widespread stygofauna species on the coastal plain. Only 2 of the 34 known coastal plain species have been recorded from a single river catchment (*Areacandona yuleae* and Tubificidae sp. WA24, Table 3.3) and the distributions of these two species may widen as additional sampling occurs.

It is unlikely that any stygofaunal species are restricted to Finucane Island because of its small size and the dynamism of coastal structures in the Pilbara (Turalski et al. 1996). Although the lime cemented beach conglomerate and dune limestone may potentially contain stygofauna habitat, the marine conditions on this low lying and geologically recent island make it unlikely that restricted freshwater species occur. Marine species are usually widely distributed compared with freshwater subterranean species. Sampling of lime cemented beach conglomerate west of Port Hedland at bores PSS261-263

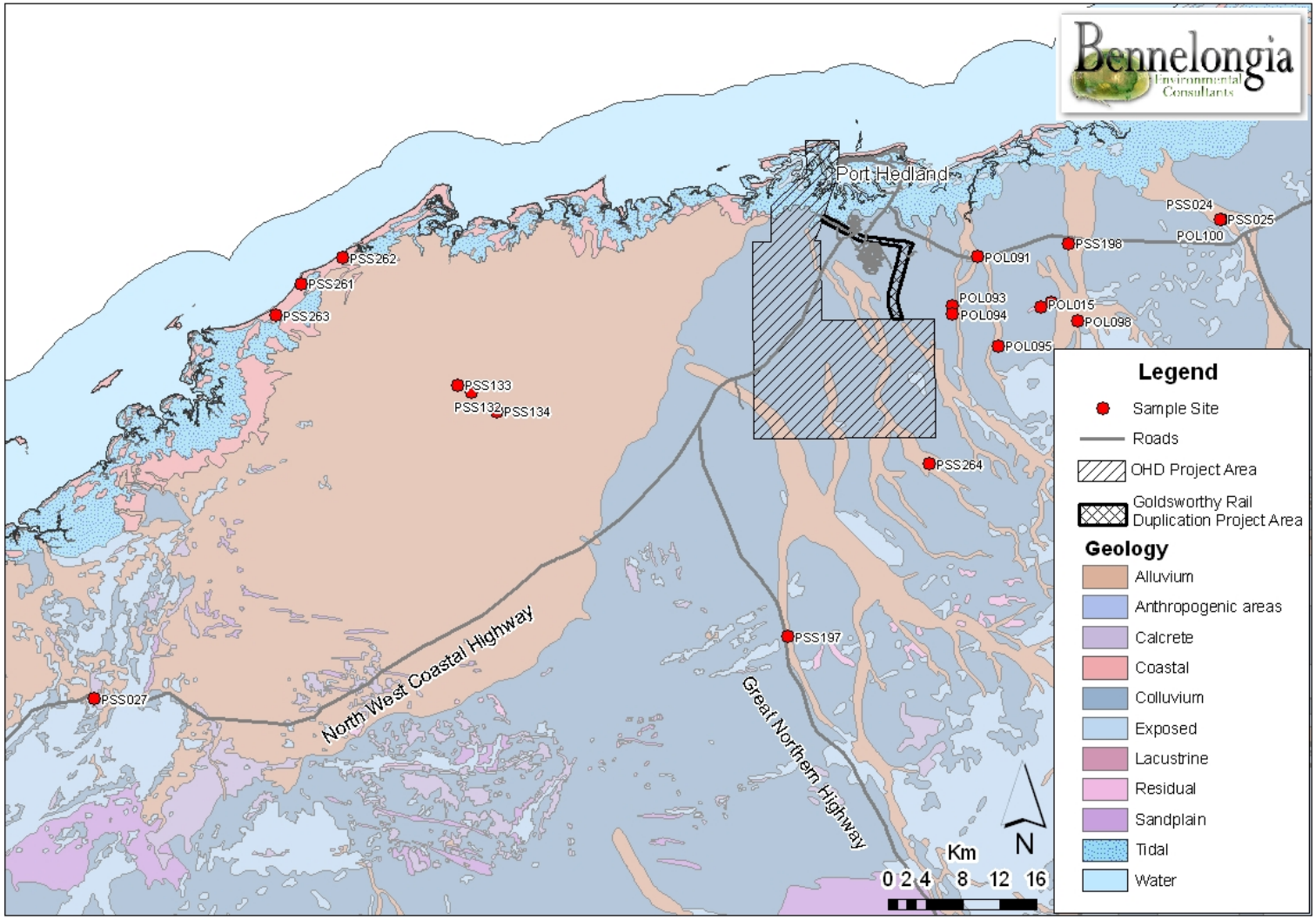

Figure 3.6. Location of Bores within 100 km of Port Hedland. Bores on the coastal side of the North West Coastal Highway or within the Turner River catchment are shown. Habitat marked as alluvium is mostly silty sand and clayey sand, colluviums is mostly sand according to the classifications used in Figure 3.2.

Table 3.3. Stygofauna within 100 km of Port Hedland in 16 Bores within the Turner Catchment and in 11 Bores North of North West Coast Highway. Available information on distribution and abundance (number of records in the Pilbara Biological Survey) of species is summarized. Bore locations shown in Figure 3.6.

Taxa	Turner catchment	North of Highway	Distribution	Abund.
Nematodes				
Nematoda sp.	1	1	N/A	
Worms				
Aeolosoma sp. 1 (PSS)		1	Pilbara	45
Aeolosoma sp. 2 (PSS)		1	Pilbara	5
Dero nivea		1	cosmopolitan	34
Monopylephorus n. sp. WA29 (ex *Pristina* WA3) (PSS)	1	1	Pilbara	30
Insulodrilus lacustris s.l. Pilbara type 1 (PSS)	1	1	NW Pilbara	3
Insulodrilus lacustris s.l. Pilbara type 2/3 (PSS)	1	1	NW Pilbara	5
Astacopsidrilus sp. WA31	1	1	Pilbara	6
Phreodrilid with dissimilar ventral chaetae	1	1	Pilbara	190
Phreodrilid with similar ventral chaetae	1	1	Pilbara	70
Tubificidae stygo type 1 (imm *Ainudrilus* WA25/26?) (PSS)		1	Pilbara	12
Tubificidae sp. WA24 (PSS)	1	1	Yule River	1
Snails				
Ancylidae sp.		1	? N Pilbara	2
Planorbidae sp.		1	Pilbara coast	46
Gastropoda sp.		1	N/A	
Mites				
Acariformes sp.	1	1	N/A	
Seed shrimps				
Cypretta seurati		1	Pilbara	76
Gomphodella sp. 2 (PSS)	1		Turner River	1
Areacandona iuno	1		P Hedland Coast	8
Areacandona jessicae	1	1	P Hedland Coast	9
Areacandona krypte	1	1	P Hedland Coast	2
Areacandona yuleae	1	1	Yule River	3
Humphreyscandona fovea[1]	1	1	Robe/Fortescue	25
Humphreyscandona waldockae	1		W Pilbara	5
Leicacandona mookae	1		Yule River	1
Copepods				
Stygoridgewayia trispinosa	1		NWA coast	23
Diacyclops cockingi	1	1	Pilbara	40
Diacyclops einslei	1		W Pilbara	12
Diacyclops humphreysi humphreysi	1	1	WA	209
Diacyclops scanloni	1		Pilbara	38
Diacyclops sobeprolatus	1	1	Pilbara	81
Halicyclops (Rochacyclops) calm	1		W Pilbara	45
Mesocyclops brooksi	1		S Australia	150
Microcyclops varicans	1		cosmopolitan	200
Elaphoidella humphreysi	1	1	W Pilbara	66
Parastenocaris jane	1		Pilbara	50
Parastenocaris sp.	1	1	N/A	
Stygonitocrella bispinosa	1		Pilbara	31

Taxa	Turner catchment	North of Highway	Distribution	Abund.
Stygonitocrella trispinosa	1		W Pilbara	38
Stygonitocrella unispinosa	1	1	Pilbara	41
Syncarids				
Chilibathynella sp.	1	1	Pilbara	6
Hexabathynella A (PSS)		1	N Pilbara	3
Hexabathynella B (PSS)		1	N Pilbara	3
Parabathynellidae sp.	1	1	N/A	
Slaters				
Microcerberidae sp.	1	1	N/A	
Scuds				
Nedsia nr *douglasi*	1		Barrow Island	1
Nedsia sp.	1	1	W Pilbara	186
Melitidae sp. 1 (PSS)	1	1	W Pilbara	41
Paramelitidae sp. 2 (PSS)	1		Pilbara	80
	39	34		

[1] Probably an identification error (see Distribution).

revealed a typical fauna of the Pilbara coastal plain consisting of between two and 10 species at a bore. All species were widespread.

The critical issue determining occurrence of stygofauna around the new car dumpers, conveyor tunnels and the stockyards is probably salinity. Examination of the salinities at which Pilbara stygofauna have been recorded suggest that the salinities of the area containing car dumpers, conveyor tunnels and stockyards are too high most of the time or in most of the area to support the occurrence of the known athalassic species of Pilbara stygofauna. In the recent Pilbara-wide stygofauna survey, only seven out of nearly 4000 records of stygofauna were in water with a salinity exceeding 10 g L^{-1} and all were under 11 g L^{-1} TDS (Figure 3.7), although lack of access to suitable bores meant areas such as the HBI plant and coastal areas with highly saline groundwater were not sampled. Water at the stockyards, car dumpers and conveyor tunnels appears mostly to vary between 10-60 g L^{-1} TDS, although there are pockets of fresher water of unknown size and temporal stability. Stygofuana species, if present within the area of the car dumpers, conveyor tunnels and stockyards, are likely to be be marine species, which typically have widespread distributions (.e.g. Lang 1965; Hartmann-Schroder & Hartmann 1978; Karanovic 2008).

3.6.3 Potential Occurrence of Troglofauna based on Habitat Assessment

Troglofauna studies are still at an early stage of development in Western Australia and the habitats used by these animals are still being documented. It is known that troglofauna occur in mineralized outcrops and low ranges throughout the Pilbara, including coastal areas (Biota 2006; Subterranean Ecology 2007; Bennelongia 2008a), and they also occur in calcretes (e.g. Edward and Harvey 2008). Troglofauna have very rarely been collected when sampling has extended away from mineralized areas into colluvium and it has been suggested sands and gravels, such as those within the proposed Outer Harbour Development and Goldsworthy rail Duplication project areas, are unfavourable habitat for troglofauna in the Pilbara (Biota 2006). However, there are difficulties trapping in such habitat and troglofaunal groups such as symphylans (millipede-like animals) have been collected in low abundance from sandy or alluvial habitat in the South-West (Biota 2005). Unpublished data gathered since this review began has shown that troglofauna do occur in Pilbara alluvium, although there appears to be no records from the coastal plain close to Port Hedland.

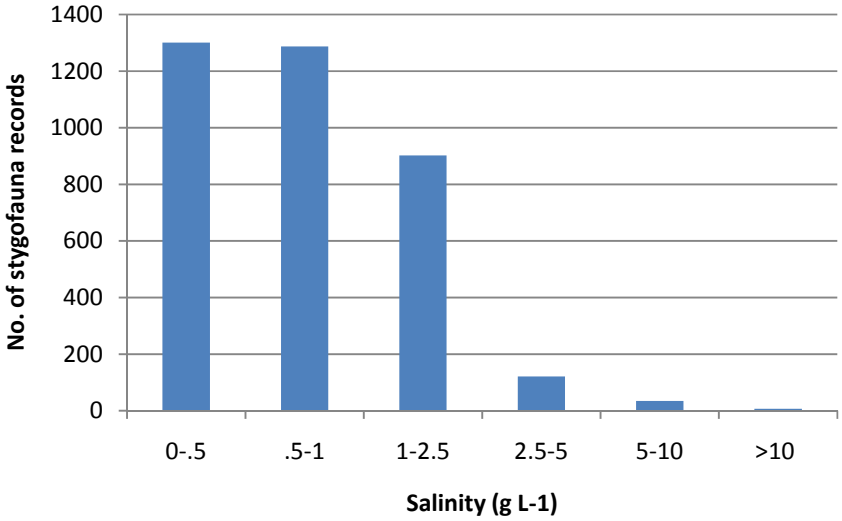

Figure 3.7. Occurrence of Stygofauna in Relation to Salinity in the Pilbara. Data based on preliminary analysis of sampling across the whole Pilbara (Halse et al. in prep).

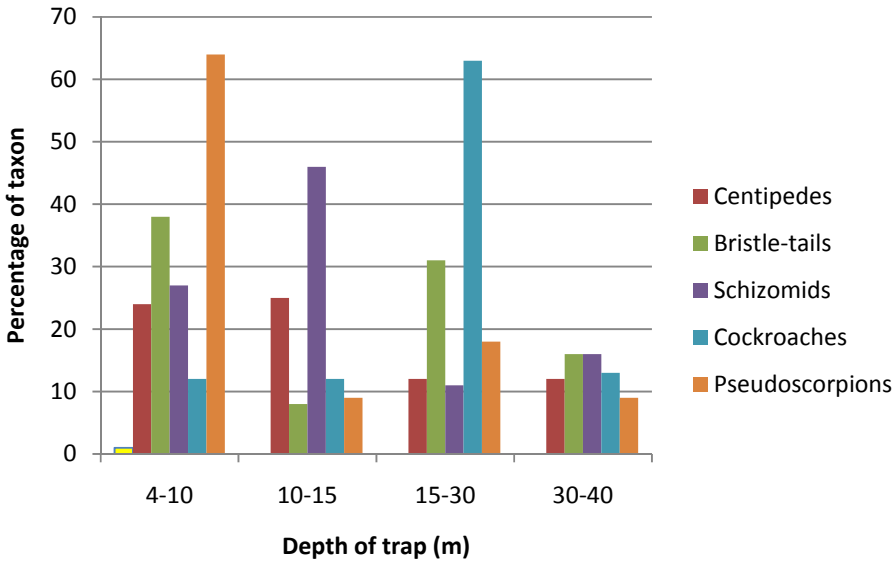

Figure 3.8. Percentage of Troglofaunal Animals Trapped at Different Depths Below Ground. Data for various higher taxonomic groups from the Robe Valley. Conditions reduced efficiency of traps at 30-40 m depth and these yields are likely underestimated. Some centipedes excluded from dataset because they were not considered to be troglofauna so that centipede total <100 %. Other taxa exclusively troglofaunal. Extracted and re-graphed from Biota (2006).

Relatively little attention has been paid to depth requirements of troglofauna but trapping by Biota Environmental Sciences showed catches for some troglofaunal groups are greatest below 10 m depth (Figure 3.8). Trapping experience suggests few troglofauna occur at depths less than about 5 m below the surface.

Theoretical reasons to expect few troglofauna at shallow depths or when there is a shallow water table, unless perhaps in unusual cave situations, are outlined below.

- Troglofauna are likely to be outcompeted at shallow depths by foraging surface species that have energy resources from the upper surface layers to enable them to be more vigorous than troglofauna (Gibert & Deharveng 2002).
- Troglofauna require a near- saturated atmosphere. During the dry season plant roots dry out the vadose zone, which forces troglofauna to move away from the surface towards the watertable where conditions remain saturated. The saturated zone is likely to be very thin when the watertable is near the surface and daytime temperatures are about 35°C.
- When the watertable occasionally approaches the surface, as happens around the stockyards and infrastructure corridor (Table 3.1, SKM 2009a), any troglofauna present will be displaced by rising water.

On the basis of the information provided above, it is considered very unlikely that any troglofauna occur at the proposed Outer Harbour Development's stockyards, car dumpers, conveyor tunnels or infrastructure corridor and Goldsworthy Rail Duplication project. The shallow depth to groundwater is likely to render habitat unsuitable. Furthermore, no troglofauna have been caught to date from similar coastal plain habitat in past studies (albeit very little, if any, trapping has occurred). Finucane Island appears even less likely to provide troglofauna habitat because the soil profile is subjected to erosion and flooding during cyclone events and the depth to groundwater is shallow.

In relation to the proposed Outer Harbour Development, it is noteworthy that the EPA recently considered that, on balance, there was a low risk of troglofauna occurring on the eastern side of Exmouth Gulf because the thickness of rock above seawater was less than 8 m, it contained no air-filled chambers or voids and the underlying groundwater was of seawater concentration (EPA 2008). Conditions in the northern part of the proposed Outer Harbour Development and Goldsworthy Rail Duplication project areas represent even shallower, equally or more saline habitats, and are likely to be even less prospective for troglofauna.

The situation with respect to occurrence of troglofauna under the proposed Outer Harbour Development's rail options to the south cannot be determined by desktop review. It is possible that some alluvium-inhabitating troglofauna species occur. However such species, if they do occur, are probably wide-ranging on the coastal plain.

4.0 Subterranean fauna risk assessment

4.1 Key Risks

The activities associated with the projects that may disturb subterranean fauna habitat or subterranean fauna are listed below.

- *Dewatering*: the construction of the proposed Outer Harbour Development car dumpers and conveyor tunnels will require dewatering to allow deep excavation (up to 25 m) to be undertaken. No dewatering will be required for the proposed Goldsworthy Rail Duplication.
- *Groundwater abstraction*: the construction of the proposed Outer Harbour Development's rail options A and B will require groundwater to be abstracted from shallow bores for dust suppression. The construction of the proposed Goldsworthy Rail Duplication is unlikely to require groundwater abstraction for dust suppression.
- *Soil excavation*: the construction of all proposed Outer Harbour Development infrastructure components will require at least shallow excavation (less than 3 m) and at localised areas during rail construction, and deep excavation (up to 25 m) required at the car dumpers and conveyor tunnels. The construction of the proposed Goldsworthy Rail Duplication will require shallow excavations (less than 3 m).

Significant groundwater or soil pollution may also detrimentally affect subterranean fauna. Possible sources of this pollution include:

- leakage of polluted dust suppression water from stockpiles associated with the proposed Outer Harbour Development;
- fuel and oil leaks from storage facilities and machinery;
- washdown of plant equipment;
- discharge from site ablution facilities, and
- spillage of maintenance chemical such as hydraulic fluids, paints and thinners.

4.2 Stygofauna

Based on survey records and geology, athalassic stygofauna are likely to occur within the southern part of the proposed Outer Harbour Development and Goldsworthy Rail Duplication project areas. These stygofauna are less likely to occur between the former Boodarie HBI plant and Finucane Island because salinities of most of the groundwater within the areas exceed the maximum values at which athalssic stygofauna have been recorded in the Pilbara. The effect of existing pollution at Finucane Island is difficult to assess but it is localized at the eastern end of the island and probably unlikely to have a major effect on any stygofauna species present.

Survey data from the adjacent coastal plain suggest most species in the southern portion of the project areas will have relatively large ranges, usually covering several river catchments. Even if species that are restricted to a single catchment occur, the homogeneous geology of the coastal plain makes it very unlikely any species could be restricted to a small area. There are no geological barriers or significant features in the project areas that might constrain a species range.

Factors potentially impacting upon stygofauna within the proposed Outer Harbour Development on stygofauna are de-watering, water abstraction and groundwater pollution (Table 4.1). Temporary de-watering will occur to construct the car dumpers and conveyor tunnels (to depth of about 25 m). Water for dust suppression is not expected to be abstracted from the development area but water for some rail construction is likely to be abstracted from shallow bores. The volumes of water required, however, are highly unlikely to result in significant aquifer drawdown. Improved management practice with regards to groundwater pollution will be employed during the course of the proposed Outer Harbour

Table 4.1. Hazards to Subterranean Fauna and Likely Impacts in the Propoposed Outer Harbour Development and Goldsworthy Rail Duplication.

Project	Hazard	Potential Impacts	
		Stygofauna	**Troglofauna**
Proposed Outer Harbour Development	Groundwater abstraction	Localised loss of stygofauna Loss of stygofauna habitat	
	Groundwater pollution	Localised loss of stygofauna	
	Soil excavation		Localised loss of troglofauna Loss of troglofauna habitat
	Soil pollution		Localised loss of troglofauna
Proposed Goldsworthy Rail Duplication	Groundwater pollution	Localised loss of stygofauna	
	Soil pollution		Localised loss of troglofauna

Development and Goldsworthy Rail Duplication projects and groundwater pollution is expected to be minimal.

This desktop review suggests it is likely that athalassic stygofauna are absent from areas where the proposed Outer Harbour Development's stockyards, car dumpers and conveyor tunnels will be located, which are the only places where significant groundwater dewatering and, therefore groundwater habitat change, will occur. If any stygofauna are present, they will probably be marine species with wide distributions and their conservation status will not be affected by localized impacts. Consequently, the development is considered unlikely to affect stygofauna.

4.3 Troglofauna

Based on geological evidence and current knowledge of distribution and habitat requirements, troglofauna are unlikely to occur between the former Boodarie HBI plant and Finucane Island and in the area of the exitsing Goldsworthy Rail Line because of the shallow depth to watertable. In addition, sandy/clayey soils are considered to provide sub-optimal habitat for troglofauna (Biota 2006; EPA 2007). Troglofauna are considered unlikely to occur in lime cemented beach conglomerate and dune limestone on Finucane Island because of the small size of the island, its low elevation and exposure to cyclonic events, and the lack of a strongly developed karstic system. However, a depauperate troglofauna community may occur in the southern part of the proposed Outer Harbour Development and Goldsworthy Rail Duplication project areas.

Troglofauna are regarded as typically having small ranges (Lamoreux 2004; Biota 2006) but these small ranges are usually associated with a geological feature. If troglofauna species occur in sandy soils in the southern part of the development area, they are unlikely to be highly restricted. Such soils (usually referred to as alluvium and colluvium, although different terminology is employed here) are very extensive habitats in the sub-region (see Figure 3.6). Troglofauna species with ranges that extend more

than 100 km have recently been recorded in the Pilbara (Bennelongia 2008b) and it is becoming clear that some troglofauna species may be regionally widespread in habitats with high connectivity or when animals have a surface-dispersal phase.

Factors potentially impacting upon troglofauna within the proposed Outer Harbour Development and Goldsworthy Rail Duplication are soil excavation and soil pollution (Table 4.1). Excavation is unlikely to impact directly on troglofauna unless it is deeper than approximately 5 m, although there may be some small secondary effects of shallow excavation on troglofauna from altered recharge patterns of water, energy and nutrients to deeper subterranean habitats (see Humphreys 1991). The only deep excavation (depth of 25 m) in the project areas will be for construction of the car dumpers and conveyor tunnels, which will take place in an area troglofauna are highly unlikely to occur. All remaining proposed infrastructure for both the proposed Outer Harbour Development and Goldsworthy Rail Duplication projects will typically require shallow excavations (less than 5 m depth), except for the Outer Harbour Development rail construction where excavations of 5 m may be required for ground leveling purposes.

This desktop review suggests troglofauna are very unlikely to occur in the northern parts of the Outer Harbour Development and Goldsworthy Rail Duplication project areas and it is stressed that the EPA (2008) reached the same conclusion in relation to similar habitat east of Exmouth Gulf. Troglofauna may occur in the southern portions of the project areas but, to date, they have not been recorded from these sandy soils. Species that do occur are unlikely to be restricted to small areas because of the lack of geological barriers or significant features in the development area to constrain species ranges. It should also be recognized that the scale of any impact from rail construction will be very small, occurring only when cuttings in low 'hills' are required. The southern portions of the project areas are relatively flat. Therefore, excavation in these areas is considered unlikely to affect troglofauna.

In summary, the Port Hedland Outer Harbour Development and Goldsworthy Rail Duplication projects appear unlikely to threaten the survival of any subterranean fauna species.

5.0 Conclusions and Recommendations

This desktop review suggests there is low probability of either stygofauna or troglofauna occurring in the areas of de-watering or deeper soil excavation associated with the proposed Outer Harbour Development.

Athalssic stygofauna are likely to occur throughout the southern part of the proposed Outer Harbour Development and Goldsworthy Rail Duplication project areas but, other than possible abstraction of groundwater for the proposed Outer Harbour Development rail construction, no impact of the project on groundwater habitats is expected in this area. Groundwater abstraction for the proposed Outer Harbour Development rail construction will result in minimal groundwater drawdown if several shallow bores are used.

Stygofauna are unlikely to occur between the former Boodarie HBI plant and Finucane Island because salinities of the groundwater in this area mostly exceed the maximum values at which athalassic stygofauna have been recorded in the Pilbara . Any species that occur are likely to be of marine origin and widespread. Therefore, the de-watering that will be associated with the construction of the proposed Outer Harbour Development car dumpers and conveyor tunnels is unlikely to affect stygofauna.

A depauperate troglofauna community may occur in the southern part of the proposed Outer Harbour Development and Goldsworthy Rail Duplication project areas, where shallow excavation will occur for rail construction, although existing data on troglofauna distribution do not show them to be present in sands of the Pilbara coastal plain. The shallow excavation envisaged for rail construction will not extend to depths where troglofauna would be expected to occur.

On the basis of the evidence available, the proposed Outer Harbour Development and Goldsworthy Rail Duplication projects are unlikely to threaten the survival of any subterranean fauna species and are unlikely to have significant effects on the population of any species.

It is considered that the desktop review accurately reflects the risks to subterranean fauna from the the proposed Outer Harbour Development and Goldsworthy Rail Duplication projects within the constraints of current knowledge. No further work on subterranean fauna is recommended as a result of this review.

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